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Triassic of the Tethys Realm

Report on the Activities of the Triassic Working-Group in Hungary

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8 Figs.

In the frame of the Country-wide Key-profile Programme a number of drillings and artificial exposures were carried out during the last years in the Transdanubian Central Mountains and in North Hungary for getting better cognition concerning composition, facies, extension, genetics and stratigraphy of the various Triassic sequences.

The so gained profiles gave important new informations about the Permian/Triassic boundary in marine facies found in the SE-foreland of the Vértes Mts. Modern investigations on the materials won from different members of Triassic of the western Central Mountains present a good occasion for amplifying the knowledge comprised in the big volumes of the old Balaton-monography published by L. LÓCZY sen. and his collaborators in 1911—1913.

In the Hungarian part of the "South Gemerides" a new reambulation on a scale 1 : 10000 is going on. It is to be expected that — having close connections with similar works of the Slovakian colleagues — a more complete picture than hitherto can be elaborated about stratigraphy and tectonics of the southern West Carpathians in the course of some years. Although our results are still in an initial stage, one may already pre-establish that the most important part of the new picture will be formed by deeper-marine sediments, the first occurrence of which coincides with the Pelsonian/Illyrian boundary. The spatial and temporal extension of the Hallstatt facies proved much wider than it was previously assumed. Some new lithostratigraphic units were discovered between the Steinalm Formation and the Tuvalian part of the Pötschen Limestone. On the basis of radiolarians, a part of the thick shale-and-schist complex of the Rudabánya and Bükk Mountains seems to be not of Triassic but of Jurassic age. The light limestones alternating with products of a submarine diabase volcanism at Nekézseny (north of the Bükk Mt.) and assigned formerly to Ladinian, proved to be of Lower Devonian age.

A great part of these results are gained by the application of micropalaeontologic and microfaciologic methods. Owing to the fairly great taxonomical confusions whose influence for judgements of the stratigraphic value was very pernicious, an international working-group has been founded by the specialists belonging to IGCP Project 4. This was a suggestion by S. KOVÁCS in order to publish a new "Catalogue of Triassic Conodonts".

In none of the occurrences the investigations have been finished. By the following selected passages only the character and main directions of our researches should be shown. A country-wide, but entirely provisional recapitulation of the present-day results and problems can be found in K. BALOGH's paper "Correlation of the Hungarian Triassic" in Acta Geologica Academiae Scientiarum Hungaricae, tome 24, 1, 3—48, Budapest, 1981, with three correlation-tables.

Transdanubian Central Mountains

1. The Permian/Triassic boundary

It has been known already for a long time that the terrestrial-lacustrine beds of the Balaton Red Sandstone Formation of Late Permian age beginning with basal conglomerate above the Early Palaeozoic phyllites along the southern border of the Balaton Highland and reaching to 800 m in thickness, are covered by the Lower Scythian Nádaskút Dolomites with a lowangle unconformity. These light-coloured and sandy dolomites, not more than 20 m in thickness, are showing toward SW minor facies changes, containing also anhydritic and glauconitic interbeds. In NE direction, however, in connection with a major facies-change of the Late Permian, the Nádaskút Dolomite is entirely absent. Actually, in the E and SE foreland of the Vértes Mountains, it is substituted by the ca 200 m thick Alcsútdoboz Limestone Member which conformably lies on the dolomitic sequence of the Latest Permian Tabajd Formation. The latter develops from the highest, fine-grained beds of the Balaton Red Sandstone Formation — here only being 200 m thick — through frequent evaporitic intercalations. So it is clear that *the Tabajd Formation appearing in the SE foreland of the Vértes substitutes the upper part of the far thicker red clastics of the Balaton Highland.*

In the well Alcsútdoboz Ad-2 the Tabajd Formation can be divided into two parts:

1341—1248 m: grey, somewhat sandy and anhydritic dolomites
1248— 916 m: well-bedded, dark dolomites with limestone, marl and siltstone interbeds.

The upper part is rather rich in *foraminifers*, *dasycladaceans* and *sporomorphs*, however rarely *scolecodonts* and *ostracods* occur. Below 1050 m the fossil content — parallel with the increasing of the sulphates — rapidly decreases. The section from 1050 to 1125 m is almost totally free of animal fossils. The deeper beds are somewhat richer in microfossils.

The most frequent microfacies of this formation are: 1. Biomicrite and fine-sandy biosparite with parallel-embedded shells. 2. Dolomicrite and dolosparite with anhydrite. 3. Clayey or sandy dolosparite (red, free of fossils).

The distribution of the most characteristic microfossils of the beds above 1050 m is to be seen in Fig. 1. Among the *foraminifers* representatives of *Hemigordiopsidae* predominate: *Baisalina pulchra* Reitlinger, *Hemigordius ovatus* Grozdilova, *Hemigordius harltoni* Cushman et al., *H. reicheli* Lys, *H. renzi* (Reichel), *H. miranda* Lipina, *H. parvus* (Nikitina), *H. permicus* Grozdilova. The following species occur only in fixed horizons: *Cyclogyra kinkelini* (Spandel) between 993—1016 m; *Ammovertella* cf. *minuta* Lipina and *Glomospira elegans* Lipina in the uppermost beds. Less frequent, but significant forms are: *Colaniella media* K. M. Maclay, *Olympina insolita* Reichel. Beside them the forthcoming forms are frequent: *Globivalvulina vonderschmitti* Reichel, *Gl. graeca* Reichel, *Gl. bulloides* Brady, *Paraglobivalvulina mira* Reitlinger, *Glomospira elegans* Lipina, *Lunucammina* cf. *caucasica* K. M. Maclay, *L.* cf. *magna* Lipina, *L. taurica* (Civrieux et Dess.), *Pseudolangella fragilis* Civrieux et Dess., *Pachyphloia gefoensis* K. M. Maclay, *P. iranica* Bozorgina, *P. lanceolata* K. M. Maclay, *Agathammina pusilla* (Geinitz), *Nodosaria tenuiseptata* Lipina, *Frondina permica* Civrieux et Dess.

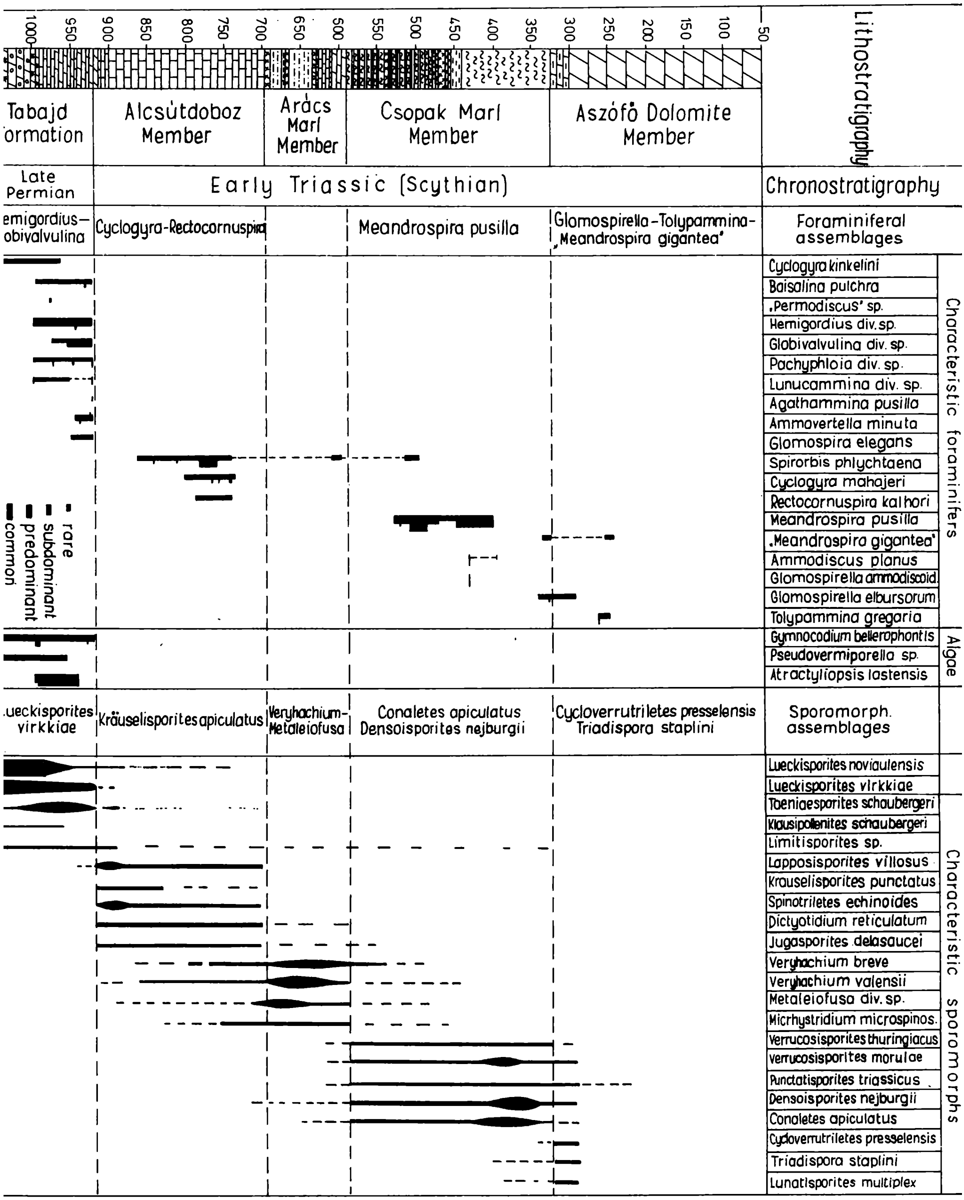


Fig. 1. **Distribution of foraminifers, dasycladaceans and sporomorphs on the Permian/Triassic boundary in the borehole Alcsútdoboz Ad-2 after A. Oravecz-Scheffer and F. Góczán.**

Except the *Paraglobivalvulina mira* REITLINGER, an indexform of the Djulfian, all the others are known from both the Djulfian and the Murgabian.

A distinct change in the *sporomorph assemblages* that can be identified with the Permian/Triassic boundary, appears at 919 m depth. Thus the uppermost 3 metres of the Tabajd Formation belong to the Lower Triassic.

From among the three lower members of the Werfen Formation of the Balaton Highland, only the Arács Member could be identified above the Late Permian dolomites of the well Ad-2. But the lack of the Nádaskút and the Hidegkút Sandstone Members can be easily explained by a facies-shift. This however has been gradually compensated higher up in the sequence, as the two uppermost complexes of the Lower Triassic, crossed by the complexes of the Lower Triassic, crossed by the well, are entirely identical with the Csopak Marl and the Aszófő Dolomite Members of the Balaton Highland.

The lowermost member of the Triassic, the Alcsútdoboz Limestone, can be divided into three parts:

916—878 m: calcareous marl alternating with limestone beds
878—830 m: calcareous marl
830—706 m: thin-bedded limestone.

The whole sequence is characterized by thin-bedding and nodular or mud-slumped structures. Its main microfacies are: 1. Micrite with thin pelitic intercalations. 2. Biosparite with red-coloured gastropodal oöids. 3. Biomicrite and biosparite with oriented shells of *Bivalvia*. 4. Clayey micrite. 5. Biomicrite with shells whose calcareous material is substituted by anhydrite.

The first *ostracodes* appear in 897—884 m depth, but the *foraminifers* start only in 50 m distance above the lithological boundary of the Triassic. The latter ones are represented by the euryhaline species *Cyclogyra? mahajeri* BRÖNN. et al. and *Rectocornuspira kalhori* BRÖNN. et al. Higher than 738 m no foraminifers were found. Instead of them *lumachella-like accumulations of molluscs and ostracods* appear in the higher part of the member. By all means, the sporomorph assemblage with the predominant *Lappisporites villosus* VISSCHER and other concurrent forms clearly differs from the *Lueckisporites virkkiae* KLAUS association of the Tabajd Formation.

The lower two thirds of the overlying, 110 m thick Arács Member consist of varied, fine sandy siltstones with parallel bedding. Its upper third part, however, is composed by dolomites, dolomarls and calcareous dolomites. The whole sequence is nearly free from animal fossils. Some *foraminifers* appear only in the basal and the uppermost beds. The *sporomorphs* are represented by the *Veryhachium—Metaleiofusa* association.

The thickness of the next Csopak Marl Member (between 593—322 m) is nearly equal to the reckonned thickness of the Hidegkút and Csopak Member of the Balaton Highland. Therefore it can not be excluded that its lower part signifies the finest-grained substitute of the Hidegkút Sandstone characterized by LÓCZY SEN. in 1913.

The Csopak Member crossed by the well Ad-2 consists of two *ABCBA* and *ABA*-type symmetrical cyclothems, where *A* signifies a ca 50 m thick marl and calcareous marl complex with 0,5—2,0 m thick limestone intercalations, *B* a ca 70 m thick clay-and-marl sequence with limestone nodules or lenses, *C*, however, a ca 30 m thick body of homogeneous marl.

The microfacies shows a wide-scale fluctuation of the transport-energy: 1. Clayey to fine-sandy micrite and sparite with parallel microbedding and frequent bioturbations. 2. Intraformational conglomerate with max. 3 cm wide, flat pebbles. 3. Mollusc-bearing micrite with fragments of crinoidal stems. 4. Ostracod-bearing biomicrite with crinoidal fragments. 5. Crinoid-bearing biosparite. 6. Oösparite with marks of small-scale unconformities. — Mud cracks prove temporary rising of the sequence over the sea-level.

Though the quantity of the bioclasts rapidly increases in the lower part of the member (between 586—531 m), *forams* (*Ammodiscus* sp, *Glomospirella* cf. *ammodiscoidea* RAUSER) are very rare here. The middle part (between 531—400 m) is characterized by a frequency of *Meandrospira pusilla* (HO), while specimens of *Nodosaria hoi scyphica* TRIFONOVA are scarce. In the upper part (between 400—328 m) *Meandrospira pusilla* (HO) is entirely lacking. But in some thin sections appears "*Meandrospira gigantea*" FARABEGOLI, a transition form between the group of *Meandrospira insolita* and the *Meandrospira dinarica*. Beside these some specimens of *Glomospirella* cf. *ammodiscoidea*, *Ammodiscus* sp., several *gastropod-* and *echinoderm-fragments* occur. In 332,7 m depth also many *ostracods*, moreover, in 330,7 m depth, some cross sections of *ammonites* could be observed. The *palynological specifics* of this member are represented by the association of *Coneletes apiculatus* REINHARDT et SCHÖN and *Densoisporites nejburgii* (SCHULZ) BALME.

The uppermost observable part of the Lower Triassic in the borehole Ad-2, the Aszófő Dolomite Member (between 47—322 m) consists of light-coloured, anhydrite-bearing dolomite beds of 2—10 cm thickness which develop from the Csopak Marl Member throughout a ca 20 m thick alternance of marl and porous dolomite. Its main microfacies are: 1. Homogeneous dolomicrite (infrequent). 2. Dolopelmicrite and dolopelsparite with intraclasts of resedimented microbeds. 3. Anhydrite-bearing dolosparite.

The microfauna of the Aszófő Member ("*Meandropsira gigantea*" FARABEGOLI, *Glomospirella elbursorum* BRÖNN. et al., *Tolypammina* cf. *gregaria* WENDT) is restricted to its lower part. Higher than 246 m it is entirely free from animal remains. The sporomorph content is characterized by the *Cycloverrutriletes presselensis* SCHULZ and *Triadispora staplini* SCHEURING assemblage.

Summarizing: In spite of the distinct palaeontological caesura caused by the rapid and entire disappearence of the Late Permian microflora and microfauna in 919 m depth, the foraminiferal evidences won from the borehole Ad-2 are not yet sufficient for the exact marking of the Permian/Triassic boundary. But the rather great gap between the disappearence of the Permian taxa and the begin of the first Triassic forams could be eliminated by means of the palynomorph assemblages which show a sharp boundary between Permian and Triassic at 919 m depth. All the fossil assemblages of the Tabajd formation (except the uppermost 3 metres) belong undoubtedly to the youngest ones in the Palaeotethys realm. The similarity with the contemporaneous South Alpine and Bükkian profiles also manifests itself by this fact.

2. The Anisian/Ladinian boundary

The superficial extension of the Anisian rocks in the Balaton Highland is shown in Fig. 2. Their section begins with the light-grey Megyehegy Dolomite

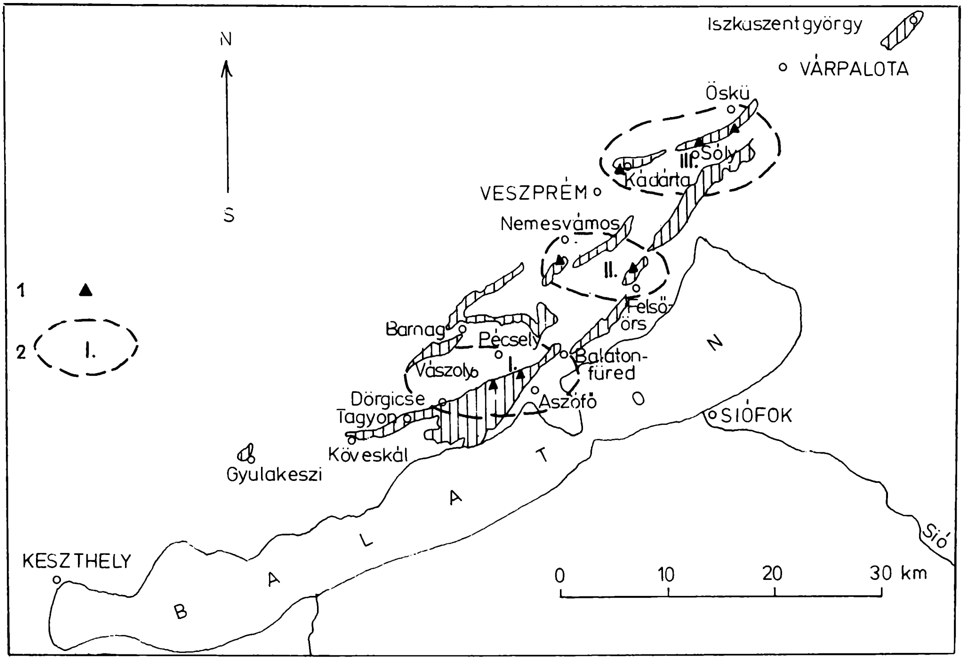


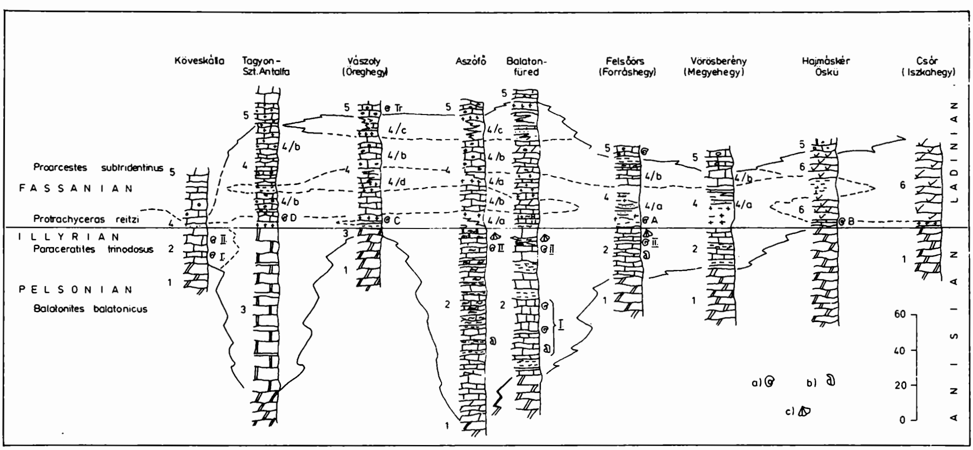
Fig. 2. **Superficial occurrences of Middle Triassic rocks in the Balaton Highland**
1. Sampling points. 2. Areals of the observed tuffaceous rocks.

Formation. This is a thinner or thicker bedded sediment containing dasycladaceans, oöids and oncoides in some places. But in the renewed artificial exposures of the hill Forráshegy at Felsőörs it is free of fossils and shows striking contact with the overlying yellowish-grey, bituminous, banded dolomitic marls. The latter ones are overlain by grey, cherty limestones intercalated locally with yellow, argillaceous cherty limestone and thin marl and siliceous marl layers. Besides spiculae of *siliceous sponges*, this part of the section contains a minor quantity of *echinoderms*, *molluscs*, *brachiopods* and *ostracods*, and — in two horizons — also *foraminifers*. The lower horizon is characterized by *Trochammina almtalensis* KOEHN-ZANINETTI and *Earlandia tintinniformis* (MIŠÍK), the upper one by *Agathammina judicariensis* PREMOLI-SILVA, *Endothyra salaji* GAŻDZICKI, *Glomospira* cf. *sinensis* HO, etc. Higher up follow *brownish-grey limestones* rich in remains of "Recoaro-brachiopods" (e. g. *Coenothyris vulgaris* (SCHLOTHEIM), *Rhynchonella decurtata* (GIRARD), *Piarorhynchia trinodosi* (BITTNER), etc.), echinoderms (*Dadocrinus gracilis* BUCH), as well as sessile foraminifers. Because of corrosion the cephalopods (*Bulogites* aff. *zoldianus* (MOJS,), *Megaloptychites* sp., *Nautilus* sp.) which have been found, were not suitable for precise identification.

The before-mentioned rocks most probably represent the Lower and Middle Anisian, as the overlying brownish-grey, biomicritic, marly limestones, containing clay intercalations and having a microfacies with filaments, radiolarians and ostracods, certainly belong to the *Paraceratites trinodosus* zone. These limestone beds namely include *Ptychites* cf. *domatus* (HAUER), *Flexoptychites flexuosus* (MOJS.), *Semiornites* sp. and *Paraceratites trinodosus* (MOJS.). In the higher situated marly intercalations there are *Daonellae* (e. g. *Daonella sturi* Benecke) and on the top of the sequence also one specimen of *Potrachyceras* sp. was found. The former descriptions also mention a lot of species of *cephalopods* and *Daonella* from these beds. Recently also *ostracods, holothurioids, conodonts* and *foraminifers* were described from here.

In Fig. 3 it can be seen that this "normal development" of the Anisian undergoes conspicuous changes both in facies and thickness. E. g. in the SW part of the hill Megyehegy at Vörösberény the transitional banded dolomite beds in the hanging wall of the Megyehegy Dolomite are missing and the limestones of the higher Anisian immediately cover the latter one. In the exposures at Hajmáskér—Öskü and at Csór (Iszkahegy) the Anisian limestones seem to be entirely replaced by Megyehegy Dolomite without ammonites.

Fig. 3. Facies and faunal zones of the Upper Anisian and Lower Ladinian. Anisian/Ladinian boundary in the Triassic of the Balaton Highland after I. Szabó.
1. Megyehegy Dolomite (Lower and Upper Anisian). 2. "Reifling-type" limestone (Upper Anisian). 3. Tagyon limestone with Dasycladaceans. 4. Buchenstein-type strata (Lower Ladinian). 4a. "Pietra verde" with thin limestone layers. 4b. Red cherty limestone. 4c. Radiolarite and silicified limestone with Posidonia. 5. Nemesvámos Limestone, red, with cherty nodules (Middle Ladinian). 6. Budaörs Dolomite with *Diplopora annulata* (Ladinian).
Anisian faunae: I. Ammonites of Balatonicus zone and brachiopods below the horizon I (Pelsonian). II. Ammonites of Trinodosus zone and *Daonellae* in the horizon II (Illyrian).
Ladinian faunae: A) Ammonites at Felsőörs (Fassanian). *B*) Ammonites at Hajmáskér (Fassanian). C) Ammonites at Vászoly (Fassanian). D) Ammonites from a borehole at Tagyon (Fassanian). Tr) Ammonites of Tridentinus zone (Fassanian).
a) Ammonites. b) Brachiopods. c) Daonellae.



The Anisian limestones reach their greatest thickness (ca 100 m) in the neighbourhood of Aszófő and Balatonfüred. The latter locality is especially important as it contains the ammonites both of the *Balatonites balatonicus* and the *Paraceratites trinodosus* zones. Therefore it seems to be possible that this locality takes over the function of the Pelsonian type-section from the Forráshegy, where *Balatonites* is missing.

On the hill Öreghegy at Vászoly and between the villages Tagyon and Szentantalfa the Middle and Upper Anisian grey limestones seem to be entirely substituted by the white, reeflagoonal, dasycladacean-bearing facies of the so-called Tagyon Limestone which includes no ammonites.

At the Anisian/Ladinian boundary, characterized by green and brown tuffaceous — argillaceous beds, this great diversity of facies becomes even. The thin limestone lamelles between the tuffite layers contain *cephalopods* of the *Protrachyceras reitzi* zone as follows: *Parakellnerites böckhi* (ROTH), *Parakellnerites felsőörsensis* (STÜRZENBAUM), *Parakellnerites hungaricus* (MOJS.), *Protrachyceras reitzi* (BÖCKH), *Protrachyceras cholnokyi* (FRECH), *Hungarites mojsisovicsi* (ROTH), *Hungarites costatus* MOJS., *Hungarites arietiformis* HAUER, *Hungarites bocsarensis* ARTHABER, *Hungarites emiliae* MOJS., *Longobardites zsigmondyi* (BÖCKH), *Ptychites angustoumbilicatus* (BÖCKH), *Flexoptychites flexuosus* (MOJS.), *Mojsisovicstheutis böckhi* (STÜRZENBAUM), *Mojsisovicstheutis baconicus* (FRECH).

Although some forms of this fauna are common with some of the Illyrian *Paraceratites trinodosus* zone, it seems very likely that the lower boundary of the Fassanian has to be drawn at the first appearence of the *Protrachyceras reitzi* accompanied by *Parakellnerites*.

Thickness and composition of this very characteristic sequence compared by LÓCZY SEN. (1913) with the South Alpine Buchenstein Formation is rather varying. In addition to the green potash-trachytic volcanic tuffs ("pietra verde") it may contain not only thicker tuffaceous and cherty limestone beds but also siliceous shale and radiolarite intercalations. Usually it is overlain by the Hallstatt-type, cherty-nodular, below red, higher up light-grey Nemesvámos Limestone Formation. According to LÓCZY SEN. (1913), the latter represents the *Prorarcestes subtridentinus* zone on the one hand and the *Daonella lommeli* zone on the other. *J. BÖCKH (1872) assigned it to the Proarcestes subtridentinus* and *Proarcestes archelaus* zone. FRECH (1911) classified the lower part — on the basis of *Protrachyceras villanovae* ARCH. and *Arpadites* — as a representative of the *Protrachyceras curionii* zone, the higher one, in which also *Daonella lomeli* WISSM. appears, as that of the *Protrachyceras archelaus* zone.

Toward NE, on the Iszkahegy at Csór, where it is underlain immediately by the Megyehegy Dolomite, the Buchenstein Formation is very thin, and its hanging wall is composed by the light-coloured Budaörs Dolomite Formation whose Ladinian age is proved by the occurrence of *Diplopora annulata* SCHAFHÄUTL.

3. Microbiostratigraphy of the Veszprém Marl Formation in the Mány-Zsámbék basin

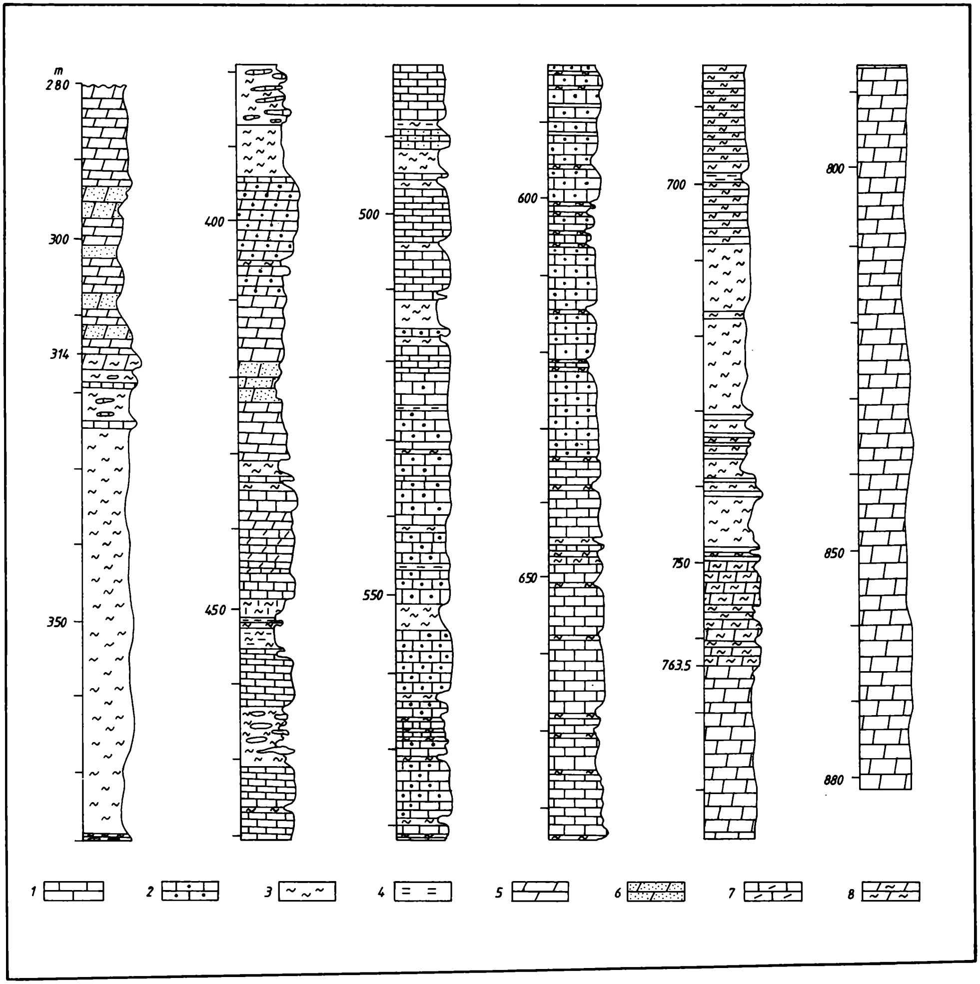
The eastern continuation of the Veszprém Marl Formation, known hitherto from the western part of the Transdanubian Central Mountains only, has been explored by 35 boreholes also in the underground of the Mány—Zsámbék basin, i. e. in the SE foreland of the Gerecse Mountains. Its total thickness between the Ladinian Budaörs Dolomite as footwall and the Tuvalian part of the Hauptdolomite Formation as hanging wall amounts in the borehole Zs-14 to 450 m (Fig. 4).

The Ladinian age of the light-coloured Budaörs dolomite of the well is made probable by foraminifers found in 855—804 m depth and determined by A. ORAVECZ-SCHEFFER, as follows:

Earlandia sp.
Trochammina almtalensis KOEHN-ZANINETTI
Agathammina austroalpina KRISTAN
Meandrospira karnica ORAVECZ-SCHEFFER
Nodosaria cf. *ordinata* TRIFONOVA
Lenticulina sp.

Between 804,0 and 763,5 m the foraminifers occur no more, they are substituted by *sponges*, *Bactryllum*, *molluscs* and *ostracods*. Because of the strong recrystal-

Fig. 4. Lithological profile through the Triassic sequence of the borehole Zs-14 after J. ORAVECZ.
1. Limestone. 2. Cherty limestone. 3. Marl. 4. Clay. 5. Dolomite. 6. Pulverulent dolomite. 7. Dolomitic limestone. 8. Dolomarl.
280—314 m: Hauptdolomite Formation. 314—763,5 m: Veszprém Marl Formation. 763,5—881,3 m: Budaörs Dolomite Formation.



lization, *Dasycladales* are absent from the 117,8 m thick dolomite sequence crossed by the deepest part of the well.

The dark-coloured Veszprém Marl Formation develops from its footwall trough some dolomarl and limestone intercalations. The bulk of its middle part, however (between 683 and 446 m) consists of partly cherty limestones alternating with thin clay, marl and clayey marl beds. Above 446 m, dolomites, cherty or limy dolomites with scarce marly intercalations form a transition to the ca 80 m thick "upper marl". The latter is joined with the practically unfossiliferous Hauptdolomite Formation by an alternation of beds (Fig. 4).

The unusual poorness of the microfauna of the Veszprém marl in the well Zs-14 prevents its detailed classification on the basis of the foraminiferal content. The whole section is predominated by relative frequency of *siliceous sponges*, *Bactryllum*, *ostracods*, *molluscs* and occasionally *echinoderms*. In the deepest part of the marl sequence (from 763,5 to 739,0 m) only these remains were found.

The first forams [*Glomospira* cf. *kuthani* (SALAJ), *Agathammina austroalpina* KRISTAN, *Agathamminoides* cf. *spiroloculiformis* (ORAVECZ-SCHEFFER) and the most primitive forms of *Aulotortus friedli* (KRISTAN)] appear at 739,0 m. These, and the *Pachyphloides klebelsbergi* (OBERHAUSER), appearing between 735—718 m and at 493,2 m, refer with certainity to Carnian.

Higher up the forams become scarcer, moreover the marl beds from 704,4 to 676,4 m are totally free of them. But between 653,9—528,0 m again some typical Carnian foraminifers were found:

Endothyra cf. *kuepperi* OBERHAUSER
Agathammina austroalpina KRISTAN
Agathamminoides cf. *spiroloculiformis* (ORAVECZ-SCHEFFER)
Gaudryina triassica TRIFONOVA

Between 641,0—505,0 m *Nodosaria* cf. *ordinata* TRIFONOVA is also relatively frequent, but the microfauna of the cherty limestones between 633—521 m and at 467,1 m is predominated by *spicules of sponges*.

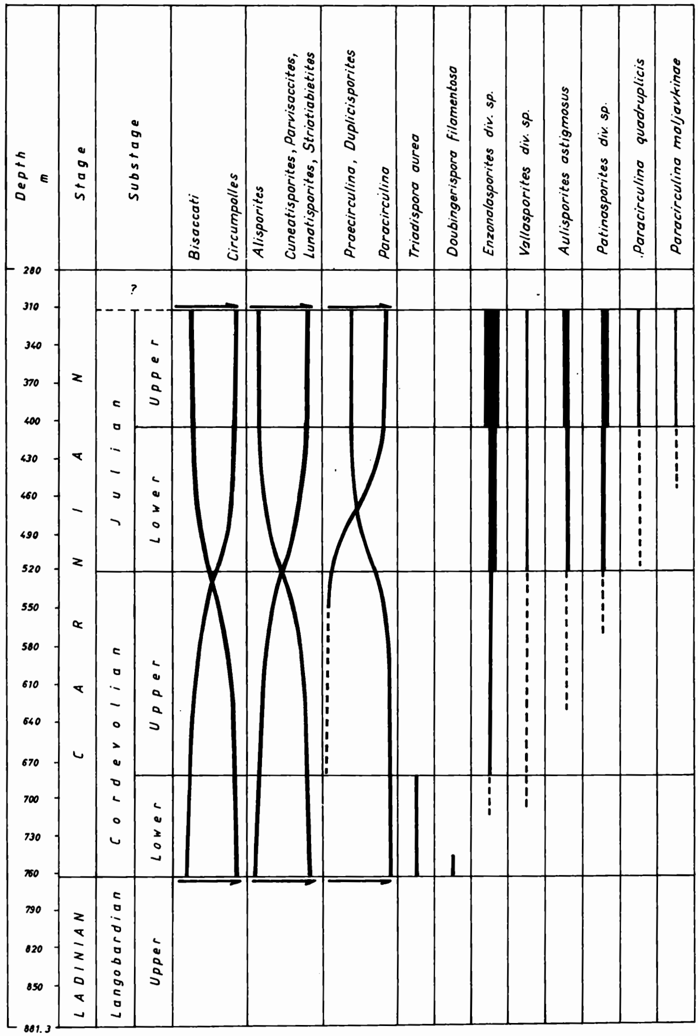
Higher than 512 m, but particularly in the uppermost part of the "upper marls" (between 332,2 and 316,0 m) the microfauna shows the predominance of *ostracods* among which species of *Simonella* can be referred to a brackish water sedimentation in the Julian substage. In this part of the section the rare occurrence of the already mentioned forams is varied by *Guttulina* sp.

The Hauptdolomite Formation above the Veszprém Marl contains no forams and only very few other animal remnants.

Essentially better results were won by palynological methods in spite of the fact that the middle and greater part of the Veszprém Marl, rich in carbonate rocks, contains only few sporomorphs. The Budaörs and the Hauptdolomite Formation is naturally free from palynomorphs. In the lower and upper part of the Veszprém Marl, however, there is a rich microflora, on the basis of which the marl sequence was divided by F. GÓCZÁN into Cordevolian and Julian (Fig. 5).

The lower boundary of the Lower Cordevolian can be placed to the first marl bed above the Budaörs Dolomite (at 763,5 m). Its upper boundary seems to coincide with the last occurrence of *Triadispora aurea* SCHEURING (683,5 m) and the beginning of the genera *Paracirculina*, *Enzonalasporites* and *Vallasporites*. The so defined Lower Cordevolian is characterized by the predominance of large bisaccate pine-pollens (*Alisporites*, *Lunatisporites*, *Cuneatisporites*, *Parvisaccites*, *Striatoabietites*). Forms marking regionally Julian are still totally missing.

Fig. 5. Palynostratigraphic divisions of the Veszprém Marl Formation in the borehole Zs-14 after F. GÓCZÁN. Arrows show increase of frequency.



The Upper Cordevolian (683,6—518,0 m) can be characterized by the beginning of a dominance-change between the groups *Bisaccati* and *Circumpolles*, as well as the first appearence of some forms becoming predominant in the Upper Julian. Beside the subdominating *Enzonalasporites*, some species of *Vallasporites*, *Aulisporites*, *Patinasporites*, *Para- and Praecirculina* are also present. The upper boundary of the substage is indicated by equal proportion of the *Bisaccati* and *Circumpolles* groups. In addition, both inside of the *Bisaccati* and the *Circumpollis*, a considerable shift in the dominance of species can be observed. E. g. beside the ubiquist *Bisaccati* (*Ovalipollis ovalis*, *O. breviformis*, *Lunatisporis acutus*) forms of

Cuneatisporites become more and more frequent and such a peculiar and new representative of *Lunatisporites* as *Lunatisporites antonescui* n. sp. appears.

The Lower Julian (518,0—406,0 m) can be delimited by means of dominance-changes within the sporomorph-assemblages. The definite predominance of the *Circumpolles*-group can be estimated even in the samples poor in pollen-grains. But even the bisaccate *Cuneatisporites* is represented by various species. Beside them a characteristic new species of *Rugubivesiculites*, as well as representatives of a new genus (*Pautschipollis*) accompany this part of the section. Within the *Circumpolles* group the first consistent appearence of *Paracirculina maljavkinae* KLAUS and *P. quadruplicis* SCHEURING is striking. The subdominance of *Aulisporites astigmosus* (LESCHIK) KLAUS and the predominance of *Enzonalasporites* are beginning here.

The Upper Julian (406,0—314,0 m) is marked by the greatest observed frequency of *Paracirculina maljavkinae*, *P. quadruplicis* and *Aulisporites astigmosus* and — beside the obvious predominance of *Enzonalasporites* and *Patinasporites* — *by the absence of the Tuvalian Riccisporites* and *Pseudenzonalasporites*.

Frequency of members of the *Circumpolles* group and the accompanied *Lycopodiacidites*, sporadicity of *Tigrisporites* as well as the striking rarity of more ombrophile farns probably render a tropical-arid climate for the time-interval of the Veszprém Marl Formation, settled down in a shallow see-water. However, the greatest importance of the uninterrupted Veszprém Marl section of the well Zs-14 consists in the recurrent appearence of several Keuper-forms within its sporomorph assemblages (*Doubingerispora filamentosa* SCHEURING, *Triadispora aurea* SCHEURING, *Infernopollenites*). It is to be hoped that the mixed occurrence of Alpine- and Germanotype taxa shall considerably facilitate the stratigraphic correlation between the contemporaneous deposits of the two different sedimentary environments.

4. Microfacial investigations on the rocks of the Late Triassic Hauptdolomite and Dachstein Limestone Formations

This study was carried out on cores of two key-section-boreholes in the North Bakony.

The lower part of the borehole Ut-8 (at the village Ugod) crossed the uppermost beds of the Hauptdolomite Formation in 120 m thickness. Its upper part being 162 m long explored an alternation of dolomites and limestones intercepting a 63 m thick dolomite body. This transitional sequence was followed by limestones which could be assigned already to the Dachstein Limestone Formation (*Fig. 6*).

The borehole Po-89 (at the village Porva) ended in the transitional beds which are composed of alternating dolomites and limestones. This part was followed higher up the profile by 400 metres of Dachstein Limestone in which 138 cyclothems could be observed.

The Hauptdolomite Formation and the transitional beds have also a cyclic structure (Fig. 6).

The Hauptdolomite sequence consists only of two alternating rock types which correspond to the members *C* and *B* of the Lofer-cyclothems: *C*) thick-banked dolomite with four kinds of microfacies (pelmicrite—microsparite; intramicrite—microsparite; micrite—microsparite; biomicrite—microsparite); *B*) thinner-banked dolomite of fine-banded (algalmat) structure with three kinds of

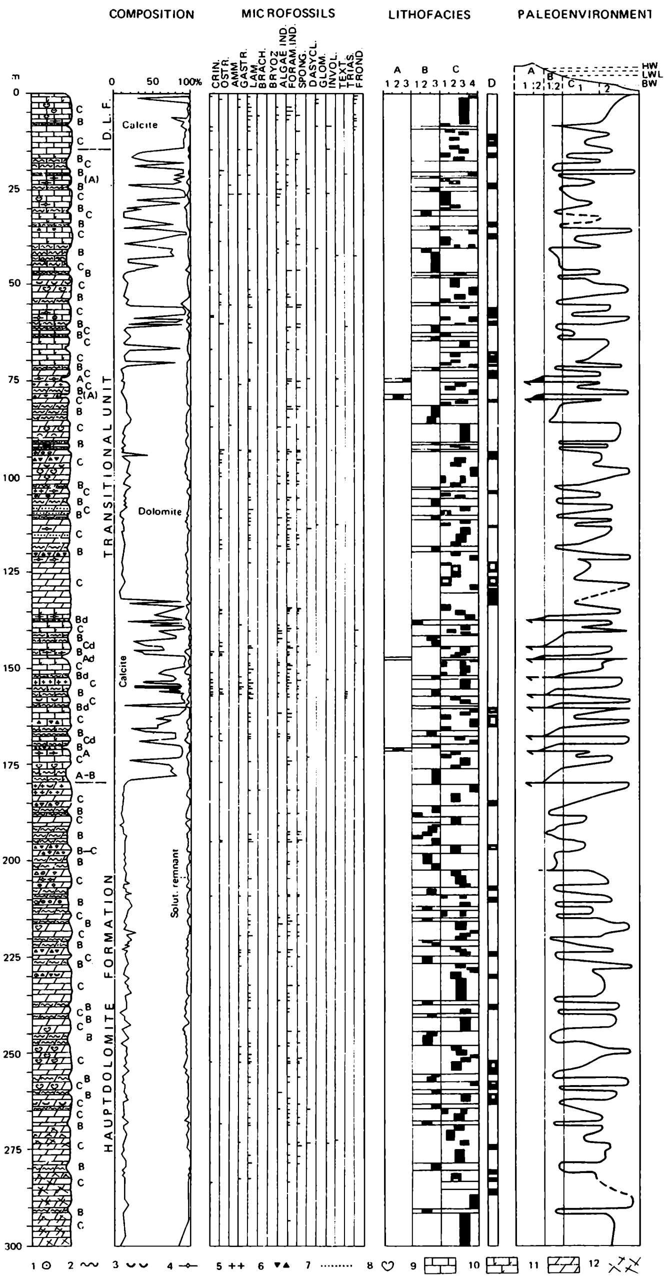


Fig. 6. Profile, microfacies and environmental data of the borehole Ugod Ut-8, after J. HAAS and K. DOBOSI.

CRIN.: Crinoids; OSTR.: Ostracods; AMM.: Ammonites; GASTR.: Gastropods; LAM.: Lamellibranchiates; BRACH.: Brachiopods; BRYOZ.: Bryozoans; SPONG.: Sponges; DASYCL.: Dasycladaceans; GLOM.: *Glomospirella*; INVOL.: *Involutina*; TEXT.: *Textularia*; TRIAS.: *Triasina*; FROND.: *Frondicularia*. D: Diagenetic mosaic-sparite. HWL: High-water level. LWL: Low-water level. BW: Base of waves.

1. Oncoids. 2. Algal mat structure. 3. Algal mat structure, torn up. 4. "Bird's eyes". 5. Trace of desiccation. 6. Autigene breccia. 7. Texture with calcite-spots. 8. Megalodontidae. 9. Limestone. 10. Dolomitic limestone. 11. Dolomite. 12. Tectonized stretch.

microfacies (micrite as well as pelmicrite with sparry fillings of shrinking-pores; alternation of pelmicrite or biomicrite with sparite-bands). The supratidal member *A* of the Lofer-cyclothems with terrigeneous components could not be observed. But this fact should not lead to the conclusion that the settling area never got to the supratidal zone. Traces of early diagenetic solution prove temporary desiccation, and also the dolomitization itself can be joined with the formation of sabkha-surfaces.

The lower part of the transitional sequence contains all the three elements of the Lofer-type cyclothems. The member *C* consists of limestones or dolomitic limestones with a micritic—microsparry texture holding only few allochems. The member *B* is always dolomitic, including fenestrae (bird's eyes) filled with sparry calcite. Their microfacies are generally identical with those of the Hauptdolomite. The member *A* is formed by 30—50 cm thick limestone beds enclosing red or greenish breccia-like grains. All the ten cyclothems of the sequence are truncated: the sediments of the regressive part appear as resedimented intraclasts in the member *A*.

The middle and upper part of the sequence are built-up by *C-B*-type cycles. Their microfacies are generally the same as the ones of the Hauptdolomite and the lower part of the transitional sequence, respectively.

The cyclothems of the Dachstein Limestone show some differences from the ideal Lofer-cyclothems described by FISCHER (1964). There is a number of the studied cyclothems less denuded, thus — unlike the cases observed by FISCHER (1975) in the Alps — the regressive algal-mat elements (marked with *B*') are predominant. In such cases the discordance-surface and the member *A* appear over the beds of algal-mat origin. Consequently, the complete basis cyclothem of the studied sequence can be described by the formula *d-A-B-C-B'-d*. A regular trend however of 5 to 8 cyclothems to form a cyclothem of higher range, a trend observed first time by SCHWARZACHER (1954) and later by FISCHER (1964), could not be stated here. In consequence of various anomalies of development, certain members of the cyclothems may be missing. The reduction or complete falling-out of member *A* is the most frequent one, but that of member *C* can only rarely be observed. In certain cases, mainly in the higher parts of the sequence, in spite of the presence of cyclicity, no break can be stated between the regressive and transgressive portions of the cyclothems overlying each other. In such cases the formula *d-A-B-C-B' + B-C-B' + B-C-d* can be applied. Special elements (e. g. red silty marl intercalations in member *A* or evaporitic dolomite interbeds between member *A* and *B*) occur very rarely in the Dachstein Limestone Formation.

Thickness of the cyclothems varies between 0,3 and 8,5 metres.

The most frequently to be observed feature of member *B* is the presence of banded, fenestral structures of wavy outlines. These can be referred to the upper part of the intertidal zone. The flat and finely banded fenestral structures and the banded, though non-fenestral types of member *B* are indicatives of a somewhat deeper part of the intertidal zone. Structures with no distinct banding seem to have been formed at the upper boundary of the intertidal zone on the one hand, or near the lower boundary of this zone on the other hand.

Member *C* in the studied profile of the Dachstein Limestone is built up by micrite. Thus it must have been formed in a shallow back-reef lagoon, in a non-agitated, but well-transilluminated subtidal environment. The intrapelmicrite type of this member frequently containing intraclasts from algal mats, appears to represent the outer margin of the subtidal zone. Other types of it were settled in juxtaposited environments that showed very small differences from one another.

On the basis of recent analogies, the genesis of the cyclothems can be imagined in such a way that — in the drier periods, in consequence of the continuous sinking of the waterlevel in the back-reef lagoon — the intratidal algal mat facies transgressed. The complete desiccation of the lagoon led to the formation of sabkha-surface and the influx of terrigene, land-derived material gave rise to a thin soil layer. In the more humid periods evaporation could not keep pace with the subsidence, the ingressed seawater tore up the topmost part of the desiccated terrestrial layers and reworked them. Afterwards, behind the reef-barriers (that permanently preserved their elevated positions), the marine lagoon was re-established again.

Aggtelek Mountains

The Triassic of this wide karst plateau continuing also in South Slovakia and belonging to the Silica nappe of the West Carpathians, is built up by many kinds of platform and basin facies whose interfingering with each other shows a rather intricate picture (*Fig. 7*).

The reddish-coloured, at least 450 m thick "Seisian" sandstone sequence is generally underlain by the Perkupa Evaporite Formation which consists of an alternation of violet and greenish siltstones, sandstones and anhydrite layers whose supposed Late Permian age could not be proved palaeontologically as yet. The first richer faunae were found only in the more calcareous "Campilian" sequence. The socle of Middle and Upper Triassic carbonate-platforms is represented by the limestone and dolomite beds of the Gutenstein Formation which is extraordinarily poor in macrofauna. Their bulk consists however of the Steinalm, Wetterstein and Tisovec Limestones, while the Furmanec Limestone of the Drienkova hora (Somhegy) at Drnava (Dernő) can be identified with the Dachstein Reef Limestone.

The deeper zones running among the reefs and reef-lagoons are indicated in some places both of the Slovakian and Hungarian territory by cherty red limestones, such as the Schreyeralm Limestone in the Illyrian or the Hallstatt Limestone in the Ladinian, Carnian and Norian stages. Beyond them, however, also the Reifling Limestone of Ladinian age bearing chertnodules at least in certain horizons, appears among the basinal facies.

By the borehole *Szőlősardó-l*, located at the southern margin of the mountains, however such a sequence was crossed in the hanging wall of the Steinalm Limestone Formation which vigorously differs from all the kinds of the basinal facies having been known in the karstregion until now. The dasycladacean-bearing Steinalm Limestone higher up the section actually transits to a grey and cherty dolomarl complex produced by strong late-diagenetic dolomitization from siltstones, cherty marls and limestones. This complex, including some specimens of *Gondolella regalis* Mosher, known hitherto from the Bithynian substage of the Anisian only, presses down the age of the underlaying Steinalm Limestone to a deeper position than earlier had been supposed. The lower part of the cherty dolomarl sequence includes also a thin intercalation of an acid volcanic tuff. By means of these traces of a contemporaneous submarine volcanic activity, joined with the rapid deepening of the settling-basin, the appearence of the chert-nodules can also be easily explained.

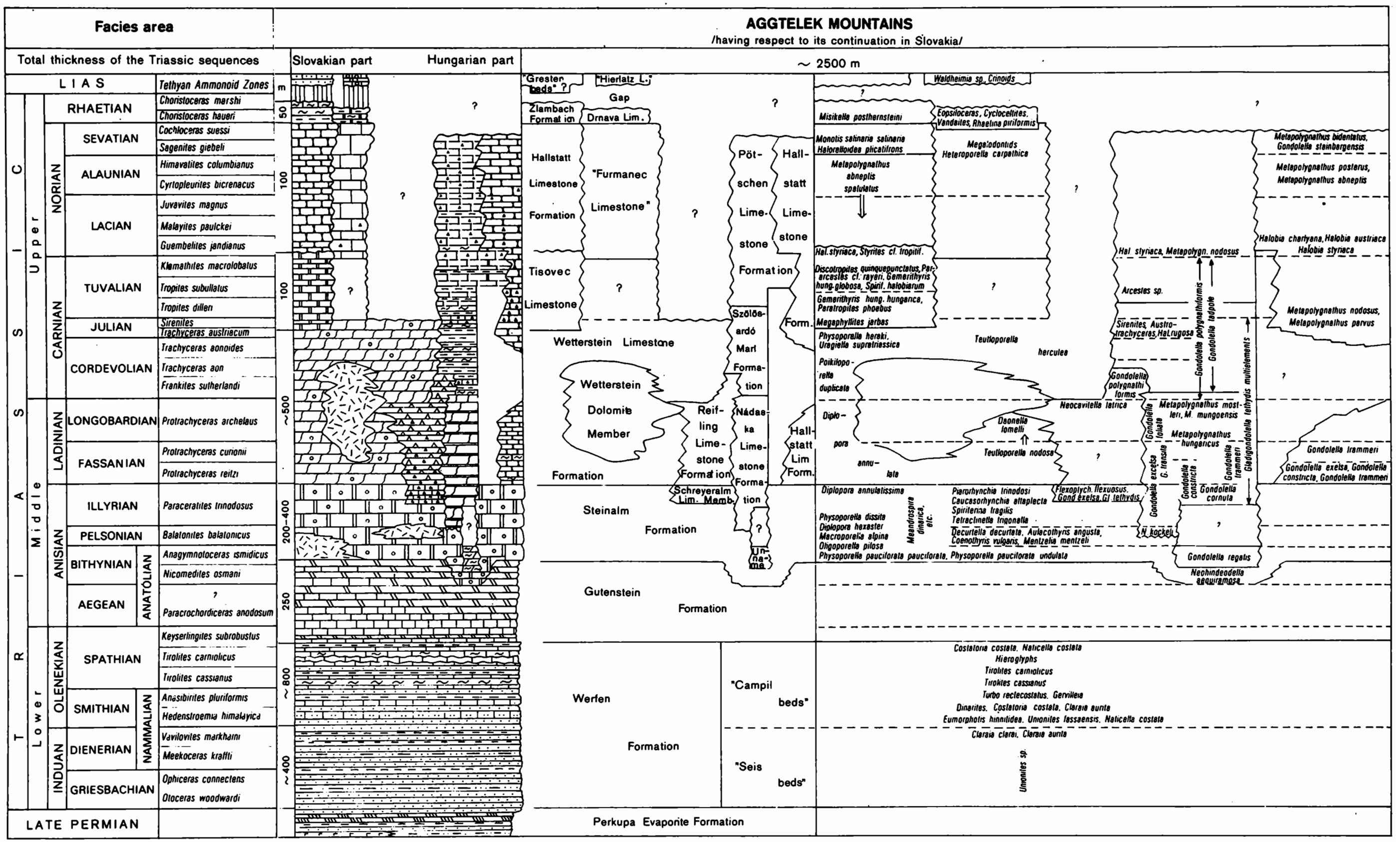


Fig. 7. Litho- and biostratigraphic sketch of the Triassic in the Aggtelek Mountains (North Hungary) after K. BALOGH (1980).

The dolomarl complex is separated from the overlaying Nádaska Limesto- ne Formation by a fault zone, thus its total thickness is unknown. Therefore foı the present it is devoid of a formal lithostratigraphic name.

The Nádaska Limestone Formation consists of varicoloured (from grey through reddish to light-grey or pink-spotted), bedded to thick bedded limestones with many protointraclasts, stromatactises and various traces of mud-slumping. On the basis of these sediment-structures it can be regarded as deposit on ar unstable submarine slope.

Above the Nádaska Limestone, the borehole Szőlősardó-1 explored the ca 70 m thick grey or dark-grey Szőlősardó Marl Formation consisting of silt- anc sandstones and marls with several cherty limestone intercalations. This sequence has hitherto been unknown in the whole Slovakian—Hungarian karstregion Though the lower boundary of this sequence is slightly crumbled, one should not reckon with a greater shortage of the sequence here. Higher up the profile however, the Szőlősardó Formation transits continuously through an alternatioı of marls and limestones to the overlying Pötschen Limestone Formatioı which represents the "grey facies" of the Hallstatt development.

The series of the basinal sediments taken as a whole, 435 metres in drilling thickness, is rather rich of conodonts and, in its higher horizons, also *Daonellc cassiana* Mojs., *Halobia rugosa* Mojs., moreover *Austrotrachyceras* sp. and *Sirenite* sp. are occuring. By means of these fossils the discussed sequence can be dividec from the upper Illyrian to the end of the Tuvalian into 16 local assemblag biozones (*Fig. 8*) which can very well be correlated with the standard conodon zones of the Tethys realm constructed by H. Kozur in 1980. In consequence of th missing of the Pelsonian and lower Illyrian in the lowermost part of the Nádask limestone of the well, the above-mentioned tectonical gap between the dolomar complex and the Nádaska Limestone is also biostratigraphically confirmed. Th Pelsonian and lower Illyrian part of the Nádaska Limestone is proved — at leas partially — in other places of the karstregion, namely in the eastern ending of th mount Alsóhegy. But it is true that here the grey dolomarls are not outcroppe below its basis.

The outcropped part of the Pötschen Limestone Formation in the southerı surrounding of the village Szőlősardó is — on the basis of its *Halobia styriaca* Mojs content — of Lower Norian (Lacian) age. It can however be supposed that it uppermost part may reach as far as the Upper Norian (Sevatian).

The Rhaetian sediment of the karstregion, that is the shallow-water Kösseı beds occurring at Drnava (Dernő) and the Zlambach beds found at Silická Brezov (Szádvárborsa) are not present (or to a very small extent only) in the Hungaria territory. The transgressing Jurassic sediments in the Hungarian part of th karstregion are eroded.

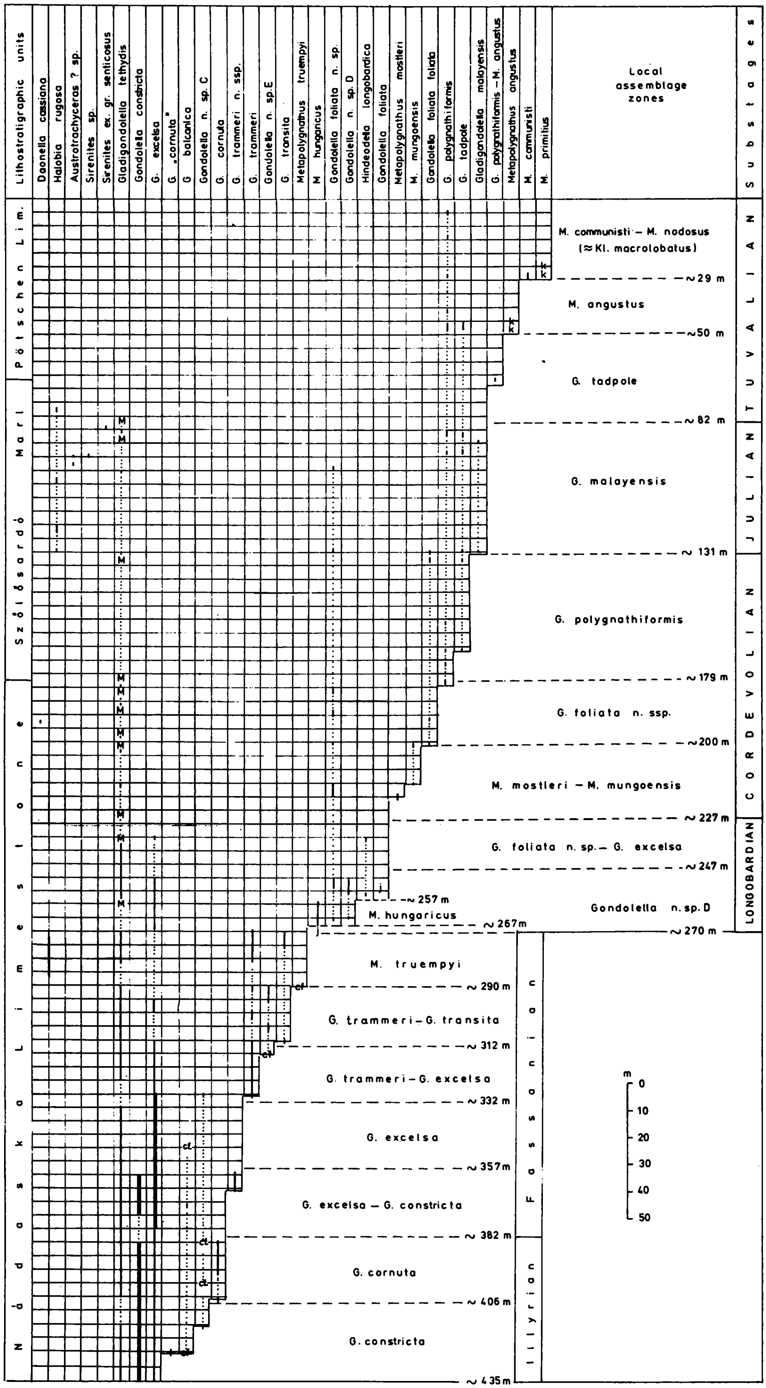


Fig. 8. Distribution of the most important faunal elements above the basis of the Nádaska Limestone Formation in the borehole Szőlősardó-1 after K. BALOGH.
M: multielements of *Gladigondolella tethydis* without platform. cf: confer. j: juvenile specimens. k: primitive forms of the species.

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