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Palynostratigraphy of the Lower and Middle Buntsandstein in north-western part of the Holy Cross Mts.

Three spore-pollen assemblages, representing *Lundbladispora obsoleta–Protohaploxypinus pantii* and *Densoisporites nejburgii* Zones, were distinguished within the Lower and Middle Buntsandstein deposits in NW part of the Holy Cross Mts. Palynofacies analysis provided for more detail data about the changes of depositional environment during the Early Triassic in the studied area. Palaeoenvironmental model used here indicates two climatic cycles in the Lower and Middle Buntsandstein.

INTRODUCTION

Palynological studies of the Lower Triassic deposits from north-western part of the Holy Cross Mts. were carried on in 1991–1993. Their aim was microflora characteristics, distinguishing of spore-pollen assemblages and working out, for the first time, palynostratigraphy of the Lower and Middle Buntsandstein deposits from mentioned area.

First data about occurrence of the Early Triassic miospores in the Holy Cross Mts. were presented by S. Dybova-Jachowicz and D. Laszko (1976, 1978, 1980). They concerned the upper part of the Middle Buntsandstein in the Szczukowice IG 1 borehole. T. Orłowska-Zwolińska identified a spore-pollen assemblage belonging to *Lundbladispora obsoleta–Protohaploxypinus pantii* Zone in the Lower Buntsandstein deposits from the Jaworzyna IG 1 borehole (unpublished). These studies were continued by author the present (A. Fijałkowska, 1990, 1991, 1992, 1993; A. Fijałkowska, A. Trzepierczyńska, 1990).

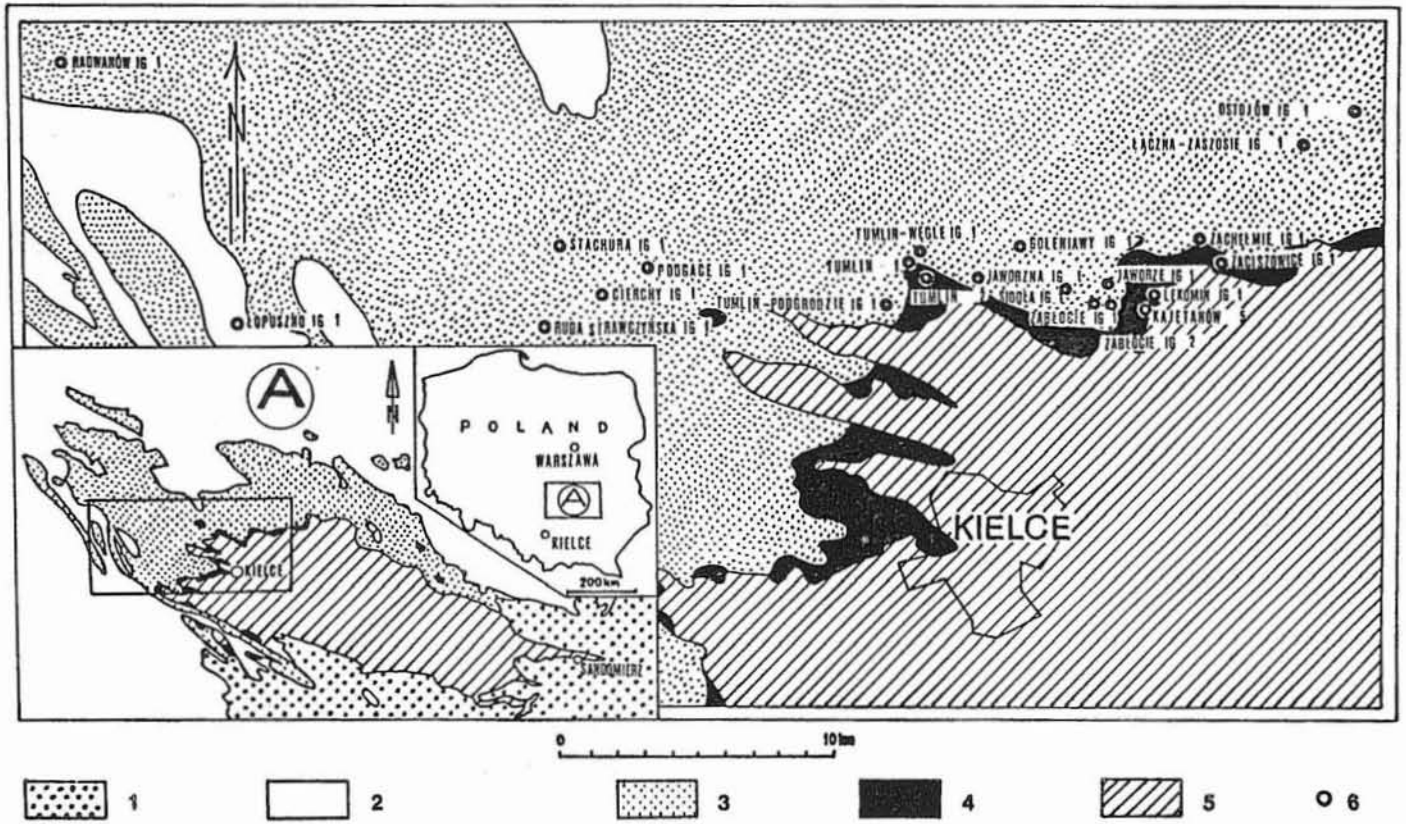


Fig. 1. Location of studied boreholes on the geological map of NW part of the Holy Cross Mts. (without Quaternary)

1 — Tertiary; 2 — Jurassic and Cretaceous; 3 — Triassic; 4 — Permian; 5 — Paleozoic; 6 — boreholes

Lokalizacja badanych otworów wiertniczych na tle mapy geologicznej odkrytej NW części Gór Świętokrzyskich

1 — trzeciorzęd; 2 — jura i kreda; 3 — trias; 4 — perm; 5 — paleozoik; 6 — otwory wiertnicze

METHODS AND MATERIALS

Palynological data from the Lower–Middle Buntsandstein interval, stated in the 22 boreholes localized in NW part of the Holy Cross Mts. were gathered and complied in this study (Fig. 1). In total 304 samples were taken from the selected sections at intervals of about 50 m. The total thickness of the studied section is 5320 m. The positive samples were obtained from the 10 boreholes (Fig. 2).

Samples were selected from a variety of lithologies, although black, grey and greenish shales were prefered. Reddish, cherry and mottled detritic deposits were found to be bare in most samples.

Maceration process was based on the HF method.

In total 80 species of miospores from 55 genera, as well as 7 species of acritarchs from 5 genera and fungial spores *Tympanicysta* were recognized (Tab. 3).

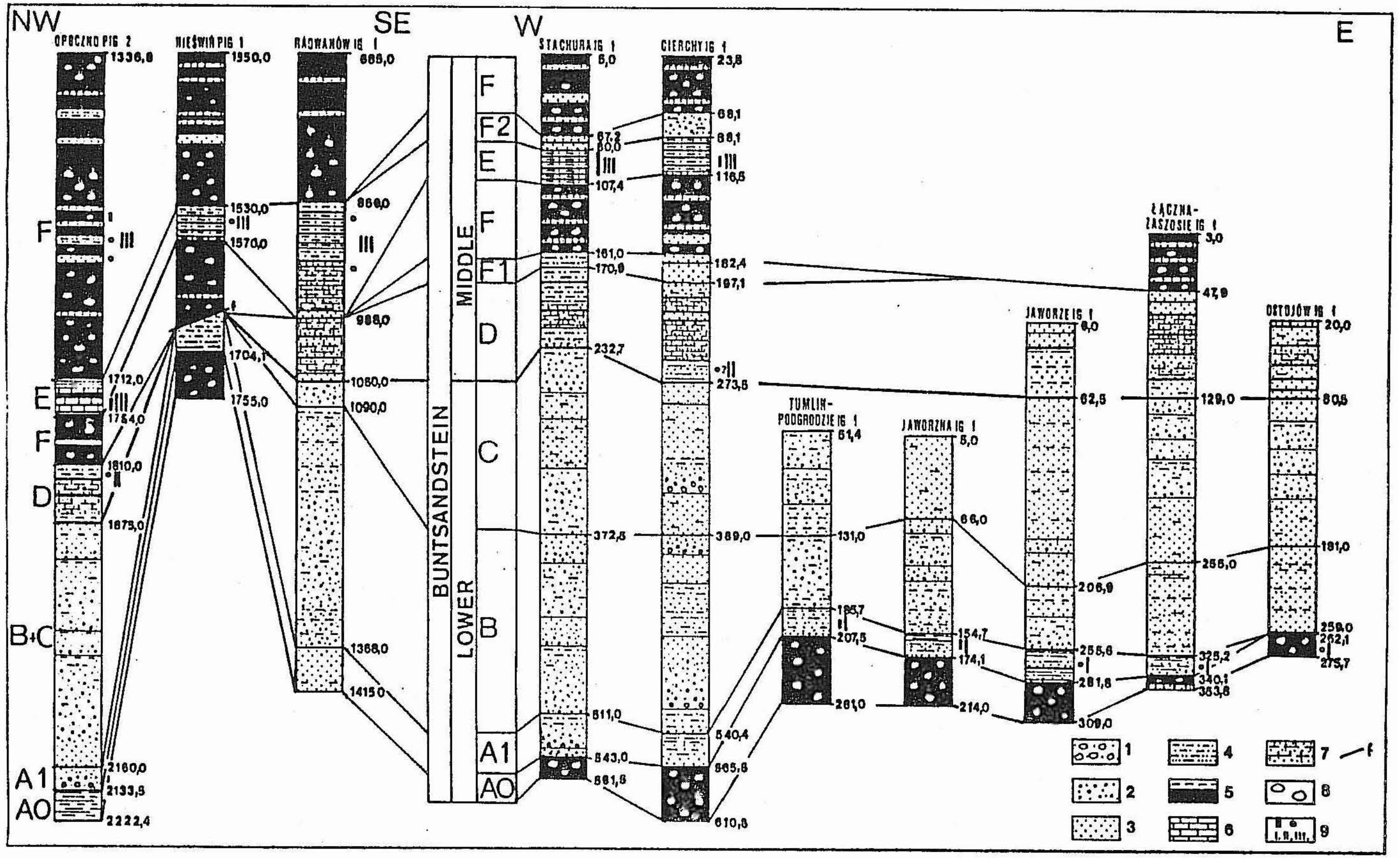
GEOLOGICAL CHARACTERISTICS OF THE STUDIED LITHOSTRATIGRAPHICAL COMPLEXES

J. Czarnocki (1925, 1926, 1927, 1931, 1939) and J. Samsonowicz (1929) produced the first lithostratigraphic framework from the Lower Triassic in the Holy Cross Mts. H. Senkowiczowa (1970; H. Senkowiczowa, A. Ślączka, 1962) estabilished currently used lithostratigraphical subdivisions of the Lower Triassic in north margin of the Holy Cross Mts. The most recent lithostratigraphical scheme of the Lower and Middle Buntsandstein for the studied area was produced by M. Kuleta (1990). She has distinguished the four following lithological complexes in the Lower Buntsandstein: A0, A1 and A0/A1, which are correlated with the Passage Beds of H. Senkowiczowa, and B, which corresponds to the Zagnańsk Beds. Within the Middle Buntsandstein she has identified also four complexes: C — which can be generally correlated with the Tumlin Beds, D — with the Gervilleia Beds, E — with the Hieroglyphic Beds and F — with the Pseudooolithic Beds (Fig. 5).

The problem of the Zechstein/Buntsandstein boundary still can be discussed. On the basis of results obtained by G. Pieńkowski (1987, 1989), M. Kuleta (1990), S. Zbroja (1990) and by author, currently this boundary is placed at the base of mudstone complex with carbonate nodules (A0), which, in the older works, was included to the uppermost Zechstein (M. Kuleta, M. Rup, 1980; Z. Kowalczewski, M. Rup, 1981, 1989; M. Kuleta, 1985; M. Rup, 1985).

THE LOWER BUNTSANDSTEIN LITHOSTRATIGRAPHY

A0 complex: dark-brown, structureless mudstones and sandy mudstones with carbonate nodules, streaks and irregular concentrations; 9.6–38.0 m thick in the studied sections (M. Kuleta, 1990); its inferred depositional environment is inland playa lake (G.


NW
SE
W
E
OPOCZNO PIG 2
NIEŚWIŃ PIG 1
RADWANÓW IG 1
STACHURA IG 1
CIERCHY IG 1
TUMLIN-PODGRODZIE IG 1
JAWORZNA IG 1
JAWORZE IG 1
ŁĄCZNA-ZASZOSIE IG 1
OSTOJÓW IG 1
BUNTSANDSTEIN
LOWER
MIDDLE
F
F2
E
F1
D
C
B
A1
AO
B+C

Pieńkowski, 1989). This complex lies in the sedimentary continuity with the uppermost Zechstein deposits.

A1 complex: reddish and dark-brown laminated sandstones and mudstones with conglomerates and coarse sandstones at the base and fine mudstones and siltstones at the top, locally it has a heterolithic character; some scores meters thick; the presence of wave sedimentary structures may suggest the shallow marine environment (M. Kuleta, 1985, 1990).

A1/A0 complex: red to dark-brown, structureless siltstones and mudstones; several meters thick; it is interpreted as overworked karstic aggradation (M. Kuleta, 1990).

B complex: rosy-red, unequigranular, cross-bedded sandstones building upwards finning cycles; 68.0–167.0 m thick; the sedimentary structures suggest fluvial environment (M. Kuleta, 1985, 1990). This complex is the main element of the Lower Buntsandstein section at the discussed area.

THE MIDDLE BUNTSANDSTEIN LITHOSTRATIGRAPHY

C complex: red, reddish, unequigranular sandstones; 52.0–151.7 m thick. The two subcomplexes — C1 and C2 — were distinguished here on the base of sedimentary-petrographical differences. These subcomplexes occur both in the iso- and heterochronous position and are joint by common aeolian depositional environment.

C1 subcomplex: red, fine- and middle-grained sandstones; such sedimentary structures as horizontal wavy laminations and erosional channels infilled with structureless sediments suggest that deposition took place in the dune and inter-dune areas as well as in the braided rivers channels (M. Kuleta, 1990). This complex dominates in the sections concentrated in the central part of studied area (Tumlin, Goleniawy, Jaworze).

C2 subcomplex: coarse- and middle-grained sandstones with the gravel admixture building simple sedimentary cycles; a few meters thick; its sedimentary structures — trough bedding of varied scales — are characteristic for braided rivers and periodical streams in desert environment (M. Kuleta, 1990). This subcomplex occurs in W and E part of the studied region.

D complex: sets of rosy-grey-dark-brown coarse-grained sandstones alternating with oolithic-grainstones or calcareous arenites and mudstones or siltstones and red-rosy unequigranular sandstones; 38–94 m thick; wavy, wavy-lenticular or cross bedding of small scale are the most typical structures for this complex. The lamination in the upper

Fig. 2. Correlation of the Lower and Middle Buntsandstein sections containing microflora in NW part of the Holy Cross Mts. (after M. Kuleta, 1990; modified)

1 — conglomerates; 2 — coarse-grained sandstones; 3 — fine-grained sandstones; 4 — mudstones; 5 — claystones; 6 — limestones; 7 — sandy limestones; 8 — carbonate nodules; 9 — spore-pollen assemblages; f — fault

Korelacja profili dolnego i środkowego pstrego piaskowca zawierających mikroflorę w NW części Gór Świętokrzyskich (według M. Kulety, 1990; nieco zmodyfikowana)

1 — zlepieńce; 2 — piaskowce gruboziarniste; 3 — piaskowce drobnoziarniste; 4 — mułowce; 5 — iłowce; 6 — wapienie; 7 — wapienie piaszczyste; 8 — gruzły węglanowe; 9 — zespoły sporowo-pyłkowe; f — uskok

Table 1

Palynomorphs occurrence in the Lower Buntsandstein of the Tumlin — Podgrodzie IG 1 borehole

Species	Lithostratigraphy (after M.Kuleta, 1990, modified)			
	Lower Buntsandstein			
	A0	A1	B	C
	261.0—207.5	207.5— −185.7	185.7–131.0	131.0–51.4
1	2	3	4	5
Calamospora tener		+		
Calamospora sp.		++		
Punctatisporites triassicus		+ +		
*Cyclotriletes micrograni*fer		++		
Cyclotriletes oligogranifer		+ +		
Cyclotriletes triassicus		+		
Cyclotriletes sp.		++ •		
Lundbladispora brevicula		+		
Lundbladispora cf. *obsoleta*		+		
Lundbladispora sp.		• ++		
Densoisporites playfordii		+		
Densoisporites sp.		v •		
Kraeuselisporites apiculatus		+ +		
Kraeuselisporites cuspidus		+• •		
Kraeuselisporites ullrichii		++		
Kraeuselisporites sp.		+•+		
Endosporites papillatus		+		
Endosporites sp.		+		
SPORITES INDET.		• • v		
Protohaploxypinus jacobii		+		
Protohaploxypinus pantii		++		
Protohaploxypinus samoilovichii		+		
Protohaploxypinus sp.		+		
Striatoabietites sp.		+		
Lueckisporites sp.		+		
Lunatisporites gracilis		+ •		
Lunatisporites pellucidus		+		
Lunatisporites sp.		+ •		
Klausipollenites decipiens		+		
Klausipollenites minimus		+		
Klausipollenites sp.		+•+		
Platysaccus niger		+		
Platysaccus papilionis		+ +		
Triadispora crassa		+		
Triadispora sp.		++		
Cycadopites coxii		• •+		
Cycadopites follicularis		+•+		
Cycadopites sp.		+•+		

1	2	3	4	5
POLLENITES INDET.		+++		
Baltisphaeridium sp.		• ++		
Micrhystridium sp.		+++		
Veryhachium sp.		++		
ACRITARCHA INDET.		+++		
Tympanicysta		++		
SPORE-POLLEN ASSEMBLAGES		I		

Palynomorph occurrence: + — 1–4 specimens; • — 5–10 specimens; v — 1–10%; x — more than 10%

part of the complex is disturbed by plant roots; its inferred depositional environment is nearshore, marine (M. Kuleta, 1990).

E complex: mainly gray or rosy-dark-brown, calcareous fine sandstones or sandy limestones rhythmically alternated with dark mudstones or siltstones; maximal thickness of 28 m; its sedimentary structures vary from horizontal and wavy to staky-lenticular and small scale cross bedding and are often disturbed by erosion or bioturbations; its environment is shallow, nearshore marine (M. Kuleta, 1990).

F complex: dark-brown, structureless mudstones and sandy mudstones with calcareous or sulphurous nodules and fine conglomerates intercalations; some scores 1 m thick; its inferred depositional environment is inland playa lake. Its position within the Middle Buntsandstein section is different in the studied area. It is divided by E complex in the central part of the region; in the W part E complex lies directly upon D complex and F complex overlies E complex; in the E part of the region F complex probably does not occur at all. There were distinguished two subcomplexes — F1 and F2 built from red, varied sandstones which have the features of continental deposits (M. Kuleta, 1990).

PALYNOSTRATIGRAPHY

The one spore-pollen assemblage (I), representing the *Lundbladispora obsoleta–Protohaploxypinus pantii* Zone, was distinguished in the Lower Buntsandstein deposits and the two assemblages (II, III), representing the *Densoisporites nejburgii* Zone, in the Middle Buntsandstein.

I ASSEMBLAGE

Characteristics. The main feature of this assemblage is appearance of the Early Triassic miospores dominated by lycopods spores *Lundbladispora* with the index taxa *L. obsoleta* Balme (Pl. II, Fig. 2) and *L. brevicula* Balme (Pl. II, Fig. 7) as well as *Densoisporites* with *D. playfordii* (Balme) Dettmann (Pl. II, Fig. 3). Ferns spores repre-

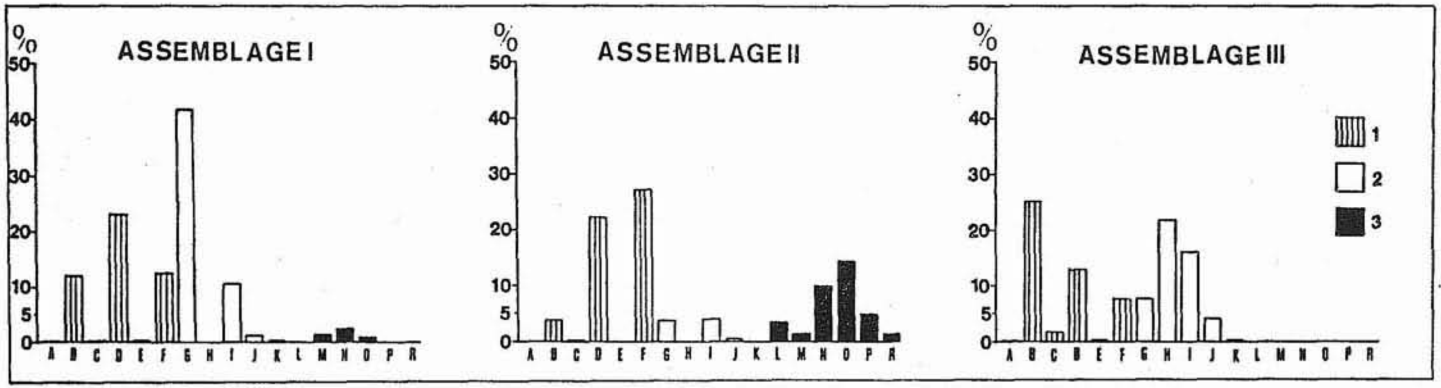


Fig. 3. Application of palaeoenvironmental model to the Lower and Middle Buntsandstein microfloristic assemblages from NW part of the Holy Cross Mts.

1 — hygrophytic elements; 2 — xerophytic elements; 3 — microphytoplankton; palynomorphs groups: A — monolete, acavate spores, B — trilete, acavate, laevigate and apiculate spores, C — trilete, acavate and murornate spores, D — trilete, cingulate and zonotrilete spores, E — *Aratrisporites* group, F — monosulcate pollen, G — taeniae (proto) bisaccate pollen, H — *Triadispora* group, I — vesicate pollen, J — (proto) monosaccate pollen, K — circumpollen group, L — *Leiosphaeridia*, M — *Micrhystridium*, N — *Baltisphaeridium*, O — *Veryhachium*, P — *Wilsonastrum*, R — *Leiophusa*

Zastosowanie modelu paleośrodowiskowego do zespołów mikroflorystycznych dolnego i środkowego pstrego piaskowca w NW części Gór Świętokrzyskich

1 — elementy hygrofilne; 2 — elementy kserofilne; 3 — mikrofitoplankton; grupy palinomorf: A — spory monolete, acavate, B — spory trilete, acavate, laevigate i apiculate, C — spory trilete, acavate i murornate, D — spory trilete, cingulate i zonotrilete, E — grupa *Aratrisporites*, F — ziarna pyłku monosulcate, G — (proto) dwuworkowe ziarna pyłku prążkowane, H — grupa *Triadispora*, I — ziarna pyłku vesicate, J — (proto) jednoworkowe ziarna pyłku, K — grupa circumpollen, L — *Leiosphaeridia*, M — *Micrhystridium*, N — *Baltisphaeridium*, O — *Veryhachium*, P — *Wilsonastrum*, R — *Leiophusa*

Table 2

Palynomorphs occurrence in the Middle Buntsandstein of the Opoczno PIG 2 borehole

Species	Lithostratigraphy (after M. Kuleta, 1990, modified)			
	Middle Buntsandstein			
	D	F	E	F
	1875.0–1810.0	1810.0–1754.0	1754.0–1712.0	1712.0–1336.8
1	2	3	4	5
Calamospora sp.		+	++	+++
Deltoispora minima			+	
Deltoispora sp.			+•	+++
Punctatisporites triassicus			v	v•
Punctatisporites sp.				vv•
Cyclotriletes microgranifer		•	••	••
Cyclotriletes oligogranifer			••	v
Cyclotriletes triassicus			+	
Cyclotriletes sp.		v	vv	xxx
Cycloverrutriletes presselensis		+	++	•xx
Guttatisporites elegans			+	
Guttatisporites microechinatus			+	
Guttatisporites sp.			++	•
Verrucosisporites sp.			+	
Lundbladispora brevicula		+	+	+
Lundbladispora willmotti		+	+	
Lundbladispora sp.		•	v+	+ •
Densoisporites nejburgii		•	vx	• •
Densoisporites playfordii		v	xx	+••
Densoisporites sp.		v	xx	vvv
Kraeuselisporites apiculatus		+		
Kraeuselisporites baculatus				++•
Kraeuselisporites sp.				• v
Anapiculatisporites sp.				+
Aratrisporites tenuispinosus				+
Aratrisporites sp.				+•
Bharadwajispora labiichensis		+		•
Bharadwajispora sp.			+	++
Dulhuntyispora minuta		+	v	vv
Dulhuntyispora sp.			+	xvv
Endosporites papillatus		v	•v	vxv
Aculeisporites variabilis		+	+	+
Proprisporites pococki			v	++
Proprisporites sp.		•	+•	++
SPORITES INDET.		x	xx	xxx
Protohaploxypinus pantii			+	
Protohaploxypinus samoilovichii			•	+
Protohaploxypinus sp.			•	•
Strotersporites sp.			+	

1	2	3	4	5
Striatoabietites balmei				++•
Striatoabietites sp.		•	v v	v•v
Protosacculina sp.			+	+
Lunatisporites albertae			+	
Lunatisporites gracilis			++	+
Lunatisporites labdacus				+
Lunatisporites microsaccatus			++	+•
Lunatisporites noviaulensis			++	+•
Lunatisporites obex			++	+
Lunatisporites sp.			•	••+
Platysaccus leschiki			+	••v
Platysaccus niger			++	••v
Platysaccus papilionis			+	+
Platysaccus sp.			++	+••
Falcisporites snopkovae				+
Falcisporites sp.			+	
Klausipollenites decipiens			•+	+
Klausipollenites minimus			+•	
Klausipollenites staplinii			v	••
Klausipollenites forma Y		+	+•	
Klausipollenites sp.		+	v v	•••
Cedripites sp.				•x
Alisporites cymbatus			+	
Alisporites ovalis			••	v
Alisporites sp.			••	v
Succinctisporites sp.				+
Brachysaccus ovalis				+
Brachysaccus sp.			+	xxv
Ovalipollis sp.			+	
Angustisulcites gorpii			++	v
Agnustisulcites grandis			•	•++
Agnustisulcites klausii			+	++•
Agnustisulcites sp.			v v	+xv
Triadispora crassa			+	+
Triadispora sp.				•
Vitreisporites koenigswaldii			••	
Vitreisporites sp.			++	
Cycadopites coxi		•	v v	vxx
Cycadopites follicularis		v	v v	+vv
Cycadopites hartii			•+	
Cycadopites sp.		v	xv	
Gnetacaepollenites sp.			++	
Monosulcites sp.		+		
Duplicisporites granulatus			•+	v+x
Duplicisporites sp.		v	+•	x
Spheripollenites balmei				+
Spheripollenites sp.		•	••	•
POLLENITES INDEN.		v	v v	vxx
Baltisphaeridium longispinosum		+		
Baltisphaeridium sp.		+		
Leiofusa sp.		v		
Leiosphaeridia sp.		v		
Micrhystridium sp.		+		

1	2	3	4	5
Veryhachium trispinoides		°		
Veryhachium sp.		•		
Wilsonastrum colonicum		v		
Wilsonastrum sp.		v		
ACRITARCHA INDET.		x		
Tympanicysta			+	
SPORE-POLLEN ASSEMBLAGES		II	III	

For the legend see Table 1

senting such genera as: *Cyclotriletes* — *C. microgranifer* Mädler (Pl. I, Fig. 7), *C. oligogranifer* Mädler (Pl. I, Fig. 3), *C. triassicus* Mädler (Pl. I, Fig. 1), *Punctatisporites* — *P. triassicus* Schulz (Pl. I, Fig. 2) and *Endosporites* — *E. papillatus* Jansonius (Pl. II, Figs. 4, 6) are also abundant. The representatives of *Guttatisporites* — *G. elegans* Visscher (Pl. II, Fig. 1), *Kraeuselisporites* — *K. apiculatus* Jansonius (Pl. III, Fig. 4), *K. cuspidus* Balme (Pl. III, Fig. 3), *K. ullrichii* Reinhardt et Schmitz (Pl. III, Fig. 1) and *Calamospora* — *C.* cf. *tener* (Leschik) de Jersey (Pl. I, Fig. 4) occur less frequent.

Among the bisaccate pollen grains, which dominate in this spectrum, striatite, forms belonging to *Lunatisporites* — *L. noviaulensis* (Leschik) Scheuring (Pl. V, Fig. 1), *L. gracilis* (Jansonius) Fijałkowska (Pl. IV, Fig. 4; Pl. V, Fig. 5), *L. labdacus* (Klaus) Fijałkowska (Pl. IV, Fig. 2), *Protohaploxypinus* — *P. pantii* (Jansonius) Orłowska-Zwolińska (Pl. IV, Fig. 6), *P. jacobii* (Jansonius) Hart (Pl. III, Fig. 7) and *Strotersporites* are the most abundant. *Klausipollenites* specimens occur less frequent. Moncolpate pollen are represented in greater number by *Cycadopites coxii* Visscher (Pl. VI, Fig. 7), *C. follicularis* Wilson et Webster (Pl. VI, Fig. 8) and *Gnetacaepollenites*.

The assemblage contains acritarchs in the amount of 6%. They are represented mainly by *Baltisphaeridium, Micrhystridium* and *Veryhachium* genera.

O c c u r r e n c e . The assemblage was identified in the Lower Buntsandstein deposits (A0 and A1 complexes) from the following boreholes: Jaworznia IG 1 at the depth of 157.0–160.1 m, Jaworze IG (260.0 m), Łączna — Zaszosie IG 1 (329.7 m), Tumlin — Podgrodzie IG 1 (190.7–204.4 m) (Tab. 1), Ostojów IG 1 (265.5–266.3 m) (Fig. 2).

C o m p a r i s o n s a n d c o r r e l a t i o n s . The assemblage is correlated to the *Lundbladispora obsoleta–Protohaploxypinus pantii* Zone distinguished by T. Orłowska-Zwolińska (1984, 1985) in the Lower Buntsandstein of the Western Poland (Tab. 5). It corresponds also to the LT-1 Zone in the scheme produced by W. A. Brugman (1983) for Western and Southern Europe. Another occurrence of similar assemblage is known from the Griesbachian deposits of Kap Stosch area in East Greenland where B. E. Balme (1979) distinguished the association *Protohaploxypinus*. Discussed assemblage can be also correlated to the spectrum from Toad-Grayling Formation, Western Canada described by J. Jansonius (1962) and from the Griesbachian deposits of Bjorne Formation in the Canadian Arctic Archipelagoo (D. C. McGregor, 1965; J. Utting, 1987). There exist also a big similarity to the other assemblages known from the other phytogeographical provinces.

Table 3

Stratigraphical distribution of palynomorphs in the Lower and Middle Buntsandstein of NW part of Holy Cross Mts.

Species	Lithostratigraphy (after M. Kuleta, 1990, modified)									
	Buntsandstein									
	Lower				Middle					
	A0	A1	B	C	D	F1	F	E	F2	F
1	2	3	4	5	6	7	8	9	10	11
Lundbladispora obsoleta	–	–								
Lueckisporites sp.	–	–			–					
Deltoispora sp.	–	–						x		–
Calamospora sp.	–	–						+		x
Punctatisporites triassicus	–	x						+		x
Cyclotriletes micrograniƒer	x	x			x			x		v
Cyclotriletes sp.	x	+			+			v		v
Guttatisporites elegans	–	–						+		v
Guttatisporites sp.	–	–						x		v
Dulhuntyispora minuta	x				–			+		v
Dulhuntyispora sp.	x							+		v
Densoisporites sp.	x	+			+			v		v
Lundbladispora sp.	–	v			x			+		+
Lycospora sp.	–	–						–		–
Kraeuselisporites apiculatus	x	x			–					x
Kraeuselisporites sp.	–	x						–		+
Playfordiaspora sp.	–							–		–
Protohaploxypinus pantii	–	x								x
Protohaploxypinus samoilovichii	–	x						x		x
Protohaploxypinus sp.	–	x						x		x
Strotersporites richteri	–	x								–
Strotersporites sp.	x	–						–		–
Lunatisporites labdacus	+	x						–		x
Lunatisporites microsaccatus	–	–						–		+
Lunatisporites noviaulensis	–	x			–			+		+
Lunatisporites sp.	+	x			+			v		v
Klausipollenites staplinii	–	–						+		x
Klausipollenites sp.	–	x			x			+		+
Platysaccus niger	–	–			–			–		–
Platysaccus sp.	–	–			–			x		x
Sphaeripollenites sp.	x				x			+		x
Duplicisporites sp.	–	–			+			x		v
Cycadopites coxii	+	+			x			+		v
Cycadopites follicularis	–	x			+			+		v
Cycadopites sp.	–	x			+			v		v
Crucisaccites sp.		–								
Gnetacaepollenites steevesii		–								
Protohaploxypinus jacobii		–								
Kraeuselisporites ullrichii		–								

1	2	3	4	5	6	7	8	9	10	11
Cyclotriletess triasikus		–			–					
Protohaploxypinus rhombeoformis		–						–		
Chordasporites sp.		–						–		
Lundbladispora cf. *obsoleta*		–								–
Deltoispora minima		x								x
Calamospora tener		–						–		+
Calamospora cf. *tener*		–						–		–
Punctatisporites sp.		+								+
Cyclotriletes granulatus		x						x		–
Cyclotriletes oligogranifer		–						+		+
Baculatisporites verus		–								–
Baculatisporites sp.		–						–		–
Densoisporites playfordii		x			+			v		v
Lundbladispora brevicula		–			–			–		–
Lundbladispora willmotti		–			–			x		–
Lycospora imperialis		x						xv		x
Endosporites papillatus		x			+			v		v
Endosporites sp.		x						x		x
Aculeisporites variabilis		–			–			–		x
Kraeuselisporites cuspidus		x								x
Aratrisporites sp.		–						x		x
Protosacculina sp.		–						–		x
Striatopodocarpites sp.		x–						x		x
Striatoabietites aytugii		–						–		–
Striatoabietites balmei		–						–		x
Striatoabietites sp.		–			x			+		+
Lunatisporites alatus		–			–			x		–
Lunatisporites albertae		–						–		–
Lunatisporites gracilis		x						–		x
Lunatisporites hexagonalis		–						–		–
Lunatisporites obex		–						–		x
Lunatisporites pellucidus		–								–
Lunatisporites transversundatus		–								–
Klausipollenites decipiens		–						x		x
Klausipollenites minimus		–						–		–
Platysaccus papilionis		–						–		–
Triadispora crassa		–						–		x
Triadispora plicata		–						x		–
Triadispora sp.		–						+		+
Vitreisporites koenigswaldii		–						x		–
Vitreisporites sp.		–						–		–
Duplicisporites granulatus		x						x		v
Gnetacaepollenites sp.		–						–		–
Densoisporites nejburgii					x			v		v
Proprisporites sp.					x			+		–
Klausipollenites forma Y					–			x		x
Bharadwajispora labiichensis					–					x
Bharadwajispora sp.					–			–		–
Monosulcites sp.					–					–
Lapposisporites villosus								–		
Lapposisporites sp.								x		
Guttatisporites microechinatus								–		
Densoisporites holospongia								–		

1	2	3	4	5	6	7	8	9	10	11
Alisporites grauvogeli								–		
Alisporites microreticulatus								–		
Cycadopites hartii								–		
Cycloverrutriletes presselensis								v		v
Cycloverrutrilets sp.								x		v
Verrucosisporites morulae								–		+
Verrucosisporites thuringiacus								–		–
Verrucosisporites sp.								v		v
Proprisporites pococki								+		–
Aratrisporites granulatus								x		–
Lunatisporites puntii								–		x
Succinctisporites sp.								–		–
Falcisporites sp.								x		–
Platysaccus leschiki								x		x
Alisporites cymbatus								x		+
Alisporites granulatus								x		–
Alisporites sp.								x		v
Brachysaccus ovalis								x		x
Brachysaccus sp.								–		+
Angustisulcites gorpii								x		+
Angustisulcites klausii								x		x
Angustisulcites grandis								x		x
Angustisulcites sp.								v		v
Apiculatisporis sp.										–
Lophotriletes sp.										–
Verrucosisporites pseudomorulae										x
Triancoraesporites sp.										–
Krytomisporites ervii										x
Perotriletes sp.										–
Concentricisporites sp.										–
Playfordiaspora crenulata										–
Aratrisporites tenuispinosus										–
Grebespora concentrica										–
Naumovaspora sp.										–
Falcisporites snopkovae										–
Paravesicaspora sp.										–
Cedripites sp.										–
Stellapollenites thiergartii										x
Guttulapollenites sp.										–
Sphaeripollenites plicatus										–
Sphaeripollenites balmei										–
Leiosphaeridia sp.		–			+					
Baltisphaeridium longispinosum		–			–					
Baltisphaeridium cf. *debilispinum*					–					
Baltisphaeridium sp.		x			–					–
Micrhystridium setasessitante		–			–					
Micrhystridium cf. *inconspicuum*					–					
Micrhystridium sp.		x			–					–
Veryhachium trispinoides		x			x					
Veryhachium irregularae		–			+					
Veryhachium sp.		x			x					–
Leifusa sp.					+			–		
Wilsonastrum colonicum					x					

1	2	3	4	5	6	7	8	9	10	11
Wilsonastrum sp.		–			+					
Tympanicysta	+	v						x		
Spore-pollen assemblages	I				II			III		

Frequency of palynomorphs occurrence: – — singly; + — seldom; x — less than 10%; v — more than 10%

II ASSEMBLAGE

C h a r a c t e r i s t i c s . *Endosporites papillatus* and *Densoisporites* with the index species *D. nejburgii* (Schulz) Balme (Pl. II, Fig. 8) dominate here among spores. The representatives of *Cyclotriletes, Lundbladispora, Kraeuselisporites* and *Proprisporites* occur less frequent. *Lunatisporites* and *Klausipollenites* taxa are the most abundant within the bisaccate pollen which dominate in this spectrum. Moncolpate pollen occur numerously.

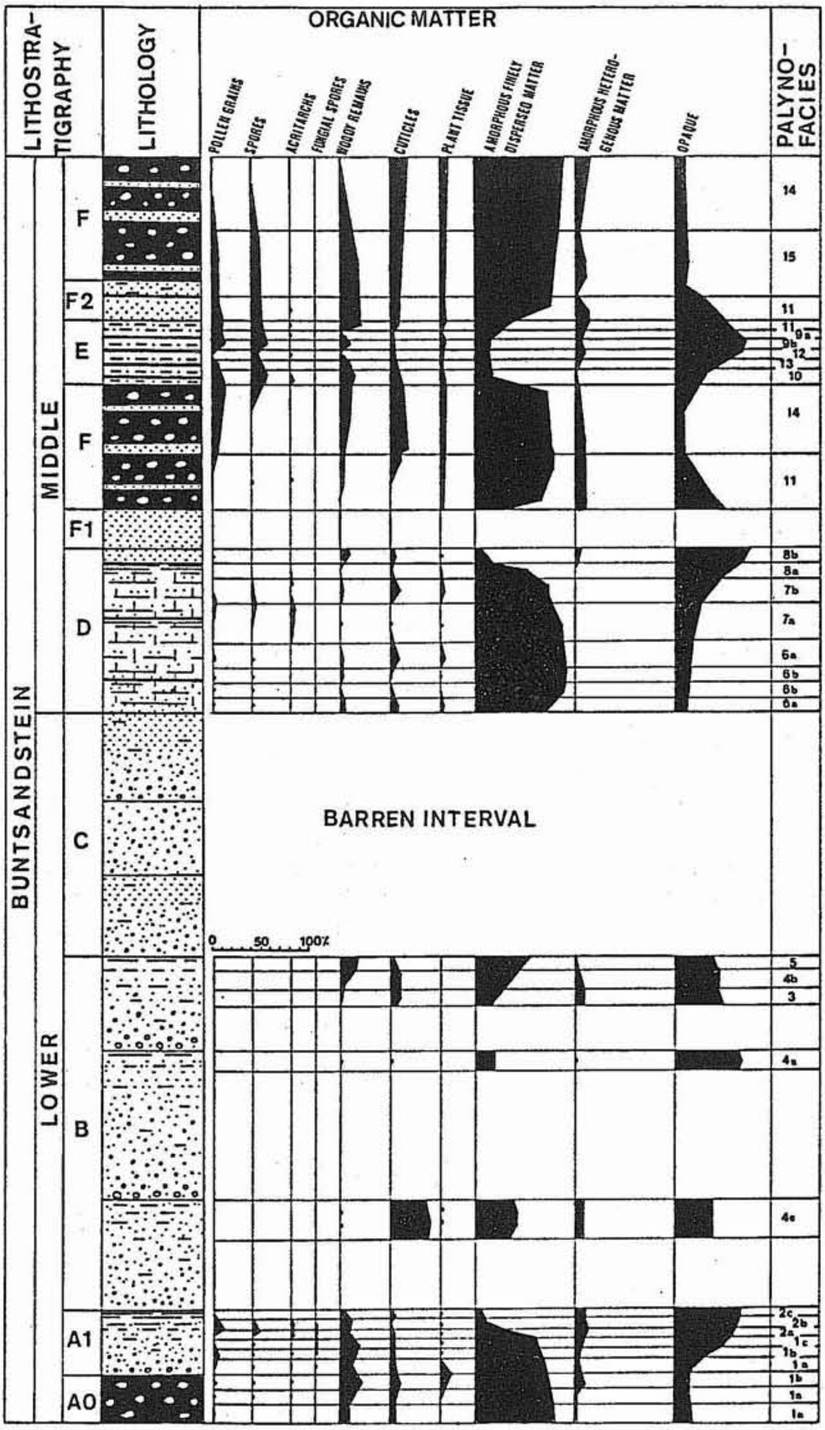
Acritarchs, which make 36% of assemblage, are dominated by *Veryhachium* — *V. trispinoides* (Jekhowsky) Fijałkowska (Pl. VI, Fig. 11). *Baltisphaeridium* and *Wilsonastrum* are less abundant and *Leiosphaeridia* and *Leiofusa* occur singly.

O c c u r r e n c e . The assemblage was distinguished in the lower part of the Middle Buntsandstein (D complex) only in one borehole — Opoczno PIG 2 at the depth of 1820.2–1822.3 m (Fig. 2; Tab. 2).

C o m p a r i s o n s a n d c o r r e l a t i o n s . This assemblage is correlated to the *Densoisporites* and acritarchs Subzone of the *Densoisporites nejburgii* Zone distinguished by T. Orłowska-Zwolińska (1984, 1985) in the lower part of the Middle Buntsandstein of the Western Poland. It can be referred to LT-2 Zone (Upper Griesbachian–Dinnerian) in the palynological scheme for Western and Southern Europe (Tab. 5). Some analogies exist between the discussed assemblage and *Taeniaesporites* association described in East Greenland by B. E. Balme (1979) as well as II assemblage recognized within the Dinnerian deposits of Canadian Arctic Archipelagoo (M. J. Fisher, 1979). The assemblage can be also correlated to the *Kraeuselisporites saepatus* Zone distinguished in the Lower Triassic of Western Australia (J. H. Dolby, B. E. Balme, 1976).

III ASSEMBLAGE

C h a r a c t e r i s t i c s . The assemblage is dominated by *Densoisporites* and *Cyclotriletes* spores. The index taxa *Cycloverrutriletes presselensis* Schulz (Pl. I, Fig. 5) is abundant. *Punctatisporites, Dulhuntyispora* and *Verrucosisporites* — *V. pseudomorulae* Visscher (Pl. I, Fig. 9), *V. thuringiacus* Mädler (Pl.II, Fig. 9) occur singly. Bisaccate pollen are dominated by *Lunatisporites* and *Klausipollenites. Alisporites* — *A. cymbatus* Venkatachala, Beju et Kar (Pl. V, Fig. 7), *A. granulatus* Klaus (Pl. V, Fig. 8), *Angustisulcites* —


LITHOSTRATIGRAPHY
LITHOLOGY
ORGANIC MATTER
POLLEN GRAINS
SPORES
ACRITARCHS
WOODY REMAINS
CUTICLES
PLANT TISSUE
AMORPHOUS FINELY DISPERSED MATTER
AMORPHOUS HETEROGENOUS MATTER
OPAQUE
PALYNOFACIES
BUNTSANDSTEIN
MIDDLE
LOWER
F
F2
E
F
F1
D
C
B
A1
A0
BARREN INTERVAL
0 50 100%
14
15
11
14
11
8b
8a
7b
7a
6a
5
4b
3
4a

A. gorpii Visscher (Pl. VI, Fig. 3), *A. klausi* Freudenthal (Pl. VI, Fig. 2), *Brachysaccus ovalis* Mädler (Pl. VI, Fig. 1), *Platysaccus* — *P. niger* Mädler (Pl. V, Fig. 3), *P. papilionis* Potonié et Klaus (Pl. V, Fig. 4), *P. leschiki* Hart (Pl. V, Fig. 6), *Triadispora* — *T. crassa* Klaus (Pl. VI, Fig. 4), *T. plicata* Klaus (Pl. V, Fig. 2) and *Stellapollenites thiergartii* (Mädler) Brugman (Pl. VI, Fig. 6) occur less frequent.

O c c u r r e n c e . The assemblage was recognized in the upper part of the Middle Buntsandstein (E and F complexes) in the following boreholes: Stachura IG 1 at the depth of 81.5–98.0 m, Cierchy IG 1 (91.1–103.9 m), Nieświń PIG 1 (1531.3 m) (A. Fijałkowska, 1991), Opoczno PIG 2 (1527.3–1591.6 and 1735.3–1752.5 m) (A. Fijałkowska, 1992) —Tab. 2 and Radwanów IG 1 (862.0–943.5 m) (A. Fijałkowska, A. Trzepierczyńska, 1990) — Fig. 2.

C o r r e l a t i o n s a n d c o m p a r i s o n s . The assemblage is correlated with the *Cycloverrutriletes presselensis* Subzone of *Densoisporites nejburgii* Zone distinguished by T. Orłowska-Zwolińska (1984, 1985) in the upper part of the Middle Buntsandstein in Western Poland. It can be referred to LT-4 Zone (Middle–Upper Spathian) in the scheme for Western and Southern Europe (Tab. 5). The certain similarity exists between the assemblages recognized in the Middle Buntsandstein of the Moesian Platform in Romania (B. S. Venkatachala et al., 1968).

PALYNOFACIES

Palynofacies analyses, in contrast to palynostratigraphical which determinates the age of rock sample on the basis of palynomorphs content, deals with the total acid-resistant organic residue. Its results can be used to determine the environment of deposition.

15 palynofacies types were distinguished within the Lower and Middle Buntsandstein lithological complexes (C complex makes an exception as no organic matter was found here) on the basis of the organic matter relative frequency (Fig. 5). The subdivison of organic matter into the allochthonous and autochthonous fractions proposed by C. J. van der Zwan (1990) was applied here. The following papers were used as a comparable materials: P. F. van Bergen et al. (1990), C. J. van der Zwan (1990) and K. Dybkjaer (1991). The results of the palynofacies analyses are summarised on the Table 4 and Figure 4.

Fig. 4. Quantitative distribution of organic matter in the Lower and Middle Buntsandstein deposits in NW part of the Holy Cross Mts.

For the lithological legend see Fig. 2

Ilościowe rozmieszczenie materii organicznej w osadach dolnego i środkowego pstrego piaskowca w NW części Gór Świętokrzyskich

Objaśnienia symboli litologicznych jak na fig. 2

Table 4

Characteristics of the palynofacies types

Palynofacies	Characteristics	Environment
1	2	3
15	Spores: *Densoisporites* and *Cyclotriletes*, black wood, yellow cuticles and plant tissue, dominated black finely dispersed amorfous organic matter (A.O.M.), black amorfous organic matter (opaque)	Inland playa lake
14	Pollen, yellow cuticles and plant tissue, black wood, dominated black finely dispersed A.O.M., opaque	
13	Spores: *Densoisporites*, black wood, dominated opaque, black finely dispersed A.O.M.	Nearshore, shallow marine
12	Single acritarchs, yellow cuticles and plant tissue, dominated opaque, black finely dispersed A.O.M.	Nearshore, shallow marine with a higher energy level than 11
11	Spores: *Densoisporites* and *Cyclotriletes*, acritarchs: *Micrhystridium*, black wood, yellow cuticles and plant tissue, dominated finely dispersed A.O.M., opaque	Nearshore, shallow marine low energy
10	Spores: *Densoisporites*, pollen, acritarchs: *Micrhystridium*, dark-brown wood, yellow cuticles, black finely dispersed A.O.M., opaque	Nearshore, shallow marine
9b	Spores: *Densoisporites, Cyclotriletes, Cycloverrutriletes*, pollen: *Lunatisporites* and *Klausipollenites*, black wood, dominated opaque	
9a	Spores: *Densoisporites, Cyclotriletes*, pollen, acritarchs, dominated opaque	
8b	Black wood, dominated opaque	Low energy, restricted, shallow marine
8a	Black finely dispersed A.O.M., opaque	
7b	Spores: *Densoisporites*, acritarchs, yellow cuticles, dominated black finely dispersed A.O.M., opaque	
7a	Spores, acritarchs: *Veryhachium, Leiosphaeridia* dominated black finely dispersed A.O.M., opaque	
6b	Single spores, yellow cuticles, dominated black finely dispersed A.O.M., opaque	Fluviatile channels on a deltaic plain
6a	Single spores, dominated black finely dispersed A.O.M.	
5	Black wood, black finely dispersed A.O.M., opaque	Flood plain
4c	Yellow cuticles, black finely dispersed A.O.M., opaque	Fluviatile channels of the braided rivers
4b	Black wood, yellow cuticles, dominated opaque, black finely dispersed A.O.M.	
4a	Dominated opaque, black finey dispersed A.O.M.	

1	2	3
3	Yellow cuticles, dominated opaque, black finely dispersed A.O.M.	Fluviatile channels of the braided rivers
2c	Single pollen, black wood, yellow cuticles, dominated opaque	Nearshore, shallow marine
2b	Pollen: *Lunatisporites, Protohaploxypinus, Klausipollenites,* spores: *Lundbladispora, Densoisporites,* acritarchs: *Micrhystridium, Baltisphaeridium,* black wood, dominated opaque	Nearshore, shallow marine
2a	Pollen: *Lunatisporites, Protohaploxypinus, Klausipollenites,* spores: *Lundbladispora, Densoisporites,* acritarchs: *Micrhystridium, Baltisphaeridium,* fungial spores, black wood, dominated black finely dispersed A.O.M.,opaque	
1c	Single pollen, black wood, yellow cuticles, dominated black finely dispersed A.O.M., opaque	Inland playa lake
1b	Single pollen and acritarchs, black wood, yellow cuticles and plant tissue, dominated black finely dispersed A.O.M., opaque	
1a	Black wood, yellow cuticles, dominated black finely dispersed A.O.M., opaque	

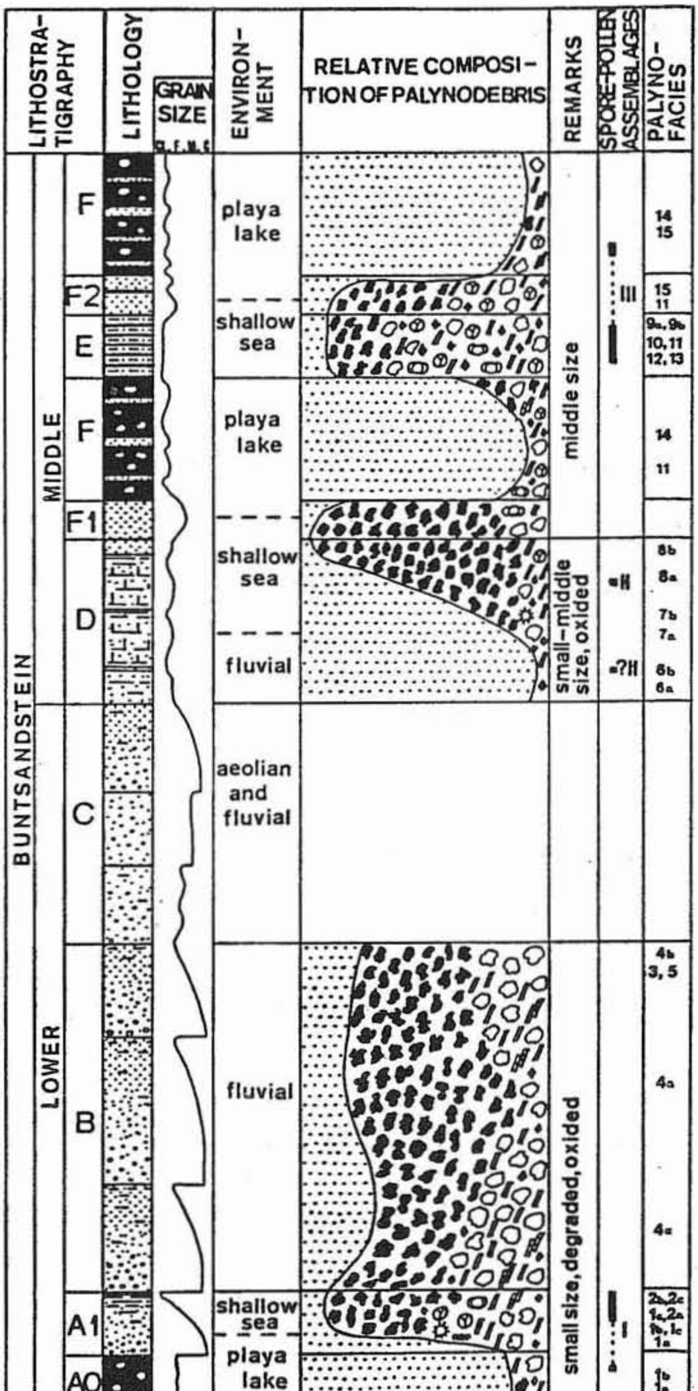
PALAEOCLIMATIC AND PALAEOENVIRONMENTAL ASPECTS

A change of sedimentological character is observed from the coarse, proximal facies finishing the Zechstein sedimentation into the playa lake facies in the lowermost Buntsandstein (A0 complex) in the NW part of the Holy Cross Mts. This change is documented also by palynofacies (1 type). It can be regarded as an echo of the Early Triassic transgression which is more distinctly marked in the deeper part of basin (G. Pieńkowski, 1989).

In the upper part of the Lower Buntsandstein (A1 complex) marine influences are marked in the deposits as a few meters thick heterolithic interbeds (M. Kuleta, 1985, 1990; G. Pieńkowski, 1989). Also the palynofacies containing acritarchs (2 type) suggests the shallow, nearshore marine environment.

A combined H. Visscher — C. J. van der Zwan (1981) and G. Jerenič — B. Jelen (1991) model, based on the statistic analyses of xerophytic and hygrophytic elements in the microfloristic assemblages, was used for the palaeoclimatic reconstructions (Fig. 3).

The xerophytic elements, belonging to the descent conifers and represented by striatite pollen of *Protohaploxypinus* and *Lunatisporites* genera (G group), are the most abundant in the I assemblage (53% of spectrum). *Klausipollenites* pollen (I group) occur less frequent. The hygrophytic elements — mainly ferns and lycopods spores — make 46% of spectrum. They are dominated by *Densoisporites, Lundbladispora* and *Endosporites* taxa (D group) as well as *Cyclotriletes* and *Guttatisporites* (E group). Cycadales pollen represented mainly by *Cycadopites* (F group) are abundant. Acritarchs, which make 6% of spectrum, are dominated by specimens of M and N groups.



LITHOSTRATIGRAPHY
LITHOLOGY
GRAIN SIZE
ENVIRONMENT
RELATIVE COMPOSITION OF PALYNODEBRIS
REMARKS
SPORE-POLLEN ASSEMBLAGES
PALYNOFACIES
BUNTSANDSTEIN
MIDDLE
LOWER
F
F2
E
F
F1
D
C
B
A1
A0
playa lake
shallow sea
playa lake
shallow sea
fluvial
aeolian and fluvial
fluvial
shallow sea
playa lake
middle size
small–middle size, oxided
small size, degraded, oxided
III
II
?II
I
14
15
15
11
9a, 9b
10, 11
12, 13
14
11
8b
8a
7b
7a
6b
6a
4b
3, 5
4a
4c
2b, 2c
1c, 2a
1b, 1c
1a
1b
1a
1
2
3
4
5
6
7
8
9
10

A slight difference in the quantity of hygro- and xerophytic components seems to suggest that there was a tropical climate with a weak tendecy toward dry during the Early Triassic (Griesbachian) at the Holy Cross Mts. area. (According to the P. A. Ziegler's (1989) reconstructions Polish area was located about the 30°N latitude at the end of the Paleozoic era).

The presence of acritarchs evidence that deposition, in that time, took place in the marine environment (Fig. 5) and occurrence of redeponed Carboniferous spores of *Triquitrites* and *Tripartites* suggests the transport from SW direction, where the Carboniferous deposits were not overlied by Permian.

A slight increase of hygrophytic elements (up to 55% of spectrum) is observed in the II assemblage. They belong mainly to D and F groups (Fig. 3). The frequency of xerophytic taxa (G and I groups) significantly decreased to 9%. Acritarchs are especially abundant (36% of spectrum) and they belong mainly to N and O groups. The hygrophytic components domination evidence an increase of humidity during the Early–Middle Dinnerian and numerous appearance of acritarchs shows that deposition took place in the marine environment.

Almost equilibrium between xero- (mainly H group) and hygrophytic element (B and D groups) is observed in the III assemblage. It can suggest that during Middle and Late Spathian period the climatic conditions became more dry, similar to those during in the Early Triassic. Sedimentation took place in the inland environment.

Thus the two climatic cycles can be distinguished on the discussed area in the Early Triassic: first which started with tropical climate in the Early Griesbachian (that is correlated with the lower part of the Lower Buntsandstein — A0 and A1 complexes) and became extremaly dry (desert, semi-desert) in the Late Griesbachian (the upper part of the Lower Buntsandstein — C complex) and second cycle which started with more humid tropical climate in the Early/Middle Dinnerian (the lower part of the Middle Buntsandstein — D complex) and became more dry (semi-arid) in the Spathian (the upper part of the Middle Buntsandstein — E and F complexes).

This cyclicity is reflected also by deposits development. It is consistent with the sedimentary megacycles distinguished by D. Mader (1992) in spite of some differences in the detail interpretation of the depositional environments. One can discuss, on the other hand, the consistency, with sedimentary cycles described by R. Fuglewicz (1980). The Suboolithic Beds in the lower part of the Lower Buntsandstein, were deposit, according to him, in the arid, semi-desert environment, whereas the Lower Oolithic Beds (upper part of the Lower Buntsandstein) originated in the open marine environment. The Interoolithic Beds (lower part of the Middle Buntsandstein) have continental character and second

Fig. 5. Reconstruction of the Early Triassic palaeoenvironment in NW part of the Holy Cross Mts.

Palynomorphs: 1 — pollen grains, 2 — spores, 3 — acritarchs, 4 — fungial spores; structured debris: 5 — woody remains, 6 — cuticles, 7 — plant tissue; amorphous matter: 8 — finely dispersed, 9 — heterogenous, 10 — opaque; for the lithological legend see Fig. 2

Rekonstrukcja paleośrodowisk we wczesnym triasie w NW części Gór Świętokrzyskich

Palinomorfy: 1 — ziarna pyłku, 2 — spory, 3 — akritarchy, 4 — spory grzybów; strukturalny debris: 5 — drewno, 6 — nabłonki, 7 — tkanki roślinne; amorficzny debris: 8 — drobnorozproszony, 9 — heterogeniczny, 10 — czarny; objaśnienia symboli litologicznych jak na fig. 2

Table 5

Correlation of spore-pollen assemblages

Chronostratigraphy			Lithostratigraphy (after M. Kuleta, 1990, modified)			Palynostratigraphy: W and S Europe (after W. A. Brugman, 1983)	W Poland (after T. Orłowska-Zwolińska, 1984, 1985)		Holy Cross Mts.	E Greenland (after B.E.Balme, 1979)	Canadian Arctic Archipelagoo (after D.C. McGregor, 1965; M. J. Fisher, 1979; J. Utting, 1987)
SCYTHIAN	OLENEKIAN	SPATHIAN	BUNTSANDSTEIN	MIDDLE	F	LT-4	*Densoisporites nejburgii*	*presselensis*	III		
		DINNERIAN			F	LT-3		*nejburgii*		*Taeniaesporites*	II
					F						
					D	LT-2		*nejburgii–-acritarchs*	II, ?II		
	INDUAN	GRIESBACHIAN		LOWER	C	LT-1					
					B		*Lundbladispora obsoleta–-Protohaploxypinus pantii*			*Protohaploxypinus*	I *Protohaploxypinus –Lundbladispora –Tympanicysta*
					A1				I		
					A0						

marine transgression occurred in the middle part of the Middle Buntsandstein. The results of palynological investigation obtained both by T. Orłowska-Zwolińska (1984, 1985) and by the author suggest that there were two marine transgression in the Early Griesbachian and Early/Middle Dinnerian in Poland.

CONCLUSIONS

1. The palynostratigraphical scheme of the Lower and Middle Buntsandstein deposits was obtained for NW part of the Holy Cross Mts. as a result of the correlation of the sections containing microflora (Tab. 3).

The differences in the vertical miospores ranges as well as in their percentage made possible to distinguish the three spore-pollen assemblages: the I assemblage — in the A0 and A1 complexes which represents the *Lundbladispora obsoleta–Protohaploxypinus pantii* Zone (Lower Griesbachian); the II assemblage — in the D complex which belongs to the *Densoisporites nejburgii* and acritarchs Subzone (Lower/Middle Dinnerian); the III assemblage — in the E and F complexes which represents the *Cycloverrutriletes presselensis* Subzone (Spathian).

Thus the presence of the Lower Bundsandstein was documented at the studied area that was disputed by some authors (see R. Fuglewicz et al., 1990) who claimed that the Middle Bundsandstein palynomorphs are the oldest Triassic microfossils known both from the near and farther margin of the Holy Cross Mts.

2. Holy Cross spore-pollen assemblages can be easily correlated with the spectra known from the other regions of Poland and Europe (Tab. 5).

3. The 15 palynofacies types were recognized in the Lower–Middle Buntsandstein section (with an exception of C complex) which, together with the lithological-sedimentary features of deposits, made possible to reconstruct the depositional environment represented by the four main types: inland playa lake, fluvial with the deposition on flood plain and in fluviatile channels and shallow marine, locally restricted (Fig. 5, Tab. 4). In the Early Griesbachian (A0 complex) deposition took place in the inland playa lake, than the marine transgression happend (A1 and A0/A1 complexes) and deposition occurred in the shallow nearshore sea. In the Middle Griesbachian (B complex) dominated fluvial sedimentation in the moderately to highly braided pebbly or sandy rivers. The environment changed into desert in the Late Griesbachian–Early Dinnerian (C complex). The next transgression took place in the Early/Middle Dinnerian (D complex). Then the basin was isolated from the open sea and deposits of E and F complexes originated in the continental muddy flood plain and playa lake.

4. On the basis of a palaeoclimatic model two climatic cycles were distinguished: first — in the Griesbachian–Early/Middle Dinnerian (that is correlated with the Lower Buntsandstein — A0–C complexes — and lower part of the Middle Buntsandstein — D complex), which began with the warm, rather dry tropic climate in the Early Griesbachian (A0 and A1 complexes) — I assemblage — and changed into arid and semi-arid during the Late Griesbachian–Early Dinnerian (C complex); second — in the Early/Middle Dinnerian–Spathian (Middle Buntsandstein — D–F complexes), which started with the humid tropical climate in the Early/Middle Dinnerian (D complex) — II assemblage — and became more dry during the Spathian E and F complexes.

5. The palaeoenvironmental as well as palaeoclimatic reconstructions suggest the possibility of distinguishing of two sedimentary megacycles in the Lower and Middle Buntsandstein. Therefore it seems more proper to include C complex to the Lower Buntsandstein.

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PALINOSTRATYGRAFIA DOLNEGO I ŚRODKOWEGO PSTREGO PIASKOWCA W PÓŁNOCNO-ZACHODNIEJ CZĘŚCI GÓR ŚWIĘTOKRZYSKICH

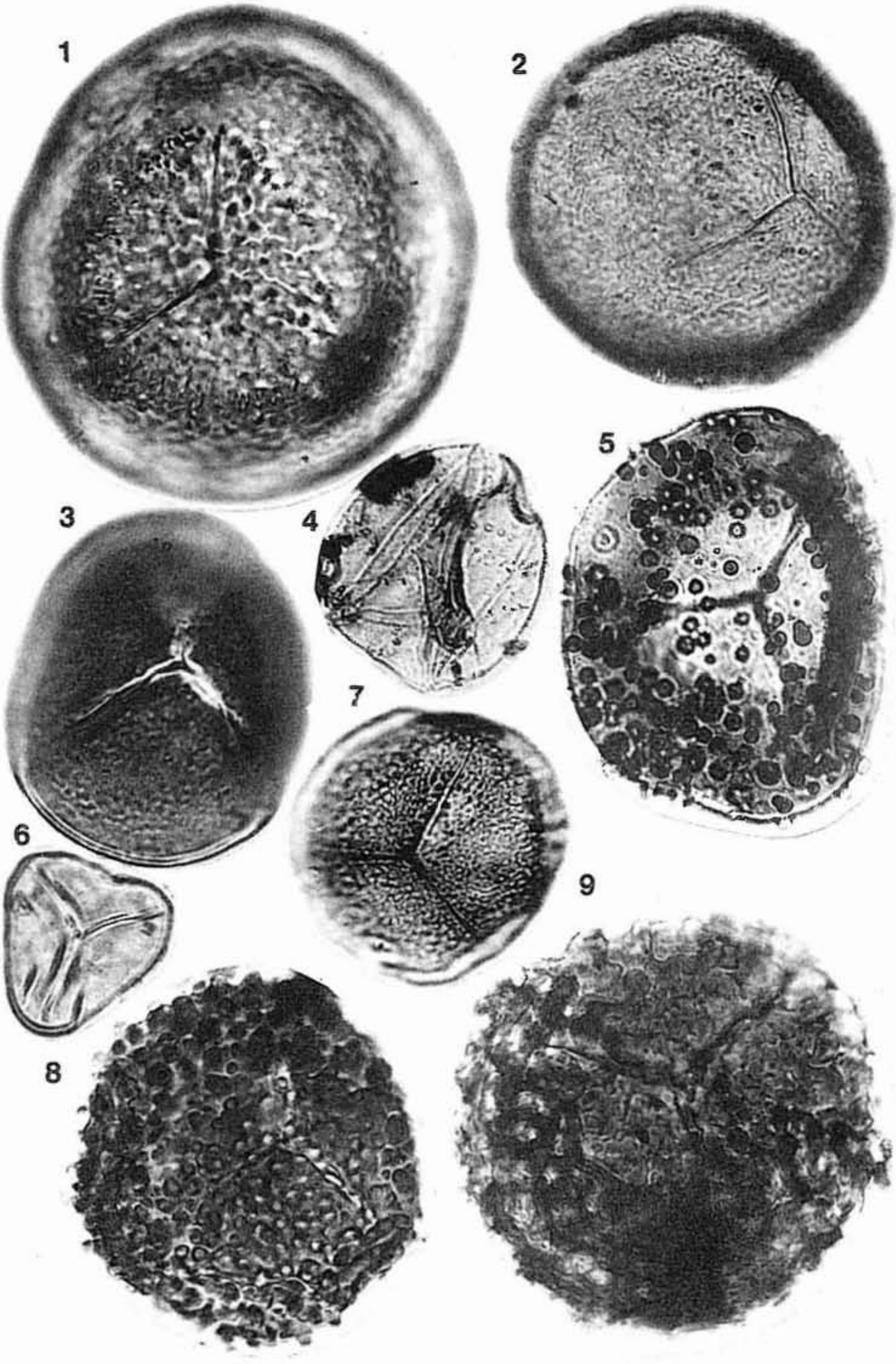
Streszczenie

W wyniku badań palinologicznych osadów dolnego i środkowego pstrego piaskowca w północno-zachodniej części Gór Świętokrzyskich wyróżniono trzy następujące zespoły sporowo-pyłkowe: I zespół reprezentujący poziom *Lundbladispora obsoleta–Protohaploxypinus pantii* (dolny pstry piaskowiec), II zespół reprezentujący podpoziom *Densoisporites nejburgii* i akritarcha (dolna część środkowego pstrego piaskowca) i III zespół reprezentujący podpoziom *Cycloverrutriletes presselensis* (górna część środkowego pstrego piaskowca).

Jest to pierwsza próba zastosowania biostratygrafii w omawianych utworach. Zespoły zidentyfikowane w Górach Świętokrzyskich dają się dobrze korelować ze spektrami opisanymi z obszaru Polski Zachodniej i Europy.

W badanych osadach wydzielono 15 typów palinofacji, na podstawie których jak również cech petrograficzno-litologicznych osadu starano się scharakteryzować środowisko depozycji. W dolnym pstrym piaskowcu zmieniało się ono od kontynentalnego typu *playa*, poprzez morskie przybrzeżne, po kontynentalne rzeczne i pustynne. W dolnej części środkowego pstrego piaskowca panowały warunki płytkiego morza, które zmieniły się na kontynentalne jeziorne (*playa*) w wyższej jego części.

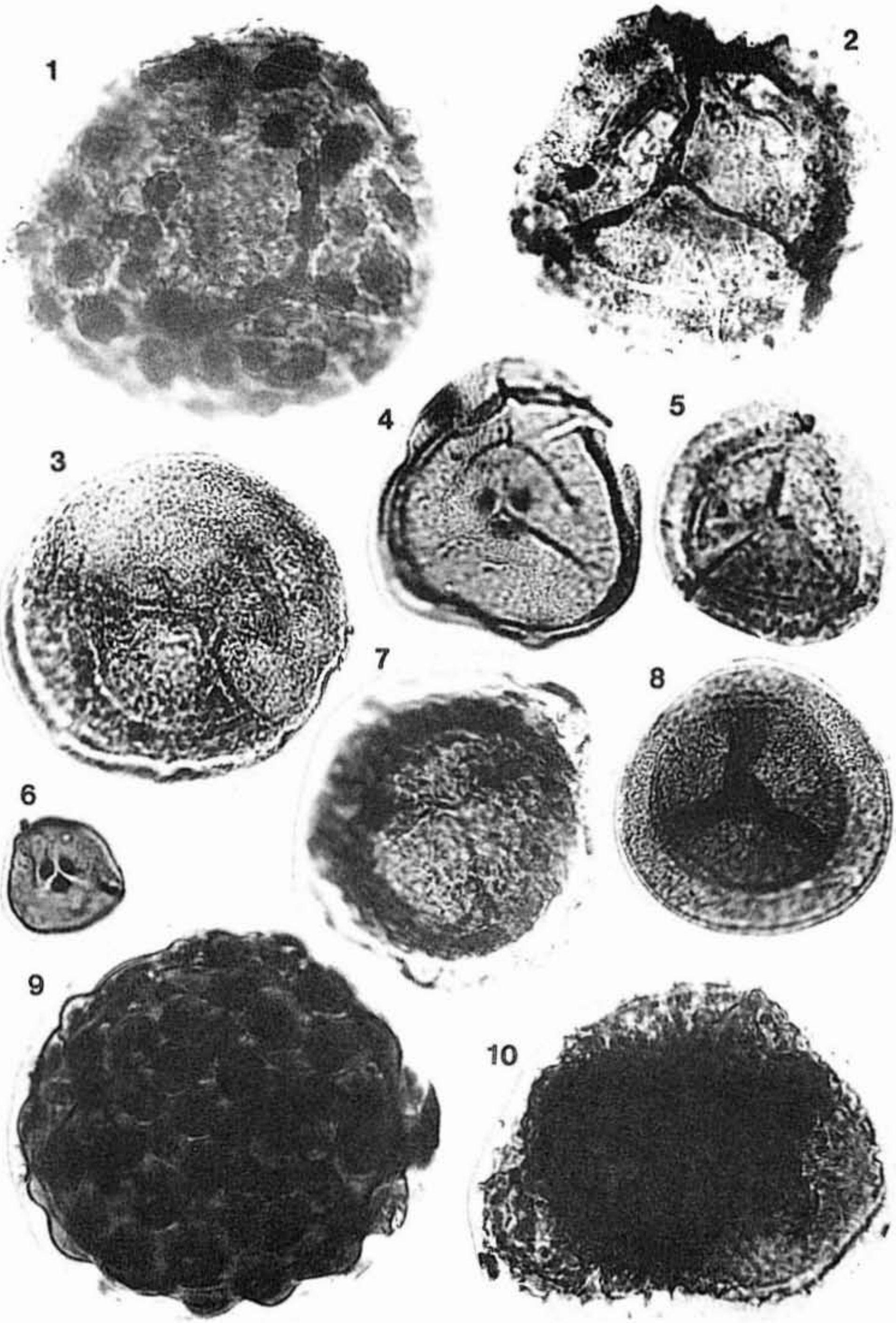
Model paleoklimatyczny zastosowany w badaniach pozwolił na wyróżnienie dwóch cykli klimatycznych: pierwszego w griesbachu, który zaczął się klimatem ciepłym (zwrotnikowym) z tendencją do suchego, przechodzącym w półpustynny i pustynny w późnym griesbachu–wczesnym/środkowym dinnerianie, oraz drugiego, który rozpoczął się klimatem zwrotnikowym, wilgotnym i zmienił na bardziej suchy w późnym dinnerianie–spatianie.



Anna FIJAŁKOWSKA — Palynostratigraphy of the Lower and Middle Buntsandstein in north-western part of the Holy Cross Mts.

PLATE I

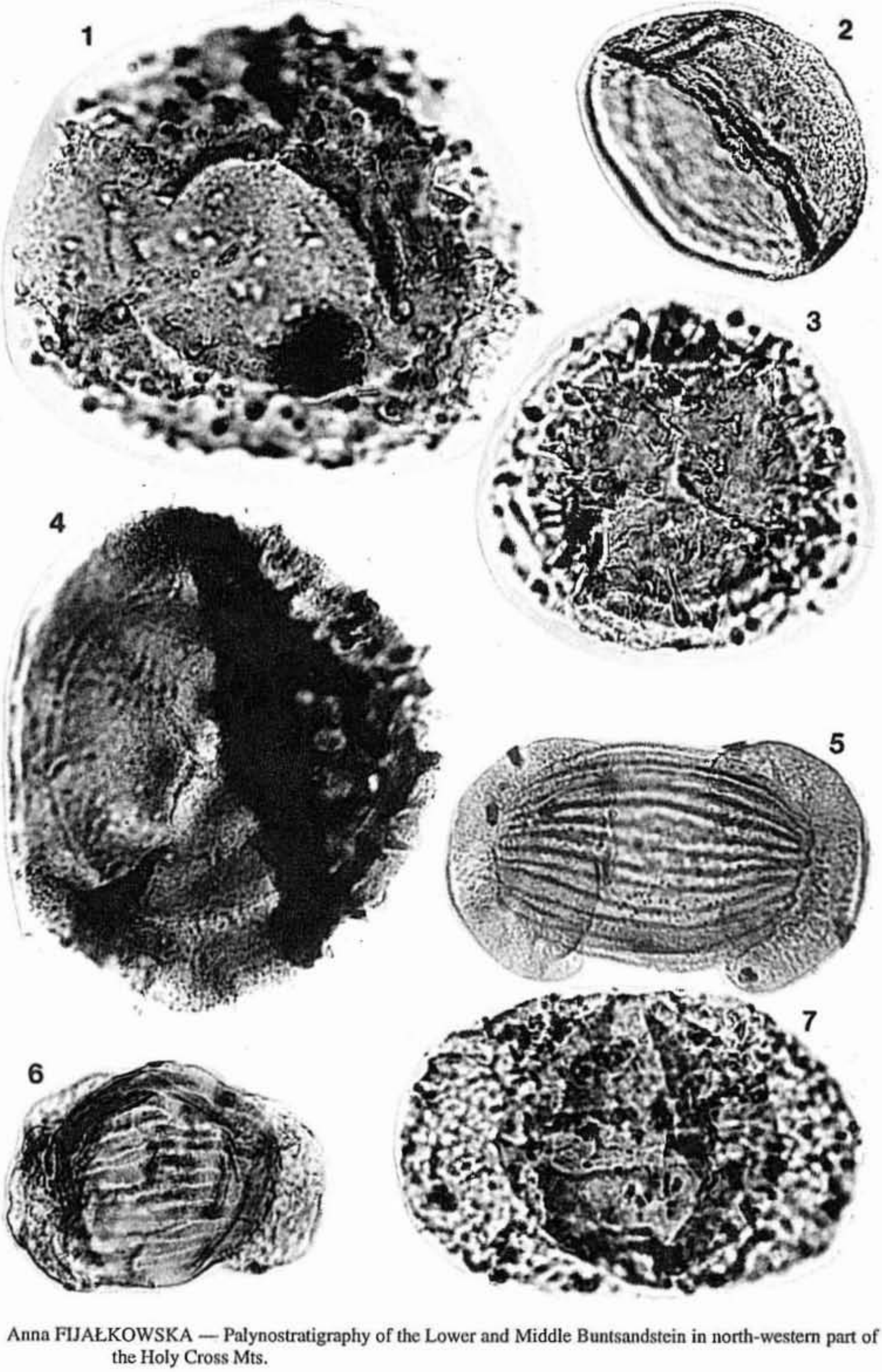
Fig. 1. *Cyclotriletes triassicus* Mädler
Łączna — Zaszosie IG 1 borehole, depth 329.7 m; Lower Buntsandstein
Otwór wiertniczy Łączna — Zaszosie IG 1, głęb. 329,7 m; dolny pstry piaskowiec
Fig. 2. *Punctatisporites triassicus* Schulz
Stachura IG 1 borehole, depth 81.5 m; Middle Buntsandstein
Otwór wiertniczy Stachura IG 1, głęb. 81,5 m; środkowy pstry piaskowiec
Fig. 3. *Cyclotriletes oligogranifer* Mädler
Tumlin — Podgrodzie IG 1 borehole, depth 190.7 m; Lower Buntsandstein
Otwór wiertniczy Tumlin — Podgrodzie IG 1, głęb. 190,7 m; dolny pstry piaskowiec
Fig. 4. *Calamospora* cf. *tener* (Leschik) de Jersey
Tumlin — Podgrodzie IG 1 borehole, depth 190.7 m; Lower Buntsandstein
Otwór wiertniczy Tumlin — Podgrodzie IG 1, głęb. 190,7 m; dolny pstry piaskowiec
Fig. 5. *Cycloverrutriletes presselensis* Schulz
Stachura IG 1 borehole, depth 81.5 m; Middle Buntsandstein
Otwór wiertniczy Stachura IG 1, głęb. 81,5 m; środkowy pstry piaskowiec
Fig. 6. *Deltoispora minima* (Couper) Pocock
Opoczno PIG 2 borehole, depth 1527.3 m; Middle Buntsandstein
Otwór wiertniczy Opoczno PIG 2, głęb. 1527,3 m; środkowy pstry piaskowiec
Fig. 7. *Cyclotriletes microgranifer* Mädler
Tumlin — Podgrodzie IG 1 borehole, depth 204.4 m; Lower Buntsandstein
Otwór wiertniczy Tumlin — Podgrodzie IG 1, głęb. 204,4 m; dolny pstry piaskowiec
Fig. 8. *Verrucosisporites* sp.
Stachura IG 1 borehole, depth 98.4 m; Middle Buntsandstein
Otwór wiertniczy Stachura IG 1, głęb. 98,4 m; środkowy pstry piaskowiec
Fig. 9. *Verrucosisporites pseudomorulae* Visscher
Stachura IG 1 borehole, depth 98.4 m; Middle Buntsandstein
Otwór wiertniczy Stachura IG 1, głęb. 98,4 m; środkowy pstry piaskowiec
Figs. 1–9 — x 1000



Anna FIJAŁKOWSKA — Palynostratigraphy of the Lower and Middle Buntsandstein in north-western part of the Holy Cross Mts.

PLATE II

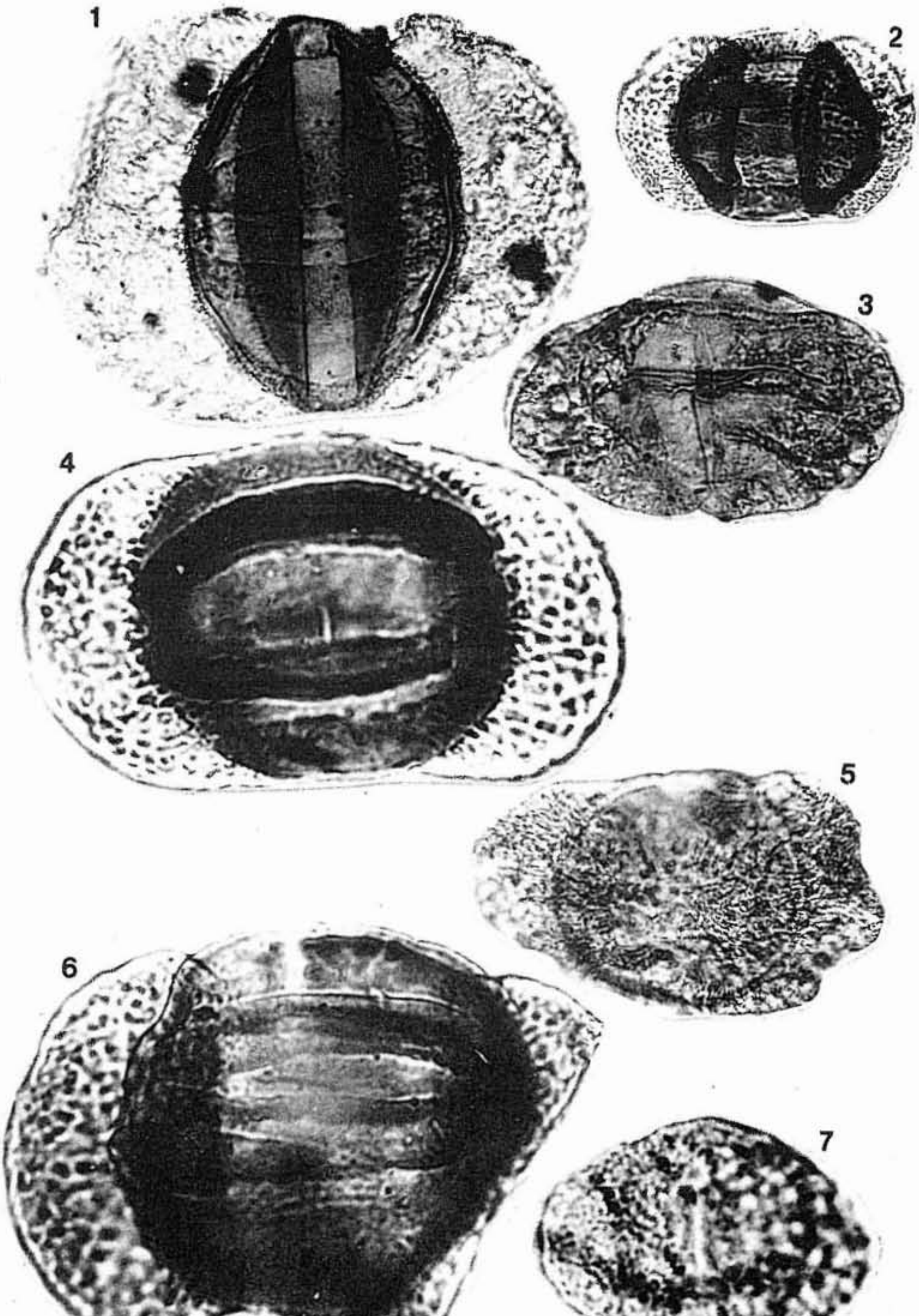
Fig. 1. *Guttatisporites elegans* Visscher
Jaworze IG 1 borehole, depth 260.0 m; Lower Buntsandstein
Otwór wiertniczy Jaworze IG 1, głęb. 260,0 m; dolny pstry piaskowiec
Fig. 2. *Lundbladispora obsoleta* Balme
Łączna — Zaszosie IG 1 borehole, depth 329.7 m; Lower Buntsandstein
Otwór wiertniczy Łączna — Zaszosie IG 1, głęb. 329,7 m; dolny pstry piaskowiec
Fig. 3. *Densoisporites playfordii* (Balme) Dettmann
Jaworze IG 1 borehole, depth 260.0 m; Lower Buntsandstein
Otwór wiertniczy Jaworze IG 1, głęb. 260,0 m; dolny pstry piaskowiec
Fig. 4. *Endosporites papillatus* Jansonius
Łączna — Zaszosie IG 1 borehole, depth 329.7 m; Lower Buntsandstein
Otwór wiertniczy Łączna — Zaszosie IG 1, głęb. 329,7 m; dolny pstry piaskowiec
Fig. 5. *Kraeuselisporites* sp.
Tumlin — Podgrodzie IG 1 borehole, depth 190.7 m; Lower Buntsandstein
Otwór wiertniczy Tumlin — Podgrodzie IG 1, głęb. 190,7 m; dolny pstry piaskowiec
Fig. 6. *Endosporites papillatus* Jansonius
Stachura IG 1 borehole, depth 81.5 m; Middle Buntsandstein
Otwór wiertniczy Stachura IG 1, głęb. 81,5 m; środkowy pstry piaskowiec
Fig. 7. *Lundbladispora brevicula* Balme
Jaworze IG 1 borehole, depth 260.0 m; Lower Buntsandstein
Otwór wiertniczy Jaworze IG 1, głęb. 260,0 m; dolny pstry piaskowiec
Fig. 8. *Densoisporites nejburgii* (Schulz) Balme
Opoczno PIG 2 borehole, depth 1820.2 m; Middle Buntsandstein
Otwór wiertniczy Opoczno PIG 2, głęb. 1820,2 m; środkowy pstry piaskowiec
Fig. 9. *Verrucosisporites thuringiacus* Mädler
Cierchy IG 1 borehole, depth 91.1 m; Middle Buntsandstein
Otwór wiertniczy Cierchy IG 1, głęb. 91,1 m; środkowy pstry piaskowiec
Fig. 10. *Lapposisporites* sp.
Nieświń PIG 1 borehole, depth 1531.1 m; Middle Buntsandstein
Otwór wiertniczy Nieświń PIG 1, głęb. 1531,1 m; środkowy pstry piaskowiec
Figs. 1–10 — x 1000



Anna FIJAŁKOWSKA — Palynostratigraphy of the Lower and Middle Buntsandstein in north-western part of the Holy Cross Mts.

PLATE III

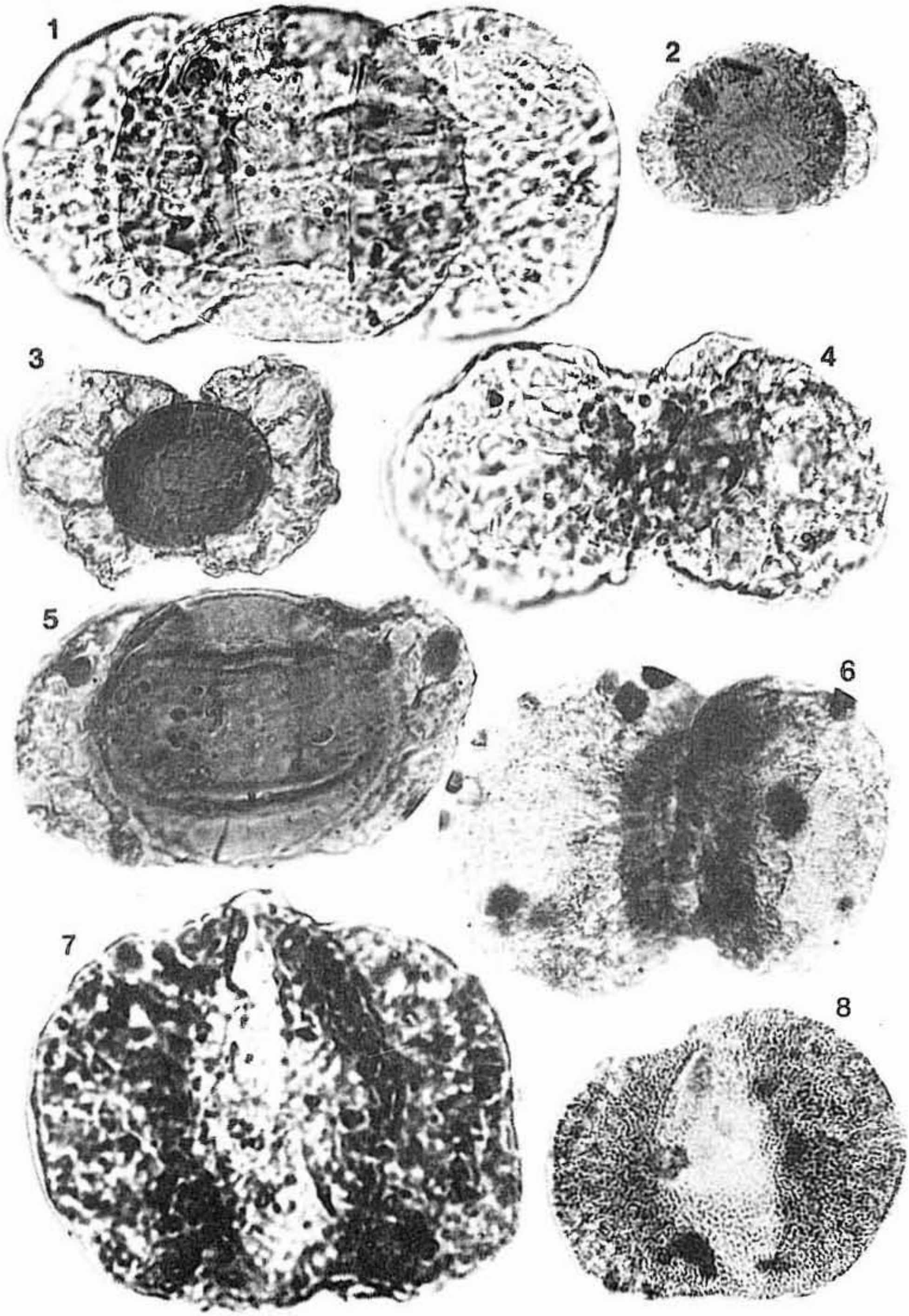
Fig. 1. *Kraeuselisporites ullrichii* Reinhardt et Schmitz
Tumlin — Podgrodzie IG 1 borehole, depth 204.4 m; Lower Buntsandstein
Otwór wiertniczy Tumlin — Podgrodzie IG 1, głęb. 204,4 m; dolny pstry piaskowiec
Fig. 2. *Aratrisporites granulatus* (Klaus) Playford et Dettmann
Cierchy IG 1 borehole, depth 103.9 m; Middle Buntsandstein
Otwór wiertniczy Cierchy IG 1, głęb. 103,9 m; środkowy pstry piaskowiec
Fig. 3. *Kraeuselisporites cuspidus* Balme
Łączna — Zaszosie IG 1 borehole, depth 329.7 m; Lower Buntsandstein
Otwór wiertniczy Łączna — Zaszosie IG 1, głęb. 329,7 m; dolny pstry piaskowiec
Fig. 4. *Kraeuselisporites apiculatus* Jansonius
Tumlin — Podgrodzie IG 1 borehole, depth 190.7 m; Lower Buntsandstein
Otwór wiertniczy Tumlin — Podgrodzie IG 1, głęb. 190,7 m; dolny pstry piaskowiec
Fig. 5. *Striatoabietites aytugii* (Visscher) Scheuring
Stachura IG 1 borehole, depth 81.5 m; Middle Buntsandstein
Otwór wiertniczy Stachura IG 1, głęb. 81,5 m; środkowy pstry piaskowiec
Fig. 6. *Striatoabietites balmei* Klaus
Stachura IG 1 borehole, depth 81.5 m; Middle Buntsandstein
Otwór wiertniczy Stachura IG 1, głęb. 81,5 m; środkowy pstry piaskowiec
Fig. 7. *Protohaploxypinus jacobii* (Jansonius) Hart
Tumlin — Podgrodzie IG 1 borehole, depth 204.4 m; Lower Buntsandstein
Otwór wiertniczy Tumlin — Podgrodzie IG 1, głęb. 204,4 m; dolny pstry piaskowiec
Figs. 1, 4 — x 1500, Figs. 2, 3, 5–7 — x 1000



Anna FIJAŁKOWSKA — Palynostratigraphy of the Lower and Middle Buntsandstein in north-western part of the Holy Cross Mts.

PLATE IV

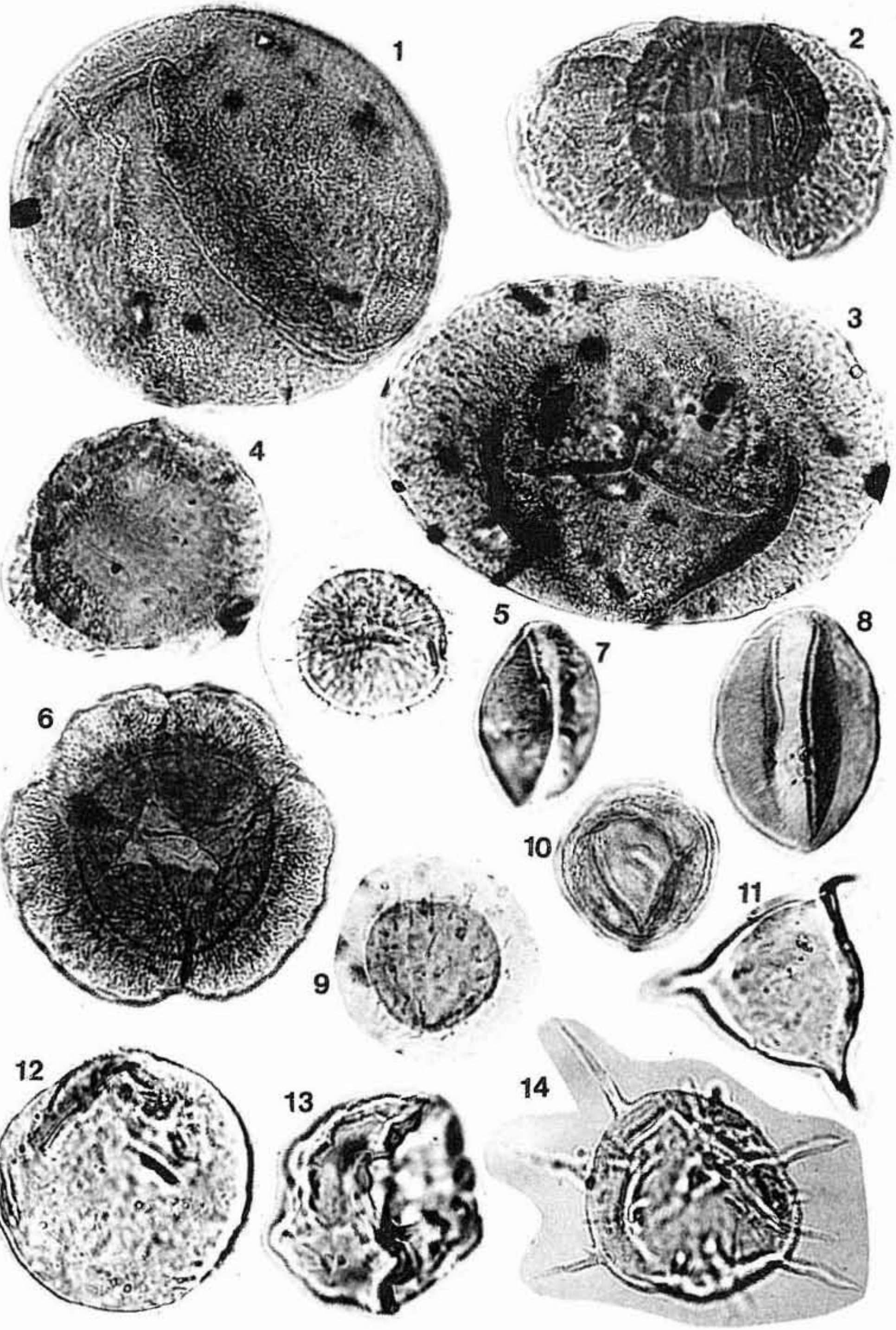
Fig. 1. *Lunatisporites puntii* Visscher
Stachura IG 1 borehole, depth 81.5 m; Middle Buntsandstein
Otwór wiertniczy Stachura IG 1, głęb. 81,5 m; środkowy pstry piaskowiec
Fig. 2. *Lunatisporites labdacus* (Klaus) Fijałkowska
Łączna — Zaszosie IG 1 borehole, depth 329.7 m; Lower Buntsandstein
Otwór wiertniczy Łączna — Zaszosie IG 1, głęb. 329,7 m; dolny pstry piaskowiec
Fig. 3. *Succinctisporites* sp.
Nieświń PIG 1 borehole, depth 1531.3 m; Middle Buntsandstein
Otwór wiertniczy Nieświń PIG 1, głęb. 1531,3 m; środkowy pstry piaskowiec
Fig. 4. *Lunatisporites gracilis* (Jansonius) Fijałkowska
Tumlin — Podgrodzie IG 1 borehole, depth 190.7 m; Lower Buntsandstein
Otwór wiertniczy Tumlin — Podgrodzie IG 1, głęb. 190,7 m; dolny pstry piaskowiec
Fig. 5. *Klausipollenites* sp.
Nieświń PIG 1 borehole, depth 1531.3 m; Middle Buntsandstein
Otwór wiertniczy Nieświń PIG 1, głęb. 1531,3 m; środkowy pstry piaskowiec
Fig. 6. *Protohaploxypinus pantii* (Jansonius) Orłowska-Zwolińska
Tumlin — Podgrodzie IG 1 borehole, depth 204.4 m; Lower Buntsandstein
Otwór wiertniczy Tumlin — Podgrodzie IG 1, głęb. 204,4 m; dolny pstry piaskowiec
Fig. 7. *Falcisporites* sp.
Cierchy IG 1 borehole, depth 91.1 m; Lower Buntsandstein
Otwór wiertniczy Cierchy IG 1, głęb. 91,1 m; dolny pstry piaskowiec
Figs. 1, 4 — x 1500, Figs. 2, 3, 5–7 — x 1000



Anna FIJAŁKOWSKA — Palynostratigraphy of the Lower and Middle Buntsandstein in north-western part of the Holy Cross Mts.

PLATE V

Fig. 1. *Lunatisporites noviaulensis* (Leschik) Scheuring
Łączna — Zaszosie IG 1 borehole, depth 329.7 m; Lower Buntsandstein
Otwór wiertniczy Łączna — Zaszosie IG 1, głęb. 329,7 m; dolny pstry piaskowiec
Fig. 2. *Triadispora plicata* Klaus
Nieświń PIG 1 borehole, depth 1531.3 m; Middle Buntsandstein
Otwór wiertniczy Nieświń PIG 1, głęb. 1531,3 m; środkowy pstry piaskowiec
Fig. 3. *Platysaccus niger* Mädler
Stachura IG 1 borehole, depth 81.5 m; Middle Buntsandstein
Otwór wiertniczy Stachura IG 1, głęb. 81,5 m; środkowy pstry piaskowiec
Fig. 4. *Platysaccus papilionis* Potonié et Klaus
Cierchy IG 1 borehole, depth 103.9 m; Middle Buntsandstein
Otwór wiertniczy Cierchy IG 1, głęb. 103,9 m; środkowy pstry piaskowiec
Fig. 5. *Lunatisporites gracilis* (Jansonius) Fijałkowska
Tumlin — Podgrodzie IG 1 borehole, depth 190.7 m; Lower Buntsandstein
Otwór wiertniczy Tumlin — Podgrodzie IG 1, głęb. 190,7 m; dolny pstry piaskowiec
Fig. 6. *Platysaccus leschiki* Hart
Opoczno PIG 2 borehole, depth 1527.3 m; Middle Buntsandstein
Otwór wiertniczy Opoczno PIG 2, głęb. 1527,3 m; środkowy pstry piaskowiec
Fig. 7. *Alisporites cymbatus* Venkatachala, Beju et Kar
Cierchy IG 1 borehole, depth 91.1 m; Middle Buntsandstein
Otwór wiertniczy Cierchy IG 1, głęb. 91,1 m; środkowy pstry piaskowiec
Fig. 8. *Alisporites granulatus* Klaus
Cierchy IG 1 borehole, depth 91.1 m; Middle Buntsandstein
Otwór wiertniczy Cierchy IG 1, głęb. 91,1 m; środkowy pstry piaskowiec
Figs. 1–6, 8 — x 1000, Fig. 7 — x 1500



Anna FIJAŁKOWSKA — Palynostratigraphy of the Lower and Middle Buntsandstein in north-western part of the Holy Cross Mts.

PLATE VI

Fig. 1. *Brachysaccus ovalis* Mädler
Opoczno PIG 2 borehole, depth 1527.3 m; Middle Buntsandstein
Otwór wiertniczy Opoczno PIG 2, głęb. 1527,3 m; środkowy pstry piaskowiec
Fig. 2. *Angustisulcites klausi* Freudenthal
Opoczno PIG 2 borehole, depth 1591.6 m; Middle Buntsandstein
Otwór wiertniczy Opoczno PIG 2, głęb. 1591,6 m; środkowy pstry piaskowiec
Fig. 3. *Angustisulcites gorpii* Visscher
Stachura IG 1 borehole, depth 81.5 m; Middle Buntsandstein
Otwór wiertniczy Stachura IG 1, głęb. 81,5 m; środkowy pstry piaskowiec
Fig. 4. *Triadispora crassa* Klaus
Cierchy IG 1 borehole, depth 103.9 m; Middle Buntsandstein
Otwór wiertniczy Cierchy IG 1, głęb. 103,9 m; środkowy pstry piaskowiec
Fig. 5. *Micrhystridium* sp.
Opoczno PIG 2 borehole, depth 1820.2 m; Middle Buntsandstein
Otwór wiertniczy Opoczno PIG 2, głęb. 1820,2 m; środkowy pstry piaskowiec
Fig. 6. *Stellapollenites thiergartii* (Mädler) Brugman
Stachura IG 1 borehole, depth 81.5 m; Middle Buntsandstein
Otwór wiertniczy Stachura IG 1, głęb. 81,5 m; środkowy pstry piaskowiec
Fig. 7. *Cycadopites coxii* Visscher
Jaworze IG 1 borehole, depth 260.0 m; Lower Buntsandstein
Otwór wiertniczy Jaworze IG 1, głęb. 260,0 m; dolny pstry piaskowiec
Fig. 8. *Cycadopites follicularis* Wilson et Webster
Tumlin — Podgrodzie IG 1 borehole, depth 204.4 m; Lower Buntsandstein
Otwór wiertniczy Tumlin — Podgrodzie IG 1, głęb. 204,4 m; dolny pstry piaskowiec
Fig. 9. *Baltisphaeridium* sp.
Opoczno PIG 2 borehole, depth 1820.2 m; Middle Buntsandstein
Otwór wiertniczy Opoczno PIG 2, głęb. 1820,2 m; środkowy pstry piaskowiec
Fig. 10. *Duplicisporites granulatus* (Leschik) Klaus
Stachura IG 1 borehole, depth 98.4 m; Middle Buntsandstein
Otwór wiertniczy Stachura IG 1, głęb. 98,4 m; środkowy pstry piaskowiec
Fig. 11. *Veryhachium trispinoides* (Jekhowsky) Fijałkowska
Opoczno PIG 2 borehole, depth 1820.2 m; Middle Buntsandstein
Otwór wiertniczy Opoczno PIG 2, głęb. 1820,2 m; środkowy pstry piaskowiec
Fig. 12. *Leiosphaeridia* sp.
Opoczno PIG 2 borehole, depth 1820.0 m; Middle Buntsandstein
Otwór wiertniczy Opoczno PIG 2, głęb. 1820,0 m; środkowy pstry piaskowiec
Fig. 13. *Sphaeripollenites* sp.
Opoczno PIG 2 borehole, depth 1591.6 m; Middle Buntsandstein
Otwór wiertniczy Opoczno PIG 2, głęb. 1591,6 m; środkowy pstry piaskowiec
Fig. 14. *Baltisphaeridium longispinosum* (Eisenack) Eisenack
Opoczno PIG 2 borehole, depth 1820.2 m; Middle Buntsandstein
Otwór wiertniczy Opoczno PIG 2, głęb. 1820,2 m; środkowy pstry piaskowiec
Figs. 1, 2, 4–10, 12–14 — x 1000, Figs. 3, 11 — x 1500