Slovak Geol. Mag., 8, 3– 4(2002), 259 – 281

New knowledge about stratigraphy of the eastern part of the Danube basin (Želiezovce Depression)

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Abstract: In the eastern part of the Danube basin the Middle-Miocene filling of the Želiezovce Depression, Oligocene deposits and pre-Tertiary basement composed of metamorphic carbonates were drilled through by a geothermal borehole HGŽ-3 near village Želiezovce. The basement of the Neogene filling is composed of Lower Badenian deposits (conglomerates, coarse grained sandstones, sandy claystones), which are represented by the Bajtava Formation. They are overlain by deposits (epiclastic sandstones with intercalations of tuffites, sandy tuffitic clays, claystones with silty admixture, siltstones) of the Pozba Formation of Middle to Later Badenian age. Above them there were recognized beds of sandy deposits of the Vráble Formation of Sarmatian age. The above mentioned lithostratigraphic units were defined on the basis of rock lithology and biostratigraphic classification of the deposits according to present molluscs, foraminifers, ostracods and calcareous nannoplankton. The study of sporomorph revealed that during the Middle to Later Badenian there was warm and humid climate characteristic by the presence of hydrophilous vegetation. The presence of swampy vegetation is characteristic for the period of the Early Sarmatian.

Key words: Danube basinm,,Želiezovce Depression, pre-Tertiary basement, Oligocene sediments, Neogene sediments, grain size analysis, fauna, flora, biostratigraphy

Introduction

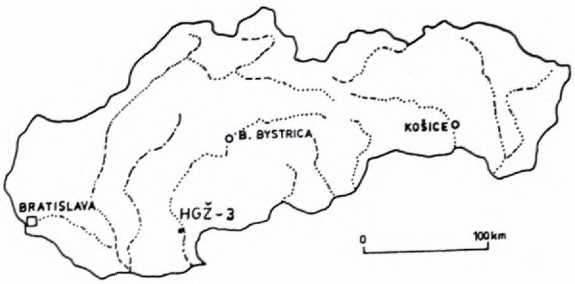
At the end of 80s of the 20th century in Želiezovce town the geothermal borehole HGŽ-3 (Bondarenková et al., 1990) was drilled. It was located at the eastern edge of the town, in the vicinity of the Hron river (Fig. 1). It was a regulas core borehole and ran through the Middle Miocene and Oligocene deposits and reached the pre-Tertiary basement.

With respect to the regional geological division the borehole HGŽ-3 is located the Trnava – Dubník Depression, which is a partial depression of the Danube Basin. Within this partial depression the borehole is located in the Želiezovce Depression (Vass et al., 1988).

Grain size analyses were carried out on the sedimentary material from the borehole. Molluscs, foraminifers, ostracods, otoliths, palynomorphs and calcareous nanoplankton were studied from the found fossil remnants. Based on the study of the mentioned fossil groups the sediments from the borehole HGŽ-3 were stratigraphically classified.

In the area of the Želiezovce Depression there are three Badenian faciestratotypes and one Sarmatian faciestratotype.

Borehole ŠO-1 is a faciestratotype of the Lower Badenian, it was drilled near the village Chľaba (Lehotayová & Ondrejičková, 1972; Ondrejičková, 1978), borehole K-5 is a faciestratotype of the Lower and Middle Badenian located near the village Salka (Brestenská, 1978a; Gabčo, 1965; Lehotayová, 1966; Planderová, 1966,



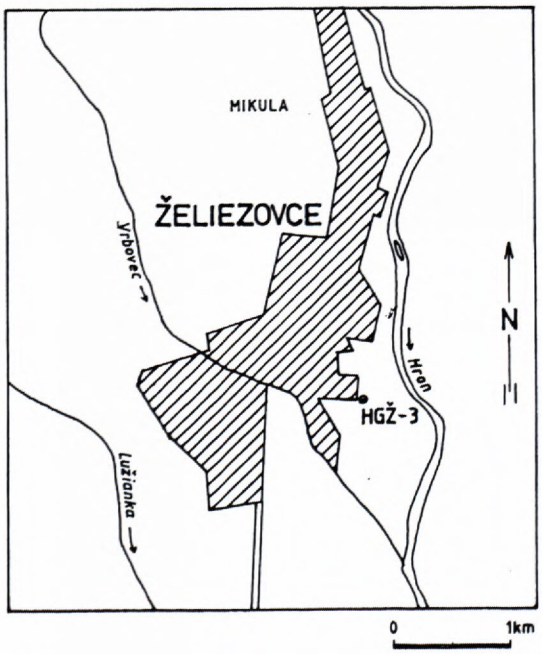
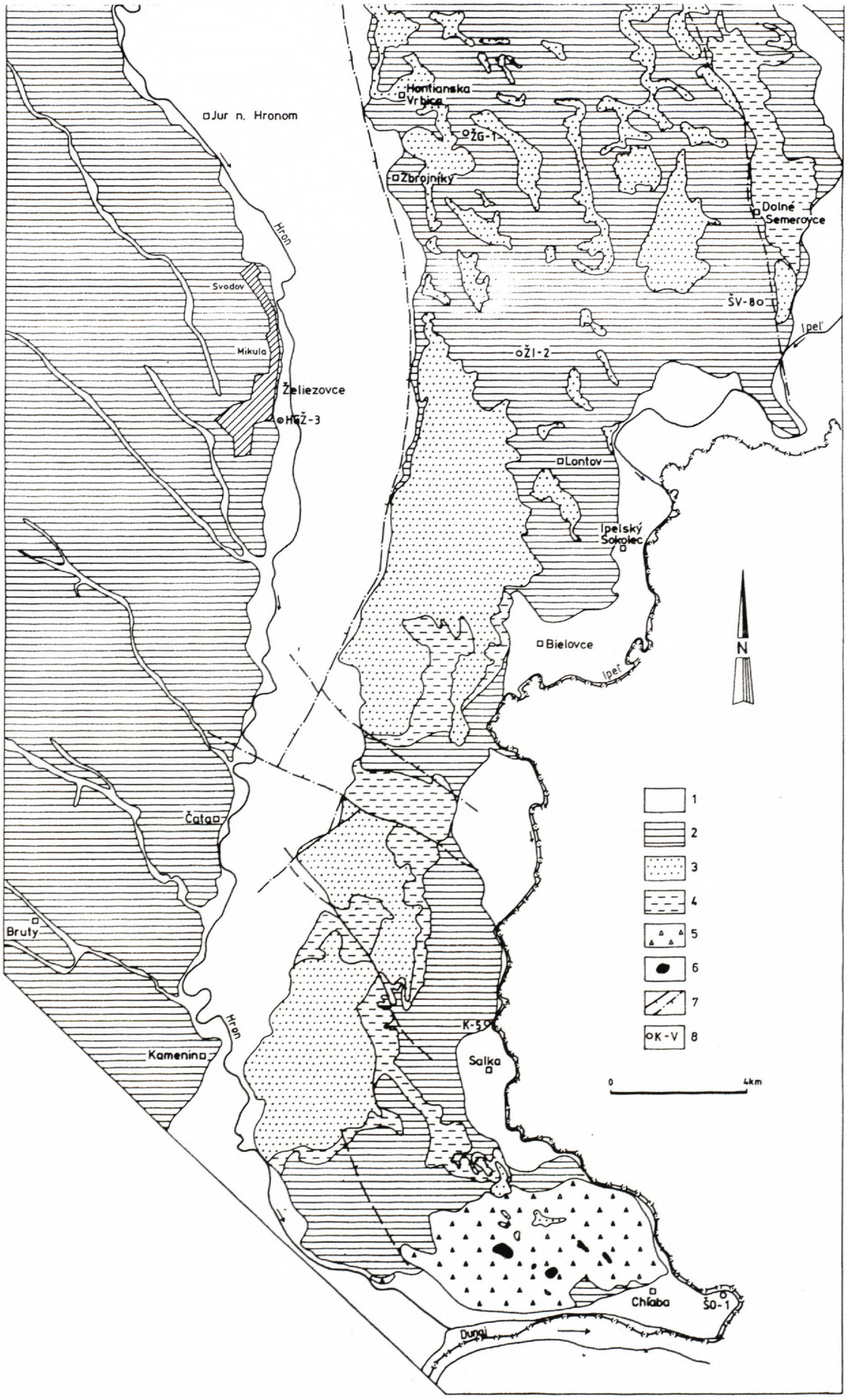


Fig. 1 Localization of the borehole HGŽ-3▶


Jur n. Hronom
Hontianska Vrbica
ŽG-1
Zbrojníky
Dolné Semerovce
Hron
Svodov
ŠV-80
Ipeľ
Mikula
ŽI-2
Železovce
HŽ-3
Lontov
Ipeľský Sokolec
Bielovce
N
Čata
Bruty
Hron
Kamenina
K-5
Salka
0
4km
Chlaba
ŠO-1
Dunaj
1
2
3
4
5
6
7
8
K-V

1966; Vass, 1964; 1966; Vass & Gabčo, 1966), borehole ŽI-2 is a faciestratotype of the Middle and Upper Badenian, which was located near the village Lontov (Brestenská , 1978b; Ivan, 1960; Mišík, 1958; Planderová, 1965a; Tejkal, 1968).

Borehole ŽG-1 is a faciestratotype of Sarmatian deposits. It is located near the village Hontianska Vrbica (Brestenská, 1974; Gabčo, 1969; Planderová, 1965b; Sitár, 1965; 1967; Švagrovský, 1965) (Fig. 2).

Beside the mentioned faciestratotypes also deep structural borehole ŠV-8 was sunly in vicinity of the borehole HGŽ-3 southward of the village Dolné Semerovce. The borehole was drilled through Neogene strata and it achieved the pre-Tertiary basement (Vass et al., 1981) (Fig. 2, 3).

By interpretation of the deposits from the borehole HGŽ-3 new information about rock composition and stratigraphy of the eastern part of the Danube basin (Želiezovce Depression) were obtained.

Review of geology of the Želiezovce depression

In the vicinity of borehole HGŽ-3 located in the Želiezovce Depression there are Sarmatian deposits outcropping, which are classified into so-called delta sedimentation (Nagy et al., 1998). In broader vicinity of the borehole south- and eastward there are also deposits of Badenian age (Fig. 2).

The oldest Neogene deposits of the Želiezovce Depression are of Lower Badenian age. They are represented by Turovce Member, what are pre-transgression deposits formed probably in near-shore delta environment (Marková in Vass et al., 1981). The mentioned deposits pass into marine deposits of the Bajtava Formation. In the lower part of the formation there are conglomerates, epiclastic volcanic sandstones and epiclastic volcanic claystones with layers of algal limestones representing peripheral deposits of the Börzöny stratovolcano. Toward the overlying beds these deposits pass into basin facies composed of gray slacking calcareous siltstones and claystones with shaly disintegration. The mentioned lutaceous deposits were deposited on circalittoral open shelf plain (Seneš & Ondrejičková, 1991). They are overlain by the Pozba Formation, which includes deposits of Middle to Upper Badenian age in sense of Kováč and Hók (in Hók et al. 1999). They are represented by epiclastic volcanic sandstones, gray calcareous clays with layers of fine- and medium grained sands, sandstones and in the marginal part organogenic sandy limestones (Nagy et al., 1998; Vaškovský et al., 1982).

The Sarmatian deposits from the vicinity of the village Želiezovce are characterized by the presence of coarse-detrital volcanic sedimentary rock of Baďany Formation and so-called delta sedimentation (Nagy et al., 1998), which southward are fining and pass into sandstones and calcareous lutaceous rocks of the Vráble Formation.

Eastward of the village Želiezovce the deposits overlying the Sarmatian (sands, clays, occasionally lignites) of Pannonian to Pontian age are found (Jiříček, 1982). They are represented by Ivanka and Beladice Formations (in sense of Fordinál et al., 2001).

Evaluation of the borehole HGŽ-3

The borehole HGŽ-3 penetrated through the complete Neogene sedimentary filling of the eastern part of the Želiezovce Depression resting on Paleogene (Oligocene) deposits. The borehole was finished in carbonate rocks of the pre-Tertiary basement.

Pre-Tertiary basement

The pre-Tertiary basement was reached in the depth interval 895,0-916.0 m. It consists of dark-gray slightly metamorphosed carbonate rocks with indistinct tectonic deformations which are manifested in the form of partly overslid and directed foliation planes. According to semi-quantitative analysis the groundmass is composed of Ca-Mg carbonate (Ca oxide 98.89 %, Mg oxide 30.69 %) with insignificant content of Fe (Fe oxide 0.41%). The cement is almost exclusively formed by Ca (Ca oxide 93.53 %) with little content of Fe (Fe oxide 1.47 %). Indistinct zonality that can be seen in the measured sample is probably the result of changes in pigmentatnion. A significant content of grains of pyrite reaching size from tenths of μm to 5 μm is present in the whole sample. The white veins are formed by crystalline $CaCO_3$.

The rocks, according to division of pre-Tertiary basement of the Danube Basin belong to the cover of the Southern Veporicum, in the sense of Vozár (in Matura et al., 2000).

Sedimentary filling

Paleogene (Oligocene)

Above metamorphic Mesozoic limestones in depth interval of 854.2 – 895.0 m there are firm gray organodetrical limestones to calcareous sandstones with clayey admixture and sporadical well rounded quartz pebbles. They are rich in fossil remnants. A sample from a depth 854.8-856.0 m (Fig. 4a, b) is composed of foraminifer-bryozoan microfacies. The basic (originally most likely micrite) is more or less re-crystallized. There is abundant re-crystallized detritus in it. The organic remnants are represented by common larger foraminifers, rare planktonic and thick-walled benthonic foraminifers, bryozoans or their fragments (some of them belong to rudite fraction by size), fragments of echinoderms, thick-walled bivalves, and coralinne algae. Mineral admixture is represented by quartz (occasionally with undulose extinction), pyrite, micas, and unidentified heavy mineral. There were

Fig. 2 Schematic map of eastern part of Želiezovce Depression with localization of faciestratotype facies boreholes and borehole ŠV-8. ***Quaternary:*** *1 – fluvial deposits 2 – eolian deposits,* ***Neogene:*** *3 – Sarmatian deposits (Vráble and Ladze Formations, Baďany Formation – "delta sedimentation") 4 Badenian deposits (Bajtava and Pozba Formations, Sebechleby Formation) 5 - volcanoclastics (Lower Badenian), 6 – pyroxene – amphibolic andesites, 7 – faults proved, assumed, 8 – borehole.*

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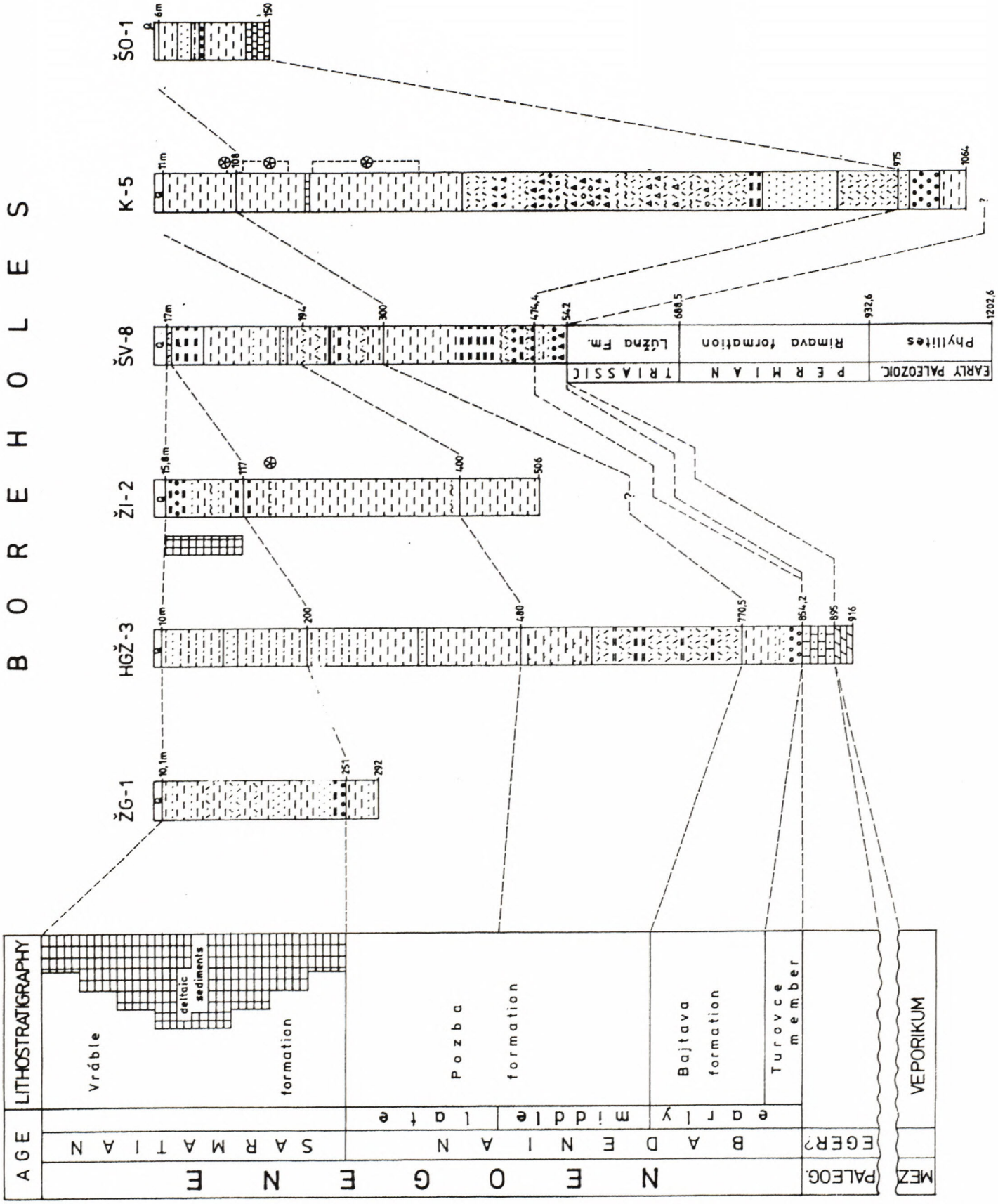
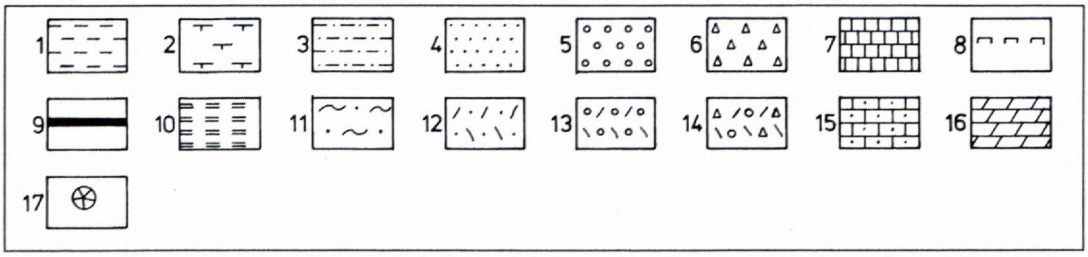


Fig. 3 Lithostratigraphy of borehole HGŽ-3 and its correlation with facie stratotype boreholes and deep structure bolrehole ŠV-8.



***Neogene**: 1 – clays, claystones, siltstones, 2 – claystones with silty admixtures, 3 – sandy clays, 4 – sands, sandstones, 5 – gravels, conglomerates, 6 – breccias, 7 – limestones, 8 – diatomite, 9 – lignite, 10 – epiclastic volcanic claystones, 11 – redeposited pyroclastics, 12 – epiclastic volcanic sandstones, 13 – epiclastic gravels with volcanic and non-volcanic material, 14 – epiclastic volcanic conglomerates, **Paleogene:** 15 – organodetrical limestones, **Mesozoic:** 16 – metamorphosed carbonates, 17 – occurrences of diatomaceous tests*

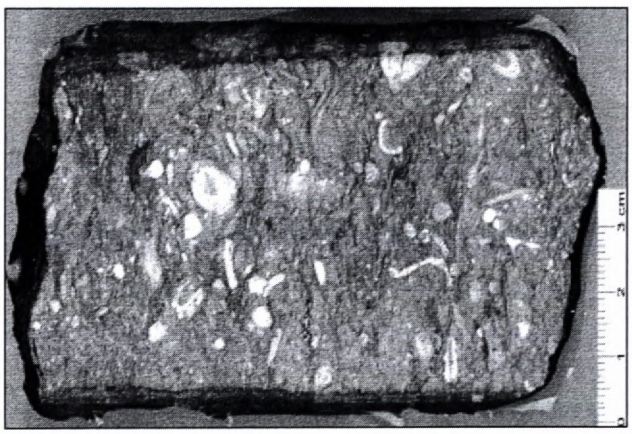
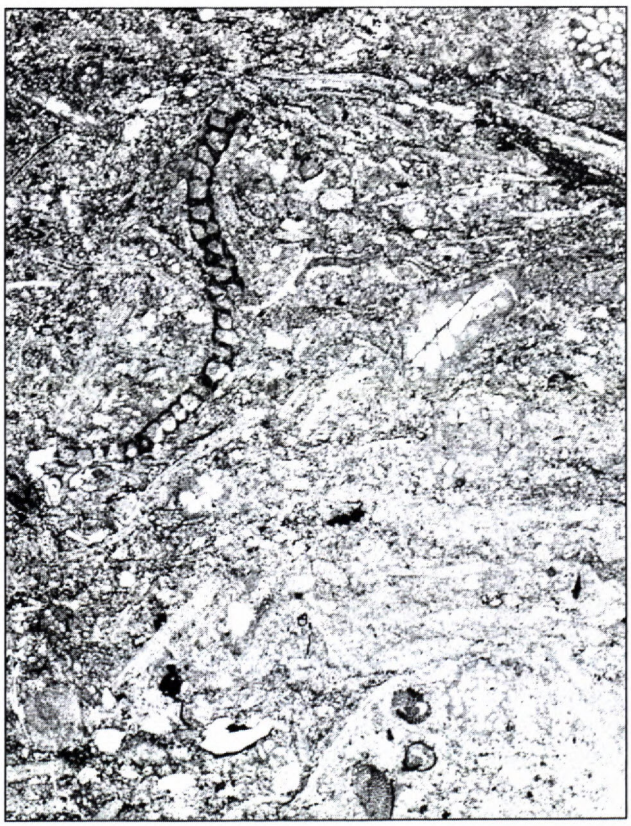


Fig. 4 Organodetrical Paleogene (Egerian?) limestone; a – borehole core from depth 854.8 – 855.0 m;



b – microphoto from the above mentioned core (dimensions of the thin section are 19.0 x 25.2 mm)

identified planktonic foraminifers of the genus *Globigerina* sp. and benthonic foraminifers *Planoperculina complanata* (DEFRANCE) and *Heterostegina* sp., which point to Oligocene, most likely Egerian age (determined by RNDr. E. Köhler, DrSc.). The occurrence of similar rocks is not known in the nearby vicinity and according to available information they do not také part are not in the complex of Štúrovo type Paleogene. Rocks of equal character and age were described as the Budikovany Member in the depressions of Lučenská kotlina and Rimavská kotlina (Vass, Elečko et al., 1989; 1992).

Neogene

The oldest Neogene deposits are located in depth interval 770.5 – 854.2 m. They are represented by the Bajtava Formation of Lower Badenian age. At the base of the formation there are conglomerates and coarse-grained sandstones, which are copying to carbonate rocks of the pre-Tertiary basement in their matter composition and they gradually pass into sandy claystones (Bondarenková et al., 1990).

Beds overlying the Bajtava Formation located in the depth interval 572.5 – 770.5 m are of Middle Badenian age. They consist of epiclastic sandstones, occasionally with intermediate layers of tuffites and sandy tuffaceous clays, and in the interval 480.0 – 572.5 of claystones with variable content of silty admixture.

The deposits of Middle-Badenian age pass without noticeable break to deposits of the Upper Badenian, which are located in depth interval 200.0 – 480.0 m. They consist of sandy clays and silts. The deposits of the Middle and Upper Badenian are part of the Pozba Formation in sense of Kováč and Hók (in Hók et al., 1999).

The deposits of the Pozba Formation are covered by deposits of the Sarmatian Vráble Formation occurring in depth interval 10.0 – 200.0 m. The base part (148.0 – 200.0 m) consists of sandy clays and silts with occasional intermediate layers of sands. In the middle part (90.0 – 148.0 m) sandstones are prevailing and the terminal part of the Vráble Formation (10.0 – 90.0 m) is formed by alternating clays, sandy clays and sandstones (Bondarenková et al., 1990).

The deposits were sampled for grain size analyses. The samples were taken from depth interval 50.2 – 552.3 m.

The samples from deeper intervals of the borehole HGŽ-3 are represented by coarse-grained silts. Upward the fractions become coarser-grained and passe to fine-

Tab. 1 Values of grain size parameters of sediments from the borehole HGŽ-3 according to Folka and Ward (1957)

Depth (m)	Md (fí) F/W	Md (mm)	Mz (fí) F/W	So (fí) F/W	Sk (fí) F/W	Kg F/W	Characterization of sediments
50,2 - 50,3	2 903	0,027	3 562	1 856	0,524	1 061	very fine sand
56,7 - 56,8	3 641	0,018	3 966	1 114	0,330	1 127	very fine sand
151,7-152,0	3 591	0,031	3 813	1 292	0,345	1 727	very fine sand
155,0-155,3	4 466	0,0096	4 217	2 451	-0,116	0,683	coarse silt
253,5-253-6	3 763	0,023	4 160	1 577	0,366	1 412	coarse silt
350,2-350,3	2 599	0,13	2 735	1 602	0,159	1 429	very fine sand
355,8-355,9	5 048	0,0058	5 254	1 906	0,053	1 043	coarse silt
454,4-454,6	5 262	0,0041	5 458	1 701	0,126	0,859	medium silt
552,2-552,3	4 921	0,007	4 899	2 173	-0,074	0,905	coarse silt

Md – median, Mz – average grain size, So – sorting coefficient, Sk – asymmetry value, Kg – kurtosis value.

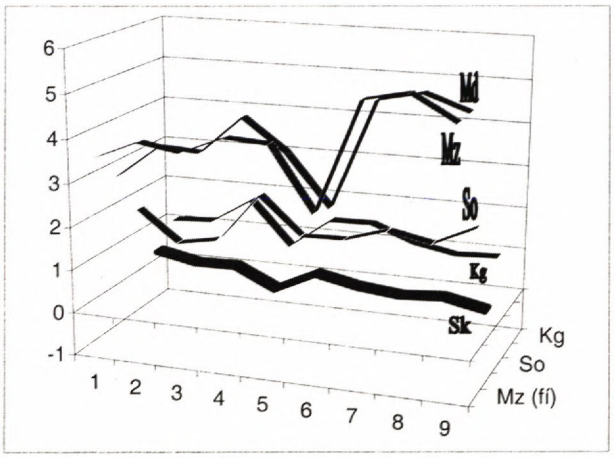


Fig. 5 Changes of grain size parameter values in the borehole HGŽ-3. Mz – average grain size, Md – median, So-sorting coefficient, Sk – asymmetry value, Kg-kurtosis value
x-axis represents depth: 1 – 50.2-50.3 m, 2 – 56.7-56.8 m, 3 – 151.7-152.0 m, 4 – 155.0-155.3 m, 5 – 253.5-253.6 m, 6 – 350.2-350.3 m, 7 – 355.8-355.9 m, 8 – 454.4-454.6 m, 9 – 552.2-552.3 m

grained sand, what generally suggests negative graded bedding of deposits (Fig. 5).

Grain size analysis (Tab. 1) of the deposits revealed that the average grain size (Mz) ranges from 2.735 (for fine-grained sand) to 5.458 (for medium-grained silt). According to Folk-Ward classification (1957) the sands and silts are slightly to weakly sorted and the sorting coefficient ranges 1.114 – 2.451.

The asymmetry of the cumulative grain size curve indicates either prevalence of fine-grained (positive values) or prevalence of coarse-grained fraction in the deposit. The asymmetry values (Sk) of the cumulative curve of the borehole HGŽ-3 are positive or near to zero in most samples, what suggests that the deposits contain a greater portion of finer-grained fraction and coarser particles are scattered in various grain size fractions. Two samples have negative values, they contain greater portion of coarser-grained fraction, what is also reflected by their very poor sorting.

The kurtosis values (Kg) suggest more on platykurtic (flat), less on very leptokuritc (steep) shapes of the cumulative curve, characterizing prevalence of fine-grained particles in the deposits.

The median (Md) ranges from 0.0041 to 0.13 mm and its values vary in the profile and at the same time increase toward the overlying part due to increasing portion of coarser grains, and so indicate a negative graded bedding.

Fauna

Mollusca

The borehole has poor content of molluscan fauna. The following fauna was identified: bivalves *Cardium* sp. (55.4 – 55.5 m; 152.8 – 153.0 m; 154.0 – 154.1 m; 154.1 – 154.5 m), *Ervilia* sp. (154.1 – 154.5 m), *Musculus sarmaticus* (GATUJEV) (152.8 – 153.0 m), and gastropods of *Mohrensternia* genus (152.8 – 153.0 m).

The presence of gastropods of *Mohrensternia* genus in depth 152.8 – 153.0 m enables to classify the fossil-bearing deposit among to the so-called Rissoa beds of the Lower Sarmatian (Papp, 1954).

Foraminifera

(Phototable I to III)

In the deposits of the borehole HGŽ-3 there was found relatively a rich association of foraminifers (Tab. 2).

In depth interval 20.0 – 55.1 m there were found siliceous and calcareous spicules of sponges (axisless, one and more axes) and re-deposited foraminifers from older Neogene stages.

A Lower Sarmatian micro-association with dominance of elfidia, however without typical form *Elphidium reginum* (ORB.), was found in depth 150.4 – 155.5 m. There are present *Elphidium flexuosum flexuosum* (ORB.), *E. rugosum* (ORB.), *Bolivina sarmatica* DIDK., "*Cibicides badenensis*" (ORB.), *Lobatula lobatula* (W.- J.), *Ammonia beccarii* (L.), for example The foraminifers are associated with centric, especially pyritizated diatoms.

In certain parts of the interval 250.4 – 457.6 m there is dominance of Bolivina-Bulimina association of foraminifers, which is typical for the Upper Badenian with occurrence of species *Bulimina elongata elongata* ORB., *Valvulineria complanata* (ORB.), *Bolivina dilatata dilatata* RSS., *Caucasina schischkinskayae* (SAMOILOVA), *Bolivina dilatata maxima* C.-Z., *Fursenkoina acuta* (ORB.), *Praeglobobulimina pupoides* (ORB.), *Praeglobobulimina ovula* (ORB.), *Bulimina elongata longa* (VENGL.), *Bolivina hebes* MACF., *Bolivina kodymi* C.-Z., *Bolivina pokornyi pokornyi* C.- Z., *Globigerina druryi*

Tab. 2 Occurrence of foraminifers in borehole HGŽ-3

Foraminifera	150,4-150,5 m	151,5-151,8 m	152,6-152,8 m	152,8-153,0 m	154 m	154,0-154,1 m	154,5-155,0 m	154,6-154,7 m	155,5 m	250,4 m	250,5-250,6 m	251,8 m	252,5-252,6 m	254,3-254,4 m	254,8 m	353,9 m	355,8 m	450,6 m	451,5 m	452,7-452,8 m	453,3 m	456,0-456,2 m	457,5-457, 6m	550,2 m	551,4 m	559,1 m	650,9 m	652,4-652,6 m	654,7-654,8 m	801,5-801,6 m	852,6-852,8 m	853,4-853,6 m
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Allomorphina trigona Rss.																								x	x	x		x				
Ammonia beccarii (L.)	x	x		x		x					x	x			x		x	x									x					
Angulogerina angulosa (Williamson)											x																					
Asterigerinata planorbis (Orb.)	x									x	x	x					x												x			
Bolivina dilatata brevis C.-Z.																							x									
Bolivina dilatata dilatata Rss.										x		x			x	x	x															
Bolivina dilatata maxima C.- Z.											x				x	x	x			x		x										
Bolivina ex gr.dilatata Rss.														x							x											
Bolivina hebes Macf.															x																	
Bolivina kodymi C.- Z.															x																	
Bolivina plicatella Cush.																									x							
Bolivina pokornyi pokornyi C.- Z.																		x		x												
Bolivina sarmatica Didk.	x																															
Bolivina scalprata retiformis Cush.																								x								
Bolivina aff. vienensis Marks																										x						
Bolivina sp.																		x		x						x			x	x		
Bolivina sp. / cf. *B.sinuosa* (Cush.) /																					x											
Budashevaella willsoni (Smith)																										x						
Bulimina aculeata Orb.																								x								
Bulimina cf.*aculeata* Orb.																				x												
Bulimina elongata elongata Orb.						x					x	x	x		x			x		x	x	x			x							
Bulimina elongata longa (Orb.)													x		x					x												
Bulimina elongata Orb.																	x		x				x				x					
Bulimina insignis Luczkowska																							x									
Bulimina striata striata Orb.																									x	x				x		
Bulimina striata mexicana Cush.																								x								
Cassidulina laevigata Orb.											x				x										x							
Cassidulina oblonga (Rss.)																								x								
Caucasina schischkinskayae (Samoil.)											x					x		x		x			x									
Cibicides badenensis (Orb.)	x																															
Cibicides sp.										x							x									x						
Cibicidoides pseudoungerianus (Cush.)																							x	x	x						x	
Cibicidoides ungerianus (Orb.)																								x	x		x					
Cribrostomoides columbiensis columbiensis (Cush.)												x																				
Cribrostomoides sp.																								x								
Cycloforina contorta (Orb.)																			x													
Elphidium crispum (L.)	x				x		x	x																								
Elphidium ex gr.*flexuosum* (Orb.)									x																							
Elphidium fichtelianum (Orb.)			x	x			x									x					x											
Elphidium flexuosum flexuosum (Orb.)	x			x	x																											
Elphidium granosum (Orb.)									x																							
Elphidium macellum (F.-M.)	x				x	x	x		x			x																				
Elphidium obtusum (Orb.)				x	x		x		x																							

Tab. 2 (continuation)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Elphidium rugosum (Orb.)	x	x		x	x	x	x	x	x																							
Fissurina sp.						x					x																					
Frondicularia sp.						x																										
Fursenkoina acuta (Orb.)											x	x	x					x		x	x	x	x	x	x			x				
Globigerina aff. *apertura* Cush.																									x							
Globigerina apertura Cush.											x																					
Globigerina bulloides Blow										x	x	x			x	x	x	x		x	x		x		x	x						
Globigerina concinna Rss.						x				x					x		x	x						x								
Globigerina diplostoma Rss.																									x							
Globigerina druryi Akers																		x														
Globigerina nepenthes Todd																									x							
Globigerina praebulloides Blow											x					x				x					x							
Globigerina quinqueloba Natland																									x							
Globigerina regularis Orb.																							x									
Globigerina sp.														x	x												x			x		
Globigerina tarchanensis Subb.- Chutz.											x															x						
Globigerinella obesa (Bolli)										x	x					x			x						x	x						
Globigerinella regularis (Orb.)																										x						
Globigerinoides quadrilobatus (Orb.)																			x		x		x		x	x						
Globigerinoides sp.																		x														
Globigerinoides subsacculifer Cita - Premoli-Silva - Rossi																					x											
'Globigerinoides trilobus (Rss.)				x		x						x			x		x		x	x	x		x	x	x	x	x			x	x	x
Globoquadrina altspira (Cush.-Jarvis)																								x						x		
Globoquadrina larmeuti Akers																								x								
Globorotalia bykovae bykovae (Aisenstat)																	x															
Globorotalia sp.															x					x												
Guttulina communis Orb.																								x	x							
Hansenisca soldanii (Orb.)											x													x	x	x						x
Hanzawaia boueana (Orb.)										x	x																					
Haplophragmoides vasiceki vasiceki C.- Z.																		x	x					x		x						
Haplophragmoides ex gr. *vasiceki* C.-Z.												x																				
Haplophragmoides sp.																			x													
Heterolepa dutemplei (Orb.)													x					x	x	x	x	x	x		x	x			x			x
Lagena acuticosta Rss.																x																
Lagena hispida Rss.											x																					
Lenticulina cultrata (Montf.)																								x								
Lenticulina sp.																										x						
Lobatula lobatula (W.- J.)	x	x					x												x													
Melonis pompilioides (F.-M.)																															x	
Nodosaria sp.																			x													
Nonion commune (Orb.)						x					x	x	x		x		x	x		x		x	x				x	x	x	x		
Nonion sp.										x																						
Orbulina suturalis Broenn.						x													x	x	x		x							x		x
Pappina bononiensis compressa (Cush.)											x												x									
Pappina bononiensis primiformis (P.-T.)											x																					
Paragloborotalia? mayeri (Cush.-Ell.)												x																				
Plectofrondicularia digitalis (Neugeb.)											x						x															
Praeglobobulimina ovula (Orb.)												x	x																			
Praeglobobulimina pupoides (Orb.)												x						x		x	x	x		x	x	x						
Praeglobobulimina pyrula (Orb.)													x							x			x									

Tab. 2 (continuation)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Praeorbulina glomerosa (Blow)												x							x											x		
Protelphidium bogdanowiczi (Volosh.)			x																													
Pullenia bulloides (Orb.)											x						x							x	x	x		x	x			x
Pullenia quinqueloba (Rss.)																								x								
Quinqueloculina sp.												x							x													
Reophax sp.																			x					x								
Reticulophragmium venezuelanum (Maync)																									x							
Sphaeroidina bulloides Orb.																						x			x	x					x	
Spiroloculina canaliculata Orb.																									x							
Spiroplectinella acuta (Rss.)																										x						
Spiroplectinella carinata (Orb.)																						x				x						
Stilostomella adolphina (Orb.)											x																					
Stilostomella advena (Cush.- Laim.)											x																x			x		
Stilostomella sp.														x	x																	
Melonis pompilioides (F.-M.)																															x	
Subbotina aff.cognata (Pishv.)																						x										
Trifarina bradyi Cush.																																
Uvigerina aculeata aculeata Orb.																			x													
Uvigerina aculeata orbignyana Czjz.																									x							
Uvigerina ex gr.semiornata Orb.																													x			
Uvigerina macrocarinata P.-T.																															x	
Uvigerina semiornata brunensis Karrer																										x						
Uvigerina semiornata kusteri von Daniels-Spiegler																										x						
Uvigerina semiornata semiornata Orb.																									x	x						x
Uvigerina sp.																x																
Valvulineria complanata (Orb.)										x		x				x	x					x			x	x						
Valvulineria marmaroschensis Pischv.																				x							x					x

AKERS, *Valvulineria marmaroschensis* PISHV., *Bolivina dilatata brevis* C.-Z., *Bulimina insignis* LUCZKOWSKA.

In depth 551.4 m the calcareous plankton is represented by *Globigerina nepenthes* TODD, limited to the Middle Badenian (Wieliczkan) and the calcareous benthos is represented by *Uvigerina aculeata orbignyana* CZJZ.

In depth 801.5 – 801.6 m *Praeorbulina glomerosa* (BLOW) was determined in the central Paratethys, which was extended only in the lower part of the Lower Badenian (Moravian) and in depth 852.6 – 852.8 m *Uvigerina macrocarinata* P.-T., the range of which in the central Paratethys is limited to the Lower Badenian only.

In depth 453.3 m the planktonic constituent has 98 % abundance in the microfauna, what suggests very good communication between deposition the sedimentation area basin and open sea.

Ostracods
(Phototab III, fig. 1)

Only scattered ostracod shells were identified in the borehole sediments. *Cytheridea hungarica* ZÁLANYI (154.0 m; 154.5 – 155.0 m) and *Henryhowella asperrima* (REUSS) (551.4 – 551.5 m).

The presence of species *Cytheridea hungarica* ZÁLANYI indicates the Lower Sarmatian age of the deposits (biozone Cytheridea hungarica - Aurila mehesi, Zelenka, 1990) and the species *Henryhowella asperrima* (REUSS) on Karpathian to Badenian age (Brestenská & Jiříček, 1978).

Calcareous nannoplankton
(Phototable IV)

In the deposits of the borehole HGŽ–3 there were determined association of calcareous nannoplankton, which are characteristic by poor preservation and content of redeposited species (of Upper Cretaceous, mainly Eocene age). The Miocene forms are rare, however, their redeposition into younger Miocene deposits was established (for example *Sphenolithus heteromorphus* DEFLANDRE in depth 250.5 – 250.6 m, *Cyclicargolithus floridanus* (ROTH & HAY) BUKRY in depth 52.5 – 52.6m, *Helicosphaera waltrans* THEODORIDIS in depth interval 154.6 – 154.7 m). In the samples from this borehole there was observed the presence of abundant diatoms and silicisponges (Tab. 3).

The individual positive samples can be evaluated as follows:

In sample from depth 52.5 – 52.6 m there was found a mixture of poorly preserved nannofossils. There were determined redeposited specimens of Eocene? – Miocene age.

The deposit from depth interval 154.6 – 154.7 m contains calcareous nannofossils occurring in Eocene and Lower Miocene horizons. Only one etched specimen of *Discoaster* sp. (resembling *Discoaster bollii* BRAMLETTE & MARTINI) was found.

The deposit is rich in diatoms and silicisponges. The sample from the depth interval 250.5 – 250.6 m is the In the samples from the depth 250.5 – 250.6 m and 251.8 m, 254.8 m there were determined nannofossils of Upper Cretaceous, Eocene and Lower Badenian age – *Helicosphaera waltrans* THEODORIDIS (NN5), *Sphenolithus*

Tab. 3 Occurrence of calcareous nannoplankton in borehole HGŽ-3

Calcareous nannofossils	**52,6-52,7 m**	**154,6-154,7 m**	**250,5-250,6 m**	**251,8 m**	**254,8 m**	**457,5-457,6 m**	**652,4-652,6 m**	**654,7-654,8 m**	**704,8-704,9 m**	**801,5-801,6 m**	**852,6-852,8 m**	**853,4-853,6 m**
Braarudosphaera bigelowi (Gran & Braarud) Deflandre		x	x	x								x
Calcidiscus leptoporus (Murray&Blackmann) Loeblich & Tappan	x	x	x	x		x		x	x			x
Coccolithus miopelagicus Bukry	x	x	x	x	x	x			x	x		
Coccolithus pelagicus (Wallich) Schiller	x	x	x	x	x	x	x	x	x	x	x	x
Coccolithus sp.	x		x						x			
Cyclicargolithus floridanus (Roth & Hay) Bukry	x	x	x	x	x	x	x	x	x			
Umbilicosphaera rotula (Kamptner) Varol	x	x	x	x	x	x	x	x				
Dictyococcites bisectus (Hay, Mohler & Wade) Bukry & Percival	x	x	x	x	x	x	x		x			
Discoaster deflandrei Bramlette & Riedel		x										
Discoaster sp.		x	x									
Helicosphaera obliqua Bramlette & Wilcoxon			x									
H. scissura Miller			x	x								
Helicosphaera carteri (Wallich) Kamptner	x	x	x	x	x	x	x	x	x			
Helicosphaera waltrans Theodoridis			x									
?*Litostromation perdurum* Deflandre			x									
Micrantholithus vesper Deflandre			x	x		x						x
Pontosphaera multipora (Kamptner) Roth		x	x	x	x	x	x					
Pontosphaera sp.		x	x	x	x		x					
Reticulofenestra pseudoumbilicus (Gartner) Gartner	x	x	x	x	x	x	x	x	x	x		
Reticulofenestra sp.		x	x			x	x					
Sphenolithus abies Deflandre			x			x						
S. heteromorphus heteromorphus Deflandre			x					x	x		x	x
Sphenolithus moriformis (Brönnimann & Stradner) Bramlette & Wilcoxon		x	x	x		x		x	x	x	x	x
Syracosphaera pulchra Lohmann			x			x			x			
Thoracosphaera sp.	x											
Reworked Paleogene nannofossils												
Cruciplacolithus tenuis (Stradner) Hay & Mohler			x	x								
Cribrocentrum reticulatum (Gartner & Smith) Perch-Nielsen		x										
Coccolithus formosus (Kamptner) Wise	x	x	x	x		x		x	x			x
Lanternithus minutus Stradner			x									
Pontosphaera enormis (Locker) Perch-Nielsen			x									
Reticulofenestra umbilica (Levin) Martini & Ritzkowski		x				x						
Tribrachiatus orthostylus Shamrai		x										
Transversopontis sp.		x										
Zygrhablithus bijugatus (Deflandre) Deflandre		x				x		x	x			x
Reworked Cretaceous nannofossils												
Arkhangelskiella cymbiformis Vekshina			x									
Broinsonia parca parca (Stradner) Bukry						x						
Micula decussata Vekshina			x	x		x						
Octolithus multiplus (Perch-Nielsen) Romein			x	x	x							
Quadrum gartneri Prins & Perch-Nielsen									x			
Reinhardtites anthophorus (Deflandre) Perch-Nielsen						x						
Zeugrhabdotus embergeri (Nöel) Perch-Nielsen			x									
Diatemecea			x					x	x			

heteromorphus DEFLANDRE (NN4-NN5), which in autochthonous position are present together in zone NN5. richest fromf the whole profile; it has the best degree of preservation.

Deposits from the depth 457.5 – 457.6 m contain nannofossils of Upper Cretaceous, Eocene and Miocene age. The prevailing species is *Coccolithus pelagicus* (WALLICH) SCHILLER. From Miocene species were determined: *Calcidiscus leptoporus* (MURRAY & BLACKMANN) LOEBLICH & TAPPAN, *Umbilicosphaera rotula* (KAMPTNER) VAROL, *Reticulofenestra pseudoumbilicus* (GARTNER), *Sphenolithus abies* DEFLANDRE.

In depth 652.4 – 652.6 m there was determined a poor association of calcareous nannoplankton with forms that are known since the Eocene and Oligocene and which become extinct in the Miocene. The only determined Miocene specie were *Umbilicosphaera rotula* (KAMPTNER) VAROL, of which the stratigraphic range is NN2-NN16 and *Reticulofenestra pseudoumbilicus* (GARTNER) GARTNER (NN4-NN15).

Similarly it is with the sample from the depth 654.7 – 654.8 m, which contained the species *Sphenolithus heteromorphus* DEFLANDRE indicating the zone NN5. The deposit contains a large amount of diatoms.

The sample from the depth interval 704.8 – 704.9 m reveals a poor association with low degree of preservation, with Miocene elements as *Calcidiscus leptoporus* (MURRAY & BLACKMANN) LOEBLICH & TAPPAN, *Sphenolithus heteromorphus* DEFLANDRE, *Reticulofenestra pseudoumbilicus* (GARTNER) GARTNER, which suggest the presence of nannoplankton zone NN5.

In the depth interval 801.5 – 801.6 m there was observed a very poor association of nannoflora, which was insufficient for stratigraphic classification.

The sample from the depth 852.6 – 852.8 m, 853.4 – 853.6 m was poor in association of calcareous nannoplankton. The most numerous species is *Coccolithus pelagicus* (WALLICH) SCHILLER and other Paleogene forms. From the biostratigraphic point of view the most significant species is *Sphenolithus heteromorphus* DEFLANDRE, pointing to zone NN5, as no specimens of *Helicosphaera ampliaperta* BRAMLETTE & MARTINI, *H. mediterranea* MÜLLER, *H. scissura* MILLER etc. were found.

In the interval 853.6 m – 654.7 m the associations of calcareous nannoplankton correspond to zone NN5. It is confirmed by occurrences of biostratigraphically most significant nannofossil *Sphenolithus heteromorphus* DEFLANDRE, without accompaniment of nannofossils typical for zone NN4. This index nannofossil was redeposited also to younger horizon (interval 250.5 – 250.6 m).

In smaller depth intervals there were not found any index nannofossils, which would allow stratigraphic classification of the deposit to the Middle of Upper Badenian. In the samples no discoastersy, were found which are common in zones NN5 and NN6 and are typical for the environment of open ocean. On the other hand, the identified foraminifer associations make possible to establish of the Middle and Upper Badenian and in the Upper Badenian there were recognized up to 98 % of planktonic constituent constituent contact with the open sea. It means, that nannoflora association could have been decimated by the influence of diagenesis in lithologically unsuitable

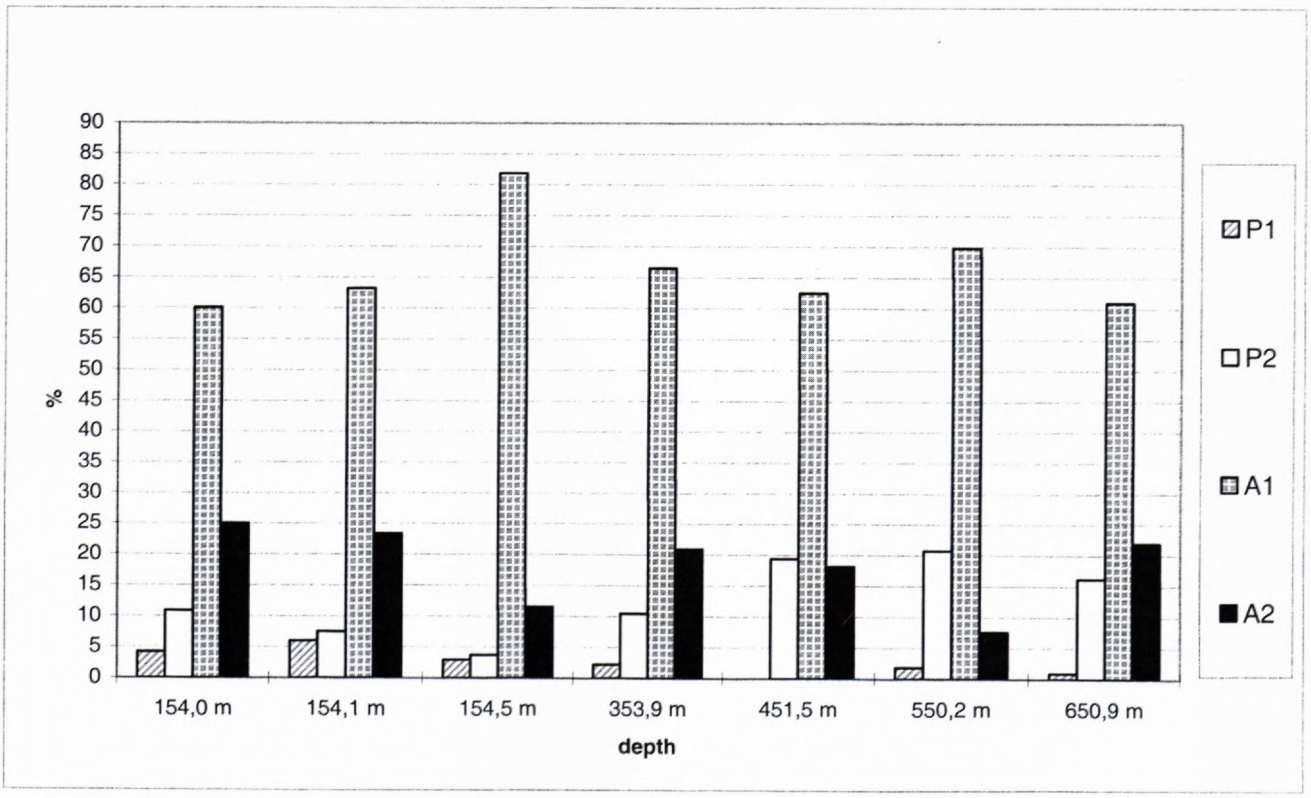


Fig. 6 Share of arctotertiary and paleotropic elements in palynospectrum of the borehole HGŽ-3
P1- paleotropic geoflora (tropical zone) P2- paleotropic geoflora (sub-tropic zone) A1 – arctoctertiary geoflora (warm temperature zone) A2 – arcoictertiary geoflora (cold temperature zone)

environment (high in Si content in deposits – as proved by the presence of abundant of diatoms and silicisponges in preparations used for the study of calciferous nannoplankton.

Otoliths

In the borehole there were found also remains of fish in form of otoliths (determined by Prof. RNDr. R. Brzobohatý, CSc.) The identified species were *Gadiculus* sp. (juv.), *Physiculus* sp. (juv.) from depth 452.7 – 452.8 m and *Diaphus* ex. gr. *debilis* (KOK.), *Photichtys* sp., *Bregmaceros* sp. from depth 551.4 – 551.5 m.

Sporomorphs
(Phototable V – VII)

Sporomorphs from the borehole HGŽ-3 were also studied. Relatively poor palynospectrum was obtained (Tab. 4).

In assignment of the taxons into individual geoflora type and into their corresponding climatic zones the terminology by Engler (1879; 1882) was used. He introduced the terms paleotropical (P) and arctotertiary (A) geoflora. According to terminology by Mai (1981; 1991) a paleotropic elements are considered evergreen plants genetically belonging into tropical (P1) and subtropical (P2) climatic zones in which their recent equivalents can be found. The arctotertiary type geoflora is characterized by coniferous and deciduous species partly defoliating, genetically belonging to warm temperate (A1), or cold temperate (A2) zones in which their recent equivalents can be found. Expression of the proportion between tree (AP) and non-tree (NAP) plant forms can suggest much about degree of afforestation of the studied locality in the given time sedion.

In depth 154.0 m the palynospectrum of sample is dominated by elements of arctoctertiary geoflora, mainly representatives of the group A1 (*Taxodium, Alnus, Pinus, Carya, Junglans, Nyssa*), less from the group A2 (*Picea, Ulmus, Corylus, Salix, Tilia*). Paleotropical geoflora is present in less amounts, in greater proportion there are present only subtropical elements of the group P2 (*Castanea, Myrica, Ilex*). Tropical plants from group P1 (*Engelhardtia*) have minimum extent (Fig. 6). It is obvious from the ratio of AP/NAP forms that the tree species were prevailing.

The sample from the depth 154.1 m contains dominantly elements form arctotertiary geoflora, the portion of elements from group A1 slightly increased and the portion of elements from group A2 slightly decreased. The share of paleotropical geoflora was reduced by half. A slight increase was recorded in herbaceous forms at the expense of wood plants. Beside sporomorphs also a representative of phytoplankton was present: (Dinoflagellata) species *Deflandrea spinulosa*, typical for Oligocene (Hudáčková in Halásová et al., 1996).

The sample from the depth 154.5 m is interesting by extraordinary high portion of arctotertiary geoflora of group A1 (*Taxodium, Pinus, Chenopodium, Alnus*), from group A2 there were determined *Picea, Abies* and *Ulmus*. Representation of paleotropical geoflora of groups P1 and P2 was minimum. In this depth, in comparison with other samples, there was determined the largest portion of herbs from NAP (Chenopodiaceae, Gramineae). In the sample there was also a representative of dinoflagellates *Achomosphaera* sp.

In the sample from the depth 353.9 m the portion of arctotertiary geoflora of group A2 (*Ulmus, Salix, Fagus*) increased by one third in comparison to the preceding sample (154.5), on the contrary, the group A1 recorded lower percentage. The elements of paleotropical geoflora of group P2 (*Castanea, Myrica*) are more abundant than in the preceding sample. From the ratio AP/NAP the significant dominance of AP forms is obvious. The portion of the herbal part significantly decreased in comparison with the preceding sample. The dinoflagellates are represented by *Achomosphaera* sp. and *Spiniferites* cf. *bentori*.

In the palynospectrum from the depth 451.5 m there were dominating elements from arctotertiary geoflora, mainly from group A1. Groups P2 and A2 were represented quantitatively nearly equally.

Absence of elements from group P1 (tropical flora) is interesting. The genera *Ulmus, Pinus, Alnus, Myrica, Castanea* were abundant to very abundant. *Salix, Carya* were common. The portion of herbal component increased only slightly (Gramineae).

In depth 550.2 m the portion of elements from the group A2 decreased and representatives of tropical flora P1 there occur again in minium amount. The abundance of the paleotropical geoflora of the group P2 increased only slightly, similarly was increased the portion of arctotertiary elements from the group A1. Portion of the herbal component of the spectrum was increased again insignificantly only. The dinoflagellates are represented by the genus *Distatodinium*.

In the sample from the depth 650.9 m the relative portion of AP/NAP has not changed. However, the increase of portion of the arctotertiary elements of group A2 along with decrease of portion of elements from the groups P1 and P2 is interesting. The genera *Pinus, Alnus, Myrica, Salix* and *Ulmus* were very abundant here.

According to the mentioned paleoflora data we can conclude that during the formation of the studied deposits there was warm subtropic climate.

Macroflora

In the deposits from the depth of 52.5 – 52.6 m an imprint of a leaf *Carpinus grandis* UNGER (determined by Doc. RNDr. V. Sitár, CSc) was found.

Characteristics of the neogene lithostratigraphic units

The results of the study of the individual fossil groups of organisms served for classification of the Neogene deposits from the borehole HGŽ-3 into the defined lithostratigraphic units (Priechodská in Harčár et al., 1988; Vass in Keith et al., 1994; Kováč & Hók in Hók et al., 1999).

The presence of foraminifers *Praeorbulina glomerosa* (BLOW), and *Uvigerina macrocarinata* P.-T. is characteristic for the oldest Neogene deposits from the borehole

Tab. 4 Representation of the individual palynomorph species (genera) in borehole HGŽ-3

Taxon/depth	154,0 m	154,1 m	154,5 m	353,9 m	451,5 m	550,2 m	650,9 m
Osmunda sp.				—			
Leiotriletes sp.							
Laevigatosporites sp.	—				—		
Taxodium sp.	—	—	—			—	
Sciadopytis type							
Abies type		—					
Cedrus sp.							
Picea type	—	—					
Pinus type sylvestris	—	—	—	—	—	—	—
Pinuspollenites type haploxylon	—	—	—	—	—	—	—
Tsuga type							
Podocarpus type							
Chenopodiaceae		—					
Liquidambar type							
Castanea sp.	—			—	—	—	—
Fagus sp.							
Quercus sp.				—		—	
Alnus sp.	—	—	—	—	—	—	—
Betula sp.							
Carpinus sp.							
Corylus sp.	—						
Myrica type	—	—		—	—	—	—
Carya sp.	—	—		—	—	—	—
Engelhardtia sp.	—						
Momipites sp.						—	
Juglans sp.	—	—					
Pterocarya type							
Salix type				—	—		—
Tilia sp.							
Ulmus sp.	—	—	—	—	—	—	—
Zelkova sp.							
Acer type							
Rhus type				—			
Ilex sp.							
Nyssa sp.				—			
Asteraceae							
Poaceae		—	—	—	—		

Occurence:	
rare	
common	—
abundant	—
very abundant	—

HGŽ-3 (770.5-916.0 m), representing the Bajtava Formation, and restricted only to the Lower Badenian (Moravian), in the central Paratethys. From the calcareous nannoplankton the most abundant was the species *Coccolithus pelagicus* (WALLICH) SCHILLER and biostratigraphically interesting *Sphenolithus heteromorphus* DEFLANDRE indicating zone NN5.

They are averlain (200.0 – 770.5 m) by Middle and Upper Badenian deposits representing the Pozba Formation.

In the depth interval 572.5 – 770.5 m there are deposits of Middle Badenian age, for which presence of foraminifers of species *Globigerina nepenthes* TODD and *Uvigerina aculeata orbignyana* CZJZ., indicating a Middle Badenian age is typical. Only a poor association of the calcareous nannoplankton was obtained there. Forms with a wide stratigraphic range were established there and except of them also *Sphenolithus heteromorphus* DEFLANDRE indicating zone NN 5 was determined. Also large amount of diatoms was identified. In these deposits also otoliths *Diaphus* ex. gr. *debilis* (KOK.), *Photichtys* sp. and *Bregmaceros* sp. were found. The presence of deep-water species *Photichtys* sp. suggests the deposition environment at the boundary between sublittoral and bathyal zone (by Brzobohatý, oral information).

In the palynospectrums of Middle Badenian deposits there are abundant forms of needles of genus *Pinus*, which abundant by continues gradually up to the Upper Badenian. Obvious occurrences of hydrophilous vegetation with representatives of *Myrica, Alnus, Salix* type are interesting. Despite the higher percentage of hydrophilous taxons we cannot speak about the existence of swamps in the area. The climate must have been very warm and humid, because in the palynospectrum more abundant of representatives of paleotropic geoflora (*Castanea*) were present.

In strata overlying Middle Badenian deposits, in depth interval 200.0 – 572.5 m there are Upper Badenian deposits.

The composition of the Upper Badenian palynospectrums was in comparison with the Middle Badenian not distinctly different on the contrary, it seems to be, insignificant differences are in sporadical to common occurrence of some taxons in depth 353.9 m, in comparison with samples from greater depths (*Cedrus, Picea, Quercus, Tilia, Zelkova, Acer* type, *Rhus*). The dominance of hydrophilous vegetation is obvious also here (*Alnus, Myrica, Salix* type). Abundant are also *Carya, Ulmus* and mainly *Pinus*. Also in this depth interval there is dominance of arctotertiary elements over paleotropical, which occured only rarely, is unambiguous.

For Upper Badenian deposits from borehole HGŽ-3 the Bolivina-Bulimina association is characteristic. The present species are: *Bulimina elongata elongata* ORB., B. elongata longa (VENGL.), *B. insignis* LUCZKOWSKA. *Bolivina dilatata dilatata* RSS., *B. dilatata maxima* C.-Z., B. *dilatata brevis* C.-Z., B. *kodymi* C.-Z., *B. pokornyi pokornyi* C.-Z., *B. hebes* MACF., *Fursenkoina acuta* (ORB.), *Praeglobobulimina pupoides* (ORB.), *Praeglobobulimina ovula* (ORB.), *Valvulineria marmaroschensis* PISHV. and *Globigerina druryi* AKERS. In the mentioned deposits there was identified a mixture of redeposited nannofossils coming from Upper Cretaceous, Paleogene and Neogene deposits.

Pozba Formation is overlain by the Vráble Formation in the depth interval 10-200 m. The presence of gastropods of genus *Mohrensternia* that indicates Lower Sarmatian age, bivalves of species *Musculus sarmaticus* (Gatujev) and genus *Cardium* was established in the lower part of the formation. From foraminifers there were found *Elphidium flexuosum flexuosum* (ORB.), *E. rugosum* (ORB.), *Bolivina sarmatica* DIDK., *"Cibicides badenensis"* (ORB.), *Lobatula lobatula* (W.- J.), *Ammonia beccarii* (L.). Foraminifers are accompanied by centric, mostly pyritized diatoms. From the microfauna ostracods of species *Cytheridea hungarica* ZÁLANYI were also found there. Their occurrence indicates the Lower Sarmatian ostracod biozone Cytheridea hungarica - Aurila mehesi (Zelenka, 1990).

Redeposited associations of calcareous nannoplankon, consisting of forms coming from Eocene and older Miocene horizons, were found in the mentioned deposits.

Representatives of arctotertiary geoflora of group A1 and from paleotropic group P2 (*Engelhardtia*) are prevailing in the palynospectrums of Lower Sarmatian deposits. By presence of swampy vegetation elements the composition of the palynospectrum in this depth interval is different from the Middle to Upper Badenian deposits. In the first place there are autochthonous elements of the association Taxodium – Alnus – Myrica – Nyssa, along with abundant occurrences of *Ulmus, Carya, Juglans, Corylus* type. The herbal portion of the growth was represented by halophytes from the family Chenopodiaceae and grasses Gramineae (Poaceae).

Conclusions

The borehole HGŽ-3 contributed to closer understanding of the geological and stratigraphic settings of the Želiezovce Depression.

In the basement of the Tertiary deposits there were metamorphosed Mesosoic carbonates belonging to the South Veporicum envelope encountered in borehole. Overlying them were identified organodetrital limestone of Oligocene (? Egerian) age, which resemble in their appearance position and presence of foraminifers to Budikovany Member from depressions of Lučenecká kotlina and Rimavská kotlina.

Overlying Oligocene deposits there were identified Middle Miocene deposits of the Neogene filling of the Želiezovce Depression. Deposits of the Bajtava (Lower Badenian), Pozba (Middle to Upper Badenian) and Vráble (Sarmatian) Formations were identified here.

The Neogene deposits from the borehole HGŽ were correlated with deposits of faciestratotype boreholes in the area of the Želiezovce Depression and deep borehole ŠV-8 (Fig. 3).

Determination of the stratigraphic stages was based on stratigraphic range of the individual fossil groups.

The Lower Badenian deposits were identified on the basis of foraminifers (*Praeorbulina glomerosa* (BLOW), *Uvigerina macrocarinata* P.-T.) and calcareous nannoplankton of zone NN5 (*Sphenolithus heteromorphus* DEFLANDRE).

The deposits of the Middle Badenian age were determined according to foraminifers *Globigerina nepenthes* TODD and *Uvigerina aculeata orbignyana* CZJZ. similarly as Upper Badenian deposits, for which the presence of Bolivina-Bulimina association was characteristic.

The Sarmatian deposits were identified according to molluscs (*Mohrensternia* sp., *Musculus sarmaticus* (GATUJEV)), foraminifers, (*Elphidium flexuosum flexuosum* (ORB.), *E. rugosum* (ORB.), *Bolivina sarmatica* DIDK.) and ostracods (*Cytheridea hungarica* ZÁLANYI).

According to presence of deepwater fish type of genus Photichtys we assume that the deposits of Middle Badenian age were sedimented on the boundary between sublittoral and bathyal zone.

Sporomorphs found in the Middle to Upper Badenian deposits indicate the presence of hydrophilous flora represented by forms *of Myrica, Alnus, Salix* type. The mentioned association testifies to a warm and humid climate. The sediments of Lower Sarmatian age are characterized by the presence of palustrine vegetation element. In first order there are autochthonous elements of the association Taxodium – Alnus – Myrica – Nyssa, and simultaneous abundant occurence of *Ulmus, Carya, Juglans, Corylus* type.

Acknowledgement:

The authors are thankful to Prof. RNDr. R. Brzobohatý, CSc. from Faculty of Nature Sciences, Masaryk University (Brno) for determination of the otoliths, Doc. RNDr. V. Sitár, CSc. from the Faculty of Nature Sciences, Comenius University (Bratislava) for determination of macroflora, RNDr. D. Boorová, CSc. from the Geological Survey of Slovak Republic for the microfacial characteristics of the organodetritial Oligocene limestones and to RNDr. E. Köhler, DrSc from the Geophysical Institute of SAV (Bratislava) for determination of Oligocene foraminifers. The presented article was elaborated on the basis of data obtained in the frame of the Project 130-1-04 Tectogenesis of sedimentary basins of the Western Carpathians and grant of PrF UK č. 8/2000.

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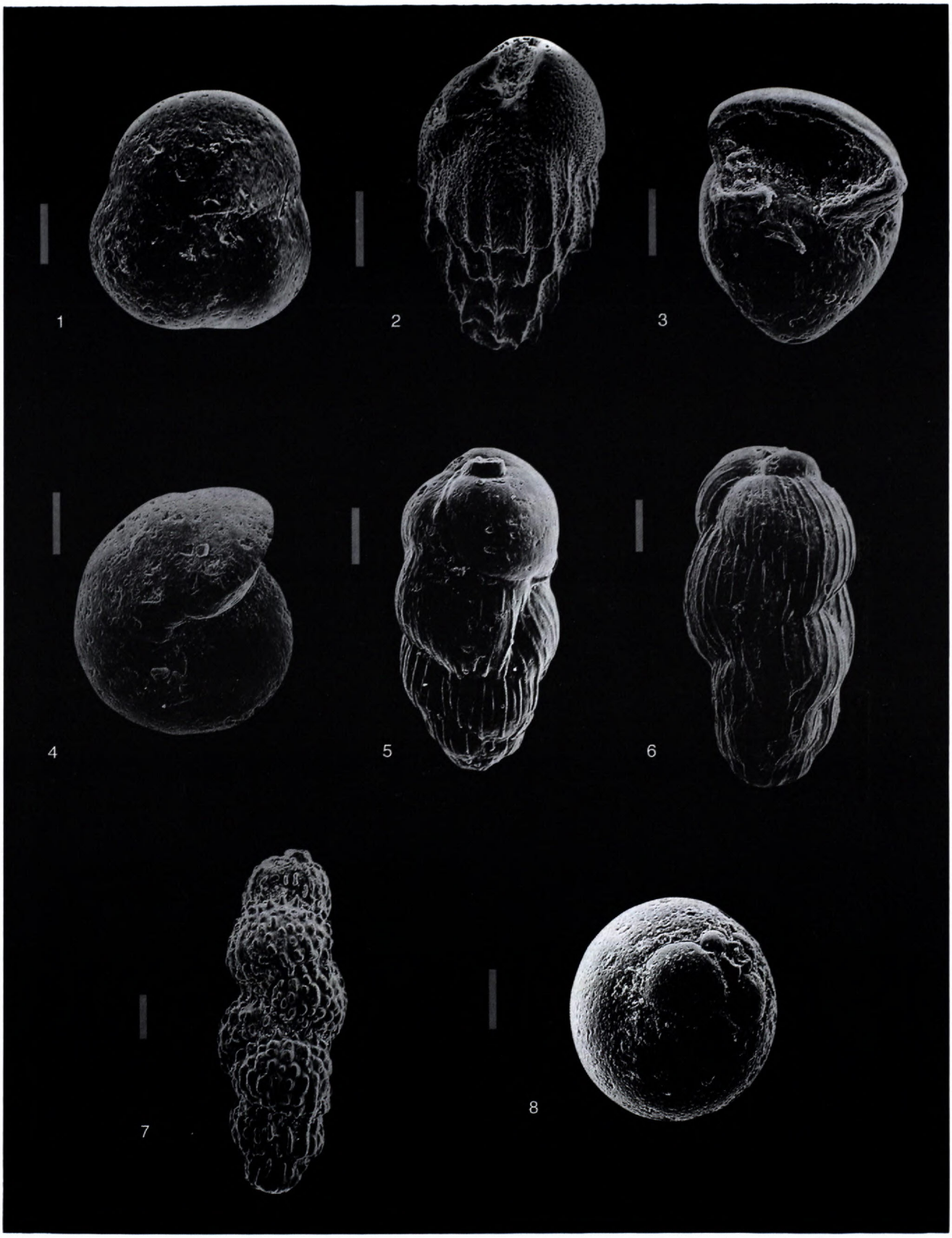
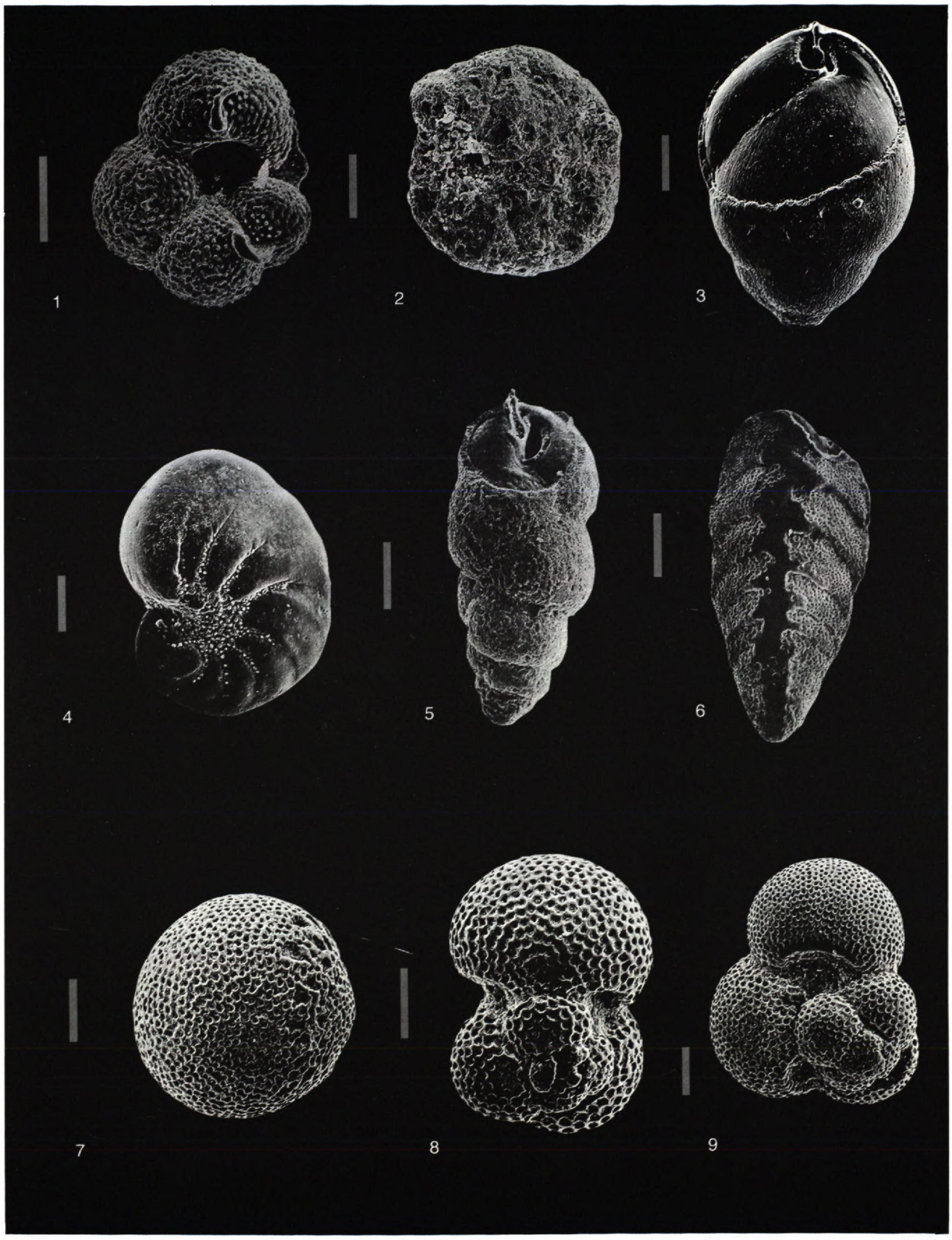
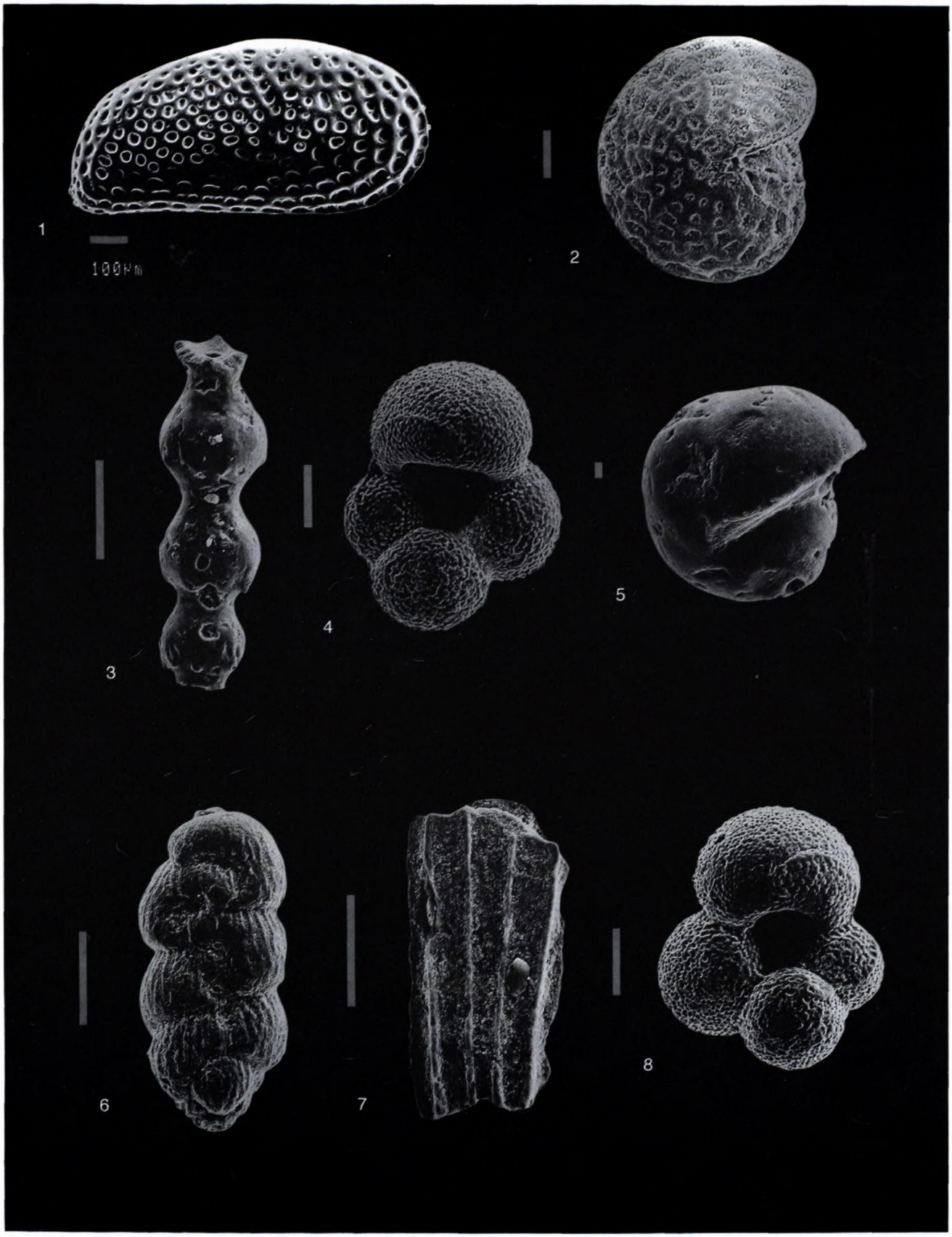


PHOTOTABLE I

1 – *Sphaeroidina bulloides* ORB., 550.2 m; 2 – *Bulimina striata mexicana* CUSH., 550.2 m; 3-4 – *Hansenisca soldanii* ORB., 550.2 m; 5-6 – *Uvigerina semiornata semiornata* ORB., 550.2 m; 7 – *Uvigerina semiornata kusteri* DANIELS-SPIEGLER, 559.1 m; 8 – *Orbulina suturalis* BROENN., 801.3 m.



PHOTOTABLE II
1 – *Globigerina praebulloides* Blow, 250.5 m; 2 – *Haplophragmoides* ex. gr. *vasiceki* C.-Z., 251.8 m; 3 – *Praeglobobulimina pupoides* (Orb.), 251.8 m; 4 – *Nonion commune* (Orb.), 251.8 m; 5 – *Bulimina elongata elongata* Orb., 254.8 m; 6 – *Bolivina dilatata maxima* C.-Z., 254.8 m; 7 – *Orbulina suturalis* Broenn., 453.3 m; 8 – *Globigerinoides trilobus* (Rss.), 453.3 m; 9 – *Globigerinoides subsacculifer* Cita-Premoli-Silva-Rossi.



PHOTOTABLE III

1 – *Cytheridea hungarica* (ZAL.), 154.0 m; 2 – *Elphidium flexuosum flexuosum* (ORB.), 154.0 m; 3 – *Stilostomella adolphina* (ORB.), 250.5 m; *Globigerina praebulloides* BLOW, 250.5 m; 5 – *Pullenia bullodes* (ORB.), 250.5 m; 6 – *Pappina bononiensis primiformis* (P.-T.), 250.5 m; 7 – *Plectofrondicularia digitalis* (NEUGEB.), 250.5 m; 8 – *Globigerina praebulloides* BLOW, 250.5 m.

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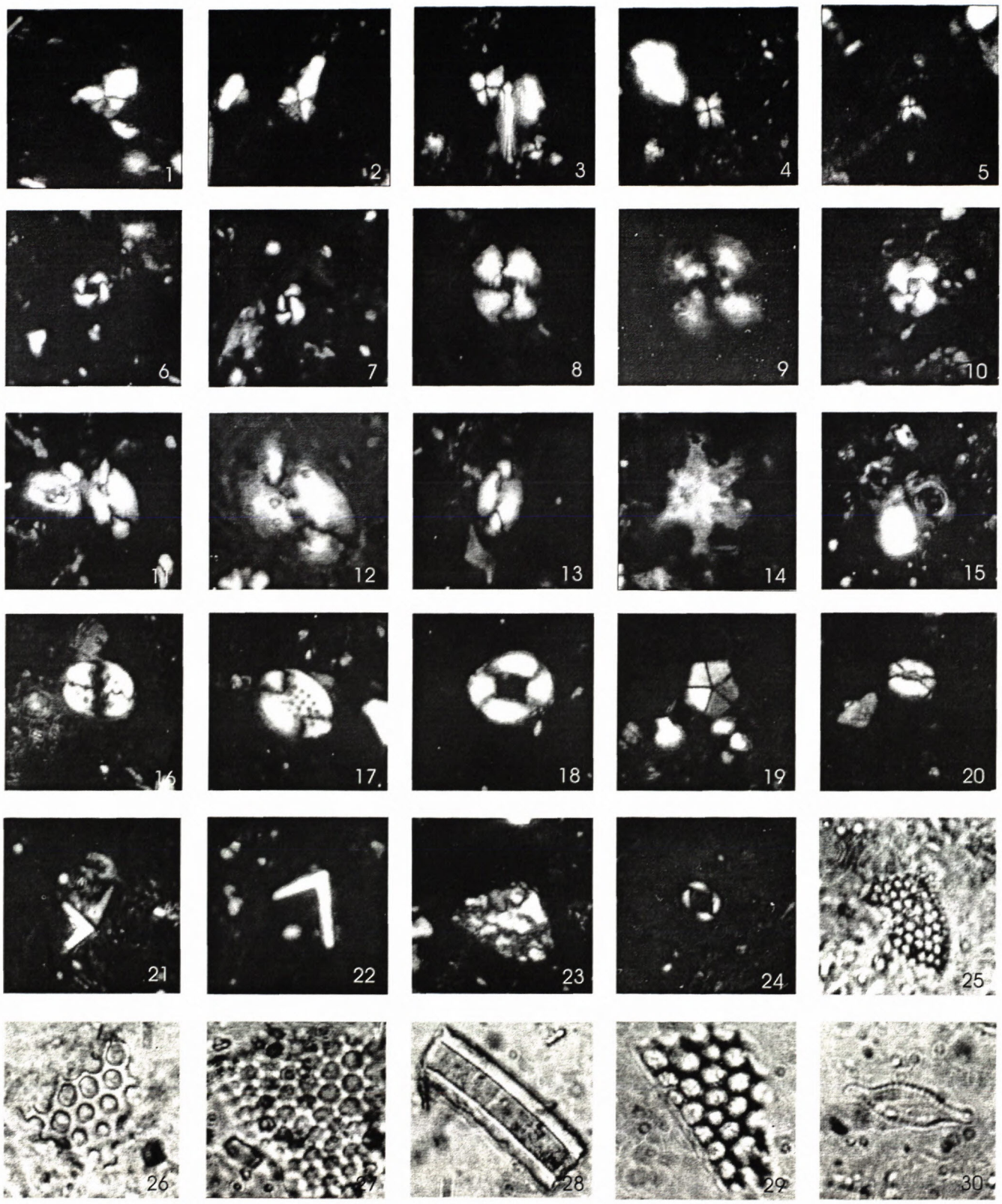

PHOTOTABLE IV

1 – 3 *Sphenolithus heteromorphus* DEFLANDRE, 250.5 – 250.6 m; 4 – *Sphenolithus abies* DEFLANDRE, 250.5 – 250.6 m; 5 – *Sphenolithus moriformis* (BRÖNNIMANN & STRADNER), 250.5 – 250.6 m; 6 – 7 *Reticulofenestra pseudoumbilicus* (GARTNER) GARTNER, 250.5 – 250.6m; 8 – 10 *Cyclicargolithus floridanus* (ROTH & HAY) BUKRY, 250.5 – 250.6 m;,154.6 — 154.7m; 11 – *Helicosphaera waltrans* THEODORIDIS, 250.5 – 250.6 m; 12 – *Helicosphaera* cf. *waltrans* THEODORIDIS, 154.6 – 154.7 m; 13 – *Helicosphaera carteri* (WALLICH) KAMPTNER, 457.5 – 457.6 m; 14 – *Discoaster* sp., 154.6 – 154.7 m; 15 – *Umbilicosphaera rotula* (KAMPTNER) VAROL, 250.5-250.6 m; 16 – *Pontosphaera enormis* (LOCKER) PERCH-NIELSEN, 250.5 –250.6 m; 17 – *Pontosphaera multipora* KAMPTNER (ROTH), 250.5 – 250.6 m; 18 – *Pontosphaera latelliptica* (BÁLDI-BÉKE) PERCH-NIELSEN, 250.5 –250.6 m; 19 – *Braarudosphaera bigelowii* (GRAN & BRAARUD) DEFLANDRE, 250.5 – 250.6 m; 20 – *Lanternithus minutus* STRADNER, 250.5 – 250.6 m; 21 – *Micrantholithus vesper* DEFLANDRE 250,5 – 250.6 m; 22 – *Micrantholithus flos* DEFLANDRE (GRAN & BRAARUD) DEFLANDRE, 250.5-250.6 m; 23 – ?*Litostromation perdurum* DEFLANDRE, 250.5 – 250.6 m; 24 *Syracosphaera pulchra* LOHMANN, 250.5 – 250.6m; 25 – 30 diatom, 154.6 –154.7 m; 30 *Fragilaria construens* (Ehrenberg) Grün. Photo by : E. Halásová; Photo n. 25, 26, 27, 28, 29, 30 magnification 1500x ; the rest magnification 1900x

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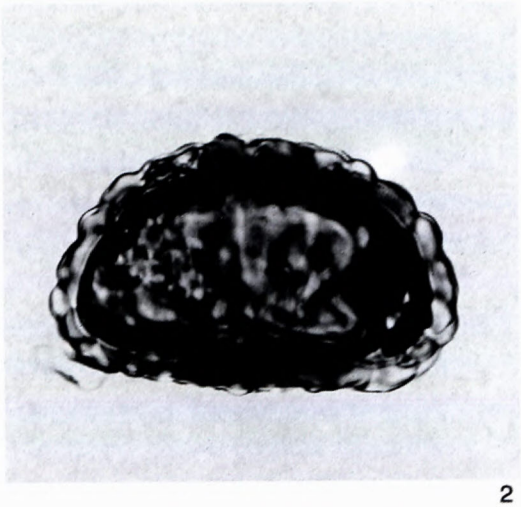

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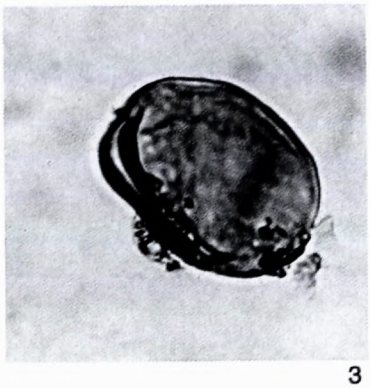

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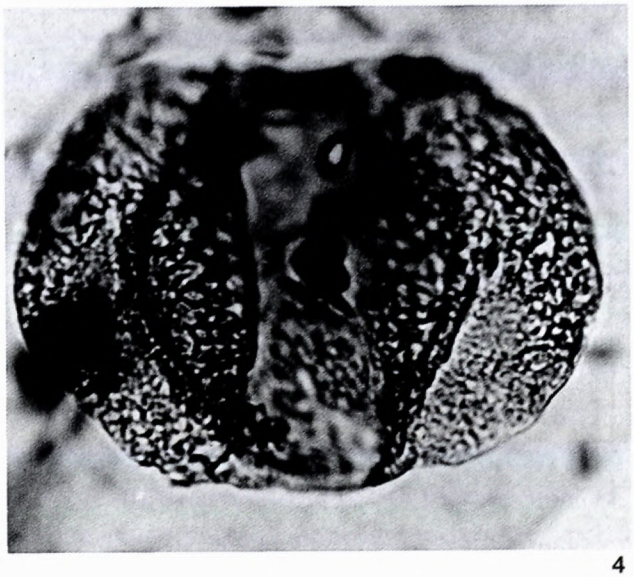

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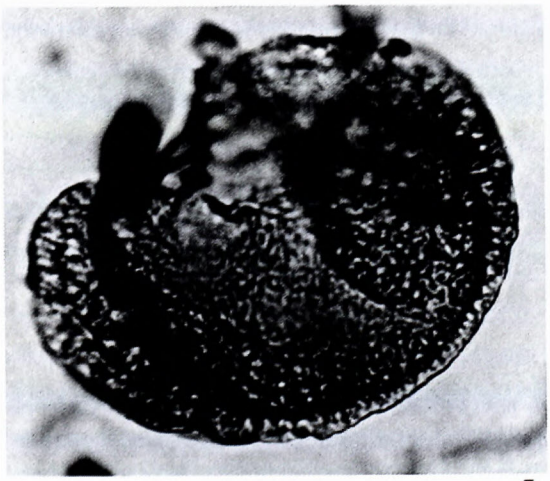

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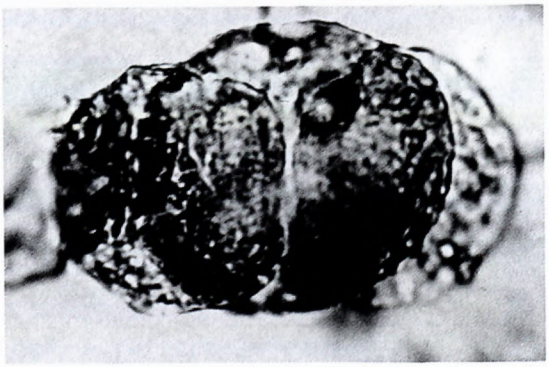

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PHOTOTABLE V

1 – *Leiotriletes* sp., 650.9 m; 2 – Polypodiaceae, 650.9 m; 3 – *Laevigasporites* sp., 451.5 m; 4 – *Pinuspollenites* type haploxylon, 154.5 m; 5 – *Cedrus* sp. 154.5 m; 6 – *Pinus* type *sylvestris*., 550.2 m,


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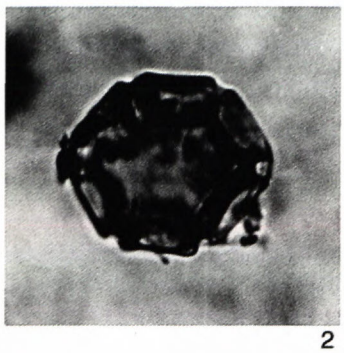
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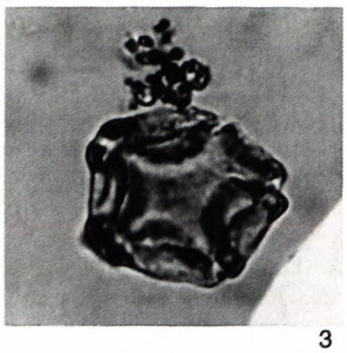
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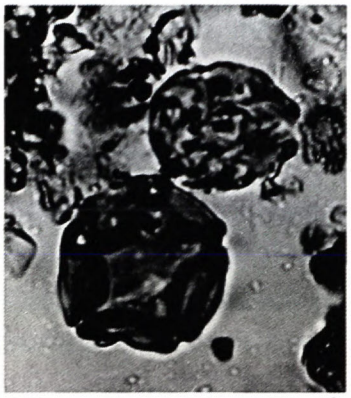
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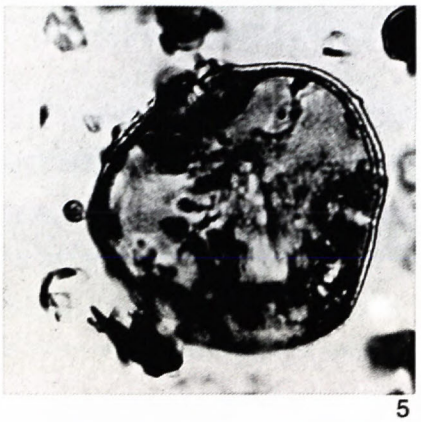
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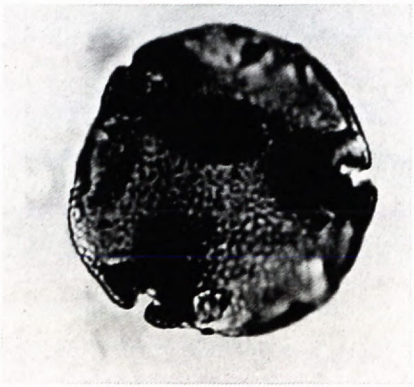
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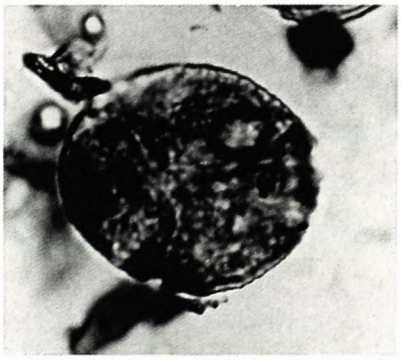
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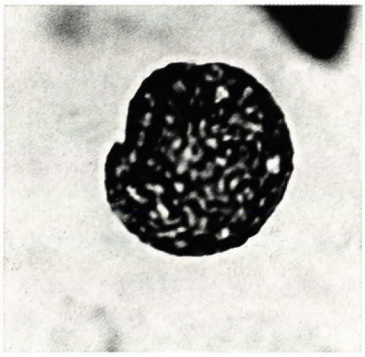
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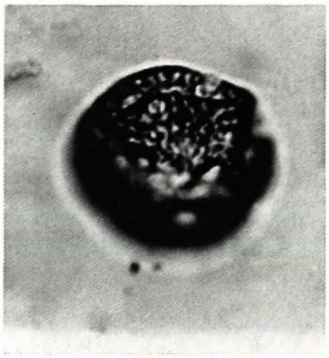
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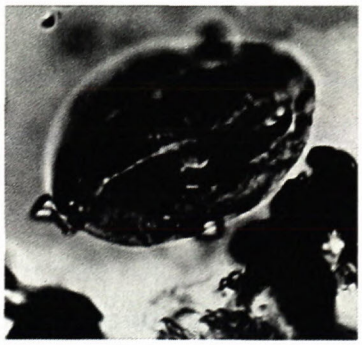
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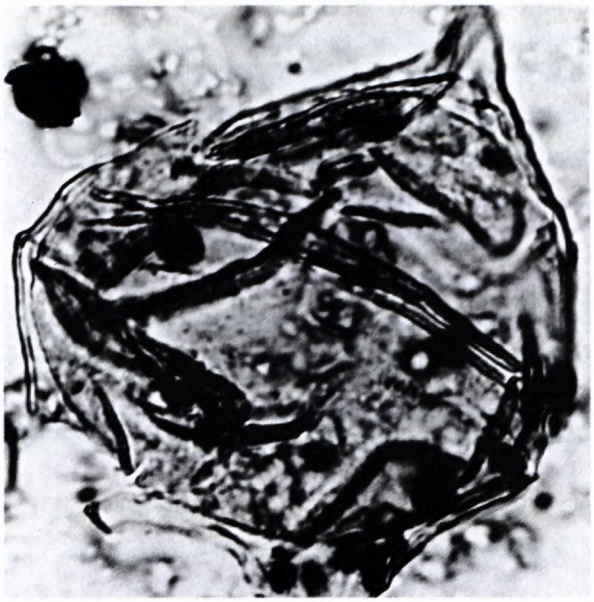
PHOTOTABLE VI

1 – *Pterocarya* type, 154.5 m; 2 – *Alnus* sp., 154.5 m; 3 – *Alnus* sp., 650.9 m; 4 – *Alnus* sp., 154.5 m; 5 – *Tilia* sp., 353.9 m; 6 – *Tilia* sp., 451.5 m; 7 – *Fagus* sp, 353.9 m; 8 – *Ulmus* sp., 451.5 m; 9 – *Liquidambar* type, 650.9 m; 10 – *Rhoipites* sp. 353.9 m; 11 – *Castanea* type, 650.9 m; 12 – *Castanea* type, 550.2 m..



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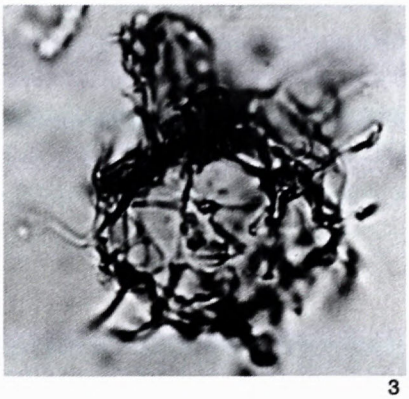
2



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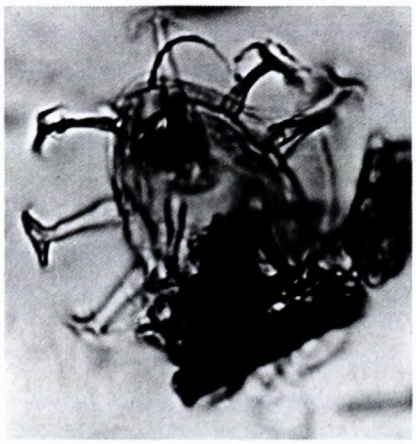

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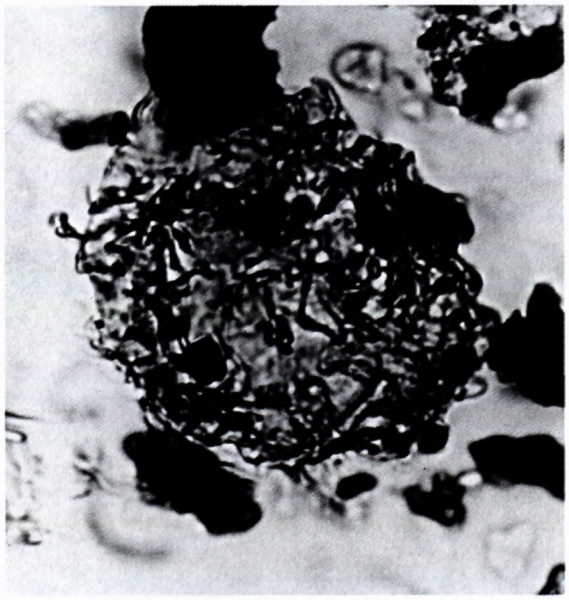

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FOTOTABLE VII

1 – *Defrandrea spinulosa* (redepozit), 154.1 m; 2 – *Spiriferites* cf. *bentori*, 353.9 m; 3 – *Achomospaera* sp., 154.5 m; 4 – *Distatodinium* sp., 550.2 m; 5 – *Cyclonephelium* cf. *vicinum* s EATON (redepozit), 353.9 m.

Photo by: M. Slamková; Magnification: 1000 x