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MICROPALAEONTOLOGICAL TAPHOCOENOSES OF THE MIOCENE POZNAŃ FORMATION (KONIN AREA, CENTRAL POLAND)

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Abstract. Palynological and microfaunistic studies on Kazimierz open-pit and BK-110 borehole (Konin area) were carried out. The organic and inorganic components of the assemblage were subject to two independent analytical methods, obligatory in palynological and microfaunistic investigations. Comparison of composition and succession of both organic and selected petrographic components allowed identification of the paleoenvironment as well as distinguishing five developmental phases in the Poznań Formation in the studied area. The presented phases of evolution of the Poznań Formation basin, in the Konin area are connected with changing hydrodynamic conditions. It reflects water level oscillation and is recorded in the facies succession as swamps through lakes and brackish lagoons and returning to open lake again.

■ micropaleontology, microflora, microfauna, taphonomy, Poznań Formation basin, Middle Miocene. Polish Lowlands.

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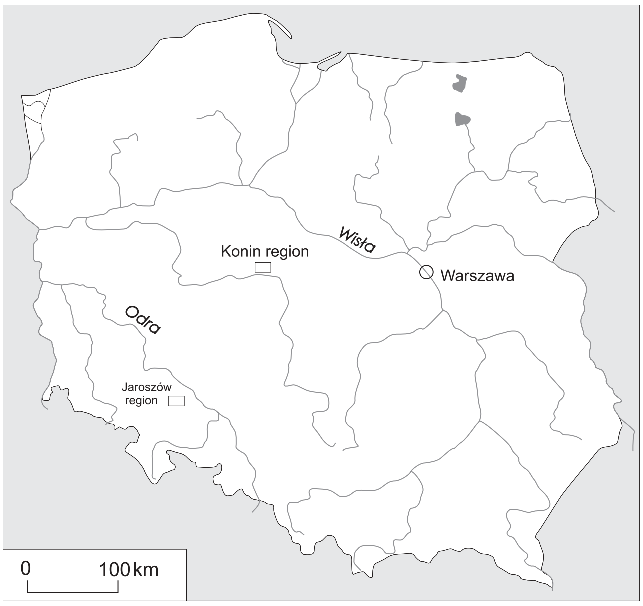
Introduction

The latest, multidisciplinary (litho-, bio- stratigraphic and biofacial) geological studies of the Poznań Formation, carried out in two areas: the Konin area in central Poland and the Jaroszów region of south-western Poland (Text-fig. 1), allowed precise calculation of the deposits' age and their depostional history (Piwocki 2001, Słodkowska 2001, 2002; Paruch-Kulczycka 2001, Paruch-Kulczycka and Giel 2002; Czapowski and Kasiński 2002; Kasiński et al. 2002).

The palynological and microfaunistic studies enabled taphonomy analysis in two sites: the “Kazimierz” open-pit and the BK-110 borehole, both located in the first studied area (Text-fig. 1). Analyzed deposits are represented by clay, lignite-clayey and sandy series (Text-fig. 2) and belong to three lithofacial members: the Grey Clays Member, the Green Clays Member, and the Flamy Clays Member (Piwocki 1998, Ziembińska-Tworzydło 1998).

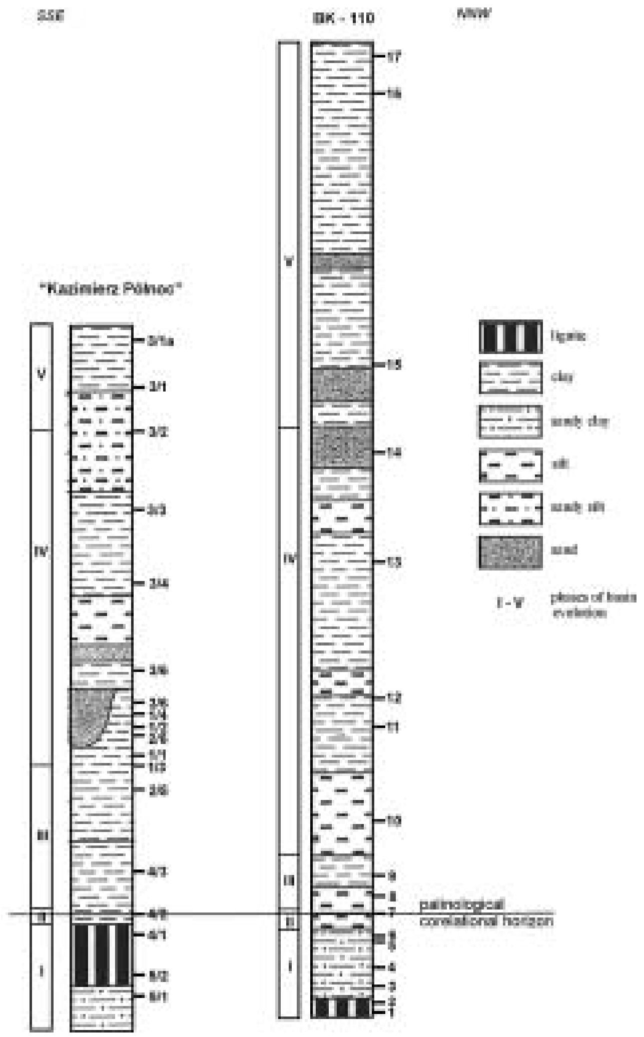
This paper presents the results of detailed taphonomy studies using two independent palynological and microfaunistic methods. Comparison of composition and succession of both organic and selected petrographic components allowed us to define the paleoenvironment, as well as to distinguish five developmental phases of the Poznań Formation in the studied area.



Text-fig. 1. Map of the study area locality.

Methods and material

Studies of taphocoenoses were based on analysis of preserved organic components in rocks. To obtain the most complete record of organic components in the assemblage,



Text-fig. 2. Lithologic profiles from "Kazimierz" open-pit and BK-110 borehole.

two independent analytical methods were applied, obligatory in palynological and microfaunistic investigations.

The analyzed material was gathered from two sites, located in the Konin area: the "Kazimierz" open-pit (18 palynological samples and 12 microfaunistic samples) and BK-110 borehole (17 palynological samples and 10 microfaunistic samples) (Text-fig. 2). The samples were divided into two parts: the first was subjected to the standard palynological preparation and the second one to the micropalaeontological procedure (Text-fig. 3).

Standard methods of palynological maceration after Fegri and Iversen (1978) were applied. Acetolyses according to Erdtman (1954) was the last stage of maceration. The palynological residuum was later analyzed under a biological microscope. The percentage contents of defined palynomorphs are listed in Tables 1 and 2.

During microfaunistical maceration, a rock sample was mechanically disintegrated and washed with running water through sieves with mesh diameters of 0.06 – 1.5 mm. The obtained residuum was then dried. Microfauna, floristic debris and mineral components (Text-fig. 4) were than separated under a stereomicroscope. Due to different sample sizes, the results of quantitative analysis present the estimated content of individual components compared to a whole sample residuum. Tables 3 and 4 contain the results of quantitative and qualitative analyses for the studied sites.

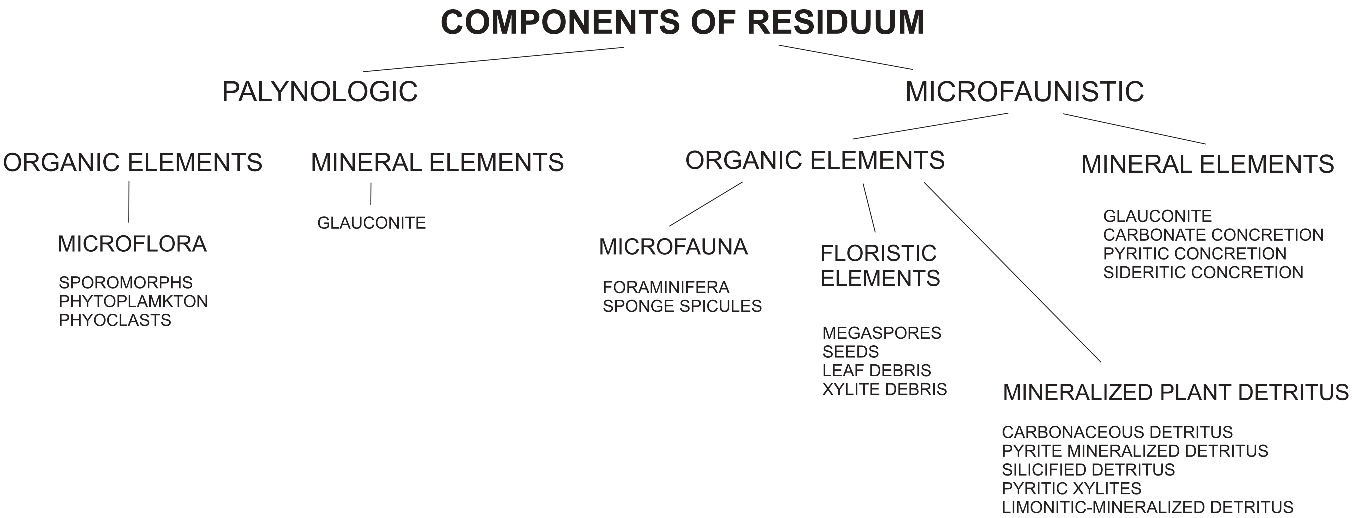
Applied palynological and micropaleontological methods allowed an examination of all sediment fractions in the range of 10 mm to 3 mm, significantly enlarging the standard spectrum of components analyzed with only one method.

This paper is supplemented by documentation/description of selected components.

ROCK

STANDARD PALYNOLOGICAL PREPARATION	STANDARD MICROPALAEONTOLOGICAL PREPARATION
KOH, HCl	**MECHANIC DISINTEGRATE**
DENSITY SEPARATION (CdJ_2 + KJ)	**RUNING WATER WASHED**
ACETOLIZE	
RESIDUUM	**RESIDUUM**
Fraction of residuum 10 – 200 µm	**Fraction of residuum 0,06 – 3 mm**
PALYNOLOGICAL SLIDE	**MICROPALAEONTOLOGICAL SLIDE**
LIGHT TRANSMISSION BIOLOGICAL MICROSCOPE	**REFLECTED LIGHT STEREOMICROSCOPE**

Text-fig. 3. Sample preparation methods.



Text-fig. 4. Components of the studied residuum.

Results

The applied interpretation method for palynological and micropaleontological data enabled analysis of the following organic components: sporomorphs, phytoplankton, phytoclasts, other floristic elements and mineralized plant detritus, as well as foraminifera, sponge spicules and some inorganic elements (glauconite grains and several types of concretions). The assemblage of palynological remains, defined in the site "Kazimierz" and in the BK-110 borehole are listed in Tables 1 and 2, the micropaleontological details are in Tables 3 and 4. Variable composition of the studied associations and varied succession of the individual components allowed the distinguishing of five developmental phases of the Poznań Formation in the Konin area (Tables 5 and 6).

The studied taphonomic spectra were dominated during the I, II and III phases by palynological and other floristic elements. During the IVth phase, microfauna and mineral elements prevailed. The Vth phase was characterized by freshwater phytoplankton and mineralized plant detritus.

Comparison and interpretation of the complex results of taphonomic, palynological and microfaunistic studies are illustrated in Text-fig. 5. Also presented are the final chrono- and lithostratygraphic correlations of phases in sedimentary evolution of the Poznań Formation.

Chronostratigraphy			Lithostratigraphy (Piwocki, 1998)		Lignite Seams	Litology	Pollen zones- -Climatic phases (Ziembińska-Tworzydło, 1998)	Konin region profiles	Phases of basin evolution, facies
PLIOCENE	LOWER	DACIAN	GOZDNICA FORMATION			sand, gravel	XIII Sequoiapollenites		
MIOCENE	UPPER	PONTIAN	POZNAŃ FORMATION	Flamy Clays Mb.		flame in color clay	XII Carpinipites-Juglandaceae		
		PANONNIAN		Green Clays Mb.	0	clay, silt and lignite rare	XI Betulaepollenites-Cyperaceaepollis		V open lake
	MIDDLE	SARMATIAN				grey clay and silt rare,	X Nyssapollenites		IV brackish-lagoon
				Grey Clays Mb.	IA	clay, silt, lignite	IX Tricolporopollenites pseudocingulum		III open lake II redeposition I marsh
		BADENIAN		I Middle Polish Lignite Seam	I	lignite	VIII Celtipollenities verus		

Text-fig. 5. Profiles of the Konin region with the backgroundstratigraphy of the upper part of the Neogene in the Polish Lowlands.

Table 1. Occurrence of palynomorphs and palynoclasts in "Kazimierz-Północ" outcrop.

Taxon/Locality/Sample number	3/1a	3/5	2/5	4/3	4/2	4/1	5/2	5/1
Spores								
Cingulisporis corrutoratus					0,4			
Corrugatispotites					0,4			
Laevigatosporites haardti					4,8	7,6	5,6	3,6
Leiotriletes							1,4	
Neogenisporis					0,7			
Osmundacidites					1,5	1,1		1,5
Stereisporites minor								0,9
Stereisporites stereoides						0,8		
Undulatisporis					0,4			
Gymnosperms								
Abiespollenites							1,4	0,6
cf. *Cupressacites*			+					
Cupressacites bockwitzensis					0,4			
Ephedripites						0,3		
Inaperturopollenites dubius					1,1	0,5	5,6	0,9
Inaperturopollenites hiatus						0,3	4,2	0,6
Laricipollenites								0,3
Pinuspollenites		+	+		24,9	30,5	30,6	19,8
Sciadopityspollenites								0,9
Sequoiapollenites					0,7	1,1		1,2
Tsugaepollenites gracilis					0,7	0,3		
Tsugaepollenites igniculus					0,4			
Tsugaepollenites maximus								0,6
Tsugaepollenites spinosus						0,3		0,3
Angiosperms								
Alnipollenites	+							
Alnipollenites verus					11,5	1,4	4,2	3,6
Araliaceoipollenites edmundi						1,9		0,9
Artemisiaepollenites					0,7			
Betulaepollenites betuloides					6,3	1,1	2,8	3,0
Carpinipites						1,9	1,4	2,4
Caprifoliipites								0,3
Caryapollenites simplex					1,1	0,8		0,9
Celtipollenites verus					0,7			0,3
Corylopollis coryloides						0,3	1,4	
Cyperaceaepollis			+					
Diospyrospollenites ovalis								0,3
Engelhardtioipollenites punctatus						0,3		
Ericipites callidus					0,4			
Ericipites ericius					4,8	1,9	4,2	1,2
Ericipites roboreus								0,3
Eucommioipollenites						0,5		
Faguspollenites					4,5	1,4	12,5	18,9
Fraxinipollenites						0,5		
Graminidites					0,7		1,4	
Ilexpollenites margaritatus					0,4	8,7		
Ilexpollenites propoinquus						2,7		
Ilexpollenitess iliacus					1,5	2,7		
Intatriporopollenites insculptus					1,1			
Intatriporopollenites instructus						2,2		0,6
Iteapollis angustiporatus								2,7
Liquidambarpollenites stigmosus					2,6	2,2	2,8	3,3
Liriodendroipollis verrucatus						0,3		
Myricipites								0,9
Myricipites bituitus						1,1		
Myricipites microcoryphaeus						0,8		
Myricipites myricoides					0,4			
Nupharipollenites					0,4			
Nyssapollenites					17,5		1,4	3,9
Nyssapollenites contortus						4,9		
Nyssapollenites rodderensis						6,5		
Pterocaryapollenites					1,5	1,4		4,5
Quercoidites					3,0			5,7
Quercoidites henrici						0,8		
Salixipollenites			+				1,4	
Symplocoipollenites latiporis						2,2		
Symplocoipollenites vestibulum						3,0		

Tricolporopollenites		+						
Tricolporopollenites cf. *Aesculus*					0,4			
Tricolporopollenites exactus						0,8		0,9
Tricolporopollenites fallax						0,5		0,6
Tricolporopollenites liblarensis					0,4	0,5		0,9
Tricolporopollenites cf. *Mangifera*					0,4			
Tricolporopollenites megaexactus						0,8		0,6
Tricolporopollenites pseudocingulum					0,7	1,1		
Tricolporopollenites satzveyensis								0,3
Ulmipollenites undulosus					2,6	1,9	18,1	11,7
Normapolles								
Trudopollis					+			
fragments			+		+			
Fitoplankton								
Crassasphaera					+			
Diagonallites						+		
cf. *Leiosphaeridia*					+			
Sigmopollis pseudosetarius			+		+			
Phytoclasts								
brown wood	++	+	+	+	++	++	+	+++
black wood	+++	+	++			++		++
cuticules			+	+		+	++	+++
tissue	+		++				+	
Mineral elements								
glauconite grains		+			+			

Table 2. Occurrence of palynomorphs and palynoclasts in BK-110 borehole.

Taxon/dept	36,9	37,6	43,3	46,41	48,6	56,95	57,3	57,9	58,1	58,7	59,2	59,7	58,9
Sample number	17	16	15	14	13	8	7	6	5	4	3	2	1
Spores													
Cicatricosisporites dorogensis							0,2						
Cingulisporis							0,2						
Favoisporites trifavus						0,3	1,5	4,2	1,4	6,9	0,4		
Gleicheniidites							0,4						
Laevigatosporites haardti					1,8	9,3	4,7	5,2	6,8	4,1	4,2		
Leiotriletes wolfii							0,2						
Lycopodiaceaesporis (Retitriletes)						0,3							
Lycopodiaceaesporis							0,2						
Neogenisporis neogenicus							0,4						
Osmundacidites				+		0,6							
Osmundacidites primarius								0,7	2,1	1,3	0,4		
Selaginellisporus echinoides						0,3	0,2						
Stereisporites												+	
Stereisporites cyclus							0,2				1,1		
Stereisporites involutus						0,3					1,1		
Stereisporites minor						0,3			0,7		3,0		
Stereisporites stereoides				+					1,1				
Toroisporites							0,4						
Gymnosperms													
Abiespollenites						1,5	0,2						
Cupressacites bockwitzensis								0,7					
Inaperturopollenites dubius						2,4	1,3	0,7	1,1	0,9	1,5		
Inaperturopollenites hiatus						0,6		1,2	0,7	0,9		+	
Piceapollis							0,4		0,4				
Pinuspollenites	+	+	+	+	39,3	22,8	19,8	22,5	23,6	27,2	28,8	+	+
Pinuspollenites alatus						2,7	1,1						

Sciadopityspollenites					1,8		0,4			1,3	0,8		
Sequoiapollenites								0,7	1,1	0,6	0,8	+	
Tsugaepollenites gracilis								1,0	1,4	0,6	0,8		
Tsugaepollenites maximus							0,9			0,3	0,4		
Angiosperms													
Alnipollenites				+									
Alnipollenites verus					7,1	6,6	6,5	3,0	8,2	3,8	4,5	+	
Araliaceoipollenites edmundi						0,6	1,3	0,7		0,6	2,7		
Arecipites butomoides							0,2	0,2		0,3			
Artemisiaepollenites			+	+	8,9	2,1	0,9	0,5			0,4		
Betulaepollenites betuloides					10,7	0,9	1,9		2,9	1,9	1,9	+	+
Caprifoliipites							0,4	0,2		0,3			
Carpinipites							0,9			0,9		+	
Caryapollenites simplex						1,2	2,6	0,7		0,9			
Caryophyllidites				+			0,2						
Celtipollenites verus						1,8				0,3			
Chenopodipollis					3,6			0,2					
Cichoraecidites gracilis				+	1,8								
Corsinipollenites						0,6	0,2						
Corylopollis coryloides							0,4				0,4		
Diervillapollenites spinosus						0,6	0,4						
cf. *Emmapollis*						0,3							
Engelhardtioipollenites punctatus								0,2					
Ericipites ericius					1,8	3,9	3,0	2,2	2,5	2,2	4,9	+	+
Ericipites roboreus										0,6			
Eucommioipollenites eucommius							0,2						
Eucommioipollenites parmularius								0,2	0,4	0,3			
Faguspollenites			+	+	3,6	7,2	5,6	4,0	3,6	3,4	4,9	+	+
Fraxinipollenites							1,1	0,5	0,7	0,9	0,4		
Graminidites				+	3,6	1,8							
Graminidites bambusoides							0,2						
Ilexpollenites iliacus							1,9		5,4	1,9	3,4		
Ilexpollenites margaritatus						1,2		2,0		1,9	3,0	+	
Ilexpollenites propoinquus							0,9	1,0		1,6	1,1		
Intatriporopollenites instructus						5,7	4,5		2,9	1,9	0,8		
Iteapollis angustiporatus								5,4	2,9		0,4		
Liquidambarpollenites orientaliformis										0,9			
Liquidambarpollenites stigmosus				+		1,2	1,1	3,5	5,7	7,2	1,5	+	
Lonicerapollis							0,2						
Myricipites bituitus							0,9			0,3			
Myricipites microcoryphaeus							0,2						
Myricipites rurensis											0,8		
Nyssapollenites				+		5,7	10,3	16,6	7,5	7,2	8,3	+	+
Nyssapollenites contortus						3,6	3,4	2,2					
Nyssapollenites rodderensis						4,8	3,2			2,2	1,5		
Persicarioipollis							0,6						
Pterocaryapollenites						2,7	1,7	0,7	2,1	0,6	2,3		
Quercoidites					10,7	1,8	5,8	6,7	5,7	2,2	3,0		+
Quercoidites cf. microhenrici										0,3	0,4		
Reevesiapollis triangulus							0,2	0,2	0,4	0,3			
Sparganiaceaepollenites polygonalis						1,2							
Spinulaepollis arceuthobioides								0,5		1,6	1,1		+
Symplocoipollenites											0,4		
Tricolporopollenites cf. *Corylopsis*						0,3	0,6	0,5	0,4				

Tricolporopollenites cf. *Corylopsis*						0,3	0,6	0,5	0,4				
Tricolporopollenites dolium					1,8								
Tricolporopollenites exactus				+		0,6	0,9	5,7	1,1	1,6	1,5	+	
Tricolporopollenites fallax							0,2	1,2	1,4	0,9	0,4		
Tricolporopollenites liblarensis								0,7	1,1	1,6	1,1		
Tricolporopollenites megaexactus					1,8			0,7	1,8				+
Tricolporopollenites pseudocingulum							0,6	0,5		1,6	1,5	+	
Tricolporopollenites cf. *Resedaceae*											0,4		
Tubulifloridites					1,8								
Ulmipollenites undulosus				+		2,4	3,4	1,7	3,2	3,8	3,8	+	
Umbelliferoipollenites							0,2						
Normapolles													
cf. *Basopollis*							+						
Semioculopollis							+						
fragments							+						
Phytoplankton													
Crassosphaera	+						+						
Leiosphaeridia	++						+						
Ovoidites ligneolus	+						+		+	+			
Sigmopollis													
Sigmopollis pseudosetarius	+					+	+					+	
Stigmozygoidites						+		+	+				
Tetrapidites								+					
marine undivided	+						+						
freshwater undivided						+						+	
Phytoclasts													
brown wood				+	+	+	++	++	++	++	++	+++	+++
black wood	+			+	+	+	++	++	++	++	++		++
cuticules						+	++	++	+			+++	+++
tissue												+++	+++

Table 3. Participation of organic and mineral components in micropaleontologic analyses from "Kazimierz-Północ" outcrop.

No. sample microfauna	Microfauna					Floristic elements				Mineral elements				
	Foraminifera		Sponge spicules			Mineralized plant debris								
	Lobatula lobatula	*Spirilina* sp.	monaxon	rhax	rhizoclon	Pyrite-mineralized xylites	Carbonaceous detritus	Pyritic mineralized detritus	Limonitic-mineralized detritus	Glauconite	Quartz	Sideritic concretion	Carbonate concretion	Pyritic concretion
1									**A**		**F**	**F**		
2	**S**								**A**	**S**	**S**	**A**		
3											**S**	**F**		**F**
4			**S**	**S**	**S**					**S**	**A**	**S**		**S**
5									**S**		**F**	**A**		
6		**S**	**S**	**S**	**S**					**S**	**A**			**S**
7		**S**	**S**		**S**					**S**	**A**	**S**		**S**
8		**S**	**S**	**S**	**S**						**F**	**F**		
9		**S**		**S**	**S**				**S**		**F**	**S**		**S**
10											**A**	**S**		
11												**F**	**A**	**F**
12						**F**	**F**	**S**			**S**			**S**

Explanation to the table 3: S – single, F – frequent, A – abundant.

Table 4. Participation of organic and mineral components in micropaleontologic analyses from BK-110 borehole.

No. sample microfauna	Microfauna				Floristic elements					Mineralized plant debris						Mineral elements				
	Foram	Sponge spicules			Megaspores			Seads	Leaves											
	Glomospira sp.	monaxon	rhaxon	rhizoclon	*Azolla nikitinii*	*Azolla pseudopinata*	*Selaginella selaginoides*	*Typha* sp.	Leaf debris	Carbonaceous xylite	Pyrite-mineralized xylites	Pyrite-mineralized detritus	Silificated detritus	Carbonaceous detritus	Limonitic-mineralized detritus	Quartz	Glauconite	Carbonate-sideritic concretion	Sideritic concretion	Pyritic concretion
1									**S**				**S**		**S**	**F**	**S**			
2		**S**											**S**		**S**	**F**	**S**		**A**	
3		**S**	**S**	**S**															**A**	
4		**S**	**S**	**S**												**A**	**F**	**A**		
5	**S**	**S**		**S**												**A**	**S**			
6																**F**				**A**
7					**F**	**F**	**S**	**S**						**F**						**F**
8														**F**						**F**
9										**A**	**S**	**S**		**A**		**S**				**S**
10										**A**	**S**	**S**		**A**		**S**				**S**

Explanation to the table 4: S – single, F – frequent, A – abundant.

Table 5. Organic and mineral components in the Poznań Formation from the "Kazimierz" open-pit.

No. sapmle palynology	No. sample microfauna	Microfauna		Microflora				Mineralized plant detritus				Mineral elements				Phases of basin evolution
		Foraminifera	Sponge spicules	Sporomorphs	Freshwater phytoplankton	Phytoclasts	Xylites	Pyritic xylites	Carbonaceous detritus	Pyrite mineralized detritus	Limonitic-mineralized detritus	Glauconite	Carbonate concretion	Sideritic concretion	Pyritic concretion	
3/1a					+	++										**V**
3/1	**1**										++			+		
3/2	**2**	+									++	+				**IV**
3/3	**3**													++	+	
3/4	**4**		+									+		+	+	
3/5	**5**					+					+			++		
3/6	**6**	+	+									+			+	
1/2	**7**	+	+									+		+	+	
2/6	**8**	+	+											+		
1/1	**9**	+	+								+				+	
1/3	**10**													+		
2/5					++	+										**III**
4/3						+										
4/2	**11**			++	+	++						+	+	+	+	**II**
4/1	**12**			++	+	++	+	+	++	+	+				+	**I**
5/2				++		++										
5/1				++		++										

Table 6. Organic and mineral components in the Poznań Formation from the BK-110 borehole.

No. sapmle palynology	No. sample microfauna	Microfauna		Microflora					Mineralized plant detritus					Mineral elements			
		Foraminifera	Sponge spicules	Sporomorphs	Freshwater phytoplankton	Phytoclasts	Macrofloristic elements (megaspores, seeds, leaves)	Xylites	Pyritic xylites	Pyrite-mineralized detritus	Silificated detritus	Carbonaceous detritus	Limonitic-mineralized detritus	Glauconite	Carbonate-sideritic concretion	Sideritic concretion	Pyritic concretion
17					+												
16																	
15	**1**			+			+				+		+	_			
14	**2**		+	+		+					+		+	+		++	
13	**3**		+	+		+										++	
11	**4**		+											+	++		
10	**5**	+	+											+			
9	**6**																++
8	**7**			++	+	++	+					+					+
7	**8**			++	+	++						+					+
6	**9**			++	+	++		+	+	+		++					+
5	**10**			++	+	++		+	+	+		++					+
4				++	+	++											
3				++		++											
2				+	+	++											
1				+	+	++											

Explanation to the table 5 and 6: I – peat-bog phase, II – redeposition phase (correlation horizon), III – lake - high water level phase, IV – brackish phase - marine influences, V – lake - low water level phase, + – rare, ++ – abundant.

Discussion

Phases of the evolution of the Poznań Formation from the Konin area ("Kazimierz Północ" outcrop and BK-110 borehole)

Phase I (peat bog)

At the base of both the outcrop profile (palynological samples no 5/1, 5/2, 4/1 and 12 microfaunistic samples) and the borehole (palynological samples no 1 to 6 and microfaunistic samples; no 9 and 10, see Tables 5 and 6) occurred sediments genetically associated with lignite accumulation. The organic assemblage in phase I consists almost exclusively of organic plant matter: xylitic material of coniferous origin, carbonaceous debris as well as pollen and spores. The pollen assemblages are characterized by good preservation and high diversity (see Tables 1 and 2) and the most abundant elements are shown on Plates I and II. The type of sediment, state of preservation of specimens, and domination of shrubs and riparian communities in the pollen spectra indicate a slow accumulation of organic matter in a stagnating bog–basin. Similar pollen assemblages were recorded in other lignite basins (Słodkowska 1998). The clear differentiation of the xylite debris with respect to size, structure, shape and colour of particles is a characteristic feature of the floristic assemblage of phase I and indicated rich plant vegetation in the vicinity of the area. The diversification of xylite debris is due to the effect of various degrees of transformation during diageneses. The xylitic material was coalified and mineralized by iron hydroxides, pyrite or markasite. The xylite coexists with carbonaceous plant detritus and pyritic concretions.

The diverse pollen assemblages were used to reconstruct different plant communities characterized by the dominance of certain taxa. In the lignite sediments in all the studied profiles, assemblages of a riparian forest wet habitat have been recorded. The riparian forest was domininated by *Pterocarya, Liquidambar, Ulmus and Carya*. The swamp forest was dominated by *Nyssa, Alnus,* Taxodiaceae and ferns. *Pinus, Quercus, Fagus, Betula, Carpinus*, *Tilia,* Araliaceae, *Engelhardia,* and *Itea*, which are also present in the assemblages of this phase, probably originate from a mixed mesophytic forest. Components of shrubby peatbogs such as the Ericaceae*, Ilex* and *Myrica* are less common. All the organic elements of phase I indicate an intensive phytogenic accumulation (Pl. 3, fig. 1). However, high taxonomical diversity and plant content indicate humid conditions. The climatic conditions are assumed to have been wet and warm, favourable for the accumulation of coal forming swamps.

The pollen content allowed a palynostratigraphical correlation of the lower parts of the outcrop profile and the core (Text-fig. 2). The pollen assemblages are correlated with the IX pollen zone with *Tricolporopollenites pseudocingulum* (Piwocki, Ziembińska-Tworzydło 1995, 1997). According to a chronostratigraphical subdivision of Neogene for the Paratethys area, this interval can be correlated with the Late Badenian and Early Sarmatian (Text-fig. 5).

Phase II (redeposition – correlation horizon)

Phase II was recognised in the outcrop profile (palynological sample 4/2 and microfaunistic sample no 11) and the borehole (palynological sample 7 and microfaunistic sample 8, see tables 5 and 6), The palynomorphs were recorded in all lignite layers in sections of all profiles from Konin region. Some of them represent reworked Middle Miocene taxa, others are assigned to extinct pollen grains of the Normapolles group from the Late Cretaceous to Middle Eocene. Additionally, Paleogene and Cretaceous spores and single specimens of marine and brackish phytoplankton have been found there (Tables 1 and 2). Preservation of all these components confirms erosion and redeposition during the Middle Miocene uplift. The specimens are poorly preserved and they have traces of corrosion on their surfaces. Based on this data we tried to define a palynological correlation in the Konin area (Text-fig. 5). This type of redeposition also took place in other profiles in the Polish Lowlands from that time (Ważyńska 1977; Słodkowska 1996, 2002) and is probably a result of hinterland uplift and successive erosion. Therefore, we propose to define the redepostion horizon as a palynological correlation horizon for all profiles of the Middle Miocene Konin region. In micropaleontologic analysis only mineral elements such as pyrite, sidirite (Pl. 3, fig. 2), and carbonate concretions were recorded (Tables 3, 4; Pl. 4, fig. 1). Presence of these components testified to geochemical changes occurring in the sediment during the diagenetic processes.

Phase III (lake – high water level)

Phase III was identified within the overlying clay complex in the outcrop profile (palynological samples no 2/5 and 4/3) and the borehole (palynological samples no 8 and 9 and microfaunistic samples no 6 and 7, see Tables 5 and 6). From this part of the profile only single sporomorphs were preserved. The micropalaeontological remains consist of well preserved megaspores of *the* water ferns *Azolla nikitinii* DOROFEEV, *Azolla pseudopinata* NIKITIN (Pl. 4, fig. 3), megaspores of *Selaginella selaginoides* (LINNÉ) (Pl. 4, fig. 2) and seeds of *Typha* sp. (Pl. 4, fig. 4). The megaspores of *Azolla* have been described from the Poznań Formation (Łańcucka-Środoniowa 1956; Ziembińska-Tworzydło, Ważyńska 1981, Mai 2000). These plants are characteristic for the *Azolla - Trapa* phase and the XIII floristic zone of Mai (Odrzywolska-Bieńkowa et al. 1979). In the Polish Lowlands, they are correlated with the IX spore-pollen zone, which is assigned to the Upper Badenian and Early Sarmatian (Piwocki, Ziembińska-Tworzydło 1995, 1997). The presence of *Azolla* indicates the rise of the lake water level. The occurrence of megaspores of *Selaginella selaginoides* (LINNÉ) indicates a temperate climate.

Phase IV (brackish-marine influence)

Phase IV is characterised by clayey, silty and partly sandy lithofacies (the outcrop profile: palynological samples 1/3, 1/1, 2/6, 1/2, 3/6, 3/5, 3/4, 3/3, 3/2 and microfaunistic samples 2 to 10; the borehole: palynological samples 10 to14 and microfaunistic samples 2 to 5 , see Tables 5 and 6). The most important elements in this phase are marine components, such as foraminifera, sponge spicules and glauconite. Foraminifera are represented by three bentonic taxa: *Lobatula lobatula* (WALKER et JACOB) (Pl. 5, figs 1, 2), *Glomospira* sp. (Pl. 5, figs 5a, 5b) and *Spirilina* sp. (Pl. 5, figs 3, 4). The foraminifera identified in the profiles do not have any biostratigraphical significance. Genus *Glomospira* sp. and *Spirilina* sp. occurred in deeper parts of the shallow basin. *Lobatula lobatula* (WALKER et JACOB) easily adapts to environmental changes and is a commonly inhabiting plant of shallow basin bottoms. This species is accompanied by numerous mineralized fragments of plants, being probably remains of "subaqual meadows" in the studied profiles.

Foraminifera tests are well preserved, without rounding and infilled with different material. Foraminifera are confined only to this phase and always co-occur with other marine indicators such as sponge spicules (Pl. 5, fig. 6) and glauconite. Carbonate–sideric and sideric concretions occur in this phase (Pl. 5, fig. 7, Pl. 6, fig. 1). The co-existence of marine components suggests an authochtonous deposition of this assemblage. Small size and rare occurrences of foraminifera suggest unfavourable conditions, for instance, removal of marine foraminfera by storm waves into brackish lagoons or freshwater coastal lakes. The influence of the sea on the Poznań Formation was also recorded in the Konin area (Kasiński et al. 2002). The foraminifera were already described in brackish horizons of the Poznań Formation from the Polish Lowlands (Dyjor 1968; Łuczkowska, Dyjor 1971; Giel 1975, 1979a, 1979b; Paruch-Kulczycka, Giel 2002) and from the Lusatica region (Eastern Germany). The marine influence was observed in the same level of the Middle Miocene sediments XI-XIII macrofloristic zones (Mai 2000). In general, sporomorphs have not been recorded (or occurred singly) in phase IV.

Occurrences of quantities of siderite (Pl. 5, fig. 1), carbonate-siderite (Pl. 5, fig. 7) and pyrite concretions were recorded among the mineral components indicating diversity of geochemical processes during sedimentation.

Phase V (lake – low water level)

The clayey sediments of this phase occur in the outcrop profile (palynological samples 3/1, 3/1a and microfaunistic sample no 1) and the borehole (palynological samples 15 to 17 and microfaunistic sample 1, see Tables 5 and 6). The spotty-coloured clays consist of green, grey-greenish and bunter clays with yellow and ochre spots of iron hydroxides (Piwocki et al. 2001). In these clays sporomorphs are usually absent or they occur scarcely and they are stratigraphically insignificant. These types of deposits were observed in many areas of the Polish Lowlands. It is supposed, that during the deposition of the clayey Poznań Formation the lakeside of the basin was inhabited by plants. However, sedimentation processes, oxydation, diagenetic, erosional and periodic aridisation of the basin (Kasiński et al. 2002) resulted in the plant debris consisting of sporopollenin not being preserved. Freshwater phytoplankton and phytoclasts are recorded in this phase. Among organic components, fossilized plant debris predominated (Pl. 6, fig. 2). The limonitic-mineralized detritus confirms complicated geochemical processes in the basin.

Conclusions

The investigation of sediments of the Poznan Formation using palynological and microfaunistical methods provided a complementary database that significantly enhances its environmental and paleogeographic interpretation. Succession of microfloristic and microfaunistic elements indicate changes in paleoenvironmental conditions (Tables 5 and 6).

The development of the Poznań Formation based on the study of the Konin area represents five phases of basin evolution. The first (I) phase is characterised by the domination of peat-bog environment sedimentation with rich pollen and spore assemblages. At the end of this phase the reworked palynomorphs and older pollen and spores were observed. This fact argues for redeposition (phase II). Phase III indicates a successive rise of the water level leading to the establishment of open lake conditions. Megaspors and seeds predominated in the sediment, while palynological matter is less frequent. Phase IV evidences brackish- marine inflows due to the presence of marine elements (foraminifera, sponge spicules, glauconite etc.). These inflows, probably affected by storm surges, are indicated by scarce mixed marine microfauna (deep and shallow water microfauna) and small amounts of glauconite. The last phase (V) indicates interruption of the marine basin. Lacustrine conditions with low water level are dominant here.

The presented phases of evolution of the Poznań Formation Basin, in the Konin area are related to changes in hydrodynamic conditions. The phases reflect water level oscillation, which is recorded in the facies succession from swamps through lakes and brackish lagoons and returning to open lake again.

Recently detailed geochemical and isotopic studies have been carried out . They will help us understand the genesis of the facial changes in the basin. Pollen analysis allowed a palynostratigraphical correlation of the lower parts of the studied profiles (lignite sedimentation) and confirmed the Middle Miocene (Text-fig. 5) age of the formation. The pollen assemblages are correlated with the IX pollen zone, Tricolporopollenites pseudocingulum (Piwocki, Ziembińska-Tworzydło, 1995).

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PLATE 1

Sporomorphs assemblage of the *IX Tricolporopollenites pseudocingulum* zone from the Konin area (I and II phases), × 400

1. ***Tricolporopollenites exactus*** (POTONIÉ, 1931) GRABOWSKA 1994 – BK-110.
2. ***Spinulaepollis arceuthobioides*** KRUTZCH, 1962 – BK-110.
3. ***Alnipollenites verus*** POTONIÉ, 1931 – "Kazimierz" open-pit.
4. ***Iteapollis angustiporatus*** (SCHNEIDER, 1965) ZIEMBIŃSKA-TWORZYDŁO, 1994 – "Kazimierz" open-pit.
5. ***Nyssapollenites*** sp. - BK-110.
6. ***Betulaepollenites betuloides*** (PFLUG, 1953) NAGY, 1969 – "Kazimierz" open-pit.
7. ***Sequoiapollenites*** sp. **–** BK 110.
8. ***Favoisporites trifavus*** KRUTZSCH, 1959 – BK-110.
9. ***Osmundacidites*** sp. – BK-110.
10. ***Inaperturopollenites hiatus*** (POTONIÉ, 1931) THOMSON et PFLUG, 1953 – „Kazimierz" open-pit.
11. ***Ericipites ericius*** (POTONIÉ, 1931) POTONIÉ, 1960 – BK-110.
12. ***Chenopodipollis* sp. –** BK-110.

13, 18. ***Pterocaryapollenites*** sp**.** – BK-110.

14. ***Faguspollenites*** sp. – „Kazimierz" open-pit.

15, 16. ***Quercoidites*** sp. **–** BK-110.

17, 22, 26. ***Liquidambarpollenites stigmosus*** (POTONIÉ, 1931) RAATZ, 1937 – BK-110.
Tricolporopollenites marcodurensis THOMSON et PFLUG, 1953 – BK-110

20, 21. ***Tricolporopollenites pseudocingulum*** (POTONIÉ, 1931) THOMSON et PFLUG, 1953 – BK-110.

23. ***Caryapollenites simplex*** (POTONIÉ, 1931) RAATZ, 1937 **–** BK-110.

24, 25. ***Intratriporopollenites instructus*** (POTONIÉ, 1931) THOMSON et PFLUG, 1953 – BK-110.

27. ***Cathayapollis*** sp.– BK-110.

28, 31. (left specimen**)** ***Pinuspollenites*** sp. – "Kazimierz" open-pit.

29. ***Tsugaepollenites spinosus*** (DOKTOROWICZ-HREBNICKA, 1954) SŁODKOWSKA, 1994 – "Kazimierz" open-pit.

30. ***Abiespollenites*** sp. – BK-110.

31. (right specimen***)*** ***Tsugaepollenites gracilis*** **(**KRUTZSCH, 1971) NAGY, 1985 – "Kazimierz" open-pit.

PLATE 2

Palynologic matter of the *IX Tricolporopollenites pseudocingulum* zone from the Konin area (I and II phases), × 185

1. Black wood debris, spores, angiosperm pollen – BK-110.
2. Brown wood debris, black wood debris, angiosperm pollen, fungal hyphae – "Kazimierz" open-pit.
3. Brown wood debris, black wood debris, cuticules, spores – BK-110.
4. Brown wood debris, black wood debris, cuticules – "Kazimierz" open-pit.

PLATE 3

Organic components of the deposits (I and II phases)

1. Xylitic and other plant mineralized debris × 30, phase I, "Kazimierz" open-pit.
2. Sideritic concretion, × 60, phase II, "Kazimierz" open-pit.

PLATE 4

Organic and mineral components of the deposits (II and III phases)

1. Carbonate concretion, phase II, "Kazimierz" open-pit, × 80.
2. ***Selaginella selaginoides*** (Linné), megaspores, phase III, BK-110, × 80.
3. ***Azolla nikitini*** Dorofeev, megaspores, phase III, BK-110, × 80.
4. ***Typha*** sp., seed (tegmens), phase III, BK-110, × 50.

PLATE 5

Organic and mineral components of the deposits (IV phase)

1, 2. ***Lobatula lobatula*** (Walker et Jakob), phase IV, "Kazimierz" open-pit, × 150.

3, 4 ***Spirilina*** **sp.**, phase IV, "Kazimierz" open-pit, × 150.

5 a,b***Glomospira*** **sp.,** phase IV, BK-110, × 150.

6. Sponge spicules: rhax, rhizoclon, monaxon, phase IV BK-110, × 120.
7. Carbonate-sideritic concretion, phase IV, BK-110, × 80.

PLATE 6

Organic and mineral components of the deposits (IV and V phase)

1. Sideritic concretion, phase IV, BK-110, × 80.
2. Microfloristic element, leaf, phase V, BK-110, × 30.

PLATE 1

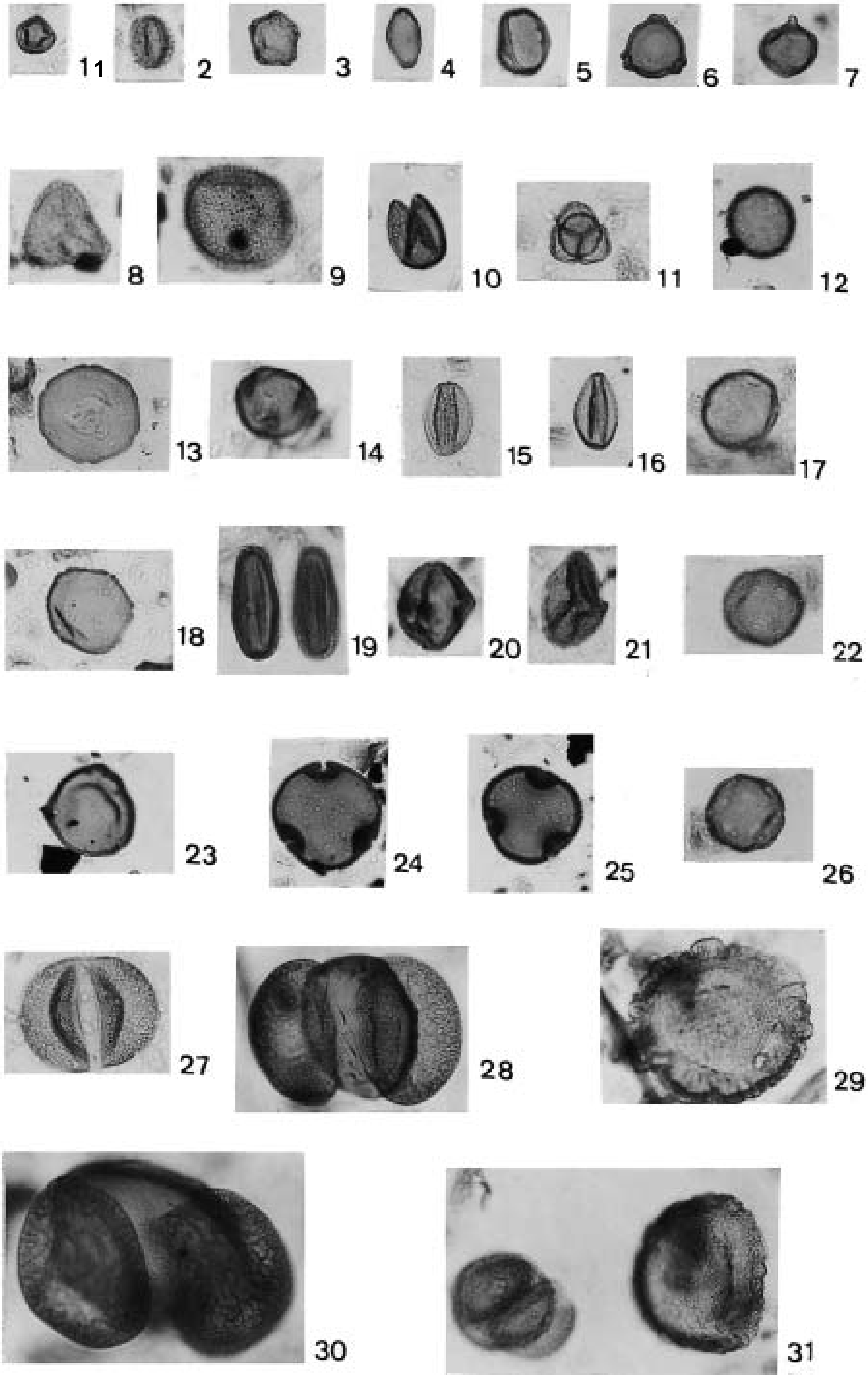
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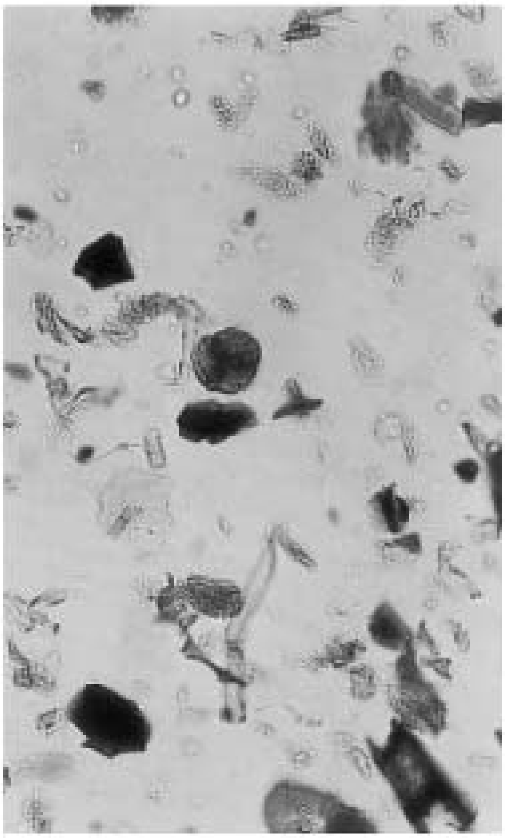
PLATE 2

1



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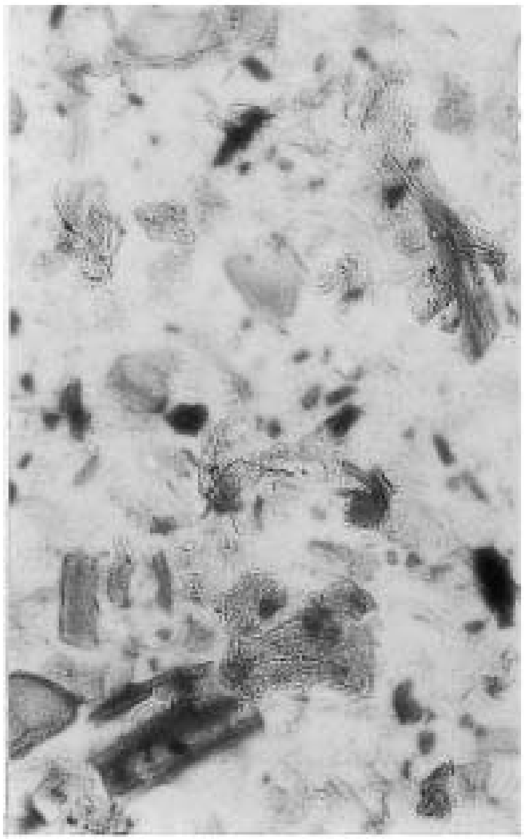

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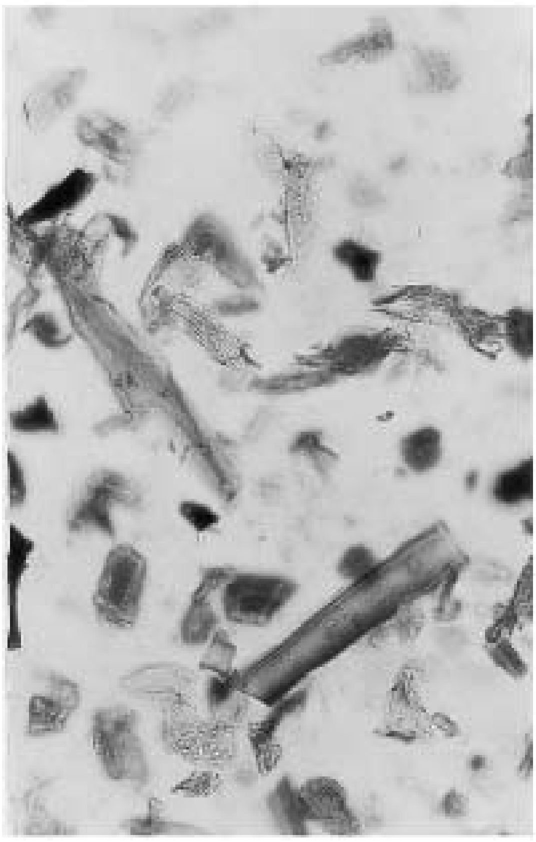

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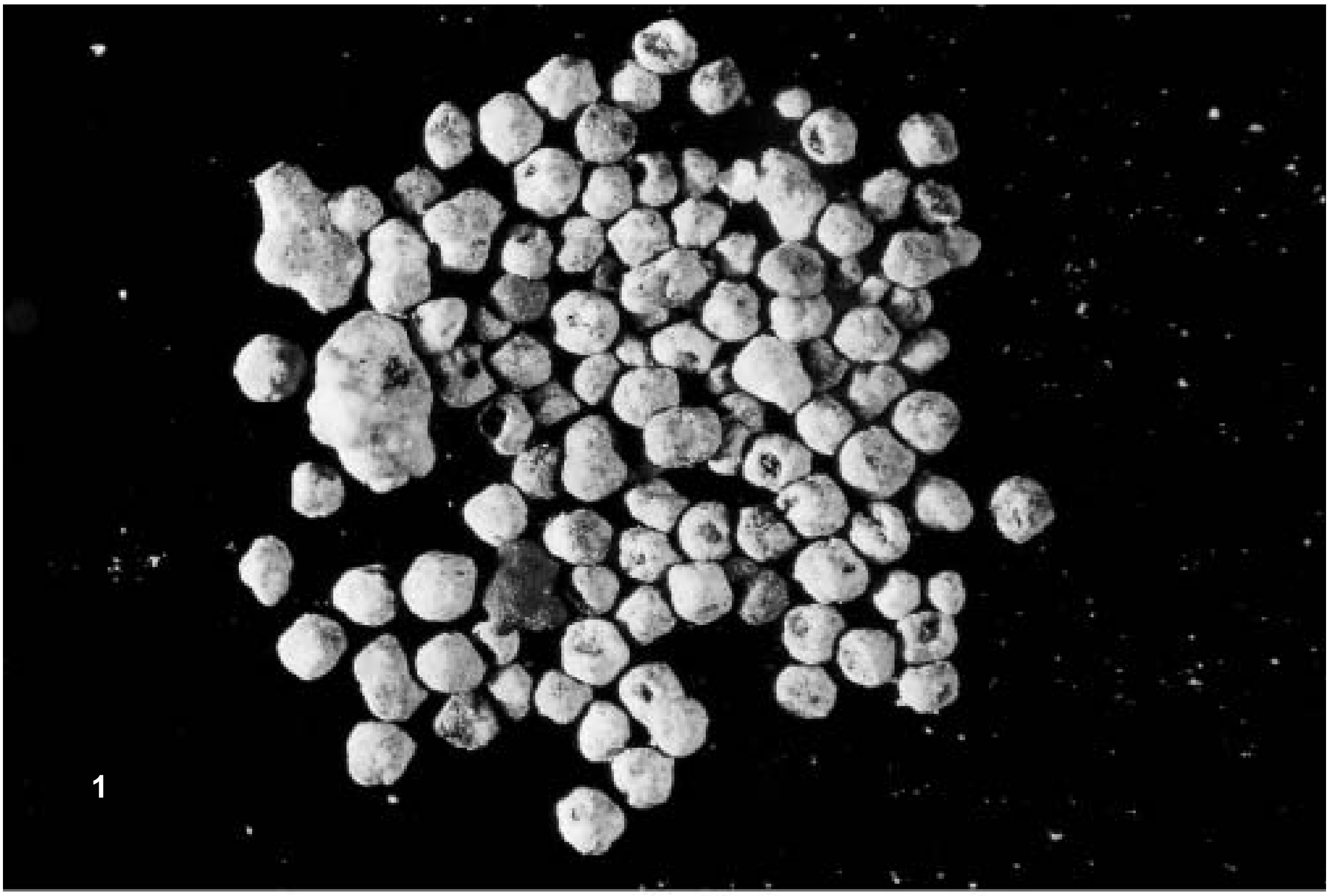


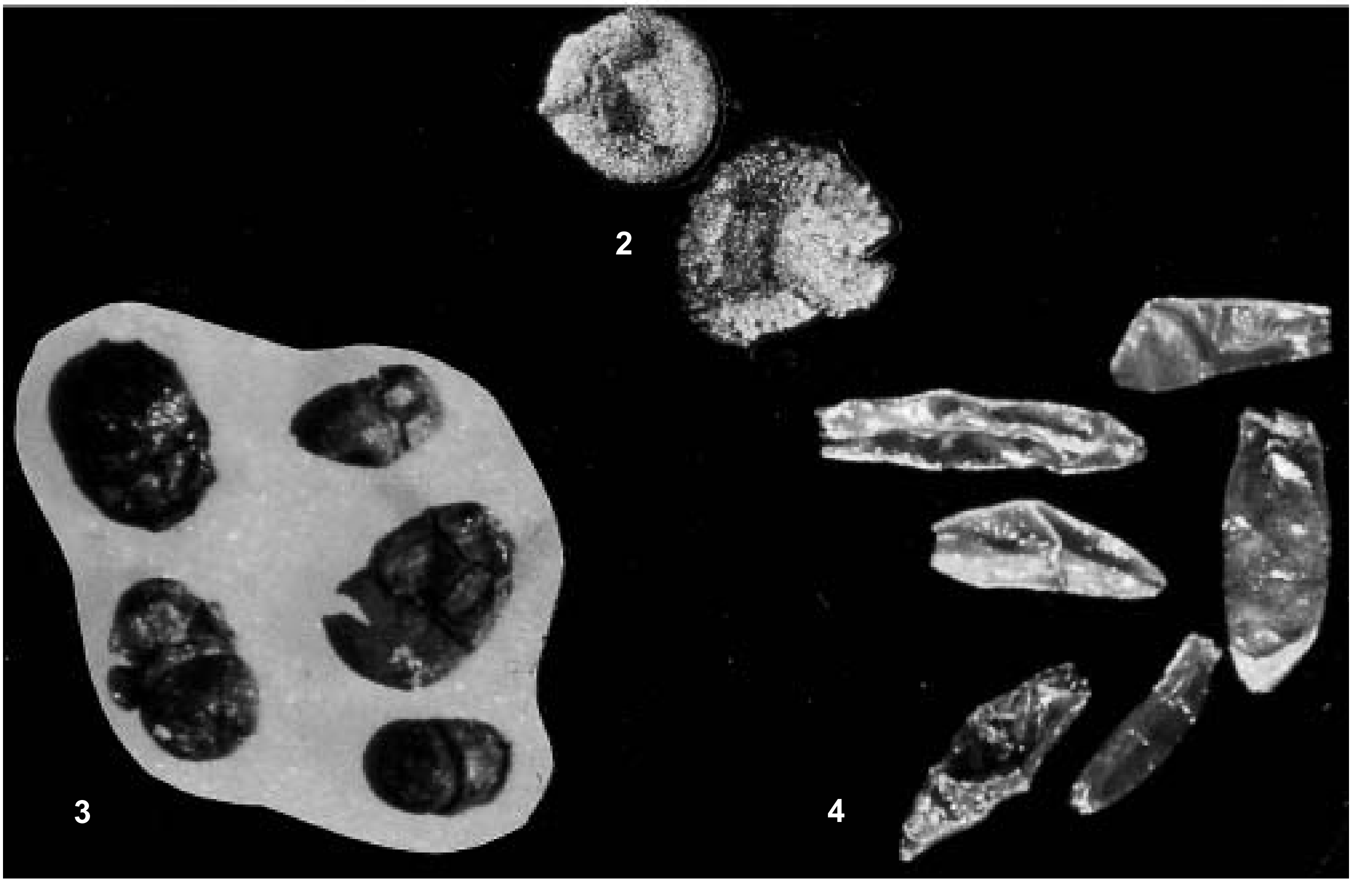
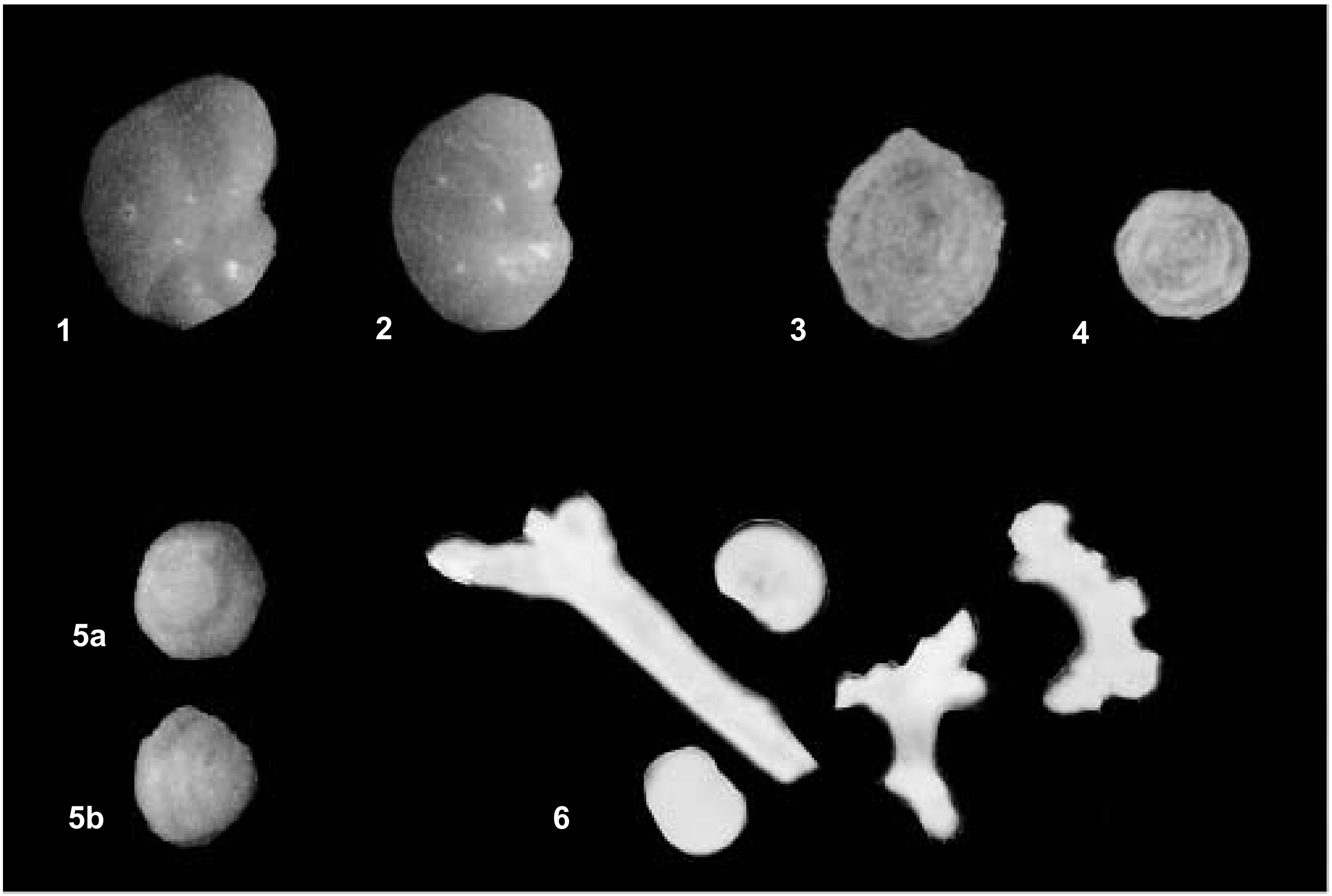
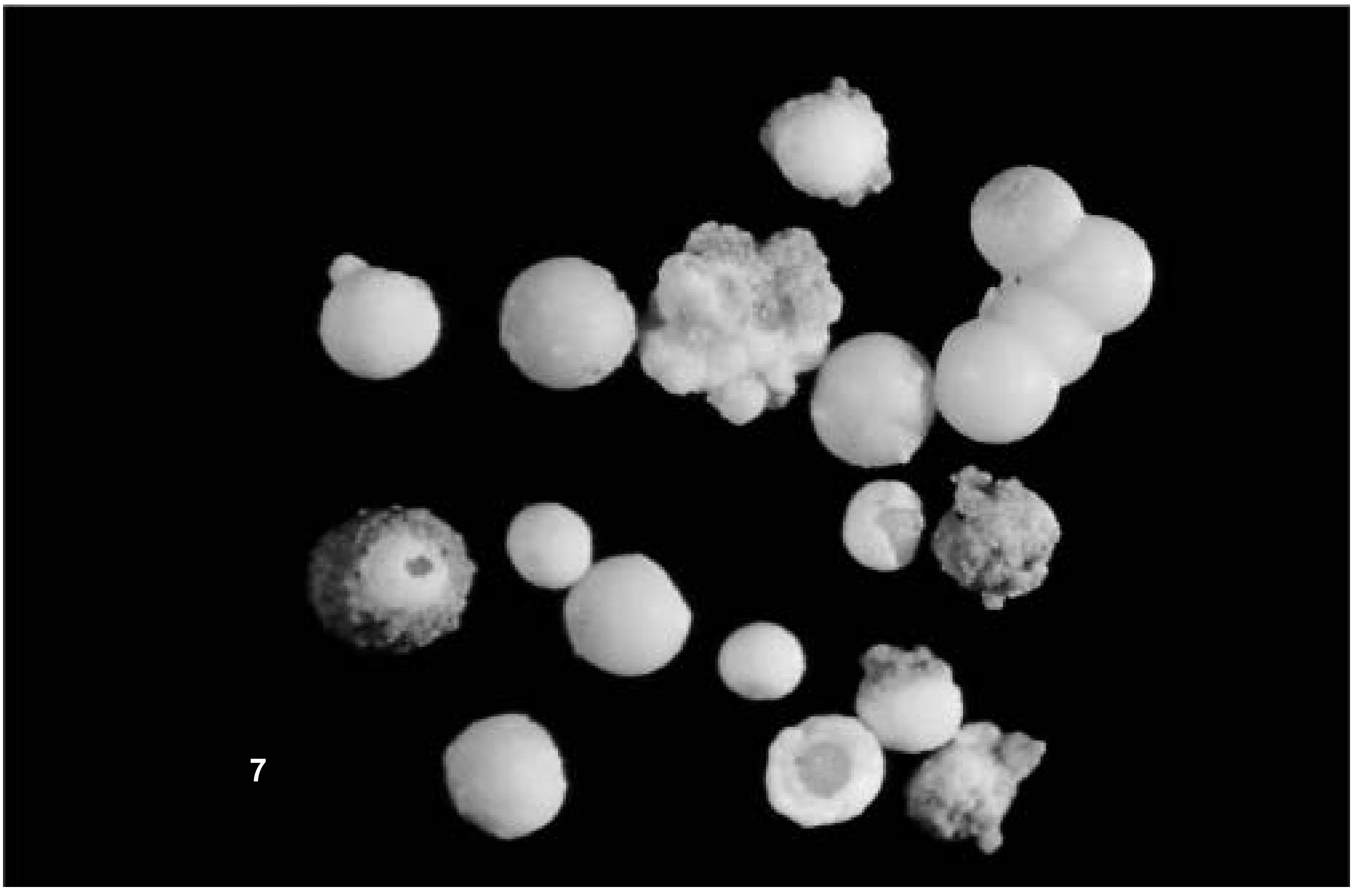
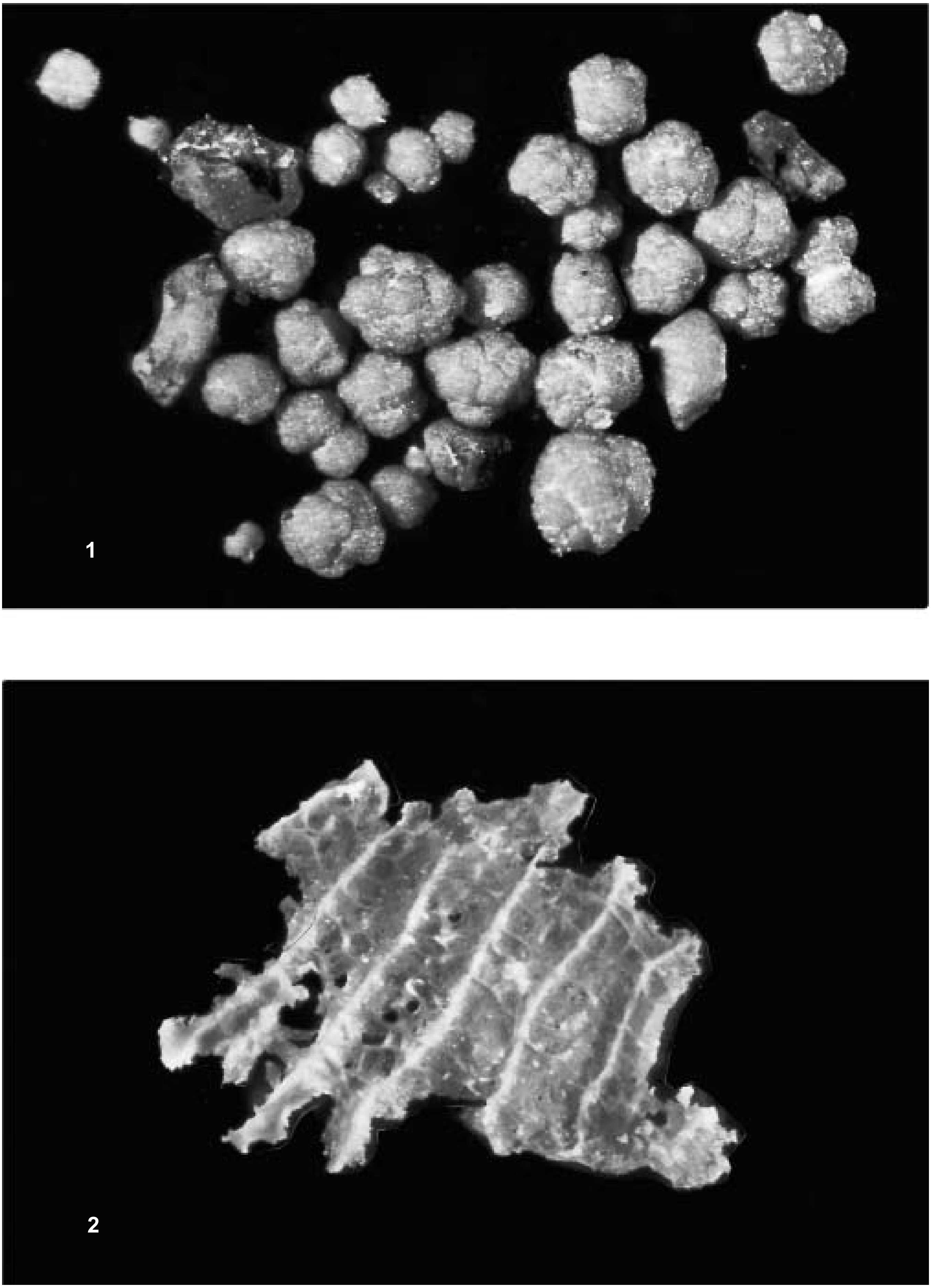


PLATE 5



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