UPPER EOCENE ECHINOIDEA FROM BUDA HILLS, HUNGARY

by

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Abstract

Five localities in Buda Hills, Budapest, yielded 1820 specimens of echinoids: 43 species of 22 genera were recognized. Six types of host rocks are interpreted as six environments; *Nummulites* limestone, sandy limestone, *Nummulites-Discocyclina* limestone, marly *Nummulites-Discocyclina* limestone, Bryozoa marl and Buda Marl indicate a gradual change from nearshore to deep water, quiet environment.

The fauna is characteristic for the Upper Eocene; Middle Eocene and Lower Oligocene species are subordinate. Comparisons with described faunas indicate Southern Alpine affinity.

Introduction

Upper Eocene formations of the Buda Hills are rich in echinoids. Collection and publication of the fauna started in the 19th century. A pioneer worker was ELEK PÁVAY (1874), who studied the echinoid fauna of the Bryozoa and Buda Marls, and described several new species. At the turn of the century and during the first decades of the 20th century faunal lists were published only on the echinoids of the *Nummulites-Discocyclina* limestone. A list of the Martinovics-hegy locality was published by LŐRENTHEY (1897) and another by LŐWY (1928). The study of SZÖRÉNYI (1929) played an extremely important role in the investigation of the Buda Hills echinoids. Describing the fauna of the Buda Marl, a detailed discussion was provided on the material of new collections, too.

The following decades brought little new information. BOKOR (1939) studied a small fauna from isolated Eocene outcrops SE of Páty. SZÖRÉNYI, following her monograph (1964) on the echinoid fauna of the Bakony Mts. started to examine the Buda Hills material, but she could not complete her work.

A modern systematic study of the Upper Eocene echinoid fauna from the Buda Hills was attempted by the author, with palaeoecological, biostratigraphical, and palaeobiogeographical interpretation. The study was based on the material in the Museum Department of the Hungarian Geological Institute, supplemented by minor new collections.

Stratigraphy

BALÁZS et al. (1981) published a synthesis of structural and facies problems of Eocene/Oligocene boundary formations in Hungary. They ranged the Middle and Upper Eocene strata of the Buda Hills into a "Buda Hills epicontinental-terrigenous-carbonate facies".

The terrigenous-carbonate Upper Eocene formations unconformably overlie Triassic limestone and dolomite, and Middle Eocene Miliolina limestone and marl; they are overlain by conformable Oligocene or disconformable Neogene and Quaternary sediments.

The bipartite Upper Eocene transgression (DUDICH, 1959) occupied most of Buda Hills. At the bottom of the stratigraphic column there are conglomerates of Triassic dolomite, limestone and chert pebbles, which turn into red algal-*Nummulites-Discocyclina* limestones of variable microfacies types (KÁZMÉR, 1982). The limestone is conformably overlain by Bryozoa marl (Mátyás Hill); the latter may be separated from the limestone by a conglomerate bed (Martinovics Hill).

The species *Nummulites fabianii* indicates Upper Eocene, Priabonian age of the *Nummulites-Discocyclina* limestone, corresponding to the *N. fabianii-Dyscocyclina* horizon (KOPEK-KECSKEMÉTI-DUDICH, 1966) of the Transdanubian Midmountains (KÁZMÉR, 1982).

The Bryozoa and Buda Marls belong to the *Isthmolithus recurvus* Zone of Priabonian stage (nannoplankton: BÁLDI-BEKE, 1970).

Localities

The studied echinoid fauna has been collected from five localities in Buda Hills:

1. Solymár, Várerdő Hill (1351 specimens)
2. Páty, Mézes Valley, Főkút Spring (221)
3. Budapest, Szépvölgy (91)
4. Budapest, Martinovics Hill (49)
5. Budapest, Vár-hegy (Castle Hill, 108)

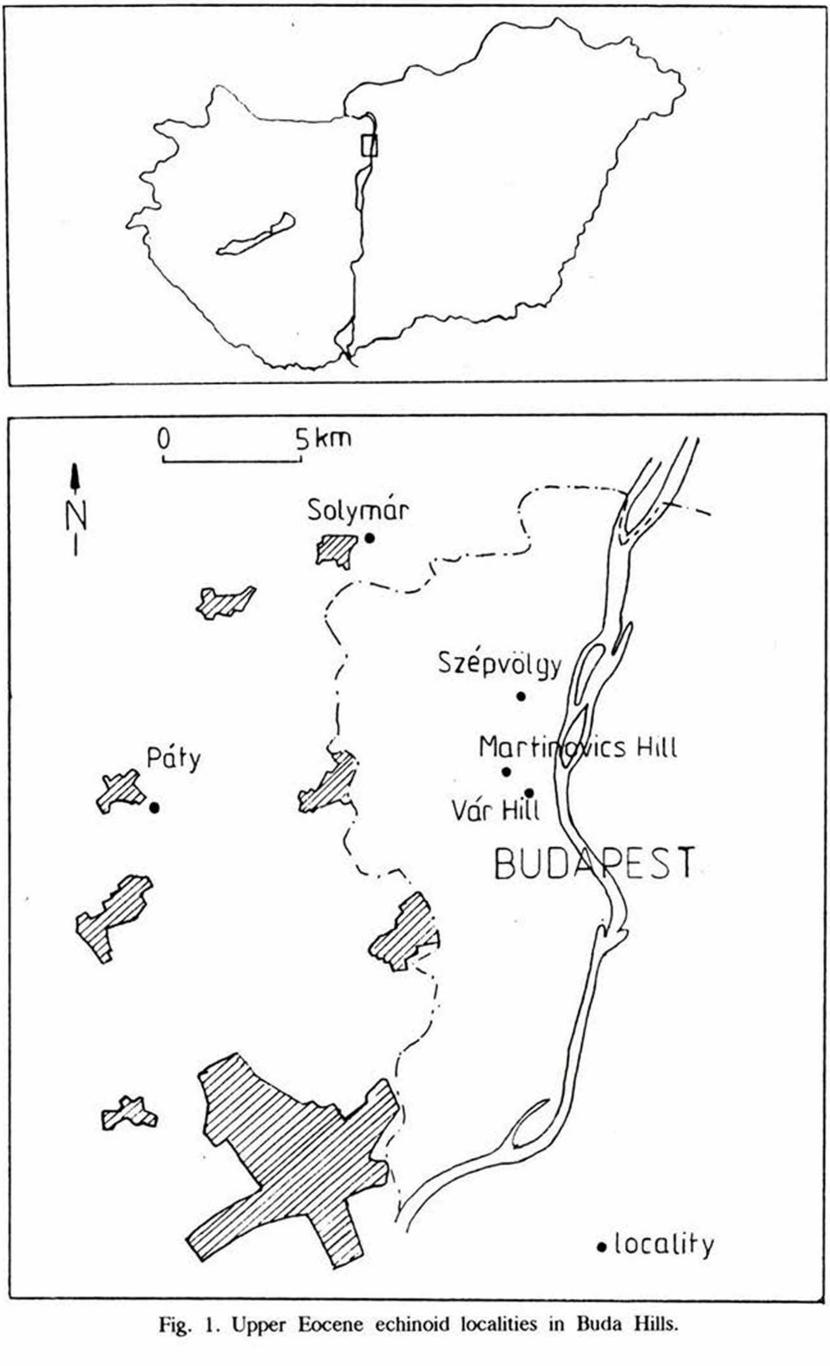

Fig. 1. Upper Eocene echinoid localities in Buda Hills.

Bed-by-bed collection was carried out at Solymár, Várerdő Hill, at Szépvölgy (in the Mátyás Hill western quarry, and at the outcrop near the "Erdei Lak" restaurant), while at Mátyás Hill, eastern quarry debris of the Bryozoa marl was examined.

Bed-by-bed interpretation of the fauna was impossible, because most of the material (from the 19th century collection) did not bear notes on the exact location or bed.

Solymár, Várerdő Hill

The profile is located about 400 m south of the railway station, in the valley of Jegenye Creek; it exposes Upper Eocene *Nummulites-Discocyclina* limestone and Middle Oligocene Hárshegy Sandstone *(Fig. 2)*. (MONOSTORI, 1967). The sequence starts with 15 m *Nummulites-Discocyclina* limestone *(Fig. 3)*, displaying tripartite subdivision (KOCH, 1872). The lower part, a 5-6 m thick *Nummulites* limestone changes into a 6 m thick sandy limestone, then turns into a 2-3 m thick *Discocyclina* limestone. The limestone is unconformably overlain by the basal beds of the Hárshegy Sandstone, a violet grey fireclay and pebbly clay.

The thick-bedded, white to light yellow *Nummulites* limestone rarely contains much sand and clay. Rock-forming quantities of corallinacean algae, *Nummulites,* Miliolina and Bryozoa occur. Discocyclinas, and Operculinas occur in subordinate quantities only. Plenty of bivalves and echinoids are found. The lower part of the *Nummulites* limestone is characterized by mass occurrence of the bivalve *Plicatula bovensis* DE GREGORIO, besides *Lentipecten corneus* SOWERBY, *Spondylus radula* LAMARCK and *Chlamys biarritzensis* D'ARCHIAC. The echinoid fauna of the lower *Nummulites* limestone is extremely rich: 1013 specimens of 20 species were found. The most frequent form is *Echinanthus scutella* LAMARCK, *Echinolampas subsimilis* D'ARCHIAC, and *Sismondia rosacea* (LESKE). Most of the fauna was collected from the sandy layers of the *Nummulites* limestone.

The violet red sandy limestone developed gradually from the lower *Nummulites* llimestone, bears relatively high clay and sand content. Some mm to 0,5 cm limestone grains occur in the sandy limestone. The *Nummulites* dominate the foraminifers, but the percentage of Discocyclinas has grown, too. Operculinas and Miliolinas are secondary in importance. The most frequent bivalves are *Chlamys biarritzensis* and *Plicatula bovensis*. The 339 echinoid specimens represent 5 species, dominated by *Echinanthus scutella* and *Sismondia rosacea.*

The sandy limestone is conformably overlain by white, platy limestone (2-3 m), without megafossils. The Priabonian limestone sequence is overlain by Hárshegy Sandstone.

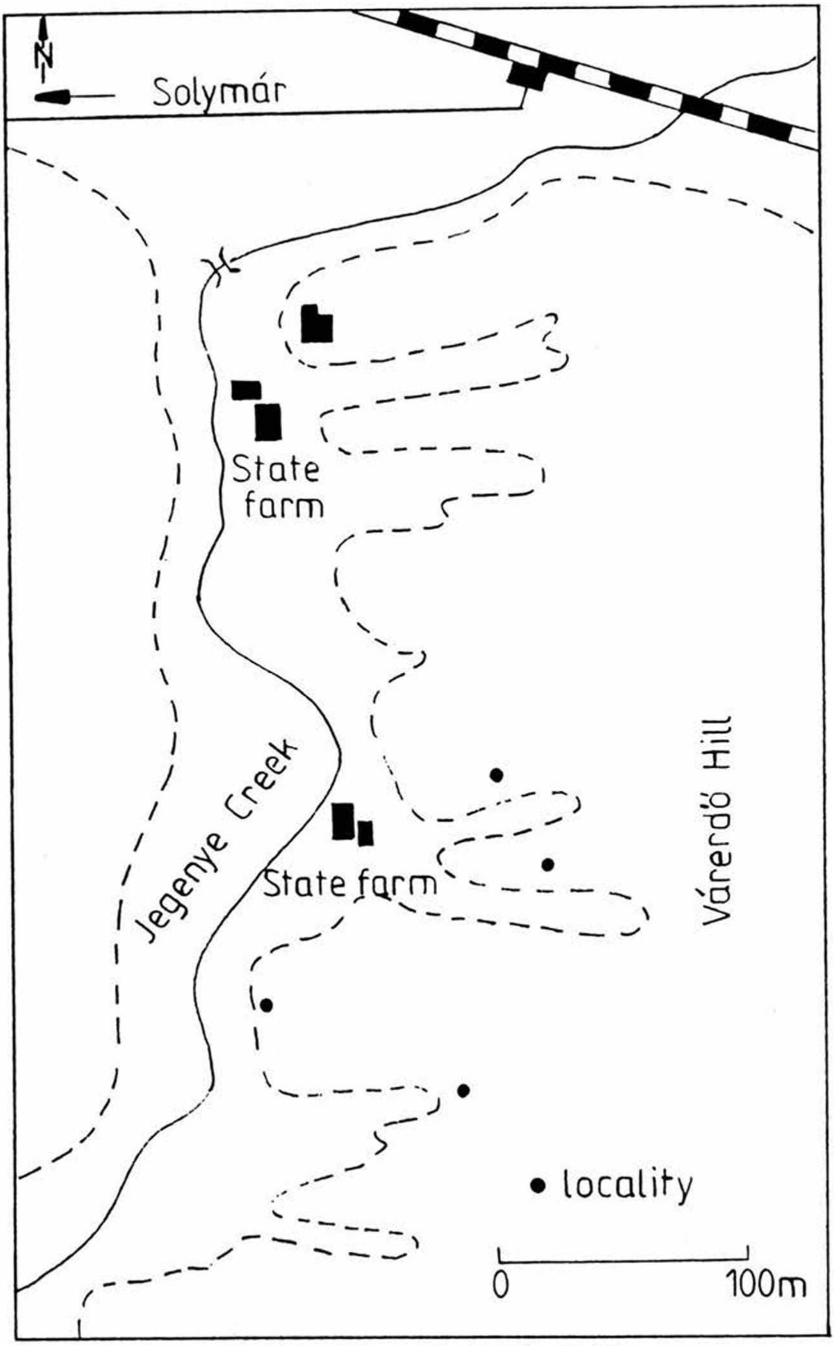

Fig. 2. Localities at Solymár, Várerdő Hill

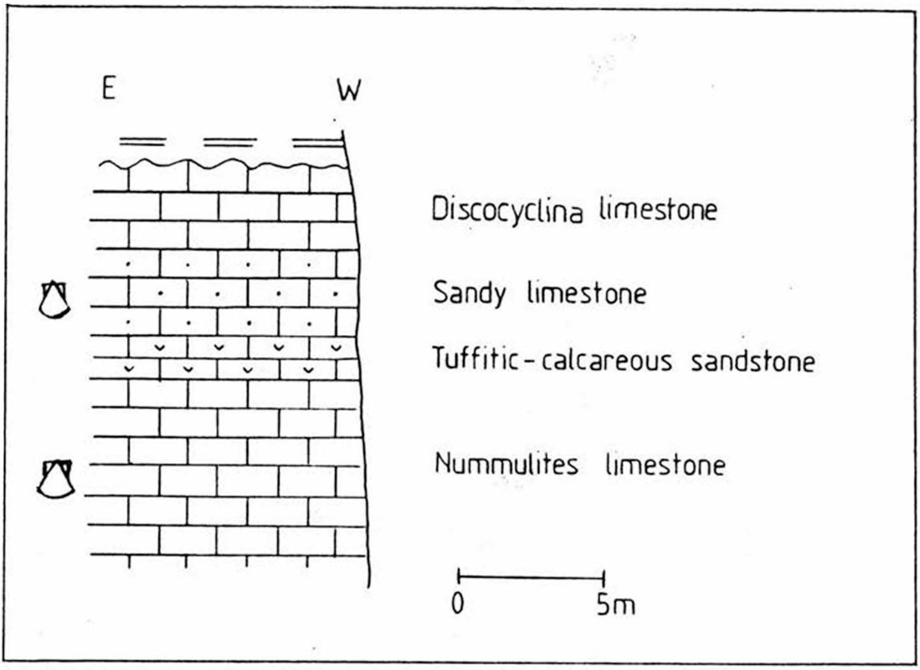

Fig. 3. Upper Eocene profile at Solymár, Várerdő Hill.

Páty, Mézes Valley, Főkút Spring

There is an outcrop of Upper Eocene *Nummulites-Discocyclina* limestone SE of Páty village, forming a 750 m long, 250 m wide quadrangle. (BOKOR, 1939). A relatively rich fauna can be collected even today from the surroundings of Főkút Spring, in marls and yellow, strongly weathered *Nummulites-Discocyclina* limestone, exposed by minor road cuts *(Fig. 4)*. The rock is rich in foraminifers, bryozoans, bivalves, gastropods, and echinoids. The echinoid fauna consists of 221 specimens of 10 species.

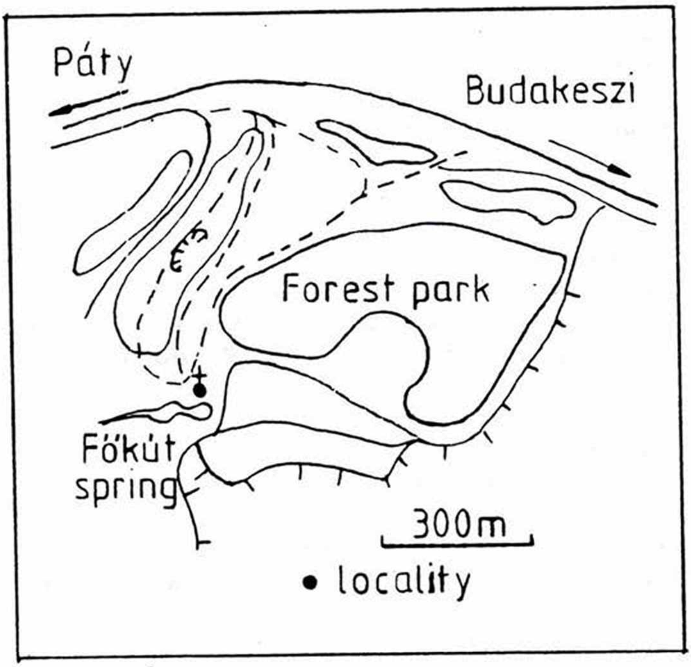

Fig. 4. Localities at Páty, Főkút Spring.

Budapest, Szépvölgy (Schöntal)

Most of the echinoid fauna of the Bryozoa marl in the Museum of the Hungarian Geological Institute was collected in the quarries and other exposures of Szépvölgy, but the exact localities are usually missing. These localities are discussed together in the present paper; as the matrix or filling material of the fossils show, all specimens are from the Bryozoa Marl, therefore this unification hopefully does not affect the interpretation.

Revisiting the possible localities, only three of them yielded larger amounts of fossils.

Mátyás Hill, western quarry

The abandoned quarry is located by the Szépvölgy Road, opposite the entrance of Pálvölgy Cave *(Fig. 5)*. At the western end of the quarry a tectonic contact of Upper Eocene conglomerates and corallinacean limestone is observed with Middle Triassic cherty dolomite. The following beds were recorded by KÁZMÉR (1982) in the quarry:

- *Discocyclina* limestone (0-10 m)
- *Discocyclina* calcareous marl (10-13 m)
- *Discocyclina* grey marl (13-15 m)
- Bryozoa marl (15-30 m)

The seuence is topped by Buda Marl.

Mátyás Hill, eastern quarry

The quarry is located about 200-250 northwest from the intersection of Mátyáshegyi Road and Kolostor Street, cut in the southern slope of Mátyás Hill. The following sequence is exposed (MONOSTORI, 1965):

- Corallinacean limestone (0-5 m)
- *Discocyclina* limestone (5-20 m)
- Bryozoa marl (20-35 m)

Locality at the "Erdei Lak" restaurant

The outcrop lies aboout 100-120 m from the house; it is rich in echinoids.

All three localities yielded fauna of the Bryozoa marl. It is light to dark grey, weathering to yellowish brown or light brown, silty marl. The rock is extremely rich in fossils. Foraminifers are dominated by Asterocyclinas and Discocyclinas. Bryozoans occur in rock-forming quantity. Certain levels yield rich echinoid and bivalve fauna. The most frequent echinoids are *Schizaster lorioli* PÁVAY and *Opissaster szechenyii* (PÁVAY). The 92 specimens belong to 8 species.

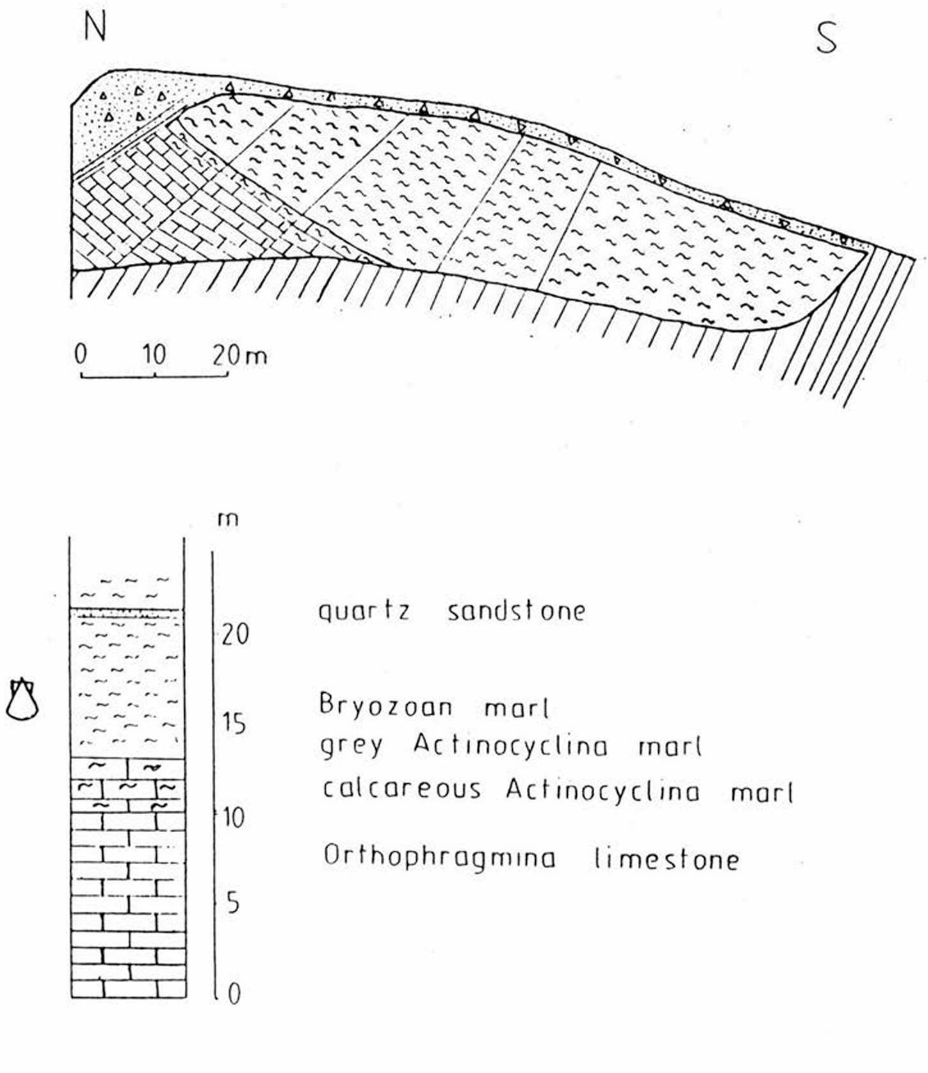

Fig. 5. Sequence at Mátyás Hill, western quarry (after KÁZMÉR, 1982)

Martinovics Hill (former Kis-Sváb Hill)

The moderately rich echinoid fauna was collected from the *Nummulites-Discocyclina* limestone and from the Bryozoa marl. Fourty-two echinoids of the former one belong to 11 species, while 7 specimens from the latter marl belong to 3 species. The abandoned quarries are not available for collecting now.

Castle Hill (Vár-hegy)

The fauna consisting of 110 specimens were collected from house foundations.

Systematic palaeontology

DURHAM and MELVILLE (1957), considering the system of MORTENSEN (1928-1951), developed a new echinoid systematics, accepted by the Treatise (DURHAM, 1966) with minor modifications. This paper follows the system of the Treatise, with a slight difference: the author accepts the opinion expressed by MORTENSEN (1984) that the *Echinanthus* genus should be included in the family Cassiduloidae based on the diagnostic features of the family.

Systematic position of the spines called *"Cidaris"* is uncertain. Several spines were called by this name in the Eocene echinoid lliterature. These occur together with plates extremely rarely, so it is not possible to join most of them to known genera. There are experiments to form corresponding morphological groups of spines and plates, but no well-supported studies are available as yet.

Representatives of the genus *"Cidaris"* live only in modern seas. Recognition of genera is based on the jaw apparatus, rarely preserved in fossil specimens. Therefore we use the name within inverted commas.

The Upper Eocene fauna of the Buda Hills contains 1820 specimens. Fourty-three species of 22 genera were recognized. The full list of the fauna is the following:

Subclassis Perischoechinoidea M'COY, 1849
Ordo Cidaroidea CLAUS, 1880
Familia Cidaridae GRAY, 1825
Subfamilia Cidarinae GRAY, 1825
Genus *Cidaris* LESKE, 1778

"Cidaris" hungarica PÁVAY, 1874
"Cidaris" oosteri LAUBE, 1868
"Cidaris" pseudoserrata COTTEAU, 1862
"Cidaris" subularis D'ARCHIAC, 1846

Subclassis Euechinoidea BRONN, 1860
Superordo Diadematacea DUNCAN, 1889
Ordo Pedinoida MORTENSEN, 1939
Familia Pedinidae POMEL, 1883
Genus *Leiopedina* COTTEAU, 1866

Leiopedina samusi (PÁVAY, 1871)

Superordo Echinacea CLAUS, 1876
Ordo Temnopleuroida MORTENSEN, 1942
Familia Glyphocyphidae DUNCAN, 1889
Genus *Echinopsis* L. AGASSIZ, 1840

Echinopsis meridanensis (COTTEAU, 1863)

Superordo Gnathostomata ZITTEL, 1879
Ordo Clypeasteroida A. AGASSIZ, 1872
Subordo Clypeasterina A. AGASSIZ, 1872
Familia Clypeasteridae L. AGASSIZ, 1835
Genus *Clypeaster* LAMARCK, 1801

Clypeaster cf. corvini (PÁVAY, 1874)

Subordo Laganina MORTENSEN, 1948
Familia Fibulariidae GRAY, 1885
Genus *Fibularia*, LAMARCK, 1816

Fibularia dacica (PÁVAY, 1874)

Familia Laganidae A. AGASSIZ, 1873
Genus *Peronella* GRAY, 1855

Peronella transilvanica (PÁVAY, 1871)

Genus *Sismondia* DESOR, 1858

Sismondia rosacea (LESKE, 1778)

Subordo Scutellina HAECKEL, 1896
Familia Scutellidae GRAY, 1825
Genus *Scutella* LAMARCK, 1816

Scutella tenera LAUBE, 1868

Superordo Atelostomata ZITTEL, 1879
Ordo Cassiduloida CLAUS, 1880
Familia Echinolampadidae GRAY, 1851
Genus *Echinolampas* GRAY, 1825

Echinolampas archiaci COTTEAU, 1883
Echinolampas benoisti COTTEAU, 1890
Echinolampas blaviensis COTTEAU, 1889
Echinolampas cf. *escheri* L. AGASSIZ, 1839
Echinolampas giganteus PÁVAY, 1871
Echinolampas globulus LAUBE, 1868
Echinolampas cf. *luciani* TARAMELLI, 1873-74
Echinolampas montevialensis SCHAUROTH, 1865
Echinolampas obesus BITTNER, 1880
Echinolampas subsimilis D'ARCHIAC, 1846

Familia Cassidulidae L. AGASSIZ et DESOR, 1874
Genus *Cassidulus* LAMARCK, 1801

Cassidulus testudinarius (BRONGNIART, 1882)

Genus *Echinanthus* LESKE, 1778

Echinanthus pellati COTTEAU, 1863
Echinanthus scutella (LAMARCK, 1801)
Echinanthus aff. *scutella* (LAMARCK, 1801)

Ordo Holasteroida DURHAM et MELVILLE, 1957
Familia Holasteridae PICTET, 1857
Genus *Titanaster* SZÖRÉNYI, 1929

Titanaster labiostoma SZÖRÉNYI, 1929

Ordo Spatangoida CLAUS, 1876
Subordo Hamiasterina A. G. FISCHER, 1966
Familia Hemiasteridae CLARCK, 1917
Genus *Hemiaster* L. AGASSIZ, 1847

Hamiaster ? arpadis (PÁVAY, 1874)

Genus *Opissaster* POMEL, 1883

Opissaster szechenyii (PÁVAY, 1874)

Familia Pericosmidae LAMBERT, 1905
Genus *Pericosmus* L. AGASSIZ, 1847

Pericosmus budensis PÁVAY, 1874

Familia Schizasteridae LAMBERT, 1905
Genus *Schizaster* L. AGASSIZ, 1836

Schizaster ambulacrum (DESHAYES, 1860)
Schizaster lorioli PÁVAY, 1874
Schizaster lucidus LAUBE, 1868
Schizaster vicinalis L. AGASSIZ, 1847

Genus *Parabrissus* BITTNER, 1880

Parabrissus pseudoprenaster BITTNER, 1880

Subordo Micrasterina A. G. FISCHER, 1966
Familia Brissidae GRAY, 1855
Genus *Brissopsis* L. AGASSIZ, 1847

Brissopsis haynaldi (PÁVAY, 1874)

Genus *Eupatagus* L. AGASSIZ, 1847

Eupatagus cranium (KLEIN, 1754)

Genus *Macropneustes* L.A GASSIZ, 1847
Subgenus *Deakia* PÁVAY, 1874

Deakia cordata PÁVAY, 1874
Deakia ovata PÁVAY, 1872
Deakia rotundata PÁVAY, 1874

Genus *Trachypatagus* POMEL, 1869

Trachypatagus hantkeni (PÁVAY, 1874)

Familia Spatangidae GRAY, 1825
Genus *Atelospatangus* KOCH, 1884

Atelospatangus gardinalei (OPPENHEIM, 1899)
Atelospatangus cf. *transilvanicus* KOCH, 1884

Genus *Semipetalion* SZÖRÉNYI, 1963

Semipetalion anomon SZÖRÉNYI, 1963

Palaeoecology

Several aothors share the opinion that echinoid faunas are especially suitable for palaeoecological interpretation, mostly due to their benthic mode of life. Besides the sea bottom type, several other factors affect the distribution of echinoids, like salinity, water temperature, depth and agitation. Their complex skeleton bears several adaptive characters indicative of ancient sedimentary environments.

Palaeoenvironmental reconstructions are carried out two ways: either we draw conclusions from the fossil on the condiditons of sedimentation, or sedimentary characters help us to understand ancient habitats (AGER, 1963). Applying the two methods together we should consider ecological conditions of modern relatives, sedimentary characters of the embedding rocks and data on the associated fauna.

Actualistic reconstruction of the Upper Eocene environment in Buda Hills is greatly facilitated by the fact, that 10 genera of 22 live in Recent seas (10 families of 13 also live today).

Up to now the most detailed study on echinoid palaeoecology is the monograph of MORTENSEN (1928-1951). His observations on Recent faunas enabled him to publish thorough discussions on the ecology of each species, and to make conclusions on their relatives on the generic and family level. General data on the ecological factors of more than 800 Recent species were published by MOORE (1966) and SMITH (1984). MOORE (1966) considered water temperature, salinity, photic conditions, hydrostatical pressure, agitation, and food availability as the most important factors in echinoid distribution, while SMITH (1984) counts on sea bottom quality, hydrodynamic system, predators, salinity, temperature, availabled food, depth, behaviour and chance.

MORTENSEN (1928-1951) provided data on the sea bottom, temperature, depth and sometimes agitation for each family and genus. DURHAM et al. (1966) completed MORTENSEN's data by some ecological factors.

Actualistic comparisons should take in mind that ecological needs may change with time.

Examining number of individuals and species in the *Nummulites* limestone at Solymár, the *Nummulites-Discocyclina* limestone at Martinovics-hegy, the marly *Nummulties-Discocyclina* limestone at Páty, in the Bryozoa and Buda Marls, definite distinctions can be made. The *Nummulites* limestone and sandy limestone are dominated by Cassiduloida and Clypeasteroida orders, the *Nummulites-Discocyclina* limestone of Martinovics-hegy is characterized by Cassiduloida and Spatangoida, the marly *Nummulites-Discocyclina* limestone at Páty is dominated by Clypeasteroida and Spatangoida, while the Bryozoa and Buda Marls yielded representatives of the order Spatangoida *(Fig. 6)*

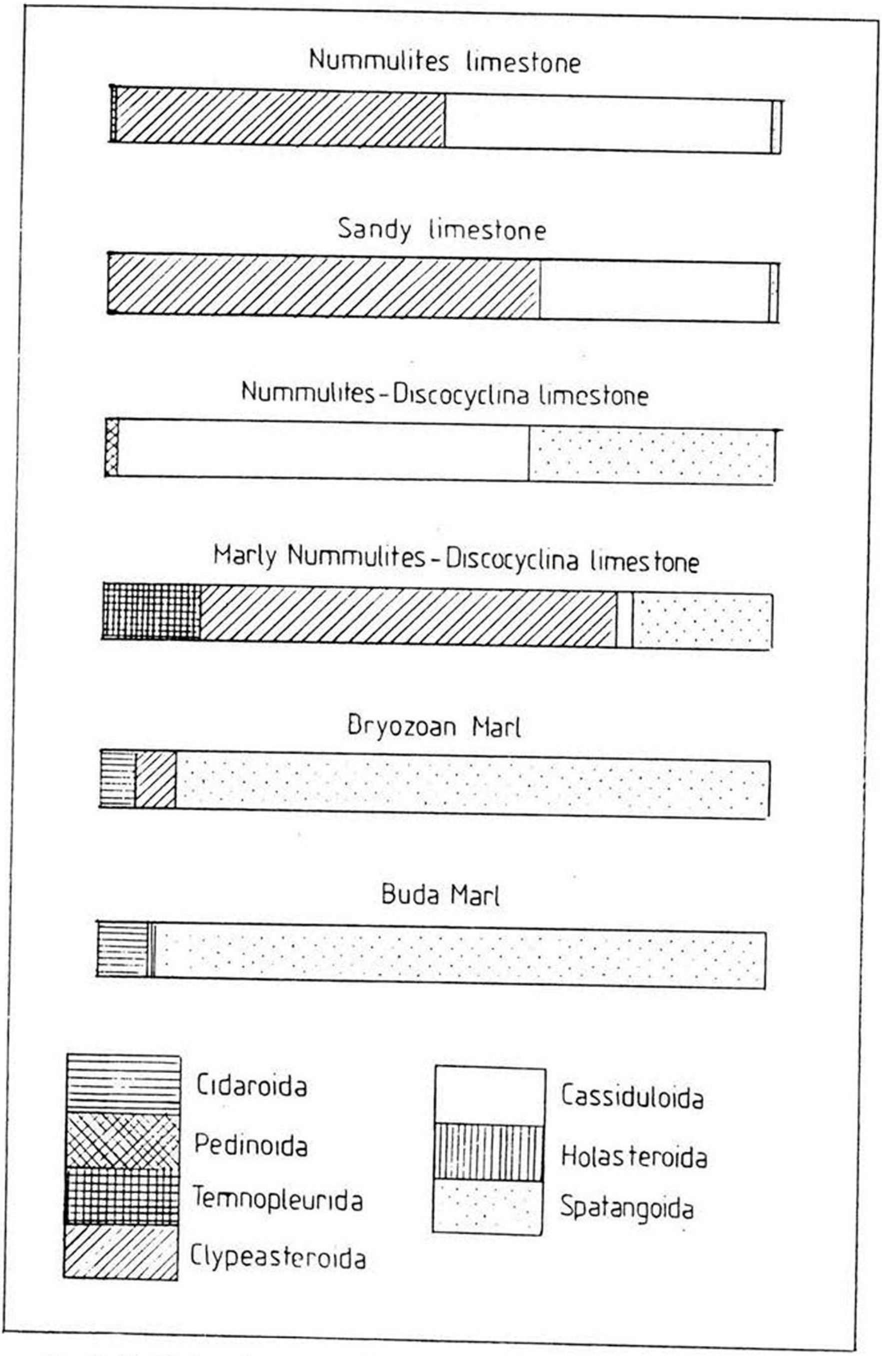

Fig. 6. Distribution of representatives of seven echinoid orders in six rock types.

Table 1. Distribution of genera in rock types

	A	B	C	D	E	F
"Cidaris" hungarica						+
"Cidaris" oosteri	+					
"Cidaris" pseudoserrata					+	
"Cidaris" subularis	+					+
Leiopedina samusi			+			
Echinopsis meridanensis				+		
Clypeaster cf. *corvini*					+	
Fibularia dacica					+	
Peronella transilvanica				+		
Sismondia rosacea	+	+		+		
Scutella tenera		+				
Echinolampas archiaci	+		+			
Echinolampas bernoisti	+			+		
Echinolampas plaviensis	+	+	+			
Echinolampas cf. *escheri*			+			
Echinolampas giganteus	+					
Echinolampas globulus	+		+			
Echinolampas cf. *luciani*				+		
Echinolampas montevialensis	+		+	+		
Echinolampas obesus	+					
Echinolampas subsimilis	+		+			
Echinolampas sp.			+	+		
Cassidulus testudinarius	+					
Echinanthus pellati	+					
Echinanthus scutella	+	+	+	+		
Echinanthus aff. *scutella*	+	+				
Titanaster labiostoma						+
Hemiaster ? arpadis						+
Opissaster szechenyii				+	+	
Pericosmus budensis						+
Schizaster ambulacrum			+	+		
Schizaster lorioli				+	+	
Schizaster locidus			+			
Schizaster vicinalis				+		
Parabrissus pseudoprenaster	+					
Brissopsis haynaldi					+	
Brissopsis sp.				+		
Eupatagus cranium	+					
Deakia cordata						+

Deakia ovata		+	+
Deakia rotundata			+
Trachypatagus hantkeni		+	+
Atelospatangus gardinalei	+		
Atelospatangus cf. *transilvanicus*	+		
Semipetalion anomon	+		

A *Nummulites* limestone
B Sandy marl
C *Nummulites-Discocyclina* limestone
D Marly *Nummulites-Discoyclina* limestone
E Bryozoan marl
F Buda Marl

The six Echinoidea biofacies types, based on differences in number of specimens and species are the followings:

1. *Nummulites* limestone (Solymár)
2. Sandy limestone (Solymár)
3. *Nummulites-Discocyclina* limestone (Martinovics Hill)
4. Marly *Nummulites-Discocyclina* limestone (Páty)
5. Bryozoa marl (Szépvölgy and Martinovics Hill)
6. Buda Marl (Vár-hegy)

The *Nummulites* limestone at Solymár was deposited in shallow, agitated water. The echinoids there had a semi-burrowing way of life. The organic-rich sediment provided a favourable habitat for mud-feeder echinoids. Differences in the sea bottom are shown by biometrical variations of *Echinanthus scutella (Fig. 7);* since echinoids are very sensitive to the conditions of their immediate habitat, the size differences should have been caused by minute differences in their microenvironment. Varying height was observed on specimens with uniform length and width. Observations of SMITH (1984) on Recent echinoids indicate, that higher forms burrow somewhat deeper in more coarse sediments, while the lower ones burrow less deep is finer sediments *(Fig. 8)*.

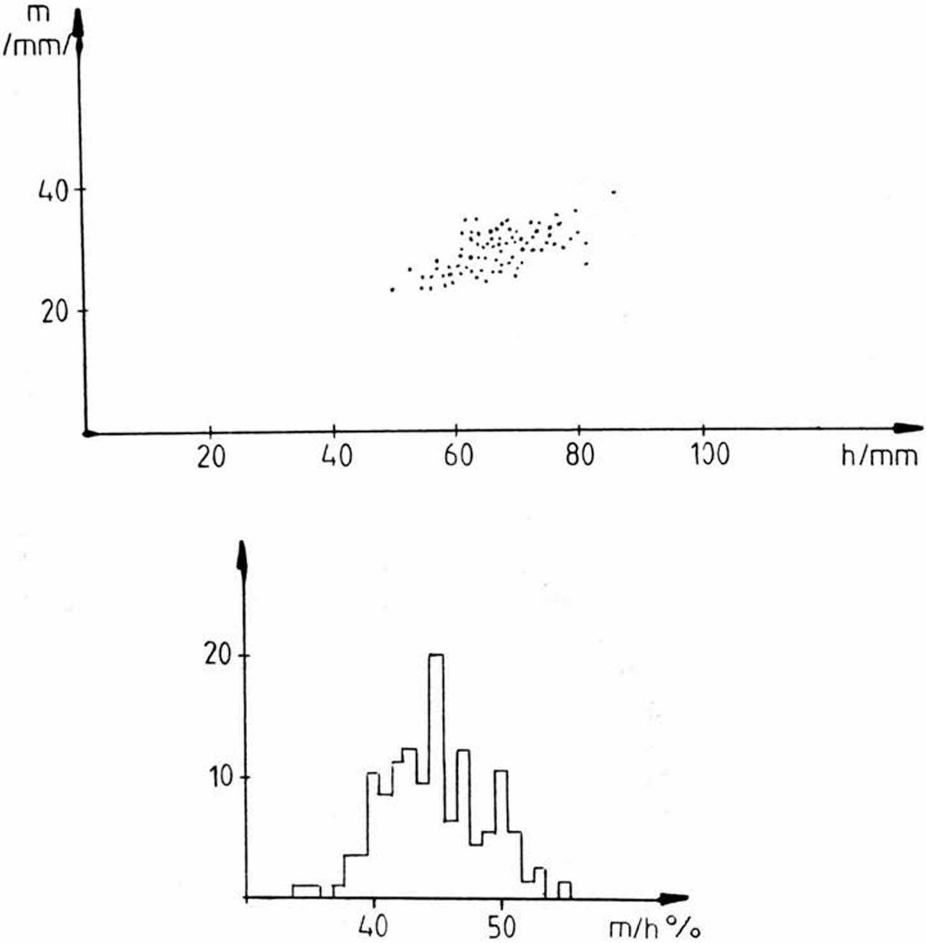

Fig. 7. Length/height plot of *Echinanthus scutella* (upper figure) and distribution by the H/L ratio (lower figure).

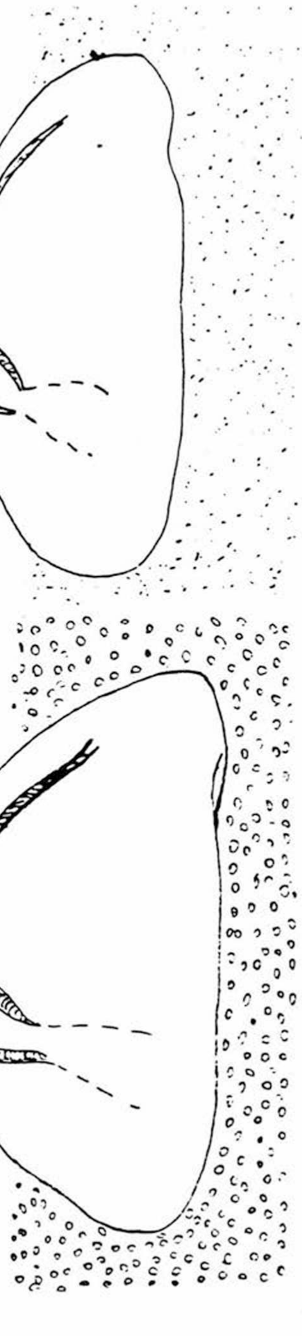

Fig. 8. Life position of *Echinanthus scutella* in fine and coarse-grained sediments.

Echinoid fauna of the sandy limestone at Solymár is poorer than that of the *Nummulites* limestone. Increased clay content produced disappearance of certain genera and appearance of new genera. Only two specimens of *Echinolampas* were found: this genus is sensitive to clay content. Representatives of the family Scutellinae, which prefer a few metres deep, agitated water over sandy-clayey bottom, occur in the sandy limestone.

Simultaneous appearance of genera preferring sandy, or fine sandy-muddy bottom is characteristic for the *Nummulites-Discocyclina* limestone. The genus *Echinolamps* was a semi-burrower is sandy, while Schizasters fully burrowed in muddy to fine sandy bottom. Water agitation was minimal in the otherwise shallow sea. Variable bottom types occurred together as indicated by the different needs of the occurring genera.

Fauna of the marly *Nummulties-Discocyclina* limestone shows transitional characters between those of the *Nummulites-Discocyclina* limestone and the Bryozoa marl. The genera *Peronella, Echinolampas, Schizaster, Brissopsis,* and *Eupatagus* need some tens of metres deep water and sandy-muddy bottom in modern environments.

Fauna of the Bryozoa marl displays completely different characters. It may be due to deeper water environment, and a change in the sediment. Representatives of genera preferring shallow marine environment and sandy bottom disappear, and forms preferring clayey to fine sandy bottom appear. All genera belong to the order Spatangoida (except the spines). Fasciola-bearing genera are especially adapted to burrowing mode of life. Modern relatives of these genera prefer muddy to fine sandy bottom, water depth ranging from tens of metres to 100-150 metres, and quiet, wave-free environment. Echinoids of the Bryozoa marl may have lived under similar conditions.

Echinoid fauna of the Buda Marl are exclusively represented by genera of the order Spatangoida. The deep, open marine environment and muddy bottom provided suitable conditions for burrowing, sediment-feeder forms. Water agitation was minimal. Modern relatives of the Buda Marl echinoids live in the depth range from 100 to several hundreds of metres.

These six rock types are correlated to six environments, displaying decrease of water agitation and increase of water depth upwards in the stratigraphic column, with bottom changing from sandy to muddy.

Palaeoenvironmental conclusions based on the echinoid fauna corroborate the observations of MONOSTORI (1965, 1967), and can be correlated to the carbonate microfacies types of KÁZMÉR (1982).

Palaeopathology

Pathological echinoids were first mentioned by SZÖRÉNYI (1931, 1973) from the Hungarian Eocene. She recognized traces of ontogenetical disturbances of the right-side anterior petal of an *Echinanthus* from Solymár and on petals of echinoids from the Bakony Mts. Twelve pathological specimens with the same features as described by SZÖRÉNYI have been observed by the author in the Solymár material. In addition, traces if injures made by several organisms were recognized on several specimens of the species *Echinanthus scutella*.

Three groups of injuries are recognized according to shape, size and frequency of occurrence:

1. Boring traces frequently occur in pore zones, in zones between the pore zones and along the petals. Rare borings occur in interpetal zones, mostly in the regions bordered by the distal terminations of petals. Diameter of borings range from 0,8 to 1,6 mm, with a circular outline. They cross the corona, except in one or two cases. The plate was slightly thickened around a boring with cylindrical outline *(Fig. 9)*.

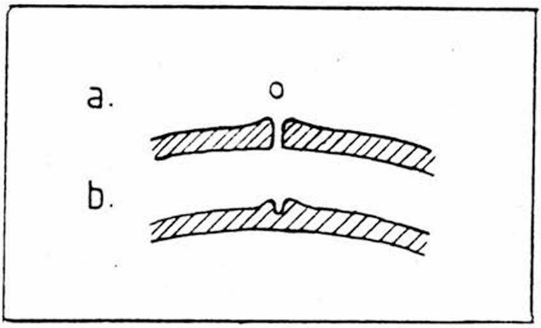

Fig. 9. Cross-section of injuries of Group 1 /1x/:
a: hole crossing the corona
b: hole not crossing the corona

2. A single specimen forms this group. The boring is cyclindrical with 2,4 mm diameter. The plate conspicuously thickened around the boring. *(Fig. 10)*.

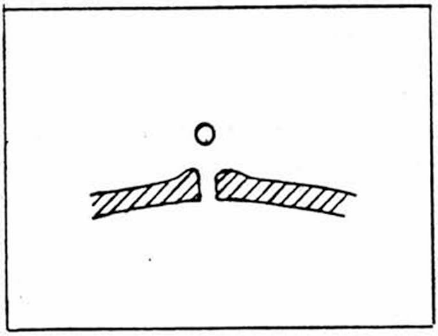

Fig. 10. Cross-section of injuries of Group 2 /1x/.

3. Oval injuries with 3-5,5 mm length and 1-3 mm width. A single specimen suffered this kind of injuries *(Fig. 11/a)*.

There are six injuries. One of them does not cross the corona, but there is a circular hole at the end of the oval depression. The injuries crossing the corona slightly taper inwards. There is no thickening around the holes *(Fig. 11/b)*.

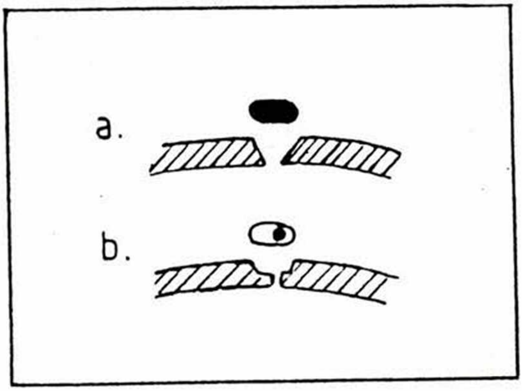

Fig. 11. Injuries of Group 3: /1x/:
a: hole crossing the corona
b: hole partly crossing the corona.

Sizes and morphologies of the injuries suggest the following conclusions:

– The first group of injuries were described by KIER (1981) on Cretaceous echinoids. He suggested, that the size, number and shape of the holes indicate borings by parasite gastropods. Predator gastropods can be excluded, since they produce only a single boring: its shape is crater-like (Naticids) or cylindrical (Muricids), due to mechanical and chemical borint (BISHOP, 1975). Contrary to this the parasite gastropods dissolve the carbonate corona by applying enzymes and acids. The produced trace is similarly cylindrical, but a bulging margin is produced due to prolonged coexistence (SMITH, 1984).

– The second group is formed by a parasite animal, which lived on the echinoid for a long time.

– The oval injuries of the third group show no thickening of the margins of the borings; we suggest that these were formed after the death of the echninoid. It is corroborated by the relatively large size and great number of the borings. The borers may have used the corona as a solid bottom and probably for scavenging.

Biostratigraphy

Tertiary echinoids are mostly suitable for palaeoecological studies. The long range of species hinders biostratigraphical evaluation. Some of the species in the Buda Hills occurs in Middle Eocene and Lower Oligocene formations, but most of them are characteristic Upper Eocene forms *(Table 2)*.

Range of echinoid species (Table 2.)

	E_2	E_3	Ol_1
"Cidaris" hungarica		+	
"Cidaris" oosteri	+	+	+
"Cidaris" pseudoserrata	+	+	+
"Cidaris" subularis	+	+	+
Leiopedina samusi	+	+	
Echinopsis meridanensis	+		
Clypeaster cf. *corvini*		+	
Fibularia dacica		+	
Peronella transilvanica		+	
Sismondia rosacea		+	
Scutella tenera		+	+
Echinolampas archiaci	+		

	E_2	E_3	Ol_1
Echinolampas benoisti	+	+	
Echinolampas blaviensis	+	+	
Echinolampas cf. *escheri*	+	+	
Echinolampas giganteus	+		
Echinolampas globulus	+	+	
Echinolampas cf. *luciani*		+	
Echinolampas montevialensis		+	
Echinolampas obesus		+	
Echinolampas subsimilis		+	+
Cassidulus testudinarius	+		
Echinanthus pellati	+	+	
Echinanthus scutella	+	+	
Echinanthus aff. *scutella*		+	
Titanaster labiostoma		+	
Hemiaster ? arpadis		+	
Opissaster szechenyii		+	
Pericosmus budensis		+	
Schizaster ambulacrum		+	+
Schizaster lorioli		+	
Schizaster lucidus	+	+	
Schizaster vicinalis	+	+	+
Parabrissus pseudoprenaster		+	
Brissopsis haynaldi		+	+
Eupatagus cranium	+		
Deakia cordata		+	
Deakia ovata		+	
Deakia rotundata		+	
Trachypatagus hantkeni		+	
Atelospatangus gardinalei		+	
Atelospatangus cf. *transilvanicus*		+	
Semipetalion anomon		+	

Palaeobiogeography

Palaeobiogeographical interpretation is mostly hindered by the variable degree of study of the neighbouring faunas. There are no modern, synthesizing monographs from the last decades; our comparisons are based on the revisions published in the first decades of the twentieth century.

Data on geographical-geological units were compared to the unified faunal list of Buda Hills, considering the differences in palaeoecology. Due to different aspects of studies, scattering of species number, different level of knowledge, and palaeoecological differences we do not apply the method of calculating coefficients to compare faunas. Number of species described from classical Upper Eocene localities and common species with the Buda Hills are shown in *Table 3*.

Number of species described from and common with forms in the Buda Hills (Table 3.)

Locality (author, year)	Species	Common species
Buda Mts.	43	–
Catalonia (LAMBERT, 1927)	35	4
Biarritz (COTTEAU, 1884-1894)	71	12
Provence (LAMBERT, 1918)	57	5
Southern Alps (OPPENHEIM, 1902)	52	19
Transylvanian Basin (KOCH, 1884)	33	9

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