KÁZMÉR Miklós (1985): Microfacies pattern of the Upper Eocene limestones at Budapest, Hungary. — Annales Universitatis Scientiarum Budapestinensis, Sectio Geologica 25 (1983), 139—152, 3 figs., Budapest.

MICROFACIES PATTERN OF THE UPPER EOCENE LIMESTONES AT BUDAPEST, HUNGARY

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(Received: 1st March 1984)

Abstract

Microfacies types of the Upper Eocene nummulitic limestone and bryozoan marl are described, based upon detailed investigations of 9 surface and subsurface sections. The environments assigned to the microfacies types range from the algal-coated conglomerate of a rocky coast through shallow marine biogenic sands, coral-algal patch reefs, *Discocyclina* accumulations and Bryozoa meadows to hemipelagic calcareous *Globigerina* marl. Relationships among lithologic character, fossil content and postulated water depth are displayed in a synoptic facies diagram.

Introduction

The Priabonian (Upper Eocene) nummulitic limestone and bryozoan marl has been investigated in 9 sections west of the Danube river, in and around Budapest (Fig. 1). The rich microfaunal content and presence of algal flora, and the fairly good preservation of fossils have been known from the papers of HANTKEN (1884) and MONOSTORI (1965). However, no detailed microfacies investigations has been made as yet, except that of VARGA (1980) and VARGA in BÁLDI et al. (1980), for the Alcsútdoboz – 3, Sóskút – 1 and Óbuda – 2 boreholes.

The Upper Eocene limestone (and some calcareous marl) beds of four boreholes and of five surface outcrops have been investigated:

Alcsútdoboz – 3
Sóskút – 1
Óbuda – 2
Nagykovácsi – 64
Budaörs, Úthegy quarry
Budapest, Martinovics-hegy, northern quarry
Budapest, Fenyőgyöngye quarry
Budapest, Mátyáshegy, western quarry
Üröm, Rókahegy, quarry N° 5.

The observed carbonate microfacies types were arranged in a sequence to form a hypothetical facies model. At the end the process of the Late Eocene transgression in the Buda Mts. is outlined.

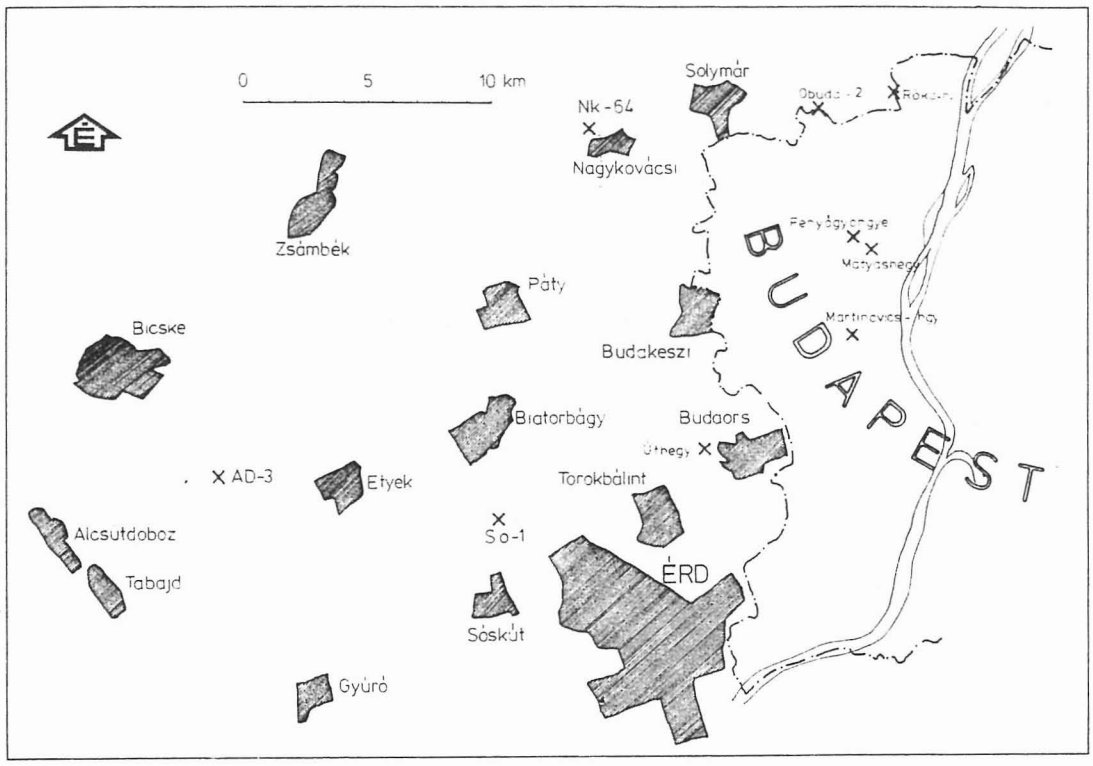


Fig. 1. Localities of Upper Eocene limestone sections around Budapest

Stratigraphy

In the surroundings of Budapest Upper Eocene formations cover mostly Triassic Dachstein Limestone or small spots of Middle Eocene sandstone and marl. The Late Eocene transgression deposited thick basal conglomerate then limestone with *Nummulites fabianii* and discocyclinids. It is followed by neritic bryozoan limestone and marl, then by a pelagic *Globigerina* marl (Buda Marl). The latter extends up to the Oligocene (HORVÁTH M., 1983, pers. comm.)

Methods

Surface and subsurface sections of at least 10 m in length were selected for sampling in intervals from 0,5 to 2,0 m. Altogether 174 samples and 297 thin sections were examined. Features visible on weathered, freshly cracked and polished rock surfaces were considered, too.

Texture of the rock (EMBRY and KLOVAN, 1972), diversity, dominance and percentage of biogenic components determined by semi-quantitative comparison charts (FLÜGEL, 1982), presence of rare but important components (e.g. extraclasts), and in some cases sorting and roundness of components and cement types were considered in the determination of microfacies types. These were interpreted as fossil environments and a facies model was established for the Upper Eocene carbonate rocks in Buda Mts.

Microfacies types

The descriptions contain the following data:
- number and denomination;
- short description;
- fossil content listed in decreasing abundance;
- localities;
- environmental interpretation.

MF – 1A: extraclast-rudstone in alga-grainstone matrix (dolomite-conglomerate in alga-grainstone matrix)

Well-rounded dolomite pebbles with grain support. The matrix contains fragments of encrusting corallinacean algae, cemented by clear, blocky sparite. Some pebbles bear algal crusts.

Fossils: mostly undeterminable Melobesioideae, a few small *Nummulites*, *Asterigerina*?, Miliolina, *Chapmanina*, echinoderm fragments, Crustacea fragments.

Locality: Alcsútdoboz – 3 borehole: 790,0 – 790,2 m.

Interpretation: submarine conglomerate fan of a rocky shore made of dolomite. Extreme environmental conditions within the zone of intense wave action.

MF – 1B: extraclast-rudstone in alga-foraminifera-grain/packstone matrix

Ghosts of rounded dolomite or limestone pebbles, recrystallized into clear sparite or filled by micritic internal sediment. The pebbles bear a thin micritic crust of microbial origin. The matrix is alga-foraminifera grainstone. The sparry cement was partly recrystallized from micrite (pseudosparite).

Fossils: much Melobesioideae; some *Terquemella*?, *Nummulites*, *Eorupertia*, *Gypsina*, porcelaneous Foraminifera, *Actinacis*-type corals, bivalve and echinoid fragments and traces of boring activity.

Localities: Nagykovácsi – 64 borehole: 53.5 m; Budapest. Martinovics-hegy, northern quarry.

Interpretation: submarine conglomerate fan of a rocky coast. Less intense wave action than in MF – 1A. Micrite crusts indicate less than 10 m water depth.

MF – 2: alga-foraminifera-grain/packstone

Fragments of red algae and various benthonic foraminifers in pseudosparite-sparite. Compaction cracks of fossils are filled by sparite. Micrite-filled foraminifers and bryozoans with geopetal infill. One sample (Sóskút – 1: 912.6 m) is characterized by a first generation of fibrous cement and a second generation of clear blocky cement, while some intergranular voids are filled by vadose micrite.

Fossils: indeterminable Melobesioideae, *Lithoporella*, *Ethelia*, Corallina; *Nummulites*, *Asterigerina*, *Acervulina*, *Gypsina*, *Eorupertia*, various smaller

foraminifers, *Hydractinia* (a hydrozoan), Actinacis-type coral, Gastropoda, Bryozoa, *Ditrupa* and echinoid fragments.

Localities: Sóskút – 1: 912.6 m; Óbuda – 2: 148.6; Nagykovácsi – 64: 49.0 – 50.7 m and 52.8 m.

Interpretation: calcareous sand, deposited in well-agitated water of several metres depth. Some parts have risen to subaerial conditions, suffering vadose cementation.

MF – 3: Nummulites-packstone

Dominant (40%) *Nummulites* shells with stylolitic contacts in micritic matrix, containing badly preserved calcareous red algae and other hyaline smaller Foraminifera.

Fossils: Melobesioideae, *Nummulites*, hyaline and porcelanous smaller Foraminifera, Bryozoa, echinoderm fragments.

Locality: Sóskút – 1 borehole: 909.9 m.

Interpretation: *Nummulites* sand deposite below wave based, with some redeposited rhodoliths. It may be a poorly developed equivalent of the Nummulites-bank of ARNI (1965).

MF – 4: alga-echinoidea-foraminifera-packstone

Overpacked biomicrite with frequent stylolitic grain contacts. Badly preserved red algae and echinoderm fragments.

Fossils: dominating indeterminable Melobesioideae and echinoid fragments. Small Bryozoa fragments, *Corallina*, *Lithoporella*, *Nummulites*, smaller Foraminifera, *Asterigerina*, *Gypsina*, *Discocyclina*, *Eorupertia*, *Heterostegina*.

Locality: Óbuda – 2 borehole: 145.0 m.

Interpretation: Medium diversity fossil assemblage deposited below wave base. Considerable compaction resulted in almost total absence of micritic matrix and overpacking of components.

MF – 5: alga-foraminifera-bryozoa-pack/grainstone

Mostly Melobesioideae in a partly winnowed micritic matrix. Pores are filled by sparite. Several algal species encrust each other as it can be deduced from different cell sizes within an oncoid. Corallinacean algal layers cover bryozoans, encrusting foraminifers (*Gypsina* and *Fabiania*) and the squamariacean alga *Ethelia*. Larger Foraminifera (discocyclinids and *Nummulites*) occur frequently, together with recrystallized corals and bryozoans. Components are badly sorted but microstylolitic grain contacts occur. There is no orientation of plate-like components in the samples. The encrusting organisms are well-preserved and bind a considerable part of the matrix.

Fossils: calcareous algae are dominant: *Lithophyllum*, *Hemiphyllum* or *Paraphyllum*, *Ethelia*, *Lithoporella;* smaller *Nummulites* are frequent: *N. vascus; Actinocyclina*, *Exagonocyclina; Asterigerina*, *Eorupertia*, *Placopsilina?*, *Fabiania*, *Alveolina*, *Pyrgo* and other Miliolina, smaller foraminifers,

Hydractinia, a calcareous sponge, ACTINACIS-type coral, *Ditrupa*, Bryozoa, Echinoidea-fragments, calcisphaera.

Localities: Alcsútdoboz – 3 borehole: 787.0 – 788.3 m; Sóskút – 1 borehole: 907.6 m; Budapest, Fenyőgyöngye quarry: 0.0 – 3.5 m and 10.0 – 13.0 m; Óbuda – 2 borehole: 127.8 m and 139.4 m; Nagykovácsi – 64 borehole: 45.4 – 47.8 m.

Interpretation: well -oxygenated, moderately agitated, favorable environment below wave base. The delicate fossils are autochthonous but original bedding has been eliminated by bioturbation. Partly bound by thin layers of encrusting organisms. Part of the coral and algal fragments originated from the area of MF – 6A (patch reefs).

MF – 6A: algal-coral-bind/bafflestone in bioclastic wacke/packstone matrix

Micrite-dominated rock with biogenic components up to 30%. Moreover, the matrix contains small, unidentifiable bioclasts. Encrusting red algae form dichotomous branches or thin crusts binding the micritic matrix. Corals were recrystallized in several steps, resulting in spar-filled voids with ghosts of septa. Some of them are encrusted by algae and sessile foraminifers. Corallinacean and squamariacean algae form oncoids with enclosed micritic layers and foraminifers.

Fossils: Melobesioideae, Scleractinia, *Discocyclina*, Bryozoa, Echinoidea fragments, *Lithoporella*, *Hemiphyllum* or *Paraphyllum*, *Ethelia*, *Mesophyllum?*, *Asterocyclina*, *Exagonocyclina*, *Operculina*, *Heterostegina*, *Asterigerina*, *Eorupertia*, *Nummulites*, *Gypsina*, *Sphaerogypsina*, *Pyrgo*, *Quinqueloculina*, *Haddonia?*, smaller benthonic and planktonic Foraminifera Gastropoda, Bivalvia, *Serpula*.

Localities: Budaörs, Úthegy quarry: 0.2 – 3.0 m and 3.2 – 8.0 m; Budapest, Fenyőgyöngye quarry: 4.0 – 9.5 m; Óbuda – 2 borehole: 103.0 m.

Interpretation: calm, well-oxygenated environment below wave base. The branching corals attenuated water motion near the sediment surface, so micritic mud was deposited and bound by red algae. The various foraminifers lived among and on the corals but a considerable part of these is possibly redeposited from nearby environments. The 5 m thick bed at Fenyőgyöngye with corals in micritic mud can be interpreted as a coral-algal mud-mound. Fragments of MF – 6A can be recognized in the area of MF – 5. where the mud-mounds were situated as small topographic highs. The extensive development of early diagenetic features indicate slow sedimentation rate.

MF – 6B: algal-coral-bind/bafflestone in extraclast-bioclast-packstone matrix

Similar to MF – 6A but contains quartz sand grains up to 15%.

Fossils: Melobesioideae, corals, *Lithoporella*, *Pyrgo* and other Miliolina, *Discocyclina*, *Ethelia*, planktonic Foraminifera, Echinoidea fragments, Gastropoda.

Locality: Budaörs, Úthegy quarry: 3.0 – 3.2 m.

Interpretation: same as of MF – 6A. The high quartz content indicates the renewal of carbonate sedimentation after the deposition of a 0.1 m thick, terrigenous sandy marl layer.

MF – 7: echinoidea-alga-bryozoa-grainstone

Bioclastic sandstone made of rounded echinoid fragments, a few algal oncoids, much algal and bryozoan fragments. The clear sparite cement is mostly part of the syntaxial rims of echinoid fragments. Many fossils contain micrite infill.

Fossils: Melobesioideae, Echinoidea, Bryozoa, *Nummulites*, *Sphaerogypsina*, Miliolina, Textulariina, *Discocyclina*, *Gypsina*, *Ditrupa*.

Localities: Alcsútdoboz – 3 borehole: 765.5 – 777.4 m; Óbuda – 2 borehole: 146.5 m.

Interpretation: polymictic calcareous sand deposited in agitated water. The grains were washed together from several places. The moving sand prevented the settlement of a diversified fauna like in MF – 6A.

MF – 8: nummulites-floatstone in echinoidea-packstone matrix

Some relatively large *Nummulites* shells "float" in micritic mud containing echinoid fragments up to 50%. The *Nummulites* shells are filled by micrite. A kind of textural inversion can be observed: small, but relatively well-sorted echinoid fragments are packed together in micritic matrix.

Fossils: Echinoidea, *Nummulites*, *Operculina*, Miliolina, Rotaliina.

Locality: Budapest, Martinovics-hegy, northern quarry: 22.9 – 21.9 m.

Interpretation: echinoidea-sand transported to a muddy sedimentation area. The *Nummulites* shells are autochthonous.

MF – 9A: Discocyclina-floatstone in alga-discocyclina-echinoidea-grain/packstone

Variable composition characterized by the dominance of Discocyclina. Most of them are intact but the thin edges of swollen specimens are frequently broken. The corallinacean fragments are well-rounded and smaller than 0.5 mm in diameter. Much of these are micritized and cannot be distinguished from peloids. Thin algal crusts (bindstone) and oncoids occur, too. Echinoid fragments are surrounded by thick syntaxial cement rim enclosing neighbouring components as inclusions. Orientation of *Discocyclina* specimens indicate bedding.

Fossils: Melobesioideae, *Discocyclina*, Echinoidea, *Corallina*, *Lithoporella*, *Ethelia*, *Exagonocyclina*, Bryozoa, smaller vagile and sessile Foraminifera and calcite-shelled Bivalvia.

Locality: Nagykovácsi – 64 borehole: 39.4 – 43.3 m.

Interpretation: This sediment was deposited seaward from environments represented by Nummulites and corals, near the base of the wave agitated zone.

MF – 9B: Discocyclina-rudstone in Discocyclina-packstone matrix

Similar to MF – 9A, but with lesser diversity of fossils. The rudstone matrix contains mostly Discocyclina with some other larger Foraminifera and considerably smaller quantity of echinoid fragments and red algae, than in MF – 9A. Stylolitic grain contacts are common.

Fossils: *Discocyclina*, Melobesioideae, Corallinoideae, *Nummulites*, *Asterigerina*, *Operculina*, *Heterostegina*, smaller Foraminifera, Bryozoa, Echinoidea.

Locality: Budapest, Mátyáshegy, western quarry: 0.0 – 5.0 m.

Interpretation: similar to MF – 9C. Optimal conditions for Discocyclina due to washing out of micritic mud resulted in the outplacing of most other organisms. It is possible that the area of this microfacies was a small topographic high of some tenth of a metre.

MF – 9C: Discocyclina-floatstone in alga-discocyclina-bryozoa-echinoidea-packstone matrix

Large, subparallel Discocyclinas with stylolitic contacts, sometimes penetrating each other. Equal amount of red algae, small Discocyclina and Bryozoa form the matrix of the floatstone.

Fossils: *Discocyclina*, Melobesioidea, Bryozoa, Echinoidea, Corallinoideae, *Operculina*, *Heterostegina*, *Asterigerina*, *Nummulites*, *Sphaerogypsina*, smaller hyaline and porcelanous Foraminifera, sessile agglutinated Foraminifera, *Ditrupa*.

Localities: Budapest, Martinovics-hegy, northern quarry: 19.7 – 13.5 m; Budapest, Fenyőgyöngye quarry: 13.5 – 15.0 m; Budapest, Mátyáshegy, western quarry: 5.5 – 16.0 m.

Interpretation: the large *Discocyclina* specimens lived in situ; the intensity of water agitation is characterized by the components of the matrix of the floatstone. Sedimentation occurred below wave base (20 to 50 m depth). Great sedimentation rate is shown by sparite fill of foraminifer chambers. It was joined by a relatively slow diagenetic process causing mutual penetration of components during compaction.

MF – 10: bryozoa-alga-extraclast-foraminifera-grainstone

Large, double-layered bryozoa crusts "floating" in polymictic bioclastic matrix. Place of dissolved aragonitic fossils shown by inclusion ghosts in blocky spar matrix. Slightly rounded quartz grains.

Fossils: Bryozoa, Melobesioideae, *Nummulites*, *Asterigerina*, Miliolina, calcitic and aragonitic Bivalvia, *Actinacis*-type coral, *Haliotus?*

Locality: Nagykovácsi – 64 borehole: 52.0 m.

Interpretation: Polymictic association washed together to the area of double-layered Bryozoa. Extraclasts indicate terrigenous influx. The encrusting red algae indicate undisturbed sedimentation at their place of origin. Probably the sparite-filled Bryozoa are autochthonous. Lower part of photic zone, near the deposition zone of calcareous bryozoan marl.

MF – 11A: bryozoa-grainstone

Well-sorted association of branching and globular bryozoans with micrite and/or sparite infill. Stylolitic grain contacts are common.

Fossils: Bryozoa, Echinoidea, Melobesioideae, smaller Foraminifera, Globigerinidae.

Localities: Alcsútdoboz – 3 borehole: 779.4 m; Sóskút – 1 borehole: 897.0 m.

Interpretation: "bryozoan-bush" deposited in streaming water near the lower boundary of the photic zone. First appearance of planktonic Foraminifera indicates the closeness of hemipelagic environments.

MF – 11B: bryozoa-packstone

Oriented, branching, double-layered or globular bryozoans with micritic or sparitic fill, partly encrusted by thick micritic layer. The syntaxial cement rim of echinoids encloses bryozoans.

Fossils: Bryozoa (80%), *Lithoporella*, Globigerinidae, smaller benthonic Foraminifera, *Discocyclina*, *Sphaerogypsina*, *Asterigerina*, *Ditrupa*,

Localities: Alcsútdoboz – 3 borehole: 784.0 m; Sóskút – 1 borehole: 902.0 m; Budapest, Martinovics-hegy, northern quarry: 8.0 m.

Interpretation: bryozoa-meadow in well-oxygenated water near the lower boundary of the photic zone. Relatively fast sedimentation prevented the full micritic infill of the bryozoan zooecia.

MF – 11C: Bryozoa-floatstone in bryozoa-wacke/packstone matrix

Thin-walled, double-layered bryozoan fragments with micrite or sparite fill. Orientation of flat *Asterocyclina* indicates bedding. Some microstylolitic grain contacts occur.

Fossils: Bryozoa, Melobesioideae, *Asterocyclina*, *Heterostegina*, Globigerinidae, Coscinophragmatinae, Miliolina, calcitized sponge spicules, calcisphaera, Echinoidea.

Locality: Budapest, Mátyás-hegy, western quarry: 16.5 – 20.5 m.

Interpretation: calmer environment than that of MF – 11A and MF – 11B; indicated by very thin-walled bryozoans and thin Asterocyclina of large diameter. Strong pelagic influence is indicated by Globigerinidae.

MF – 12: bryozoa-foraminifera-mollusca-packstone

Badly preserved, small, biogenic fragments in micritic matrix. Parallel position of the dominating bryozoans indicates bedding.

Fossils: fragments of branching Bryozoa, smaller, hyaline and porcelaneous Foraminifera, thin-shelled Mollusca, Globigerinidae, Echinoidea, Melobesioideae, calcitized sponge spicules.

Locality: Alcsútdoboz – 3 borehole: 755.0 – 758.5 m.

Interpretation: echinoidea and red algae indicate redeposition from shallow marine environments, while Globigerinidae indicate pelagic influence. Presence of thin-walled Bryozoa, thin mollusc fragments and sponge spicules correspond to the proximity of pelagic environment. This sediment was deposited below photic zone, where biogenic carbonate production was

attenuated due to lack of light and consequently percentage of terrigenous material increased.

This microfacies type – together with MF – 11A, MF – 11B and MF – 11C – from the so-called bryozoan marl of the Buda Mts.

MF – 13: Globigerina-wackestone

Whole and fragmented Globigerinidae, some other smaller foraminifers and thin-shelled, subparallel mollusc fragments floating in homogenous, clayey micrite.

Fossils: Globigerinidae, Bivalvia, red algae, sponge spicules, Echinoidea spines.

Locality: Alcsútdoboz – 3 borehole: 747.0 – 750.0 m.

Interpretation: globigerina marl (= Buda Marl), deposited in bathyal environment of the upper flanks of the continental slope. Small fragments of red algae and echinoid spines indicate slight resedimentation.

MF – 14A: echinoidea-alga-foraminifera-packstone

Well-sorted, rounded, echinoidea-, red algal and foraminifer fragments in equal quantity. Vagile and sessile benthic foraminifers, the latter include a considerable quantity of *Gypsina*. Less than 10% extraclasts: chert, quartz, dolomite, all in micrite-microsparite matrix. Inhomogeneous texture: indistinct spots one with third of original grain size, with much bryozoans and microsparitic matrix.

Fossils: Echinoidea, micritized red algea, *Corallina*, *Nummulites*, *Gypsina*, *Chapmanina*, *Eofabiania?*, hyaline smaller Foraminifera, Bryozoa, *Ditrupa*, Crustacea.

Locality: Üröm, Rókahegy, quarry no. 5: 0.0 – 26.0 m

Interpretation: see MF – 14B.

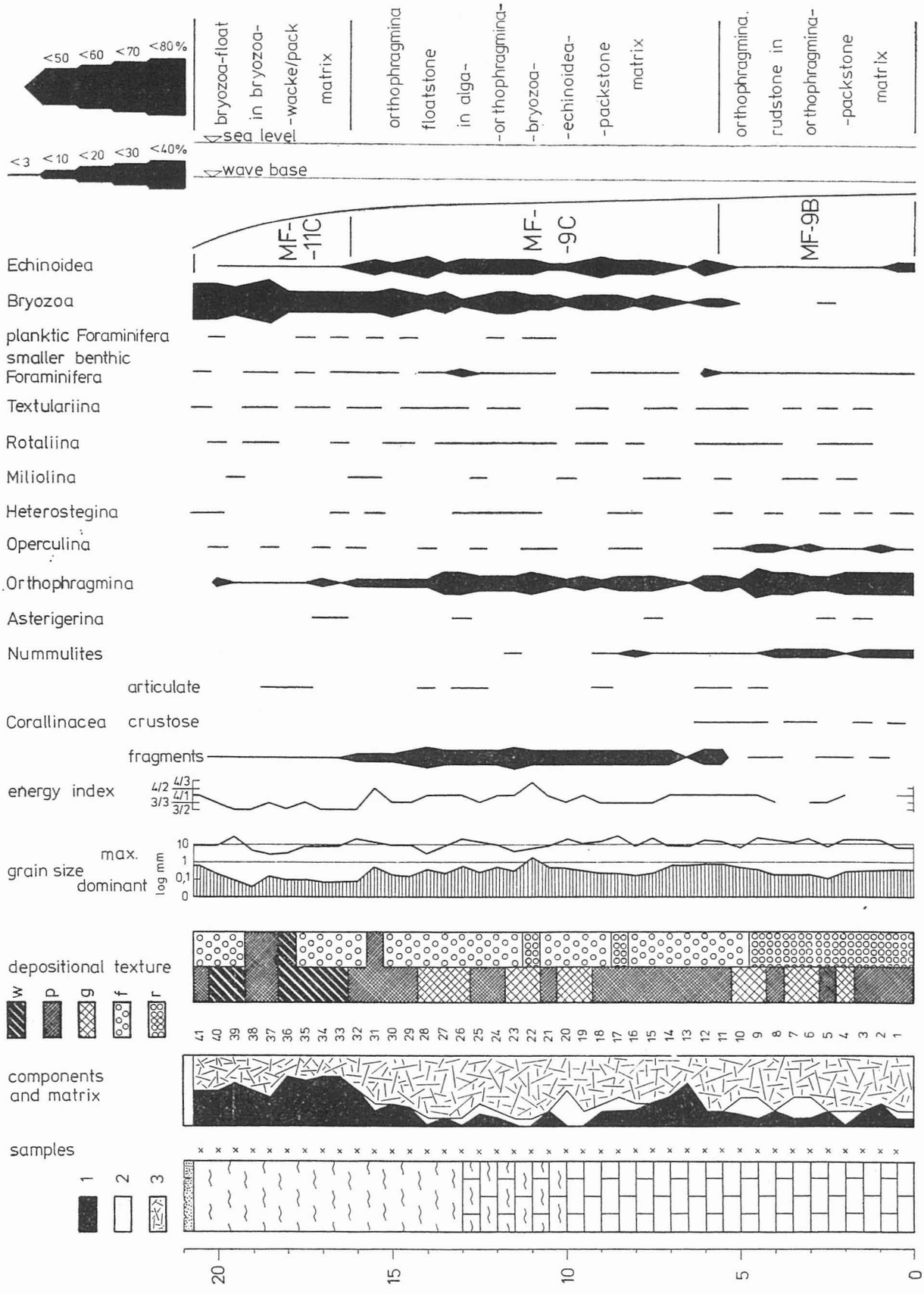
MF – 14B: extraclast-alga-foraminifera-pack/grainstone

Medium to badly sorted components in inhomogeneous matrix. Much extraclast (different kinds of cherts, quartz) but less echinoids than in MF – 14A. The encrusting foraminifer *Gypsina* froms tube-like bodies of not more than 1 cm in length and 3 – 4 mm in diameter, or it encrusts bivalve fragments.

Fossils: red algae, *Gypsina*, *Nummulites*, *Fabiania*, *Chapmanina*, calcisphaera, hyaline and porcelaneous Foraminifera, Bryozoa, Echinoidea, Crustacea.

Locality: Üröm, Rókahegy, quarry no. 5: 27.5 – 31.0 m.

Interpretation: the most conspicuous components are the *Gypsina* tubes: these are remnants of the foraminifer which encrusted the stems of sea grasses. After the death and decay of the plant the central hollow was filled by the surrounding sediment. The sorting and composition indicates an environment within the wave agitated zone. The sea grass meadows slowed the water motion near the bottom so micrite couldn't be winnowed out. The presence of sea grasses indicate a well-oxygenated environment in the upper part of the euphotic zone.


bryozoa-float in bryozoa-wacke/pack matrix
orthophragmina floatstone in alga-orthophragmina-bryozoa-echinoidea-packstone matrix
orthophragmina rudstone in orthophragmina-packstone matrix
<50 <60 <70 <80%
<3 <10 <20 <30 <40%
sea level
wave base
MF-11C
MF-9C
MF-9B
Echinoidea
Bryozoa
planktic Foraminifera
smaller benthic Foraminifera
Textulariina
Rotaliina
Miliolina
Heterostegina
Operculina
Orthophragmina
Asterigerina
Nummulites
Corallinacea
articulate
crustose
fragments
energy index
4/2 4/3 4/1 3/3 3/2
grain size
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10 1 0,1 0
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samples
1 2 3
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Microfacies sequence of Mátyáshegy, western quarry

The microfacies diagram of Mátyáshegy quarry (Fig. 2.) is an excellent example of microfacies delimitation. There are two changes of rock type (from limestone to calcareous marl to marl) in the lithologic column on the left side. Neither the matrix-constituent composition, nor the percentage of fossils follow the lithologic changes observed in the field by the naked eye. The microfacies types has been delimited on the presence or absence of corallinacean algal fragments, disappearance of *Nummulites* and *Operculina*, decrease of *Discocyclina (= Orthophragmina)* and appearance of Bryozoa and echinoid fragments.

The microfacies diagram shows a constant, gradual change of environments below wave base, due to slow, even sinking of the basin.

Microfacies pattern

The following criteria were considered for the interpretation of depositional depth for each microfacies. Large quantity of coarse, terrigenous debris (dolomite clasts and pebbles) was regarded as abrasion conglomerate. Chert fragments indicated nearshore environment, too, as cherty dolomite formed the postulated shore. Type of matrix (micrite or sparite) indicates agitation of water. Sparite was precipitated in interstitial spaces from where lime mud has been washed out. This occurred mostly in depths less than 20 m, i.e. in the zone of wave agitation. Deep-water currents can produce microfacies types similar to shallow water ones but these are of limited lateral extent. Ratio of components and matrix may be an important feature: e.g. mud-supported texture indicates that disaggregation of biogenic components dominates over accumulation. This is characteristic for less favourable – in this case for deep neritic – environments. Dominant grain size is characteristic for water agitation, but the maximal one refers to the size of autochthonous organisms only.

One or two specimens of some fossil groups (calcareous red algae, *Discocyclina*, Bryozoa, Echionidea) can be found in almost all facies types, but their enrichment is an important facies indicator.

Disappearance of red algae is due to bad photic conditions: these facies types (containing large amounts of bryozoans) were assigned to the deeper shelf (100 – 200 metres).

◀ *Fig. 2.* Microfacies diagram of Mátyáshegy, western quarry. The lithological boundaries (left side) does not show any coincidence with change in fossil content (middle).

1 = micrite
2 = sparite
3 = bioclasts

w = wackestone
p = packstone
g = grainstone
f = floatstone
r = rudstone

The comprehensive Fig. 3. shows the microfacies pattern: matrix and texture, percentage of most important fossils and postulated water depth are included for each microfacies types. The sequence was established following the increase in water depth, increase of shore distance indicated by the decrease of extraclastic content and ecological needs and/or tolerance of fossils. Probably, this pattern contains subjective elements, mostly in the arrangement of facies types deposited at wave base.

Unfortunately, MF – 14A and MF – 14B couldn't be included in the facies pattern as the stratigraphic position of the Rókahegy quarry no. 5. is uncertain. Possibly it is a calcareous heteropic facies of bryozoan marl but this hypothesis needs further verification.

The following depositional environments can be postulated in the Buda Mts. and its surroundings during Late Eocene time:

- Submarine debris fan of a rocky coast (MF – 1A, – 1B and – 2);
- Protected lagoon with open circulation of normal saline, well-oxygenated, less agitated water. Diversified fossil communities lived in this environment, where biological production exceeded disaggregation but lime mud wasn't washed out (MF – 2, – 3, – 4 and – 5.)
- Shoal of sand-size particles washed together, partly with subaerial, vadose cementation. It was deposited far from the shore as it doesn't contain any terrigenous components (MF – 7).
- Coral-algal patch reef below wave base. The branching corals attenuated water currents so micrite mud was deposited and bound by encrusting red algae (MF – 6A, – 6B).
- Outer part of the shallow shelf: *Discocyclina* lived here in large quantity, below wave base. The lumachella-like beds are autochthonous, since the thin foraminifers couldn't bear significant transportation – MF – 8, – 9A, – 9B, – 9C).
- Deeper shelf dominated by bryozoans. MF – 10 contains some fragments of corallinacean red algae but the deeper environments are devoid of them. The grainstone texture developed locally following the winnowing effect of deep-water currents. In this depth of 50 to 100 metres the biogenic carbonate production was inhibited and, consequently, the ratio of terrigenous clay minerals increased (MF – 10, – 11A, – 11B, – 11C).
- Shelf margin and beyond: hemipelagic environment from one hundred to several hundred metres. Characteristic microfacies is the *Globigerina*-wackestone (MF – 13). Following the further decrease of carbonate content the terrigenous material became dominant: this is the Buda Marl.

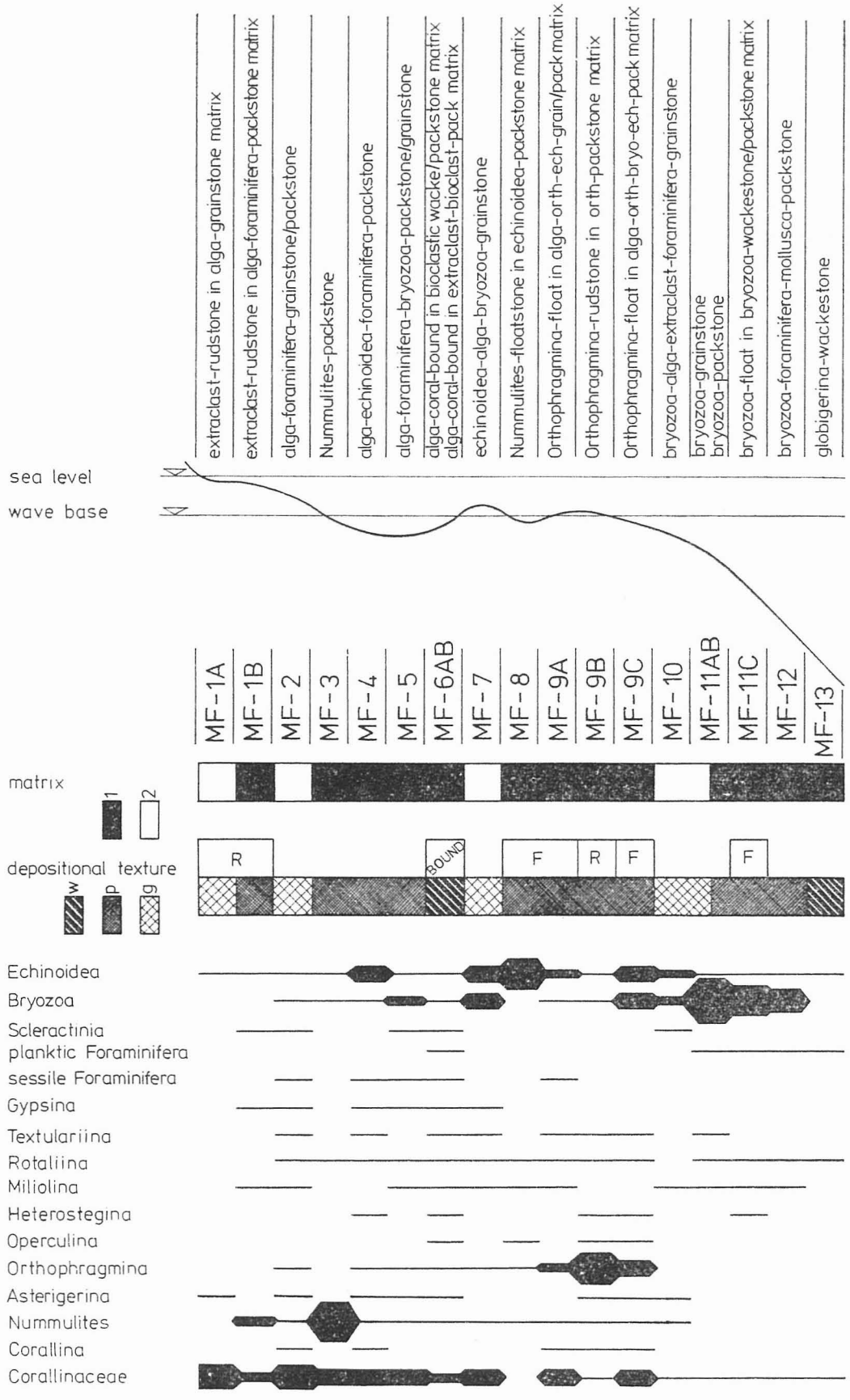

Fig. 3. Microfacies pattern of the Upper Eocene carbonate rocks at Budapest. The curved line indicates change in sedimentation depth between neighbouring microfacies types.

w = wackestone
p = packstone
g = grainstone

1 = micrite
2 = sparite

Conclusions

Overview of the Upper Eocene formations in and around Buda Mts. showed a general sinking of the basin, manifested in different facies in different tectonic blocks. The transgressive sequence started with a conglomerate of Triassic dolomite, limestone and chert pebbles and debris. It was followed by the deposition of algal limestone showing a variable range of microfacies. By the deepening of the sea the role of carbonate sedimentation decreased and limestone was replaced by bryozoan marl and then by Buda Marl with globigerinids.

This hypothetical sequence of events was constituted from the observations made in 9 sections. The transgressive sequence of microfacies types is conspicuous in every section but some facies may be absent or may return. No simple correlation could be established among the sections during this work. This behavior of facies types indicates differential motion of tectonic blocks during Late Eocene time. (A first draft of this hypothesis was made by DUDICH (1959), recognizing gradual Priabonian transgression on the Buda Mts.

Acknowledgements

Professor J. FÜLÖP initiated this work and provided financial support. P. VARGA put the samples of Alcsútdoboz – 3, Sóskút – 1 and Óbuda – 2 boreholes and his unpublished data at my disposal and gave me significant help in the field and in the *Nummulites* determinations. M. MONOSTORI presented me with his sample collection of the Mátyáshegy, western quarry. Professor T. BÁLDI, M. HORVÁTH, and P. MÜLLER helped with valuable advices. CS. PÉRÓ, P . VINCZE, L. CSONTOS and L. FÉLEGYHÁZY assisted me in the field. L. CSONTOS translated some French papers.

Their help s greatly acknowledged herein.

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