INTERNATIONAL ASSOCIATION OF SEDIMENTOLOGISTS
HUNGARIAN GEOLOGICAL SOCIETY

TENTH REGIONAL MEETING
IAS
BUDAPEST 24-26 APRIL 1989

EXCURSION GUIDEBOOK

Edited by
G. Császár

Published by
Hungarian Geological Institute

EXCURSION B7

CLASTIC AND CARBONATE SEDIMENTATION IN AN EOCENE STRIKE SLIP BASIN AT BUDAPEST

by

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INTRODUCTION

The Upper Eocene sedimentary basin at Budapest was formed upon a dissected, karstified Triassic surface.

Alluvial and marine plateaus, scarps and basins received coarse clastic and carbonate sediments transported by braided rivers, longshore currents, rockfalls, slumps, debris flow, and turbidity currents, respectively.

Uplift and karstification, block tilting and dyke opening, contemporaneous with uninterrupted basin sedimentation nearby, are indicators of a strike-slip regime.

The Buda Hills are part of the Bakony terrane, having been located within the Alps before Oligocene time. This tectonically controlled Upper Eocene sequence may indicate the initial steps of a continental escape along the Periadriatic fault system.

STOP 1

Róka Hill, quarry 1 (Ibolya Street)

E_3 slope apron profile: from conglomerate to limestone; and Ol_1 basin with turbidites and olistoliths

— Southern face (upper part of the succession) (Fig. 1, 2)

An upper member of the Lower Oligocene Tard Clay Formation is preserved in a downfaulted block. It is unconformably or disconformably underlain by Upper Eocene Discocyclina limestone.

Here the Tard Formation contains grey, argillaceous marl and marl (clay minerals: illite + kaolinite), intercalated with dark grey laminnites. The latter contain abundant plant remains and fish scales indicating intermittent anoxic conditions in the water column.

Allodapic limestone beds are made of Nummulites and other larger foraminifers, bryozoans, and corallin algae. Olistoliths (dm-size) of Bryozoa marl and nummulitic limestone are scattered throughout. Quartz pebbles and isolated Nummulites occur in two lower pebbly marl beds.

While benthonic fossils (larger foraminifers and ostracods) are of Upper Eocene age (Kecskeméti-Varga, 1985; Varga, 1985), the plankton is mixed: autochtonous forms refer to the Lower Oligocene (Báldi et al.,1984)

Speculation on the depositional environment: Thin turbidites with olistoliths may indicate deposition on a proximal fan, in an interdistributary plain, near the slope. Multiple sources of redeposited material should be considered.

— Western face (middle part of the succession) (Fig. 3)

The Upper Eocene fossiliferous, pebbly limestone contains an irregular conglomerate bed. The limestone is made of neritic fossils: coralline algae, larger foraminifers (including the epiphytic Gypsina), echinoid fragments, and some crushed, whole echinoids.

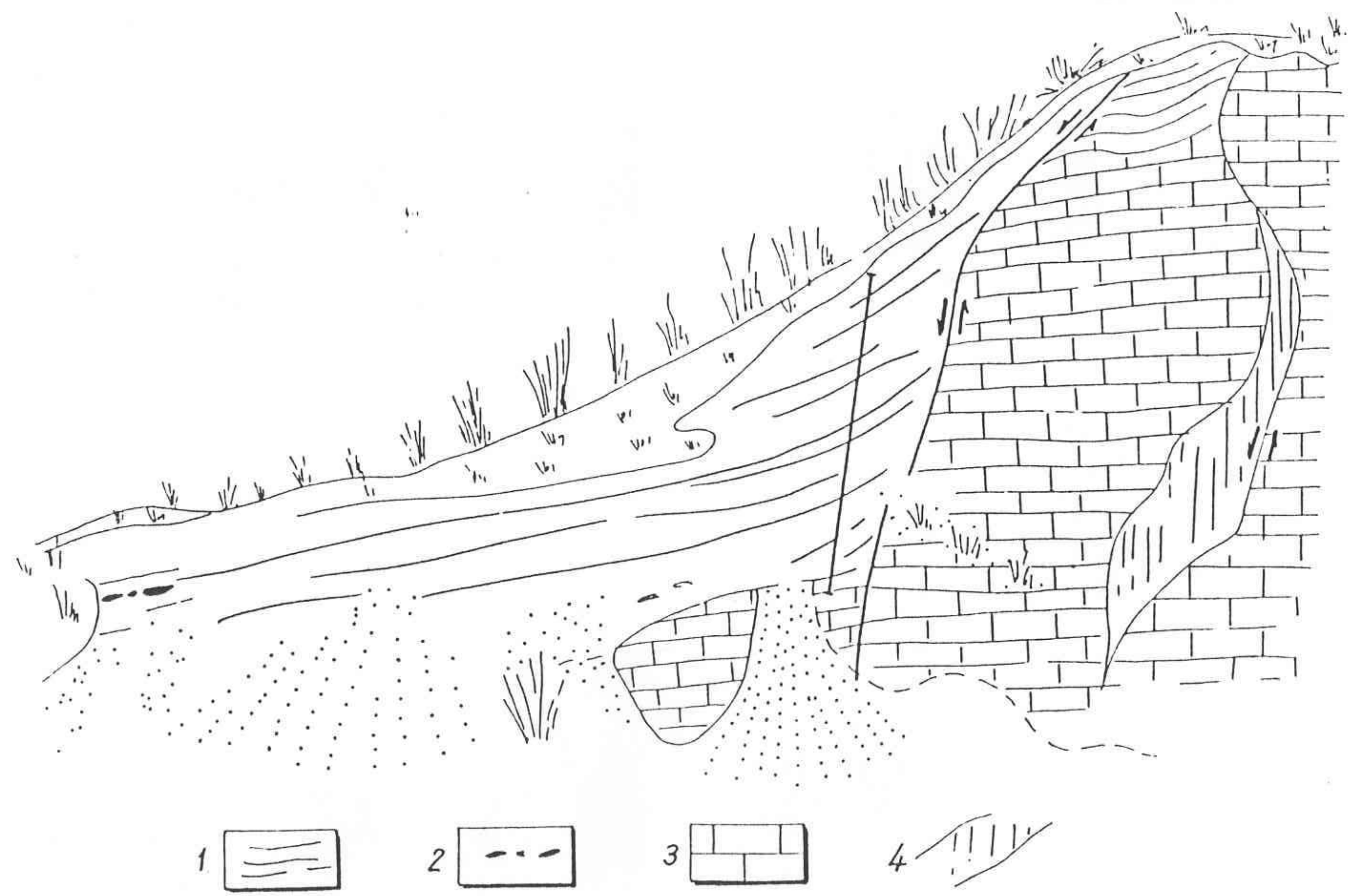

Fig. 1 Róka Hill, quarry 1, southern face. Lower Oligocene proximal fan with thin carbonate turbidites and olistoliths

1. carbonate turbidites in Tardy (01), 2. olistoliths, 3. Discocyclina limestone, 4. fault striae

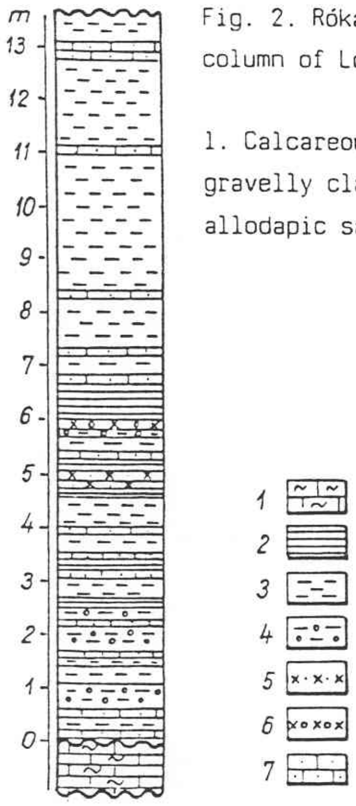

Fig. 2. Róka Hill, quarry 1, southern face. Lithologic column of Lower Oligocene Tardy Clay (after Nagymarosy, 1987)

1. Calcareous marl, 2. microlaminated clay, 3. clay, 4. gravelly clay, 5. sandy tuffite, 6. tuffitic gravel, 7. allodapic sandy limestone and calcareous sandstone inter beddings

The western face shows numerous features produced by slow or rapid movement on an instable slope:

— poor, irregular, often contorted bedding;

— scattered pebbles and conglomerate lenses in limestone;

— clasts of semi-consolidated limestone mixed with argillaceous-calcareous matrix (synsedimentary brecciation);

— poor, inverse to normal grading;

— fragment of clay bed with coal band;

— irregular (also vertical) orientation of flat pebbles and echinoid tests;

— synsedimentary(?) closed faults, etc.

— Northern face (lower part of the succession) (Fig. 4)

Proximal fan conglomerate and sandstone (oversteepened by synsedimentary block faulting). Conglomerate cons tuents are mostly dolomite and

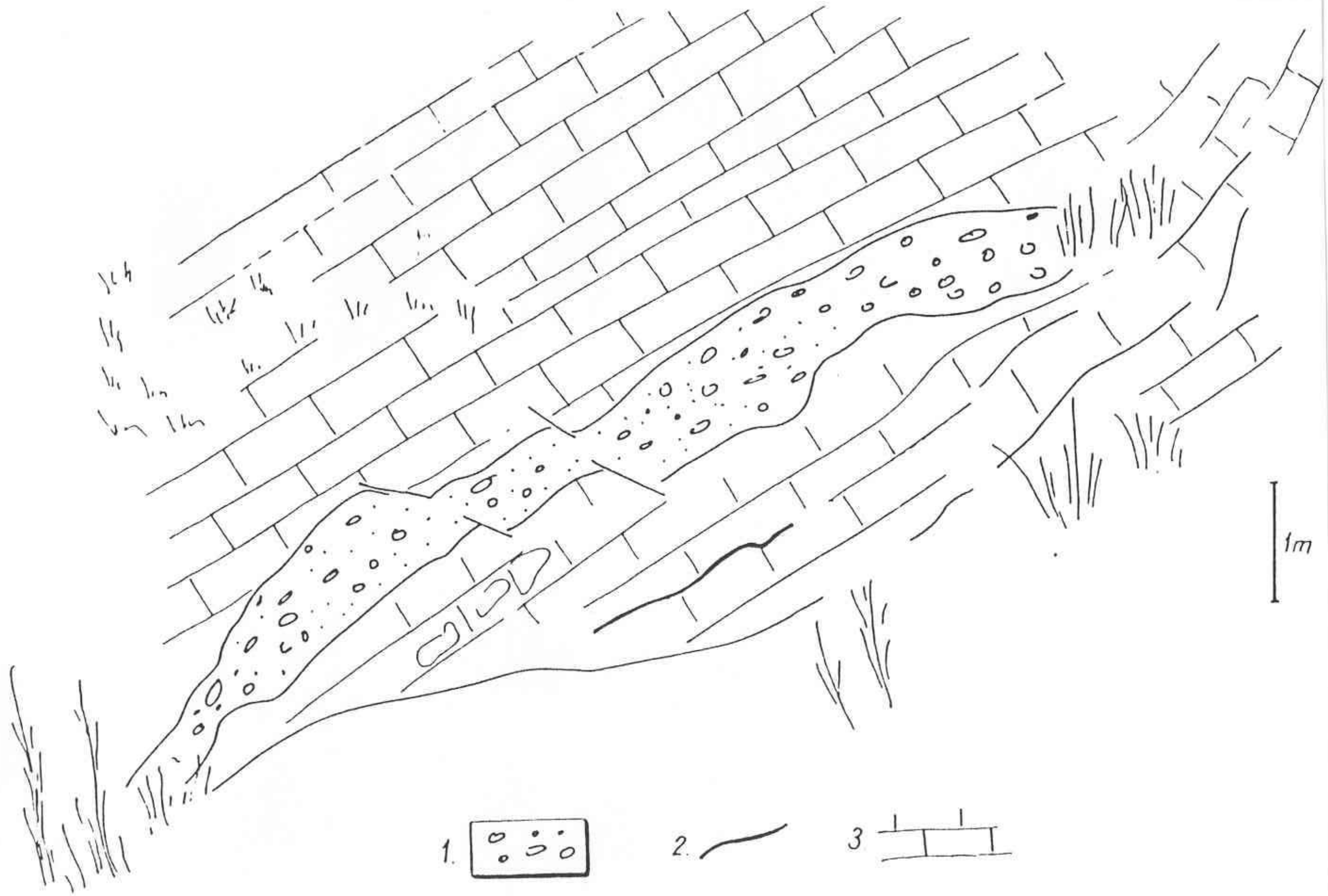

Fig. 3. Róka Hill, quarry 1, western face. Limestone and conglomerate lobes of a slope apron
1. Conglomerate, 2. clay and coal, 3. Gypsina limestone

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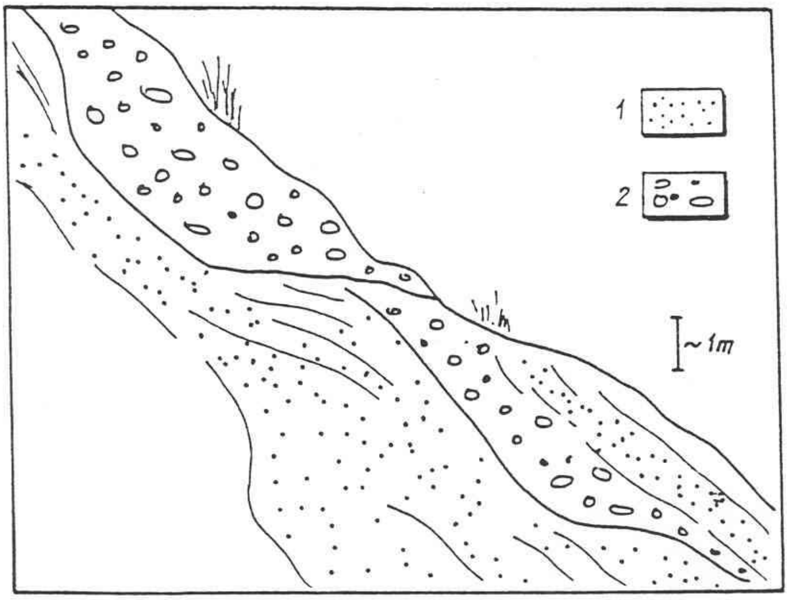

Fig. 4. Róka Hill, quarry 1, northern face. Intersecting channels in pebbly sandstone

1. Sandstone, 2. gravel

chert, rare andesite pebbles. It forms channels, graded beds, and is found irregularly scattered within the sandstone. Features of a slope in motion

— deformed channel fills;

— intimately mixed conglomerate and sandstone;

— pebbly sandstone;

— limestone blocks (dm-size) scattered in conglomerate and sandstone

— poor, contorted bedding.

Estimated pitch of channel axis shows that transport direction was oblique to the scarp.

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STOP 2

Róka Hill, quarry 2 (entrance: Tulipán Street)

Cross-section of a sediment-covered scarp (Fig. 5, 6)

The stepped surface of a compact Triassic limestone breccia displays the outline of an Upper Eocene scarp. The slopes are covered by steep beds of sandstone, pebbly sandstone, and conglomerate. Distorted channels, pebbly sandstone, mixing of sandstone and conglomerate indicate deformation the soft sediment while slowly moving downslope. Subsequent down-faulting of the southeastern block produced the extremely steeply dipping beds.

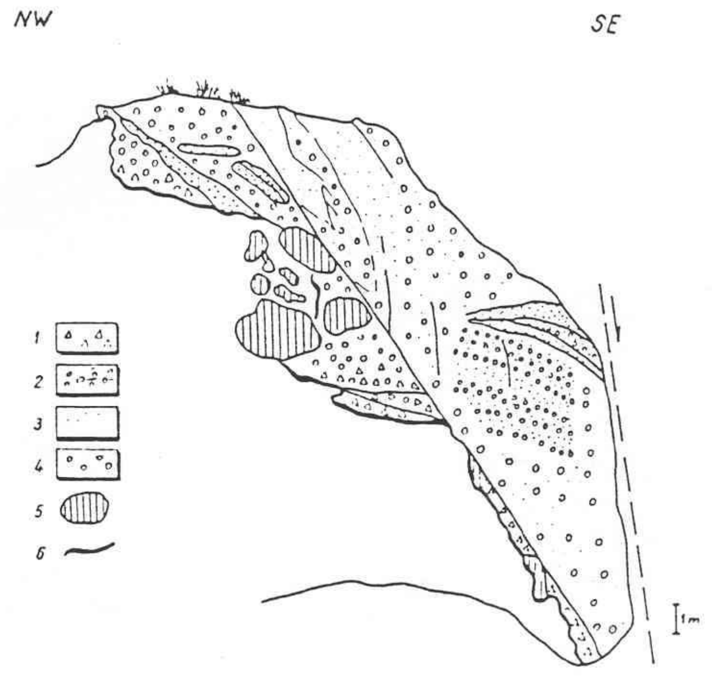

Fig. 5. Róka Hill, quarry 2, Cross section of an Upper Eocene scarp, covered by sediments of the slope apron. Conglomerates form distorted channels and together with pebbly sandstone suffered soft—sediment deformation on a steep slope. 1. Breccia, 2. conglomerate, 3. sandstone, 4. conglomerate and sst. undifferentiated, 5. karstic cavities(? age), 6. eroded surface

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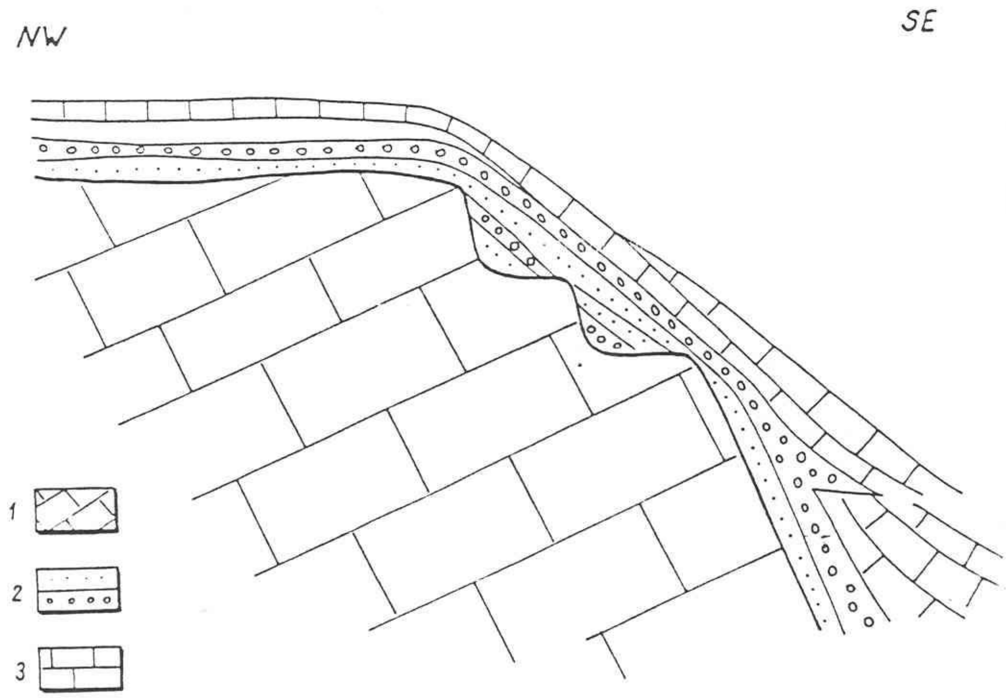

Fig. 6. Reconstruction of the Upper Eocene scarp sequence as exposed in Róka Hill quarries 1 and 2

1. Limestone breccia (Triassic), 2. sandstone and conglomerate (Eocene), 3. Gypsina limestone (Eocene)

The triangular conglomerate bodies in the footwall of the major faults are preserved original fills of the stepped scarp surface.

The flat top of the Triassic limestone may have been the plateau behind the scarp. It is covered by fluviatile sandstone and conglomerate, overlain by Gypsina limestone farther west.

Caves in the Triassic limestone and in the carbonate-cemented Eocene sandstone may have been formed by Pleistocene(?) thermal waters.

STOP 3

Róka Hill, quarries 3 and 4 (entrance: Ürömi Road) (Fig. 7, 8)

Eocene buried karst

Quarries 3 and 4 expose the limestone plateau behind the scarp seen in quarries 1 and 2. Spectacular karst forms (caves, dolines, sinkholes) cut in Triassic limestone have been preserved by the overlying Upper Eocen fluviatile sandstone and conglomerate (quarry 3, northern face).

The fluviatile beds are overlain by Upper Eocene shallow marine Gypsina limestone (quarry 4, western face).

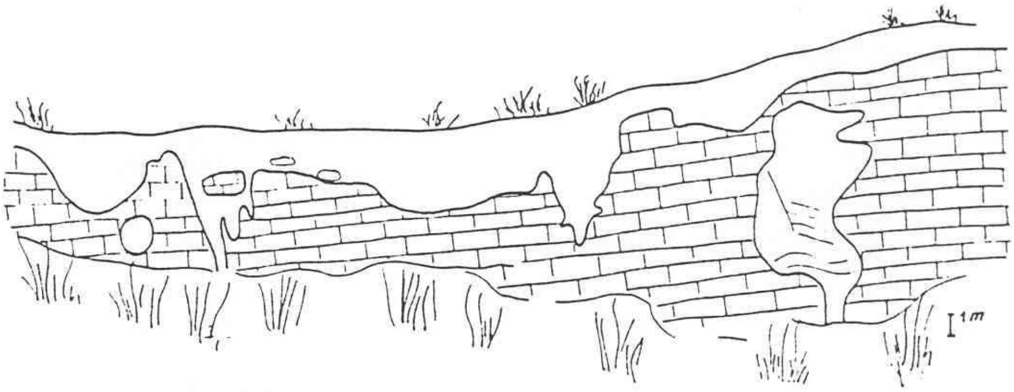

Fig. 7. Róka Hill, quarry 3, northern face. Triassic limestone, karstified during Eocene time. Caves, sinkholes and dolinas are filled by calcareous-sandy cave sediments and/or Eocene fluviatile sandstone and conglomerate

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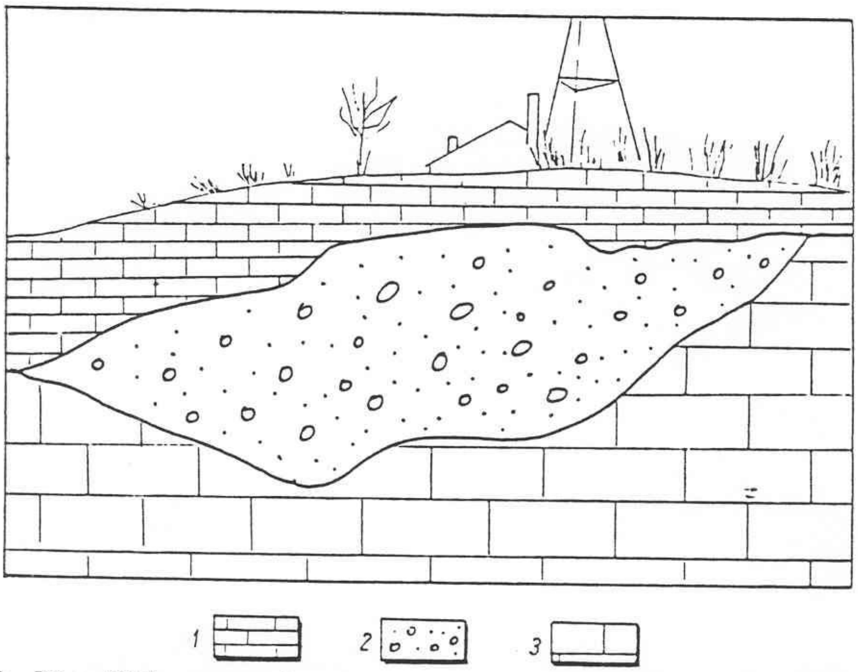


Fig. 8. Róka Hill, quarry 4, western face, below the geodetic tripod. Upper Eocene dolina-filling fluviatile sandstone overlain by Gypsina limestone

1. Eocene limestone, 2. conglomerate and sst. undifferentiated, 3. Triassic limestone

STOP 4

Fenyőgyöngye, quarry (Fig. 9, 10)

Upper Eocene algal limestone and coral bioherm

The sequence of the abandoned quarry lying 100 m to the south of Fenyőfő Inn exposes the lower member of uninterrupted carbonate sequences in the Buda Hills. Coarse, bioclastic limestone (rhodoliths, foraminifers) irregularly alternate with coral patches. The middle part of the quarry (accessible on a narrow terrace) exposes a 3 m thick bioherm of the coral

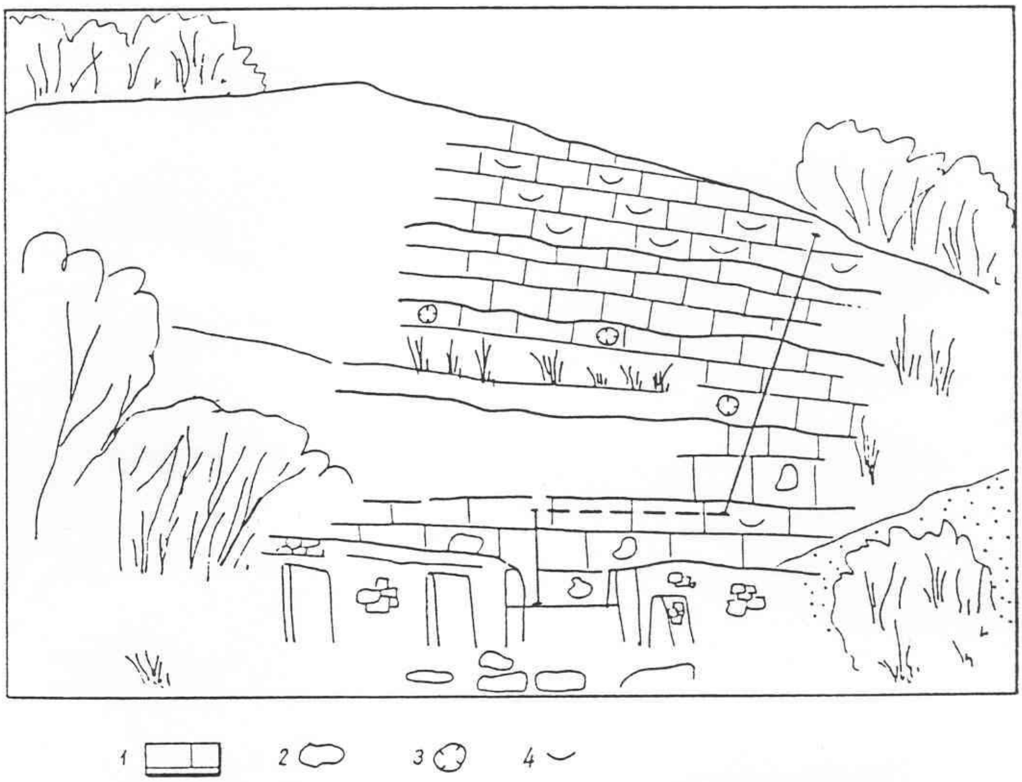


Fig. 9. Fenyőgyöngye, quarry. Upper Eocene algal limestone with coral bioherm

1. Limestone with, 2. rhodoliths, 3. corals, 4. Discocyclina 239

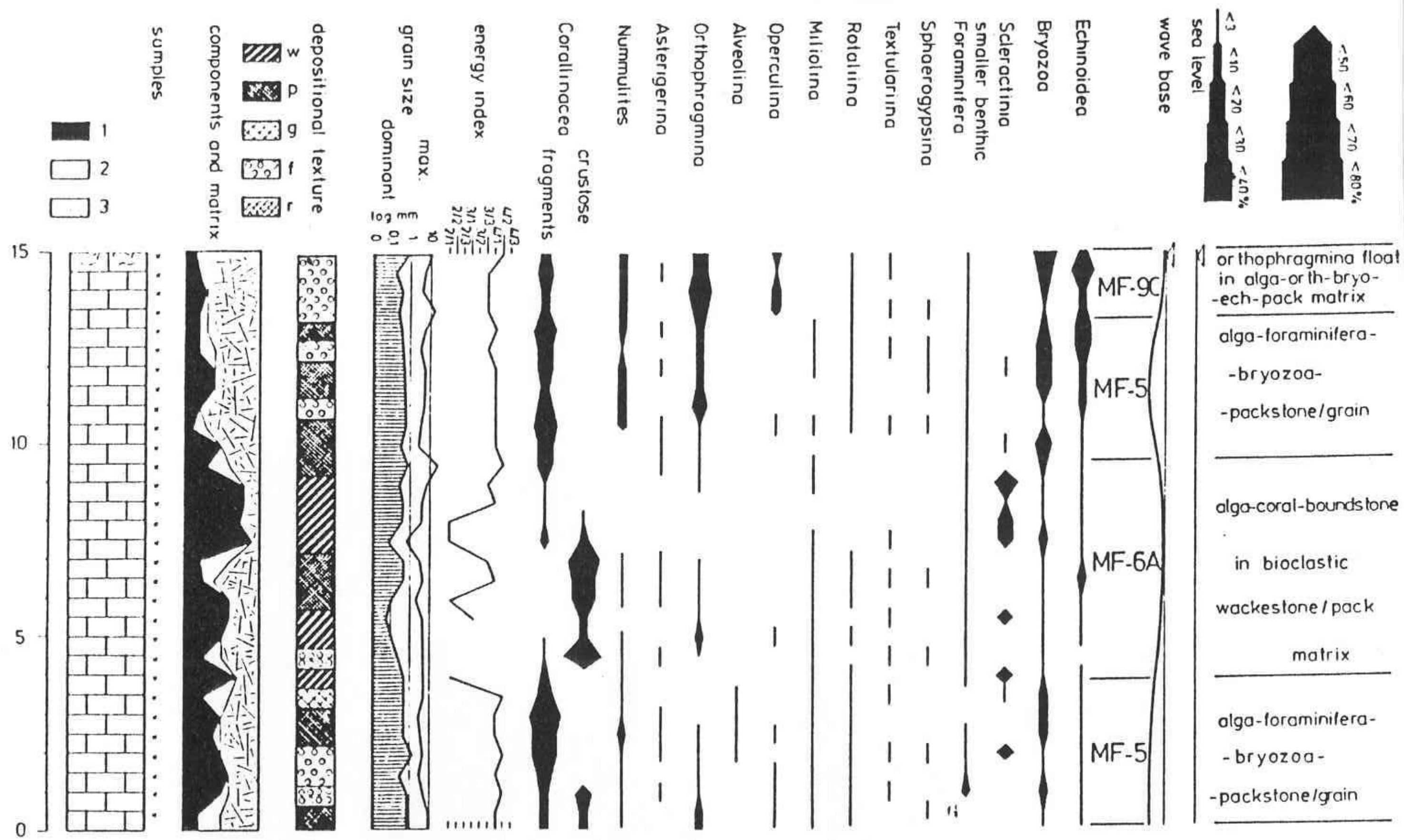


Fig. 10. Fenyőgyöngye, quarry. Microfacies plot of Upper Eocene algal (MF-5), coral (MF-6A), and Discocyclina (MF-9C) limestone (Orthopragmina in the plot = Discocyclina). (Kázmér, 1982)

1. Micrite, 2. sparite, 3. bioclast, w = wackestone, p = packstone, g = grainstone, f = floatstone, r = rudstone

Porites, frequently encrusted by coralline algae. The amount of corals decreases upwards; bryozoans appear, together with the larger foraminifer Discocyclina.

The locality displays an autochthonous sequence, where water depth slowly increased upwards. Modern relatives of Porites usually live above wave base, in less than 10 m deep water (Zlatarski and Martinez-Estalella, 1982), while Discocyclinas probably preferred environments below wave base.

STOP 5

Mátyás Hill, western quarry (Fig. 11, 12)

Upper Eocene Discocyclina limestone/marl and Bryozoa marl

The quarry is a natural conservation area. It hides several entrances to the Mátyáshegy Cave, member of a more than 10 km long cave system lying within a 1 km-radius circle.

The sequence of the abandoned quarry exposes the upper member of uninterrupted carbonate successions of the Buda Hills. It ranges from Discocyclina limestone full of larger foraminifers, through a Discocyclina-Bryozoa marl to pure Bryozoa marl. The facies change is gradual: the sea bottom slowly subsided from some ten metres to about a hundred or more metres of depth (Monostori, 1965).

The lower beds frequently yield bivalves (mostly pectinids) (Bodó, 1989) and echinoids (Bartha, 1989).

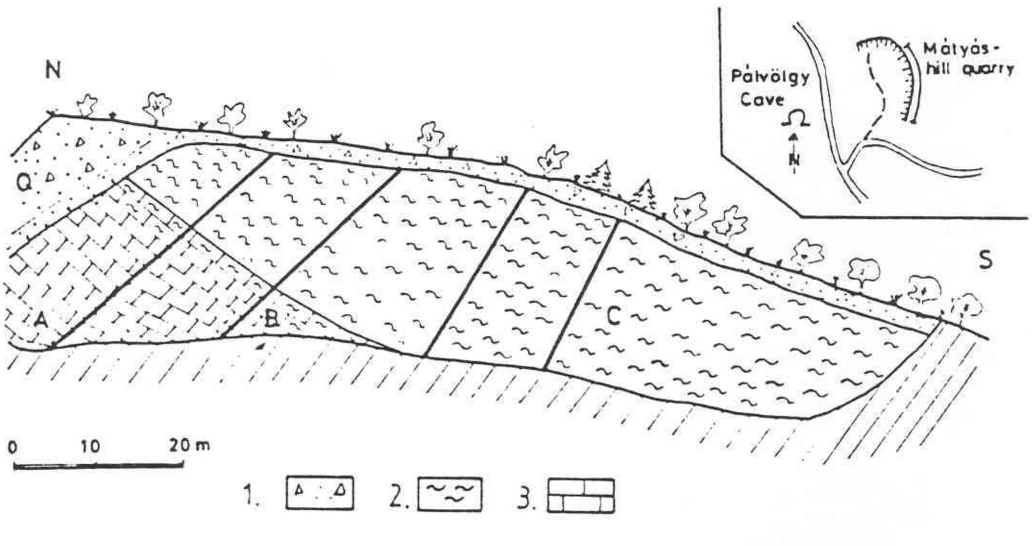


Fig. 11. Mátyáshegy, western quarry. Upper member of the uninterrupted carbonate sequence: Discocyclina limestone/marl and Bryozoa marl. (Monostori in Báldi et al. 1983)

1. Debris, 2. marl, 3. limestone

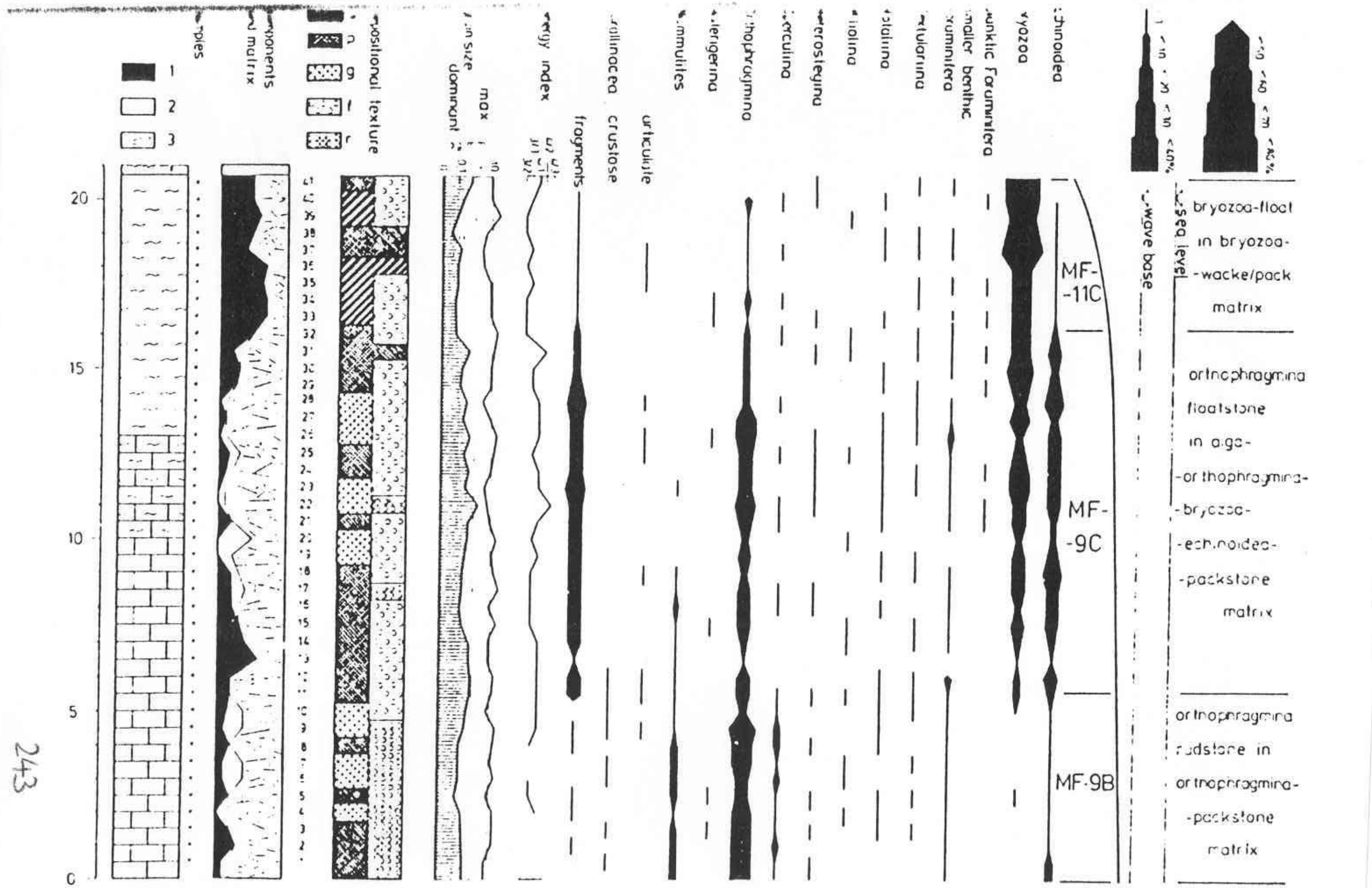


Fig. 12. Mátyáshegy, western quarry. Microfacies plot of Discocyclina limestone/marl and Bryozoa marl. Lithological boundaries (left) show poor correlation with changes in fossil content. (Kázmér, 1985) (For legend, see Fig. 10)

STOP 6

Pusztaszeri Street, No. 7, road cut (Fig. 13-15)

Upper Eocene Buda Marl: turbidites and slumps

The profile is a member of the uninterrupted succession of Upper Eocene formations in the Buda Hills. It is underlain by Bryozoa marl and overlain by Lower Oligocene Tard Clay (neither is to be seen here).

The autochthonous marl beds contain a rich benthonic foraminifer and ostracod fauna; both are mixtures of bathyal and neritic forms (Monostori, 1985, 1986, 1987). Planktonic foraminifers and nannoflora indicate Late Priabonian age (Báldi et al., 1984).

The calcareous turbidites contain almost only bioclasts: coralline algae, echinoid fragments, bryozoans, benthonic foraminifers, ostracods. Elongated grains arc arranged parallel to the bedding. Thick layers are made of larger bioclasts than thin ones (Báldi et al., 1983; Nagymarosy, 1986).

Turbidite/marl ratio widely varies in Buda Hills (from about 5:1 to 1:10); but usually less and less turbidites occur upwards in the sequence.

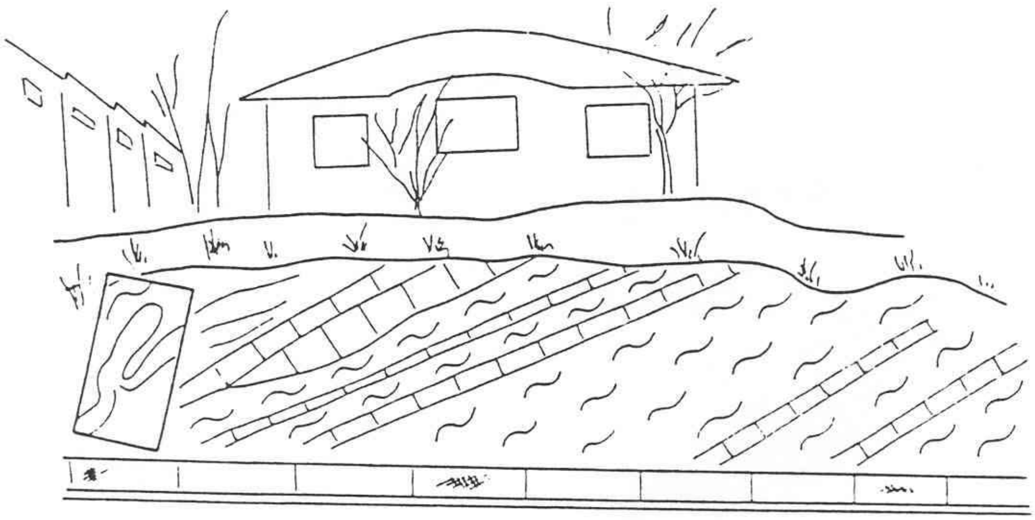


Fig. 13. Pusztaszeri street, road cut. Upper Eocene Buda Marl: turbidites and slumps

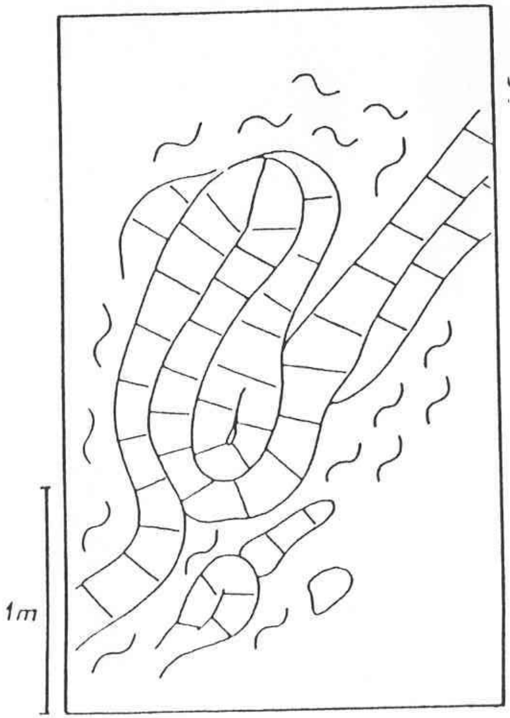


Fig. 14. Pusztaszeri street, road cut. Slumped fold of a calcareous turbidite in Buda Marl

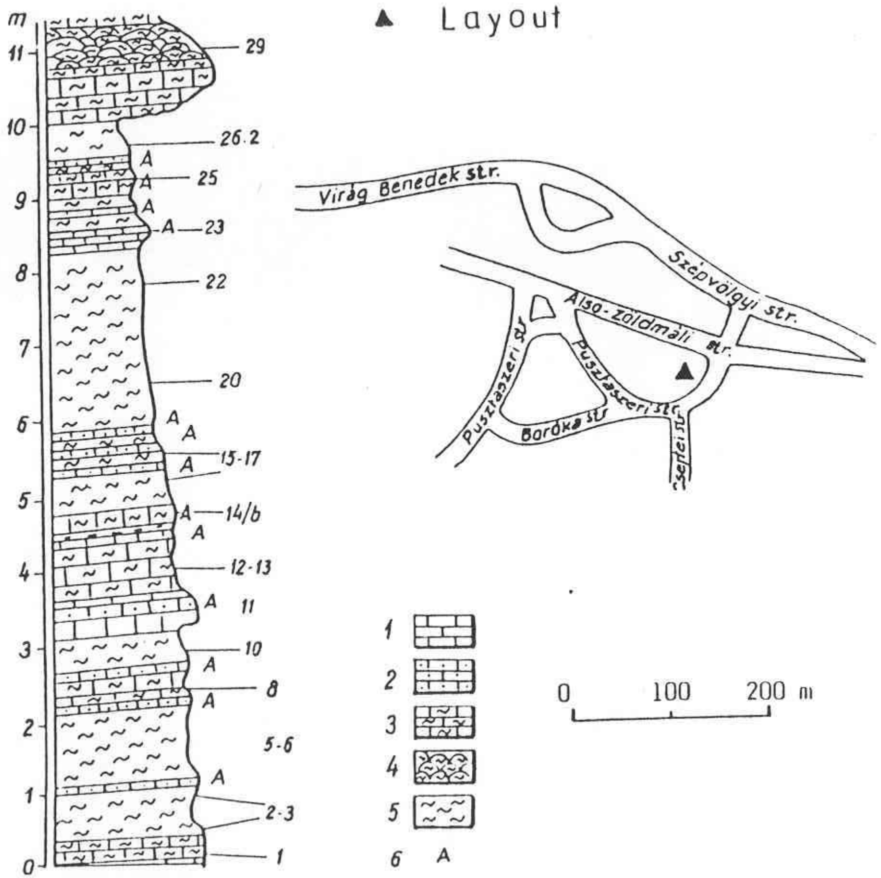


Fig. 15. Pusztaszeri street, road cut. Upper Eocene Buda Marl with turbidites: location and measured section (Nagymarosy,1986) 1. Limestone, 2. allodapic calcareous sandstone, 3. calcareous marl, 4. microlaminated calcareous marl, 5. marl, 6. allodapic limestone bed

STOP 7

Gellért Hill (walk from the Citadel down to Hotel Gellért) (Fig. 16)

Eocene scarp: interfingering apron and basin sediments

The steep eastern cliff of Gellért Hill is made of Upper Triassic Hauptdolomit. Unconformably it is overlain by Upper Eocene breccias, sandstones and conglomerates.

The southeastern ridge of Gellért Hill, extending from the Liberty Statue to Hotel Gellért exposes the scarp, its apron and the interfingering basin sediments. Eocene rocks in the ridge were cemented by silica, limonite and little baryte during a Middle Oligocene hydrothermal event (Báldi and Nagymarosy, 1976).

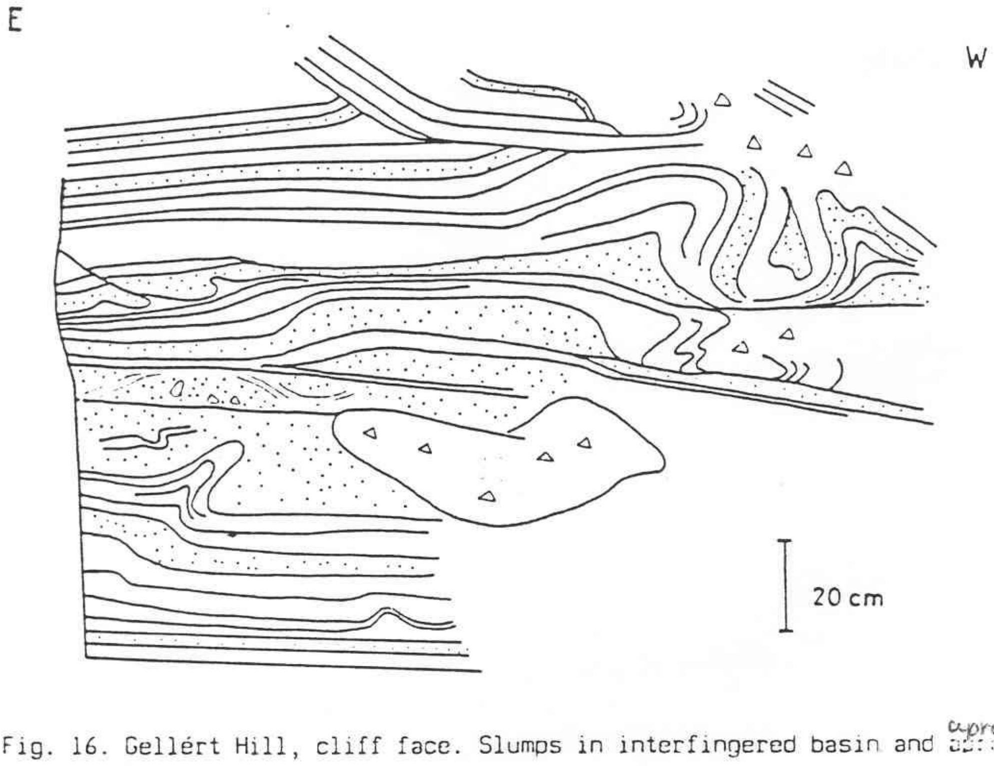


Fig. 16. Gellért Hill, cliff face. Slumps in interfingered basin and apron sediments

Several minor outcrops will be visited, as weather permits. Two of them are briefly described here:

A) Resedimented breccias, conglomerates and sandstones are intimately mixed in this cliff face. Clasts are chert, cherty limestone, and rare dolomite. The clast- or matrix-supported fine conglomerate and pebbly sandstone have calcareous and silty matrix. While moving downslope, the semi-consolidated calcareous mud/sand teared, forming pull-apart structures. Their boundaries may be indistinct; the matrix between them contains much more chert fragments than the clasts themselves. Some limestone fragments contain corallina algae, Nummulites, echinoid plates, bryozoans, and vertically oriented Discocyclinas.

B) A five-metre-high cliff face exposes thin beds of grey (silicified) marl alternating with chert-sandstone layers and lenses. Frequent truncation surfaces can be observed. Minor sedimentary folds verge in opposite directions within a single layer. Slumps perpendicular to the rock face may have produced them in an almost fluid state of the sediment.

STOP 8

Ördögorom (Devil's Cliff) (Fig. 17, 18)

Sandstone dyke

Folded Upper Triassic cherty dolomite forms the white cliff. At the NW and there is a ca. 20 m high, vertical sandstone dyke. It is 3-4 m wide at the top and cuts through the dolomite down to the road. Thin, horizontal, vertical, and oblique auxiliary dykelets protrude from the main dyke. There are other, even larger dykes covered by vegetation further up by the road.

The dyke is filled by grey, fine conglomerate, pebbly sandstone, and fine sandstone, probably Upper Eocene in age (Wein, 1977). The pebbles are chert, quartzite and dolomite. Two sources must be considered: one yielded well rounded to subangular, white or grey quartzite pebbles. Their diameter is usually less than 1 cm and never exceeds 5 cm. Another source produced angular to subrounded dolomite and chert clasts, ranging up to 15 cm in size.

Several kinds of minor sedimentary structures are observed in the dyke fill:

— alternation of fine sand and conglomerate (middle inset)

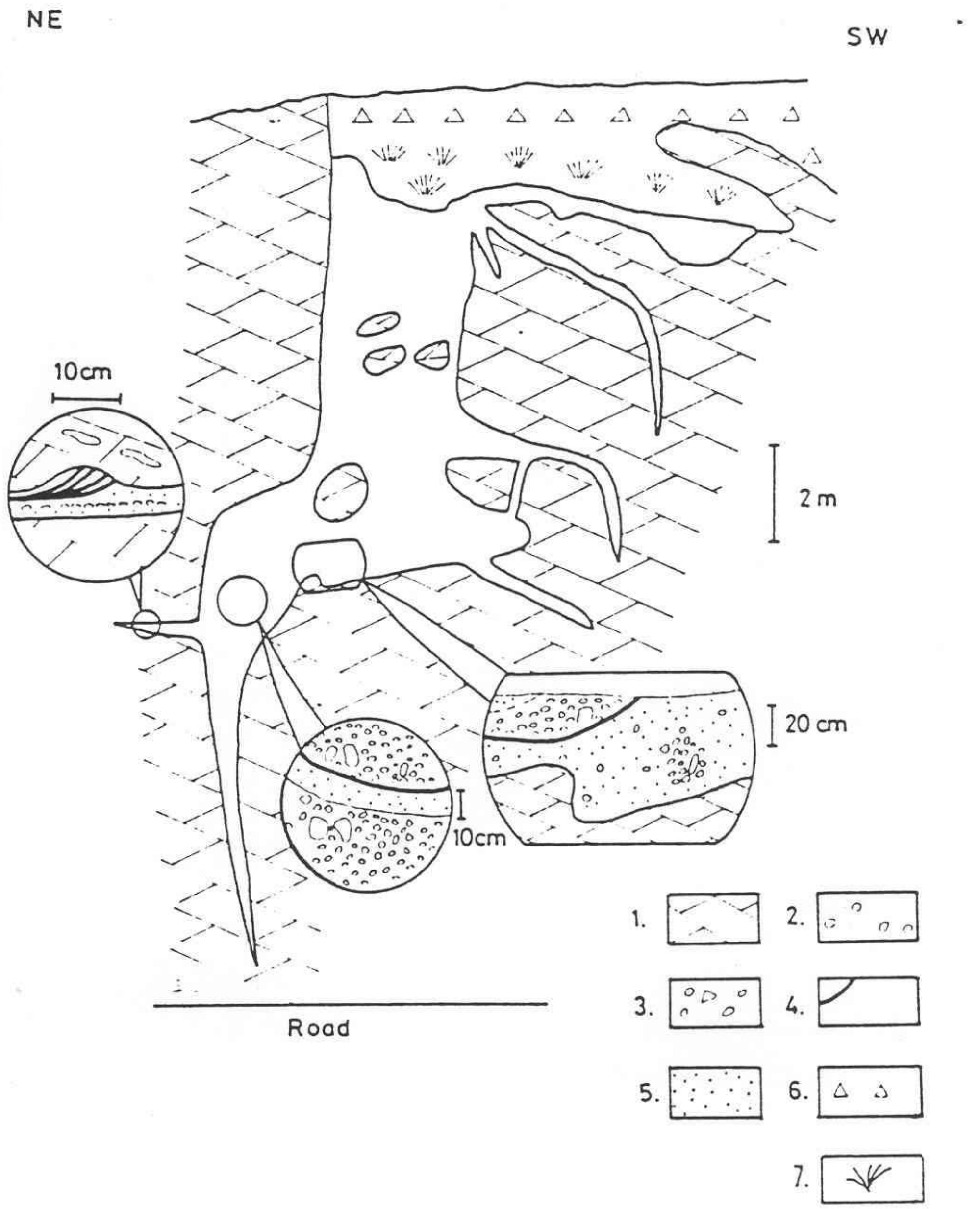
— small conglomerate-filled channels in pebbly sandstone (right inset)

— dolomite sand accumulation with inclined bedding (left inset).

Thin, white calcareous film covers some bedding planes.

The dyke was open for a relatively long time; it was filled by currents passing along the dyke, probably in a submarine environment.

In the upper part of the dyke (rectangular frame and Fig. 18), thin sandstone and gravel beds terminate at the wall rock under acute angles. Inside, several minor normal faults dissect the bedding planes, producing a stepped, dish-like structure between the two walls. The faults are parallel with the dyke (NW-SE; stereographic projection, lower hemisphere). This peculiar geometry was established either by synsedimentary extension of the fissure, or by compaction, or both.



ig. 17. Ördögorom. Sandstone dyke in Triassic cherty dolomite. Channel conglomerates indicate currents along the dyke.
. Triassic dolomite, 2. coarse sandstone with pebbles and clasts, 3. fine onglomerate with large clasts, 4. calcareous film, 5. fine sandstone, 6. debris, 7. bush 249

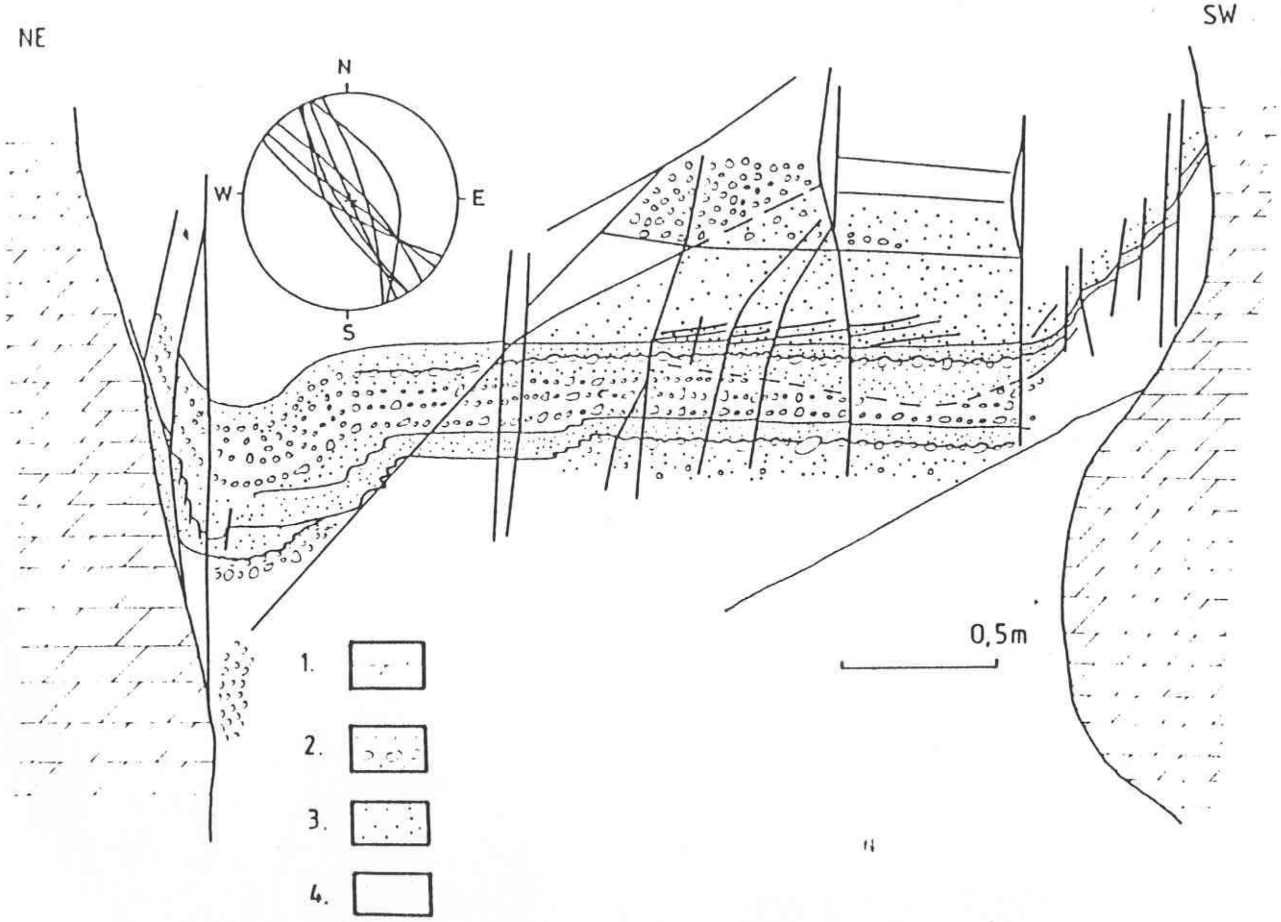


Fig. 18. Ördögorom, Eocene sandstone dyke. Small normal faults in the dyke fill: synsedimentary extension and/or compaction

1. Cherty dolomite, 2. sandstone with pebble bands, 3. coarse sandstone, 4. calcareous sst-silt

STOP 9

Budaörs, Út Hill quarry (Fig. 19)

Intra-Priabonian unconformity

The quarry on the SE side of Úthegy hill NW of Budaörs has exposed the Upper Eocene Nagysáp Limestone in a virtual thickness of 8 m. The strata dip at 180/45^{0}. The rock underlying them is unknown, the overlying beds are represented by bryozoan Buda MArl which follows the Nagysáp Limestone with an intra-Priabonian erosional and angular unconformity.

The exposure has exhibited a sequence consisting of 0.2 to 0.7 m thick limestone beds which contain, in one place, a 0.1 m thick intercalation of sandy marl. The lower interval of the white and drab bioclastic limestone underlying the sandy marl contains mollusc shell fragments, red algae incrusting them, skeletal elements of echinoids and, in the higher parts, coral colonies (0—2.9 m). The 0.2 m of limestone above the marl (2.9—3.0 m) was observed to contain some redeposited volcanoclastic material. It is in the red algal, corallinaceous limestone above the marl, from 4.7 m downwards, that the first discocyclines and asterigerines appear.

Judging by the micrite content of 50—80% observed in thin sections, the limestone is supposed to have been deposited at a depth of 20 to 50 m below the zone of wave action (subtidal zone).

In the algal-corallinaceous limestone there are cavities and fissures of karstic origin that are filled with calcilutite and calcareous sandstone showing a peculiar watch-glass type of stratification. The karsted limestone is overlain with an erosional and angular unconformity by a nummulitic—coarsely bioclastic limestone that is thin-bedded (1 m) and dips S at 20^{0}, to be followed in turn by a bryozoan marl affected by subsequent silicification (about 1.5—2.0 m).

By analogy, the "lower" limestone in the exposure may be dated as belonging to the lower part of the Priabonian, while the "upper" limestone and marl may be assigned to the Upper Priabonian. The silicification of the marl seems to have taken place in later Oligocene time. 251

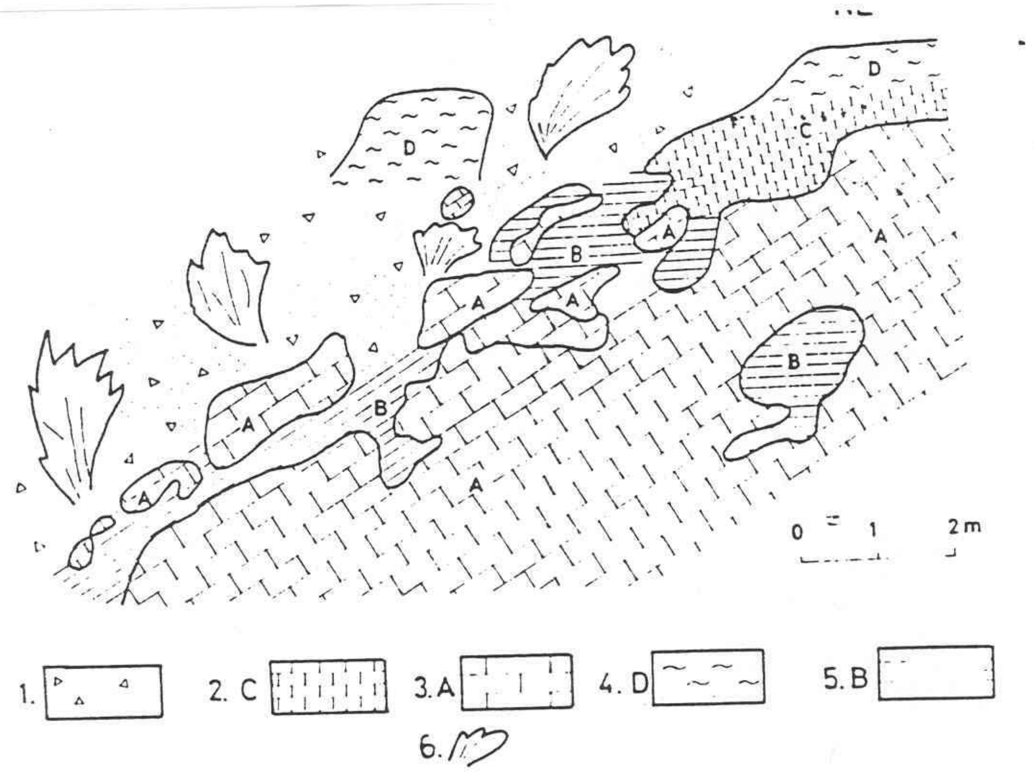


Fig. 19. Budaörs, Út Hill. Intra-Priabonian unconformity between Nummulites limestone and Bryozoa marl. (Nagymarosy, 1986)
1. Talus, 2. Nummulitic limestone, 3. algal-corallinaceous limestone, 4. silicified bryozoan marl, 5. calcareous silt-calcareous sandstone cavity fill, 6. shurb

The importance of the profile stems from the fact that it shows quite spectacularly the intra-Priabonian event that resulted in uplifting the older Priabonian formations and which led to an erosional hiatus and angular unconformity. This process put a definite end to the Eocene sedimentary cycle, but in the Buda Hills the temporary energence was followed by a new transgression, still in Eocene time. The "upper" limestone and marl may already be regarded as representing the initial member of the Oligocene sedimentary cycle.

STOP 10

Budaörs, Odvas Hill (Fig. 20, 21)

Cliff and wave-cut platform(?) covered by slope apron sediments

Middle Triassic dolomite forms most of the hill north of Budaörs; a Upper Eocene sequence is exposed in the southern flank, in road cuts. Walking northwards we find first a partly silicified Bryozoa marl, under- lain by brown bioclastic limestone. It is followed by conglomerates, peb- bly siltstone, dolomite conglomerate and breccia. The latter gradually change into brecciated dolomite, then into compact dolomite. Between the breccia and the dolomite, a sedimentary dyke of cherty sand cuts along th boundary. It was injected into the wall rock and fractures in the dolomi and pore space in the breccia/conglomerate are filled by chert sand. The dyke was displaced by faults.

Climbing the slope on the eastern side of the valley we find a sui- able observation point to look at Odvas Hill. A stepped erosion surface cuts horizontal layers of Triassic dolomite; the cover is Upper Eocene breccia/conglomerate. The clasts are almost exclusively local dolomites some of them bear traces of boring bivalves. Dip of bedding is ca. 45^{o} on the scarps and horizontal on wave-cut platforms.

The Odvas Hill slope is probably a fossil, drowned cliff coast of Upper Eocene age.

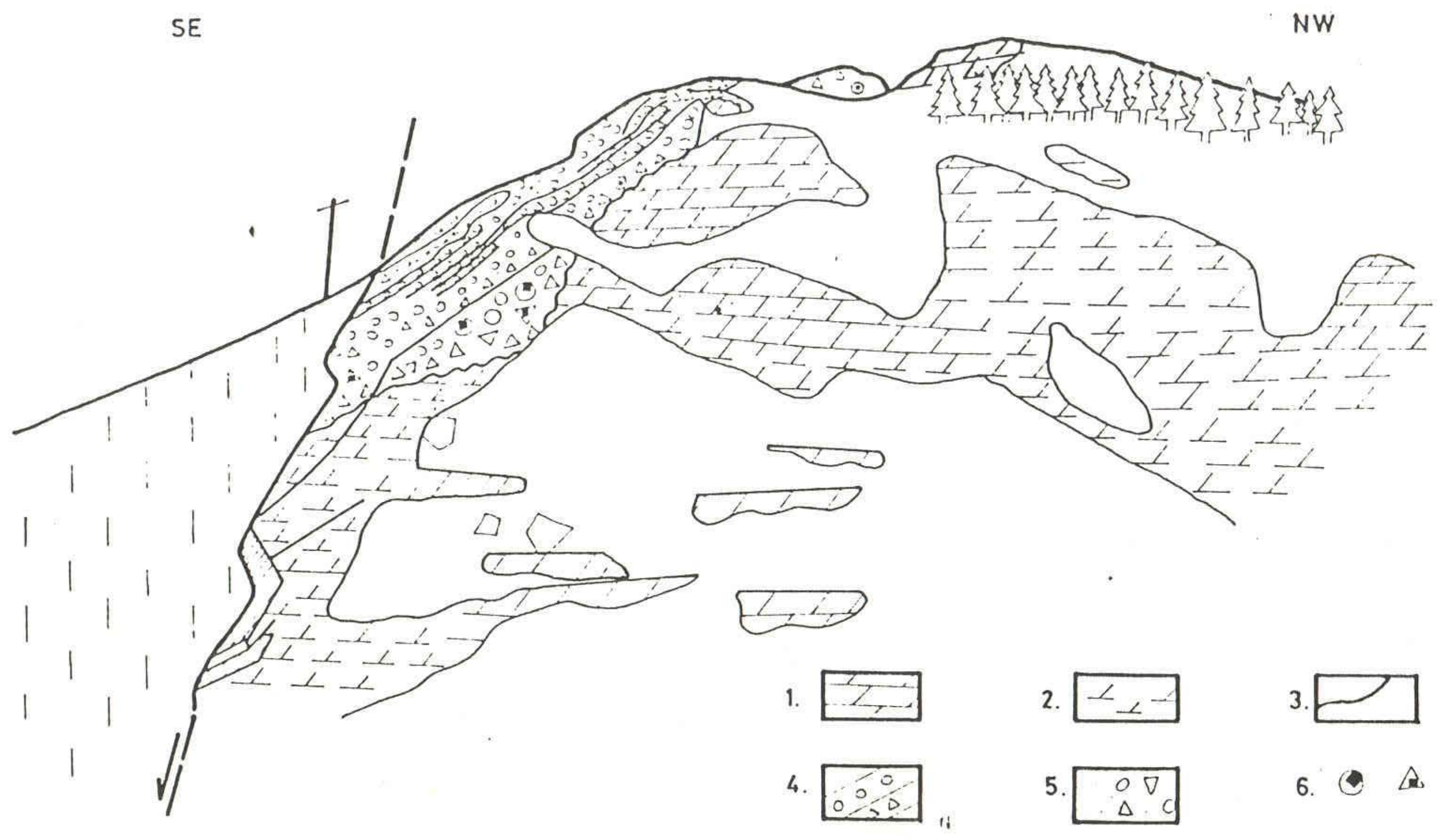


Fig. 20. Budaörs, Odvas Hill, eastern flank. Panoramic view of Eocene cliff and wave-cut platform, covered by slope apron sediments

1. Bedded dolomite (Triassic), 2. slightly brecciated dolomite, 3. erosion surface, 4. bedded Eocene breccia/conglomerate, 5. sandy conglomerate/breccia, 6. pebble or clast with boring traces

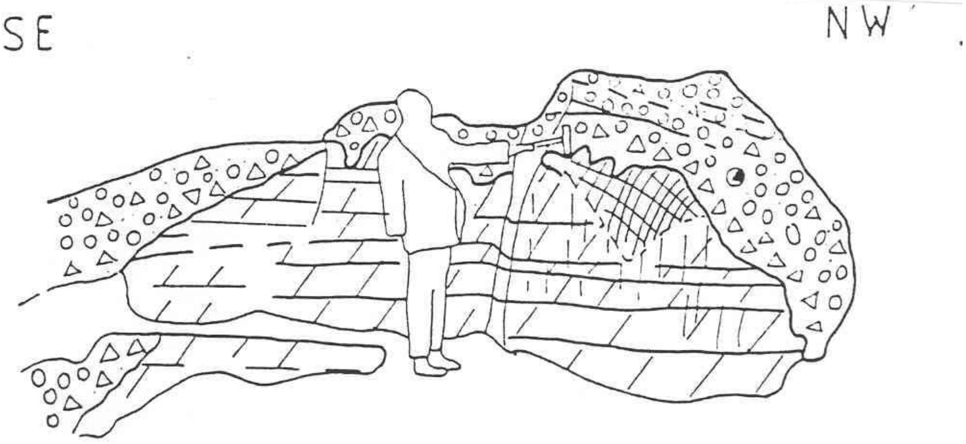


Fig. 21. Budaörs, Odvas Hill, eastern flank. Triassic dolomite stack on an Eocene wave-cut platform, covered by slope apron sediments (For legend, see Fig. 20)

Acknowledgements

The authors are greatly appreciate the generous help of Professor Tamás Báldi and are greatly indebted to the colleagues in the Departments of Geology and of Palaeontology, Eötvös University, for patient discussions and criticisms of ideas.

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