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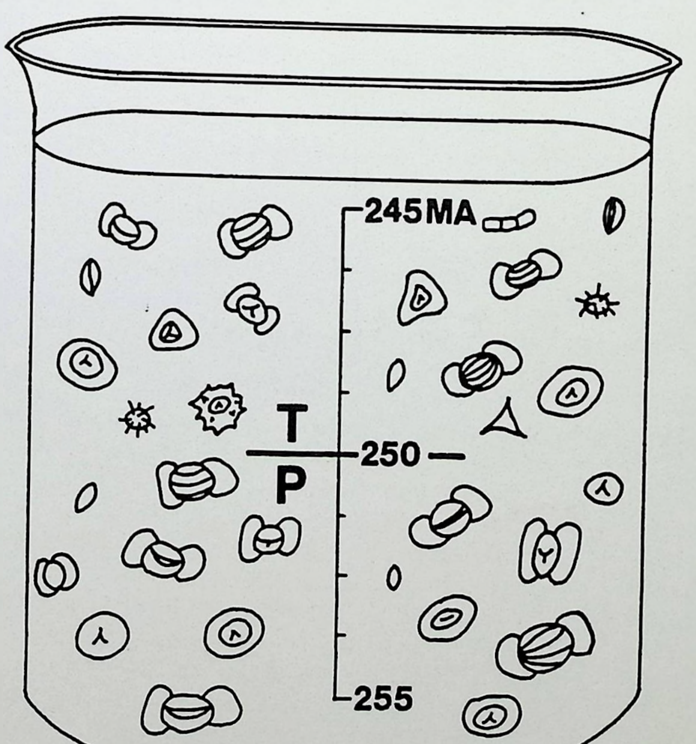
PALYNOLOGICAL ASPECTS OF THE PERMO - TRIASSIC SUCCESSION IN THE HOLY CROSS MOUNTAINS, POLAND



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Palynological aspects of the Permo-Triassic succession in the Holy Cross Mountains, Poland

with 4 Figures, 3 Tables and 7 Plates

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Summary

A palynostratigraphic study of the Permo-Triassic sequence in the Holy Cross Mountains resulted in the identification of four spore-pollen assemblages which represent Lueckisporites virkkiae and LT1 palynological zones.

The correlation was drawn between the Holy Cross spore-pollen assemblages and the contemporaneous spectra known from the other European regions assigned both to the German and Alpine basins.

The paleoclimatic model obtained from this study indicates the consequent aridation during the Late Permian, documented by the distinc domination of the xerophytic elements in the miosores spectra and an increase of humidity in the Early Triassic.

Streszczenie

W wyniku badań palinologicznych osadów zechsztynu na obszarze Gór Świętokrzyskich wyróżniono trzy zespoły sporowo-pyłkowe należące do późnopermskiej zony Lueckisporites virkkiae oraz jeden zespół reprezentujący wczesnotriasowa zonę LT1.

Przeprowadzono korelację między zespołami świętokrzyskimi a równowiekowymi spektrami znanymi z innych obszarów Europy, należących zarówno do basenu germańskiego jak i alpejskiego.

Paleoklimatyczny model otrzymany w wyniku tych badań wskazuje na panowanie suchego klimatu w czasie późnego permu, udokumentowanego wyraźną dominacją kserofitycznych elementów w obrębie zespołów miospor oraz na wzrost wilgotności we wczesnym triasie.

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INTRODUCTION

This paper presents the first complitely, as far as the geological conditions allowed, palynozonation for the Permo-Triassic sequence in the Holy Cross Mountains. This zonation is applied to the boundary problem.

The Upper Permian (Zechstein) - Lower Triassic (Lower Buntsandstein) section in the Holy Cross Mts has been known from several boreholes (Fig. 1). All palynological data come from the borehole samples.

The currently used lithological scheme of the Polish Zechstein, based on Richter-Bernburg's (1955) sedimentological cycles, was estabilished by Wagner, Piątkowski and Peryt (1978) and addopted to the Holy Cross Mountains by Kowalczewski (1978), Pawłowska (1978), Rup (1985) and Kowalczewski and Rup (1989).

Kuleta (1985, 1990) proposed the lithostratigraphic framework for the Lower Bundsandstein in this area.

Any faunistic studies, with an exception of foraminifera from the Lower Zechstein elaborated by Jurkiewicz (1962, 1966), didn't bring the satisfactory results. Therefore the palynological research seemed to be the only chance for the creation of biostratigraphical scheme. It was begun by Kotańska and Krasoń (1966) who listed some species of the Upper Permian miospores from Gałęzice region (SW part of the Holy Cross Mts). This studies were continued by Dybova-Jachowicz and Laszko (see Dybova-Jachowicz, 1976; Dybova-Jachowicz, Laszko, 1976; Dybova-Jachowicz, Jagielska, 1977; Dybova-Jachowicz, Laszko, 1978, 1980; Dybova-Jachowicz, 1981) who finally distingushed one spore-pollen assemblage in the Zechstein and two - in the Middle and Upper Buntsandstein. The palynological documentation of the Zechstein-Buntsandstein boundary has been an open problem till the author's investigations. They indicated palynological hiatus at the boundary which was considered to be lithological continuity (Kuleta, 1985; Pieńkowski, 1989).

The Zechstein-Lower Buntsandstein palynological assemblages have been for the first time used as paleoenvironmental and paleoclimatological indicators. Their interpretation should help to understanding the geological events in the Holy Cross Mountains.

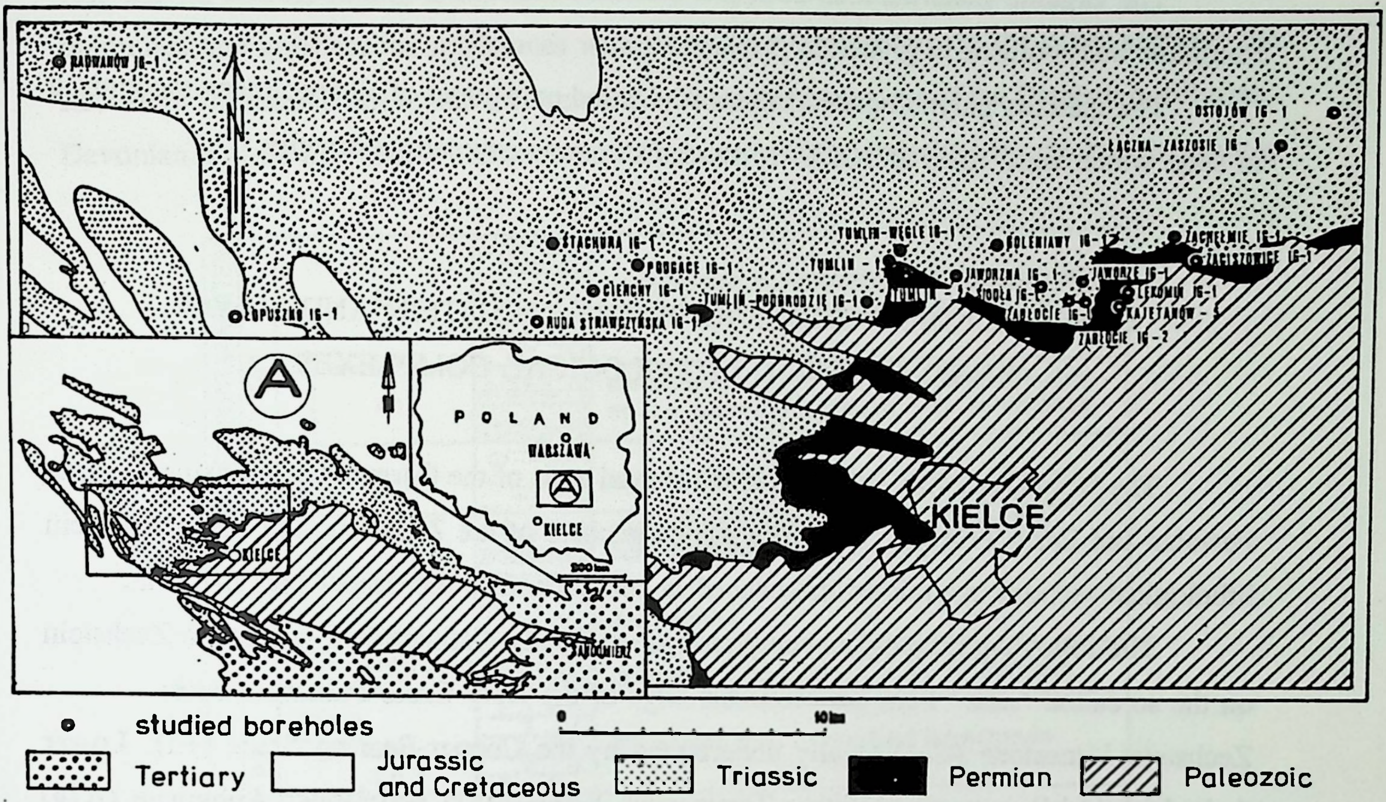


Fig. 1.

Location map of boreholes

METHODS AND MATERIALS

Palynological data from 22 boreholes was complied in this study (Fig. 1). The total 680 samples were taken from the selected sections at intervals about 200 m. The summary lengh of the studied core was 4050 m. Finally the 285 samples appeared positive.

Samples were collected mainly from the black, dark grey and greenish mudstones, siltstones, fine grained clayey sandstones, limestones and marls. Almost all samples from the detritic red, reddish and mottled deposits were negative.

Samples of material weighing 30-50 g were crumbled mechanically and then treated with the following reagents: 1) 10% HCl; 2) 40% HF in the cold state for a period of 3-7 days; 3) washed with a distilled water and treated at 70 C for 2 hours in 10% HCl; 4) flotated in heavy liquid $CdJ_2 + KJ_2$, with a specific wieght of 2,1.

The organic material thus obtained was oxidated in 30% HNO for 24 hours. The residuum was moluted in glycerine gelly.

The quantity palynological analysis was based on a count of all specimens recognized in slide which were fixed as 100%. Microplankton was counted separatelly.

GENERAL CHARACTERISTIC OF THE ZECHSTEIN AND LOWER BUNTSANDSTEIN LITHOLOGICAL COMPLEXES

The Holy Cross Mts belonged to the coastal zone of the German basin during the Late Permian and Early Triassic. Therefore some members of the Zechstein and Buntasndstein lithological sections are missed or reduced in comparison to the deeper part of basin.

The following lithological complexes are currently distinguished within the Zechstein on the so-called "near" Permian-Mesozoic edge of the Holy Cross Paleozoic core: Zechstein Limestone (Ca1) locally underlaying by the Copper-Bearing Shale (T1), Lower Anhydrite (A1d) in some sections, Terrigenous Series (T1r) and Upper Anhydrite (A1g) which all form the Werra Cycle (PZ1); the Strassfurt Cycle (PZ2) is developed as the Terrigenous Series T2r; the Grey Pelite (T3), Platy Dolomite (Ca3) and only locally Main Anhydrite (A3) represent the Leine Cycle (PZ3). The Uppermost Zechstein deposits consist of the Top Terrigenous Series (Pzt) (Tab.1).

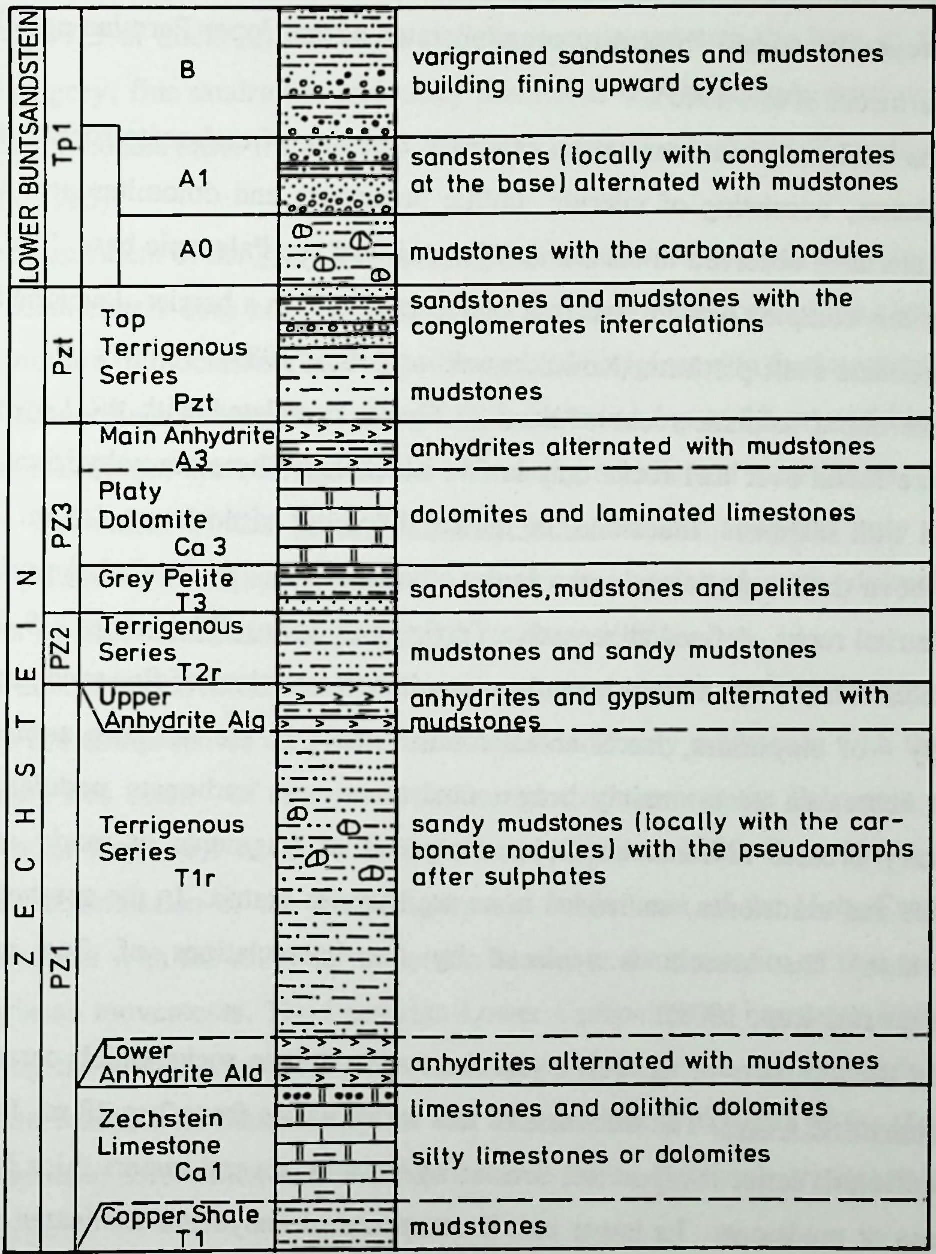
In those Zechstein sections, in which both the sulphates of PZ1 Cycle and the chemical deposits of the PZ3 Cycle are missing, all the rocks overlaying the Zechstein Limestone have been defined as Terrigenous Upper Permian Series (P2t).

The boundary between Zechstein and Buntsandstein has been determinated within the "variegated" clastic series only on the basis of lithological criteria, and thus should be regarded as hypothetical (Kowalczewski and Rup, 1989).

Three complexes were defined in the Lower Buntsandstein deposits: A0 ("knobby"), A1 and B (Kuleta, 1985) (Tab. 1).

The PZ1 deposits are connected with the maximum spreading of the Zechstein basin at the studied area (Wagner et al., 1978) and run into the maximum thickness of 54,0-179,5 m among the Upper Permian rocks (Rup, 1985). They usually begins with the Zechstein Limestone (Ca1). It is olny in few boreholes that could be distinguished thin layers

(1,5-2,5 m) corresponding to the horizon of the Copper-Bearing Shale (T1). These are marly dolomites and argillaceous mudstones with sulphide mineraliztion. In the other sections the Zechstein Limestone lies on the differentiated, Paleozoic basement of the Cambrian, Silurian, Devonian and Lower Carboniferous rocks. It is very often underlied by the conglomerates



Tab. 1.

Lithostratigraphy of the Zechstein and Lower Buntsandstein in the Holy Cross Mountains.

of differentiated lithology and thickness. Besides the most common variant composed of the pebbles of the Devonian limestones and dolomites there occur conglomerates built of the Cambrian and Lower Devonian sandstones. The thickness of these conglomerates varies from few to 200 m. The problem of their stratigraphical position has not been solved so far. According to some authors (Rup, 1985) they belong to the Lower Permian but their top part probably represent so-call "basement conglomerate" of the Upper Permian age (Pawłowska, 1964; Czarniecki et al., 1965).

The Zechstein Limestone is an extensive complex of carbonate rocks, up to 30-100 m in thickness, consisting of micritic, oolitic limestones and dolomites and marls. More detritic material is observed in the sections located near the Paleozoic base. The microfacies show that this complex was formed in a lagoon zone and in a barrier developed at the edge of the carbonate shelf platform (Kowalczewski and Rup, 1989).

The oldest sulphate rocks of the PZ1 Cycle, correlated with the Lower Anhydrite (A1d) were found over Ca1 rocks only in five boreholes. These are anhydrites and gypsum alternated with siltstones, mudstones or muddy dolomites of thickness 3-6 m.

Above these anhydrites, and - in the other sections - above Ca1 deposits, there are mainly detrital rocks, defined as recessive Terrigenous Series (T1r), up to 7,5-42,2 m thick. These are calcareous and dolomitic mudstones with intercalations of fine sandstones and - less frequently - of claystones, marls and dolomitic marls in the northern subregion. In the southern subregion occur mainly brown mudstones with carbonate nodules. There is a sedimentary breccia in some boreholes composed of fragments of marly and dolomitic limestones and mudstones, embedded in an argillaceous matrix. In the southern part of the studied area, this breccia is replaced by the intercalations of fine conglomerates (Kowalczewski, Rup, 1989).

In the top parts of the PZ1 cycle there are sulphate rocks which correspond to the Upper Anhydrite (A1g). The thickness of this series varies from 2 to 28 m. In the majority of boreholes this series is bipartites, divided by the thin, several meters thick layer of brown claystones or mudstones. Its lower part is composed of andydrites laminated with clay, the upper one is distinctly dominated by sulphates. Equivalents of these rocks are mudstones with the thin layers of algal limestones in the southern subregion. In the A1g deposits there is also a sedimentary breccia corresponding most probably to the Upper Anhydrite Breccia (BrA1g).

The supossed deposits of the Strassfurt Cycle (PZ2) are represented only by detrital rocks - sandstones and mudstones referred to the recessive Terrigenous Serie (T2r) of thickness 4,5-27,5 m.

The Leine Cycle (PZ3) sediments occur in most of the sections and they are better developed than those of the PZ2 Cycle. Rocks, that are equivalent to the Grey Pelite (T3), can be distinguished in some sections. These are grey, strongly calcareous mudstones and siltstones 0,6-7,5 m thick. In the W part of the investigated area the base of this series is composed of grey, fine sandstones and sandy mudstones which becomes more conglomeratic closed to the Paleozoic base. It creates an important correlation horizont (Kowalczewski, Rup, 1989; Rup, 1985).

The equivalent of the Platy Dolomite (Ca3) is more widely distributed. In the southern subregion its thickness does not exceed 2m; it occurs there in the form of the algal limestones with an admixture of bioclasts. These deposits probably originated in the intertidal zone (Rup, 1985). In the northern subregion Ca3 deposits are thicker (up to 10 m) and bipartite: algal biolitites at the bottom are overlain by the alternating micrite and marl layers.

The equivalent of the Main Anhydrite (A3) was distinguished only in the four boreholes. These are sulphates, mainly anhydrites, laminated with dolomicrites and dolosparites of the total theckness of 1,0-3,1 m (Rup, 1985).

All the rocks above Ca3 and A3 deposits are regarded as the Top Terrigenous Series (Pzt). They are composed of the brown sandstones and sandy mudstones with the carbonate nodules and - less often - of claystones and conglomerates near the Paleozoic core. Their thickness varies from 10,9 to 53, 7 m (Kowalczewski, Rup, 1989; Rup, 1985).

The accumulation of the Permian deposits in the area of the Holy Cross Mts was closely connected with the relief of the terrain in and tectonic activity of that region during the late Variscan movements. The Cambrian-Lower Carboniferous basement which had been folded during the Upper Carboniferous was deeply graded before the Zechstein. The relief of the terrain reached its mature stage at that time. Towards the end of the Zechstein the exposed Paleozoic core which had not been covered by the Zechstein transgression reached its senile stage.

During the Permian the Holy Cross Mts were subject to slow elevating movements. It was only three times that these movements were stopped by the short-term lowering trends. These lowering movements led to marine transgression of the Cycles PZ1 and PZ3 which reached the "near" margin of the Holy Cross Mts and to the transgression of Cycle PZ2 which covered the "distant" peripheries of this region. The lowering pulsations were marked by varying intensity and they lasted on this area for a longer (PZ1) and shorter (PZ3) period (Kowalczewski, Rup, 1989).

The following lithological complexes are distinguished within the Lower Buntsandstein: A0, A1 and B. The lowermost A0 complex lies in the sedimentological continuity with the Zechstein deposits. It is composed of brown, structureless mudstones and sandy mudstones containing the carbonate nodules and irregular concentriations. The thickness of this series varies from 9,6 to 38, 0 m (Kuleta, 1985). This complex originated, according to Pieńkowski (1989), in the playa like environment and was an echo of the Lower Triassic transgression in the Central Poland.

The A1 complex was identified in the seven boreholes. It is formed by the reddish and brown, sandy and muddy deposits (20,5-67,0 m thick) with the conglomerates and coarse sandstone at the bottom. In the top there dominate siltstones and mudstones with the wavy sedimentary structures which show the marine character of the deposit (Kuleta, 1985).

The B complex is the main member of the Lower Buntsandstein section in this area. It reaches the maximum thickness of 68,0- 167,0 m. Lithologically is monotonous, built of pink-reddish, varie -grained, sometimes conglomeratic sandstones. The cyclity of sedimentation with the upward fine-grained sequences is the most characteristic feature of this deposit. The other sedimentological structures as large-scale diagonal bedding indicate the river environment of the deposition (Kuleta, 1985).

SYSTEMATICS

In total 90 species of miospores belonged to 34 genera and 7 species of acritarchs were identified in the investigated material. Miospores were classified according to the systematics presented by Potonié (1956, 1958, 1960, 1970) and Potonié and Kremp (1954, 1955, 1956a, 1956b) completed with the following papers: Dybova and Jachowicz (1957), Jansonius (1962), Klaus (1963) Hart (1964, 1965) Visscher (1966), Scheuring (1970), Dibner (1971) and Foster (1983).

A new form *Laevigatisporites giganteus* Dybova et Jachowicz f. *microsignus* was distinguished within the spores and a new combination - *Lycospora permica* (Inosova, 1976) was proposed. A new species *Illinites kosankei* was described among the bisaccate pollen grains and few new combinations were introduced into *Lunatisporites* (Leschik, 1956) Scheuring 1970 genus: *L. alatus* (Klaus, 1963), *L. gracilis* (Jansonius, 1962), *L. labdacus* (Klaus, 1963), *L. obex* (Balme, 1963) and *L. transversundatus* (Jansonius, 1962). A new species name *Lunatisporites microsaccatus* was proposed for the form *Taeniaesporites* sp. U Jansonius 1962 and *Triadispora visscheri* - for *Triadispora muelleri* Visscher, 1966.

LIST OF THE DETERMINED SPECIES

Anteturma **Proximegerminantes** Potonié, 1970
Turma **Triletes-Azonales** Potonié, 1970
Subturma **Azonotriletes** Luber, 1935
Infraturma **Laevigati** (Bennie et Kidston, 1886) Potonié, 1956
Genus *CALAMOSPORA* Schopf, Wilson et Bentall, 1944
Calamospora pedata Kosanke, 1950 - Pl. I, fig. 2
Calamospora plicata (Luber et Waltz, 1941) Hart, 1965 - Pl. I, fig. 1

Genus *LAEVIGATISPORITES* Dybova et Jachowicz, 1957
Laevigatisporites giganteus Dybova et Jachowicz, 1957 f. *microsignus* f.nov. - Pl. I, fig.5
Laevigatisporites minimalis f. *pulla* Dybova et Jachowicz, 1957 - Pl. I, fig. 4

Genus *PUNCTATISPORITES* (Ibrahim, 1933) Potonié et Kremp, 1954
Punctatisporites triassicus Schulz, 1964 - Pl. I, fig. 8

Infraturma **Apiculati** (Bennie et Kidston, 1886) Potonié, 1958
Genus *APICULATISPORITES* (Ibrahim, 1933) Potonié et Kremp, 1956
Apiculatisporites apiculatus f. *media* Dybova et Jachowicz, 1957 - Pl. I, fig. 9
Genus *CYCLOTRILETES* Mädler, 1964
Cyclogtriletes microgranifer Mädler, 1964 - Pl. I, fig. 3
Cyclotriletes oligogranifer Mädler, 1964 - Pl. I, fig. 7

Infraturma **Verrucati** Dybova et Jachowicz, 1957

Genus *VERRUCOSISPORITES* (Ibrahim, 1933) Potonié et Kremp, 1956

Verrucosisporites pseudomorulae Visscher, 1966 - Pl. I, fig. 6

Rodzaj *GUTTATISPORITES* Visscher, 1966

Guttatisporites sp. - Pl. I, fig. 15

Turma **Zonales** (Bennie et Kidston, 1886) Potonié, 1956

Subturma **Zonotriletes** (Waltz, 1935) Potonié et Kremp, 1954

Infraturma **Cingulati** Potonié et Kremp, 1954

Genus *LYCOSPORA* Schopf, Wilson et Bentall, 1944

Lycospora permica (Inosova, 1976) comb. nov. - Pl. I, fig. 12

Genus *DENSOISPORITES* (Weyland et Krieger, 1953) Dettmann, 1963

Densoisporites playfordii (Balme, 1963) Dettmann, 1963 - Pl. I, fig. 17

Genus *LUNDBLADISPORA* (Balme, 1963) Playford, 1965

Lundbladispora brevicula Balme, 1963 - Pl. I, fig. 13

Lundbladispora cf. *obsoleta* Balme, 1970 - Pl. I, fig. 14

Turma **Monoletes** Ibrahim, 1933

Subturma **Azonomonoletes** Luber, 1935

Infraturma **Laevigatimonoletes** Dybova et Jachowicz, 1957

Genus *LAEVIGATOSPORITES* Ibrahim, 1933

Laevigatosporites vulgaris (Ibrahim, 1932) Ibrahim, 1933 f.*minor* Loose, 1934 - Pl. I,fig. 11

Anteturma **Variegerminantes** Potonié, 1970

Turma **Saccites** Erdtman, 1947

Subturma **Monosaccites** (Chitaley, 1951) Potonié et Kremp, 1954

Infraturma **Monpolsacciti** (Hart, 1965) Dibner, 1970

Subinfraturma **Proximalsaccini** Dibner, 1970

Genus *FLORINITES* Schopf, Wilson et Bentall, 1944

Florinites sp. - Pl. I, fig. 10

Genus *PERISACCUS* (Naumova, 1953) Potonié, 1958 emend. Klaus, 1963
Perisaccus granulatus Klaus, 1963 - Pl. I, fig. 16

Subinfraturma **Distalsaccini** Dibner, 1970
Genus *ENDOSPORITES* Wilson et Coe, 1940
Endosporites hexarecticulatus Klaus, 1963 - Pl. I, fig. 19

Genus *POTONIEISPORITES* Bharadwaj, 1954
Potonieisporites simplex Wilson, 1962 - Pl. I, fig. 18

Infraturma **Dipolsacciti** (Hart, 1965) Dibner, 1970
Subinfraturma **Parasaccini** (Maheshwari, 1967) Dibner, 1970
Genus *CORDAITINA* (Samoilovich, 1953) Hart, 1963
Cordaitina donetziana Inosova, 1976 - Pl. I, fig. 19, 20
Cordaitina uralensis (Luber, 1941) Dibner, 1970 - Pl. II, fig. 7

Genus *NUSKOISPORITES* Potonié et Klaus, 1954
Nuskoisporites dulhuntyi Potonié et Klaus, 1954 - Pl. II, fig. 4
Nuskoisporites klausi Grebe, 1957 - Pl. II, fig. 5

Subinfraturma **Apertacorpini** Dibner, 1970
Genus *TRIZONAESPORITES* (Leschik, 1956) Klaus, 1963
Trizonaesporites grandis Leschik, 1956 - Pl. II, fig. 1,3

Genus *PLICATIPOLLENITES* Lele, 1964
Plicatipollenites indicus Lele, 1964 - Pl. II, fig. 2

Subinfraturma **Amphisaccini** (Lele, 1965) Dibner, 1970
Genus *CRUCISACCITES* Lele et Maithy, 1964
Crucisaccites cf. *latisulcatus* Lele et Maithy, 1964 - Pl. II, fig. 6

Subturma **Disaccites** Cookson, 1947

Infraturma **Striatiti** Pant, 1954

Genus *PROTOHAPLOXYPINUS* (Samoilovich, 1953) Hart, 1964 emend. Morbey, 1975

Protohaploxypinus jacobii (Jansonius, 1962) Hart, 1964 - Pl. III, fig. 3

Protohaploxypinus cf. *latissimus* (Luber et Waltz, 1941) Samoilovich, 1953 - Pl. III,fig. 2

Protohaploxypinus pantii (Jansonius, 1962) Orłowska-Zwolińska, 1984 - Pl. III, fig. 6

Protohaploxypinus cf. *rhomboeformis* (Polukhina, 1960) Hart, 1964 - Pl. III, fig. 4

Protohaploxypinus samoilovichii (Jansonius, 1962) Hart, 1964 - Pl. III, fig. 1

Genus *STROTERSPORITES* (Wilson, 1962) Klaus, 1963

Strotersporites richteri (Klaus, 1955) Wilson, 1962 - Pl. III, fig. 8

Strotersporites wilsoni Klaus, 1963 - Pl. III, fig. 11

Genus *STRIATOPODOCARPITES* (Zaricheva et Sedova, 1956) Hart, 1964

Striatopodocarpites sp. - Pl. III, fig. 13

Genus *STRIATOABIETITES* (Sedova, 1956) Hart, 1964

Striatoabietites aytugii (Visscher, 1966) Scheuring, 1970 - Pl. III, fig. 5

Striatoabietites balmei Klaus, 1964 - Pl. III, fig. 7

Genus *LUECKISPORITES* (Potonié et Klaus, 1954) Jansonius, 1962

Lueckisporites virkkiae Potonié et Klaus, 1954 - Pl. VII, fig. 1-6, 8-9

Lueckisporites virkkiae Potonié et Klaus, 1954 with a "dark body" f. nov. - Pl. VII, fig. 7

Genus *LUNATISPORITES* (Leschik, 1955) Scheuring, 1970

Lunatisporites acutus Leshik, 1955 - Pl. III, fig. 14

Lunatisporites alatus (Klaus, 1963) comb. nov. - Pl. III, fig. 9

Lunatisporites gracilis (Jansonius, 1962) comb. nov. - Pl. III, fig. 10

Lunatisporites hexagonalis (Jansonius, 1962) Scheuring, 1970 - Pl. III, fig. 15

Lunatisporites labdacus (Klaus, 1963) comb. nov. - Pl. III, fig. 16

Lunatisporites microsaccatus (Jansonius, 1962) comb. nov. Pl. III, fig. 17

Lunatisporites multiplex (Visscher, 1966) Scheuring, 1970 - Pl. IV, fig. 7

Lunatisporites noviaulensis (Leschik, 1956) Scheuring, 1970 - Pl. IV, fig. 1
Lunatisporites obex (Balme, 1963) comb. nov. - Pl. III, fig. 12
Lunatisporites ortisei (Klaus, 1963) Góczán, 1987 - Pl. III, fig. 18
Lunatisporites transversundatus (Jansonius, 1962) comb. nov. - Pl. IV, fig. 4

Genus *PROTOSACCULINA* (Maliavkina, 1953) Jansonius, 1962
Protosacculina sp. - Pl. IV, fig. 14

Genus *VITTATINA* (Luber, 1941) Wilson, 1962
Vittatina costabilis Wilson, 1962 - Pl. IV, fig. 3
Vittatina hiltonensis Chaloner et Clarke, 1962 - Pl. IV, fig. 5
Vittatina subsaccata Samoilovich, 1953 - Pl. IV, fig. 2, 6
Vittatina vittifera (Luber et Waltz, 1941) Samoilovich, 1953 - Pl. IV, fig. 11

Genus *HAMIAPOLLENITES* Wilson ex Jansonius, 1962
Hamiapollenites cf. *bifurcatus* Jansonius, 1962 - Pl. IV, fig. 12

Infraturma **Disacciatrileti** Leschik, 1956
Genus *KLAUSIPOLLENITES* Jansonius, 1962
Klausipollenites decipiens Jansonius, 1962 - Pl. IV, fig. 15
Klausipollenites minimus Góczán, 1987 - Pl. IV, fig. 9-10
Klausipollenites schaubergeri (Potonié et Klaus, 1954) Jansonius, 1962 - Pl. IV, fig. 8
Klausipollenites staplinii Jansonius, 1962 - Pl. IV, fig. 13

Genus *FALCISPORITES* (Leschik, 1956) Klaus, 1963
Falcisporites snopkove Visscher, 1966 - Pl. IV, fig. 11
Falcisporites zapfei (Potonié et Klaus, 1954) Leschik, 1955 - Pl. IV, fig. 16

Genus *VESICASPORA* Schemel, 1951
Vesicaspora schemeli Klaus, 1963 - Pl. IV, fig. 17

Genus *PARAVESICASPORA* Klaus, 1963

Paravesicaspora splendens Klaus, 1963 - Pl. IV, fig. 20

Genus *PLATYSACCUS* (Naumova, 1937) Potonié et Klaus, 1954

Platysaccus leschiki Hart, 1960 - Pl. V, fig. 1

Platysaccus niger Mädler, 1964 - Pl. V, fig. 3

Platysaccus papilionis Potonié et Klaus, 1954 - Pl. V, fig. 2

Infraturma **Disaccitrileti** Leschik, 1956

Genus *ILLINITES* (Kosanke, 1950) Potonié et Kremp, 1954

Illinites elegans Kosanke, 1950 - Pl. V, fig. 8

Illinites kosankei sp. nov. - Pl. V, fig. 10 (holotype)

Illinites unicus Kosanke, 1950 - Pl. V, fig. 6

Genus *VITREISPORITES* (Leschik, 1955) Jansonius, 1962

Vitreisporites sp. - Pl. V, fig. 12

Genus *JUGASPORITES* (Leschik, 1956) Foster, 1983 emend. Tiwari et Singh, 1984

Jugasporites delasaucei (Potonié et Klaus, 1954) Leschik, 1956 - Pl. V, fig. 4

Jugasporites latus (Leschik, 1956) Foster, 1983 - Pl. V, fig. 7

Jugasporites lueckoides Klaus, 1963 - Pl. V, fig. 9

Jugasporites paradelasaucei Klaus, 1963 - Pl. V, fig. 15

Jugasporites parvus (Klaus, 1963) Foster, 1983 - Pl. V, fig. 5

Jugasporites purus (Leschik, 1956) Tiwari et Singh, 1984 - Pl. V, fig. 11

Jugasporites schaubergeroides Klaus, 1963 - Pl. V, fig. 13

Genus *TRIADISPORA* (Klaus, 1964) sensu Brugman, 1979

Triadispora crassa Klaus, 1964 - Pl. V, fig. 17, 19

Triadispora plicata Klaus 1964 - Pl. V, fig. 16

Triadispora visscheri (Visscher, 1966) comb. nov. - Pl. V, fig. 14

Infraturma **Disaccimonoleti** Klaus, 1963

Genus *LIMITISPORITES* (Leschik, 1956) Klaus, 1963

Limitisporites leschiki Klaus, 1963 - Pl. V, fig. 20

Limitisporites moersensis (Grebe, 1957) Klaus, 1963 - Pl. V, fig. 18

Limitisporites cf. *parvus* Klaus, 1963 - Pl. VI, fig. 2

Limitisporites rectus Leschik, 1956 - Pl. V, fig. 21

Genus *GARDENASPORITES* Klaus, 1963

Gardenasporites heisseli Klaus, 1963 - Pl. VI, fig. 3

Gardenasporites leonardii Klaus, 1963 - Pl. VI, fig. 1

Gardenasporites cf. *moroderi* Klaus, 1963 - Pl. V, fig. 22

Gardenasporites cf. *oberrauchi* Klaus, 1963 - Pl. V, fig. 23

Genus *CHORDASPORITES* Klaus, 1963

Chordasporites sp. - Pl. VI, fig. 13

Subturma **Polysaccites** Cookson, 1947

Infraturma **Polysacciti** Cookson, 1947

Genus *CRUSTAESPORITES* Leschik, 1956

Crustaesporites globosus Leschik, 1956 - Pl. VI, fig. 4

Turma **Plicates** Naumova, 1937

Subturma **Praecolpates** Potonié et Kremp, 1954

Infraturma **Praecolpati** Potonié et Kremp, 1954

Genus *PAKHAPITES* Hart, 1965

Pakhapites sp. - Pl. VI, fig. 5

Subturma **Polysaccites** Erdtman, 1952

Infraturma **Polyplicati** Erdtman, 1952

Genus *GNETACAEPOLLENITES* (Thiergart, 1938) Jansonius, 1962

Gnetacaepollenites steevesi Jansonius, 1962 - Pl. VI, fig. 6

Subturma **Moncolpates** (Wodehouse, 1935) Iversen-Troels et Smith, 1950

Infraturma **Inorti** (Naumova, 1937) Potonié, 1958

Genus *CYCADOPITES* (Wodehouse, 1935) Wilson et Webster, 1946

Cycadopites coxii Visscher, 1966 - Pl. VI, fig. 7

Cycadopites follicularis Wilson et Webster, 1946 - Pl. VI, fig. 8

Genus *MONOSULCITES* (Cookson, 1947) Couper, 1953

Monosulcites sp. - Pl. VI, fig. 9

Group **Acritarcha**

Genus *LEIOSPHAERIDIA* (Eisenack, 1938) Dovnie, Evitt et Sarjeant, 1963

Leiosphaeridia sp. - Pl. VI, fig. 11

Genus *BALTISPHAERIDIUM* (Eisenack, 1958) Dovnie, Evitt et Sarjeant, 1963

Baltisphaeridium debilispinum Wall et Downie, 1963 - Pl. VI, fig. 15

Baltisphaeridium longispinosum (Eisenack, 1931) Eisenack, 1969 - Pl. VI, fig. 27

Genus *MICHRYSTRIDIUM* (Deflandre, 1937) Sarjeant, 1967

Michrystridium recurvatum Valensi, 1953 - Pl. VI, fig. 12

Michrystridium setasessitante Jansonius, 1962 - Pl. VI, fig. 14

Michrystridium cf. ***stellatum*** Deflandre, 1945 - Pl. VI, fig. 10, 22, 25

Genus *VERYHACHIUM* (Deunff, 1954) Deunff, 1958 emend. Loebil et Tappan, 1976

Veryhachium irregulare Jekhowsky, 1961 - Pl. VI, fig. 17-19

Veryhachium trispinoides (Jekhowsky, 1961) comb. nov. - Pl. VI, fig. 21

DESCRIPTION OF THE NEW SPECIES, NEW FORMS AND SOME NEW COMBINATIONS

Laevigatisporites giganteus Dybova et Jachowicz, 1957 f. *microsignus* f. nov.
(Pl. I, fig. 5)

Holotype: Pl. I, fig. 5.

Type horizon: Zechstein (PZ1)

Type locality: borehole Siodła IG 1, depth 182,5 m, Holy Cross Mts, Poland.

Derivation of name: [Greek.] *micros* - small, [Lat.] *signum* - mark, a spore with a comparatively small tetrad mark.

Diagnosis. - Amb circular or elliptical with small triradiate tetrad mark. Exine smooth.

Description. - Spore diameter 80-130 μm. Amb circular or elliptical. Arms of disticnt tetrad mark stright, 1/4 spore radius long, Exine thin, smooth.

Remarks. - The most characteristic feature is a small size of tetrade mark which differs it from the other forms of this species.

Occurrence. - Poland: the Holy Cross Mountains, Zechstein.

Lycospora permica (Schwartzman, 1976) comb. nov.

(Pl. I, fig. 12)

1976 *Lycospora pseudohirta* var. *permica* sp. et var. nov; E. G. Schwartzman in; J. K. Inosova, A. M. Krusina, E. G. Schwartzman, p. 63, pl. 4, fig. 23, 24.

Holotype: Schwartzman 1976, pl. 4, fig. 23.

Type horizon: Lower Permian.

Type locality: Donieck Basin, Ukraina.

Description. - Spore diameter 32-48 μm. Amb triangular with slightly convex sides. Triradiate tetrad mark distinct with arms narrowed at the ends, reaching outer spore margin. Wide cingulum which becomes transparent toward the equator. Exine proximately fine-grained, on the distal side and cingulum - coarse-grained or pillate.

Occurrence. - Poland: the Holy Cross Mts, Zechstein (PZ1); Ukraina: Donieck Basin, Lower Permian.

Lueckisporites virkkiae Potonié et Klaus, 1954 with a "dark body" f. nov.

(Pl. VII, fig. 7)

1970 *Parmasporites* gen. nov.; H. Kotańska, p. 153-158, pl. 1, fig. 1-3.

Holotype: Pl. VII, fig. 7.

Type horizon: Zechstein (PZ3).

Type locality: borehole Podgace IG 1, depth 97,7 m, the Holy Cross Mts, Poland.

Diagnosis. - Bisaccate pollen grain. Central body outline circular, sacci hemispherical. In the polar position of pollen grain, dark shield ("body") is visible in middle of central body.

Description. - Total grain size 50-80 μm. Bissacate pollen grain diploxylonoid in outline. Central body circular or ovale. Sacci semicircular or less than semicircular. Sacci bases convex. Dimension of distal zone is of 1/2 central body lenth. Monolete mark on proximal pole. Exine of central body fine reticulate divided by cleary visible laesura into two hemispheres. In the middle of central body round or oval dark shield of variable size (usually its diameter equals about 1/3 central body diameter), devoided of sculpture. Exine of sacci reticulate.

Remarks. - The specimen is a specific preservation form of *Lueckisporites virkkiae* in the environment with a increased salinity. The "dark body" is a preserved, inner cell's contents according to Dybova-Jachowicz. This suggestion can be confirmed by the fact, that the morphological variability, the same as within the *Lueckisporites virkkiae* palynodeme, is observed here. For example *L. virkkiae* norm Aa, Ab, Ac and Bb with a "dark body" were identified.

Occurrence. - Poland, Zechstein, specially numerous in the PZ3 series.

Lunatisporites microsaccatus (Jansonius, 1962) comb. nov.

(Pl. III, fig. 17)

1962 *Taeniaesporites* sp. U; J. Jansonius, p. 65, pl. 14, fig. 1-2.

Holotype: Jansonius 1962, pl. 14, fig. 1.

Type horizon: Lower Triassic.

Type locality: Western Canada.

Derivation of name: [Greek.] *micros* - small, [Lat.] *saccus* - bladder, a pollen grain with the small, reduced bladders.

Description. - Total grain size 15-30 μm. Bisaccate pollen grain haploxylonoid in outline. Central body circular or oval. Sacci folded under central body or strongly reduced so only the distal sacci bases are visible which together with the proximal central taeniae cause an characteristic "check" pattern. Sometimes sacci larger, falciform in ouline. Monolete mark at the proximal pole sometimes visible. Exine on proximal side of central body divided into four taeniae of smotth or fine-grained sculpture. Sacci exine infrareticulate.

Remarks. - The small size of sacci distinguishes this specimen among the other representatives of *Lunatisporites* genus.

Occurrence. - Poland: the Holy Cross Mts, Upper Zechstein- Middle Buntsandstein (PZ3-Tp2); Western Canada, Lower Triassic; Canadian Arctic Archipelago, Lower Triassic.

Illinites kosankei sp. nov.

(Pl. V, fig. 10)

Holotype: Pl. V, fig. 10.

Type horizon: Zechstein (Pzt).

Type locality: borehole Siodła IG 1, deph 183,2 m, Holy Cross Mts, Poland.

Derivation of name: from the name of American palynologist R. M. Kosanke, creator of the genus *Illinites*.

Diagnosis. - Bisaccate pollen grain haploxylonoid in outline. Central body circular or oval. Small tetrade mark. Exine of central body smooth.

Description. - Central body lengh 32-38 μm (holotype - 36 μm),
central body width 22-30 μm (holotype - 26 μm),
sacci lengh 20-28 μm (holotype - 26 μm),
sacci width 20-24 μm (holotype - 21 μm).

Bisaccate pollen grain haploxylonoid in outline. Central body oval with longitudal elongation in polar view and circular in lateral view. Sacci smaller than central body, hemispherical, grouped on the narrow distal side which width equals 1/10-1/8 of central body width. Sometimes sacci touch themselvs. Sacci bases convex. Small, triradiate tetrade mark with arms of the 1/6 body radius lengh on proximal pole. Exine of central body smooth to infragranulate. Sacci exine regular, reticulate.

Remarks. - A small tetrade mark and a very narrov distal side distinguish this species within the other representatives of genus *Illinites*.

Occurrence. - Poland: the Holy Cross Mts, Upper Zechstein.

Triadispora visscheri (Visscher, 1966) comb. nov.

(Pl. V, fig. 14)

1966 *Triadispora muelleri* (Reinhardt et Schmitz, 1962 emend. Reinhardt, 1964) comb.

nov.; H. Visscher, p. 352-353, pl. 12, fig. 1-2, text-fig. 22e.

Holotype: Visscher 1966, pl. 12, fig. 1.

Type horizon: Lower Triassic.

Type locality: Hengelo, the Netherlands.

Derivation of name: from the name of the Dutch palynologist H. Visscher, creator of this species.

Disscusion. - The author proposes to introduce the new species name for the pollen described by Visscher as *Triadispora mulleri* to differentiate it from the monosaccite pollen grain *Hexasaccites muelleri* (Reinhardt et Schmitz, 1962) Reinhardt, 1964.

Description. - Trisaccate pollen grain. Central body big, circular. Sacci less than hemisphaerical in outline, concentrated together on distal side. Triradiate tetrade mark with arms of the 1/4 body radius lengh on proximal pole. Exina on proximal side of central body granulate or reticulate. Sacci exina delicate, reticulate. Remarks. - The always present three sacci are the most characteristic feature of this species.

Occurrence. - Poland: the Holy Cross Mts, Lower Zechstein; the Netherlands, Lower Triassic.

PALYNOSTRATIGRAPHY

The palynostratigraphic framework estabilished for the Zechstein-Lower Buntsandstein in the Holy Cross Mts is composed of four spore-pollen assemblages which represent the Late Permian Lueckisporites virkkiae and Early Triassic LT1 zones. These assemblages, in ascending stratigraphic order, are:

I. Lueckisporites virkkiae Ab,

II. Lueckisporites virkkiae Ac,

III. Lueckisporites virkkiae Bc,

IV. Protohaploxypinus sp. div. and Densoisporites playfordii.

These assemblages are described below and summarized in Table 2. Detailed palynozonation of the four selected, most complete boreholes is given in Appendix 1. All taxa defined in this study are alphabetically listed in Appendix 2. The morphology of the selected, age-significant species is described in Appendix 3.

The following criteria were used by the indentification of these assemblages:

1) the lengh of the species vertical ranges with a particular allowance for the moment of their first appearance and decline;

2) the changes in the frequency of the morphological norms within the *Lueckisporites* palynodeme; the regularity of the lower norms (Aa, Ab, Ba) domination within the older Zechstein deposits, noticed by Visscher (1971, 1978) has been confirmed here;

3) the changes in the frequency of monosaccites pollen grains; their quantity decreases in the younger beds;

4) the presence of acritarchs.

ASSEMBLAGE I: Lueckisporites virkkiae Ab

The base of this assemblage is defined by the first appearance of the Late Permian taxa with the index species *Lueckisporites virkkiae*, the top - by the last appearance of such species as: *Hamiapollenites* cf. *bifurcatus*, *Crustaesporites globosus* and *Plicatipollenites indicus*.

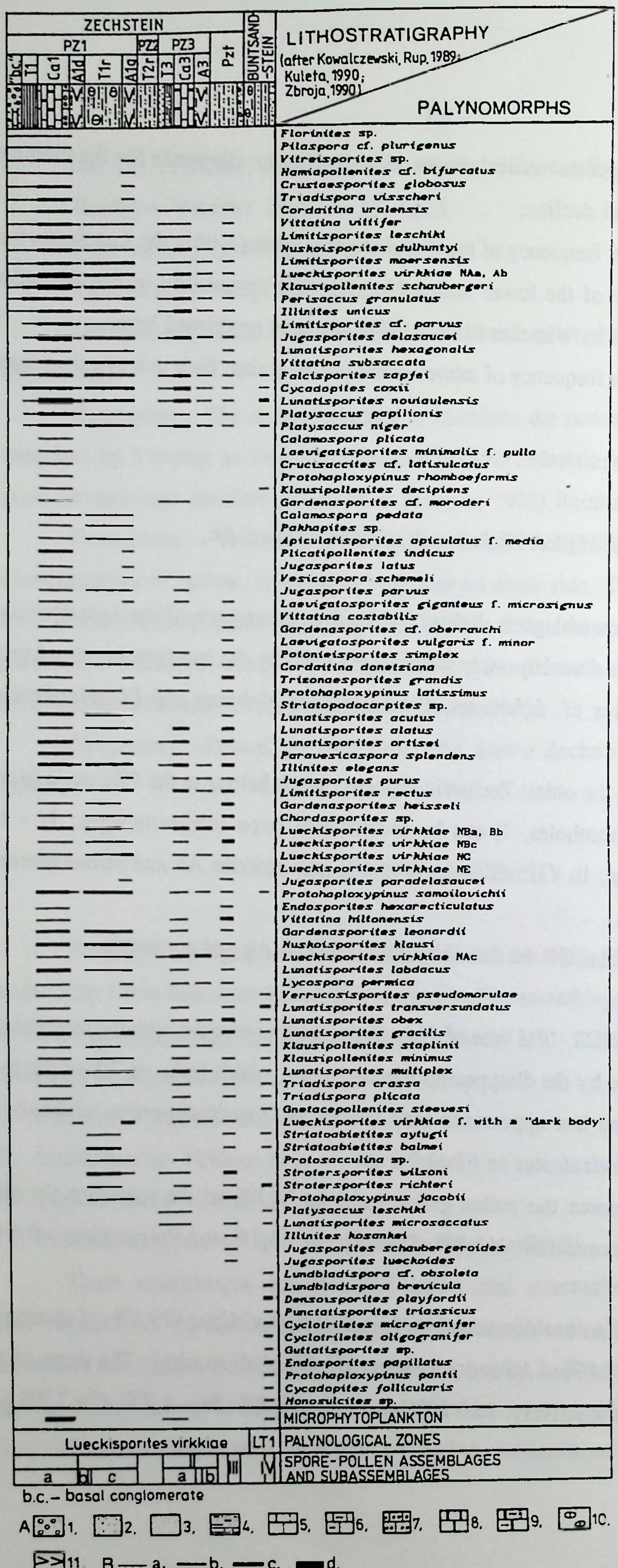
It was identified in the oldest Zechstein deposits, which belong to the PZ1 cycle in the majority of the studied boreholes. It can be divided into three subassemblages: Ia - L. virkkiae Ab and acritarchs, Ib - L. virkkiae Ab and Ic - L. virkkiae Ab and Strotersporites sp. div.

SUBASSEMBLAGE Ia: Lueckisporites virkkiae Ab and acritarchs

CHARACTERISTICS - The base of this subassemblage coincides with the assemblage base and the top is defined by the disappearance of acritarchs, which make up 7% of the hole spectrum, and also by the last appearance such species as: *Laevigatisporites minimalis* f. *pulla*, *Crucisaccites* cf. *latisulcatus* or *Florinites* sp.

Among the miospores the pollen grains make up 91,6% of the spectrum (in this: Disaccites - 73,6%, Monosaccites - 14,0%, Praecolpates - 3,1% and Polysaccites - 0,8%) and spores - 8,4%.

The disaccate pollen are dominated by *Lueckisporites virkkiae* (19,0% of spectrum) characterized mainly by the low Aa and Ab norms (67,9% of all species). The share of the higher norms accounts respectively: Ac - 3,2%; Ba, Bb - 15,8%; Bc - 4,7%; C - 7,9% and % - 0,5%.



Tab. 2.

Sporomotphs occurrence in the Holy Cross Mts. A Lithology: 1 - conglomerates, 2 - coarse sandstones, 3 - fine sandstones, 4 - mudstones and siltstones, 5 - limestones, 6 - marly limestones, 7 - oolitic limestones, 8 - dolomites, 9 - marly dolomites, 10 - carbonate nodules, 11 - sulphates. B Palynology: occurrence of sporomorphs: a - sporadically, b - singly, c - not frequent, d - frequent; spore-pollen assemblages: Ia - L. virkkiae Ab and acritarchs, Ib - L. virkkiae Ab, Ic - L. virkkiae Ab and Strotersporites sp. div., IIa - L. virkkiae Ac and acritarchs, IIb - L. virkkiae Ac, III - L. virkkiae Bc, IV - Protohaploxypinus sp. div and D. playfordii

The genus *Lunatisporites* is the second under the consideration of frequency in this subassemblage (16,0%). It is represented mainly by *L. noviaulensis* (82,0% of species). *L. multiplex*, *L. acutus* and *L. hexagonalis* occurr less frequently here.

Klausipollenites schaubergeri, *Limitisporites moersensis* and *Jugasporites delasaucei* are very important elements of this spectrum. The following genera are represented numerously in comparizon to the younger assemblages: *Hamiapollenites* (3,2% of spectrum), *Vittatina* (2,7%) and *Vitreisporites* (1,9%).

The monosaccate pollens are dominated by *Nuskoisporites* with species: *N. dulhuntyi* and *N. klausi*. The other taxa (*Cordaitina, Perisaccus, Potonieisporites, Trizonaesporites, Plicatipollenites, Florinites, Crucisaccites*) occur seldom or sporadicaly.

The Polysaccites are represented only by one species *Crustaesporites globosus*.

The following species are the most important among spores: *Calamospora pedata, C. plicata, Laevigatisporites* sp. div. and *Lycospora permica*.

Acritarcha are dominated by *Veryhachium* (75,6% of group). *Baltisphaeridium, Leiosphaeridia* and *Michrystrium* occur less frequently.

OCCURRENCE. - This subassemblage was stated in the deposits corresponds to the Copper-bearing Shale (T1), Zechstein Limestone (Ca1) (Fig. 2), locally in the carbonate beds within the "basement conglomerate" and lowermost part of the Lower Anhydrite (A1d) in the 14 boreholes.

COMPARISON AND CORRELATION. - German basin: the Late Permian assemblage, similar to described above but containig more *Lueckisporites virkkiae* specimens (about 40%), was reported from the Copper-Bearing Shale and Zechstein Limestone in Western Germany (Leschik, 1956; Grebe, 1957, Grebe and Schweitzer, 1962) (Tab. 3). Similar subassemblage (EZ1') but with the higher content of acritarchs (24,0%) was described in the Lower Magnesian Limestone, England (Clarke, 1965; Pattison et al., 1973). Alpine basin: L. virkkiae Ab and acritarchs subassemblage can be probably correlated with II1 assemblaage identified in the upper part of Ad member within the Balaton Red Sandstone Formation, Transdanubian Central Range, Hungary (Barabas-Stuhl, 1990 (unpublished)) and it is similar to the assemblage described from the Grodner Sandstain Formation of Salzgebirges, Austria (Potniw et Klaus; 1954, Klaus, 1955). It can be also correlated with subphaze 2 of L. virkkiae phaze Ab stated in the Val Gardena Formation, Dolomites, Italy (Visscher and Brugman, 1988). The possible correlations with assemblages reported from the ohter places outside of Europe are presented in Table 3.

SUBASSEMBLAGE Ib: Lueckisporites virkkiae Ab

CHARACTERISTICS. - The base of the subassemblage is defined by the first appearance of *Lueckisporites virkkiae* f. with a "dark body" and top - by general enrichment of miospores. This is a very poor spectrum in respect both to quality and quantity differentiations of taxa.

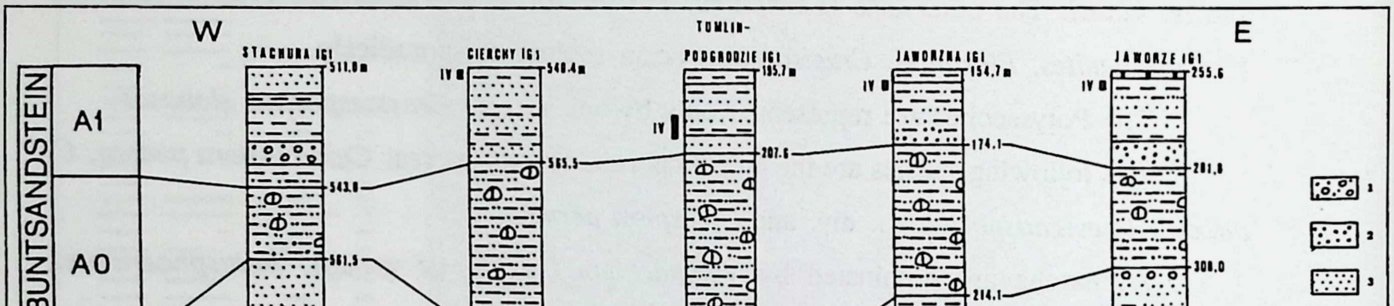


Fig.2.

Correlation of the selected, typical Permo-Triassic sequences in the Holy Cross Mts. Lithology: 1 - conglomerates, 2 - coarse-grained sandstones, 3 - fine-grained sandstones, 4- sandy mudstones, 5 - mudstones, 6 - siltstones, 7 - limestones, 8 - marly limestones, 9 - marls, 10 - dolomites, 11 - marly dolomites, 12 - carbonate nodules, 13 - sulphates (gypsum and anhydrite). Palynology: 14 - spore-pollen assemblages: Ia - Lueckisporites virkkiae Ab and acritarchs, Ib - L. virkkiae Ab, Ic - L. virkkiae Ab and Strotersporites sp. div., IIa - L. virkkiae Ac and acritarchs, IIb - L. virkkiae Ac, III - L. virkkiae Bc, IV - Protohaploxypinus sp. div. and Densoisporites playfordii.

Among the miospores the pollen grains make up 94,0% of the spectrum (in this: Disaccites - 91,9% and Praecolpates - 2,9%) and spores - 4,0%.

The disaccate pollens are dominated by *Lueckisporites virkkiae* (34,4% of spectrum) with Aa and Ab norms and the characteristic form with a "dark body" (4,8% of spectrum). *Lunatisporites noviaulensis* also occurrs frequently (22,7%). The content of *Klausipollenites schaubergeri* is 13,5%. The representatives of *Limitisporites, Platysaccus, Gardenasporites* and *Illinites* are found sporadically.

Spores are dominated by *Calamospora* and *Lycospora.*

OCCURRENCE. - This subassemblage was regonized in the Lower Anhydrite deposits (A1d) only in four boreholes.

COMPARISON AND CORRELATION. - It is difficult to make any correlation of this very poor subassemblage.

SUBASSEMBLAGE Ic: Lueckisporites virkkiae Ab and Strotersporites sp. div.

CHARACTERISTICS. - The base of this subassemblage is defined by the first appearance of the following striatite pollens: *Strotersporites wilsoni, S. richteri, Striatoabietites balmei, S. aytugii* and *Protosacculina* sp. The top coincides with the whole assemblage top.

Among the miospores the pollen grains make up 94,3% of spectrum (Disaccites - 78,1%, Monosaccites - 13,5%, Praecolpates - 2,5%, Polysaccites - 0,2%) and spores - 5,7%.

Lueckisporites virkkiae, represented by the following norms: Aa, Ab (47,3% of species), Ac (9,3%), Ba, Bb (21,0%), Bc (8,2%), C (4,3%), E (0,6%) and form with a "dark body" (9,3%), dominates within spectrum (28,1%). An increase of higher norms frequency is observed here in comparison with the older subassemblages. The specimens of *Klausipollenites* and *Lunatisporites* occurr in the same quantity (about 15% of spectrum). This last genus is represented not only by *L. noviaulensis* but also by: *L. alatus, L. labdacus, L. ortisei* and *L. gracilis*. The other taxa occurr singly or scattered. An increase number of *Falcisporites* specimen (3,4% of spectrum) is remarkable. Distinctly has decreateded the frequence of *Vittatina* (to 0,9%), *Vitreisporites* (0,6%) and *Hamiapollenites* (0,3%).

Nuskoisporites is still dominated among the monosaccate pollens. The representatives of *Perisaccus, Cordaitina* and *Potonieisporites* are less abundant.

Spores are dominated by *Calamospora* and *Laevigatosporites*.

OCCURRENCE. - This subassamblage was found in the Terrigenous Series (T1r) and Upper Anhydrite (A1g) deposits in majority of studied boreholes. Only in the one borehole its base lies in the uppemost part of the Lower Anhydrite (A1d).

COMPARISON AND CORRELATION. - German basin: Late Permian assemblage, similar to described above, but containing twice more *Klausipollenites* specimen (35% of spectrum) was was reported from the Upper Anhydrite of Western Germany (Leschik, 1956). A very big likeness exists between the EZ" subassemblage from the upper part of the Lower Magnesian Limestone, England (Clarke, 1965; Pattison et al. 1973). This last one differs only in the higher (10,9%) content of *Falcisporites*. Alpine basin: This subassemblage can be correlated with the subphaze 4 of Ab Lueckisporites phaze described in the top of Val Gardena Formation, Italy (Visscher and Brugman, 1988) (Tab. 3).

ASSEMBLAGE II: Lueckisporites virkkiae Ac

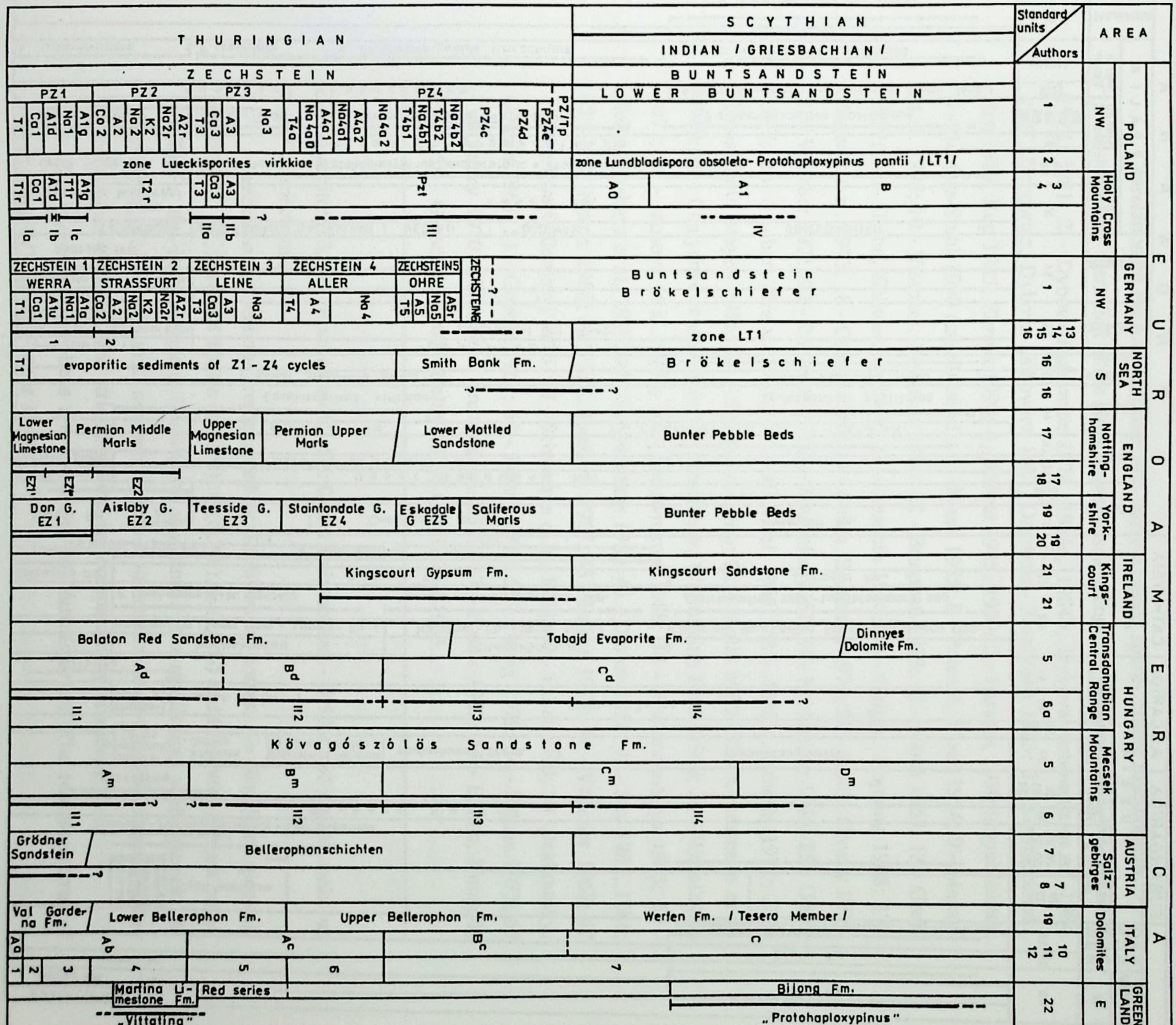
The base of this assemblage is defined by the first appearance of *Lunatisporites microsaccatus*. The top boundary is usually difficult for clear determianation.

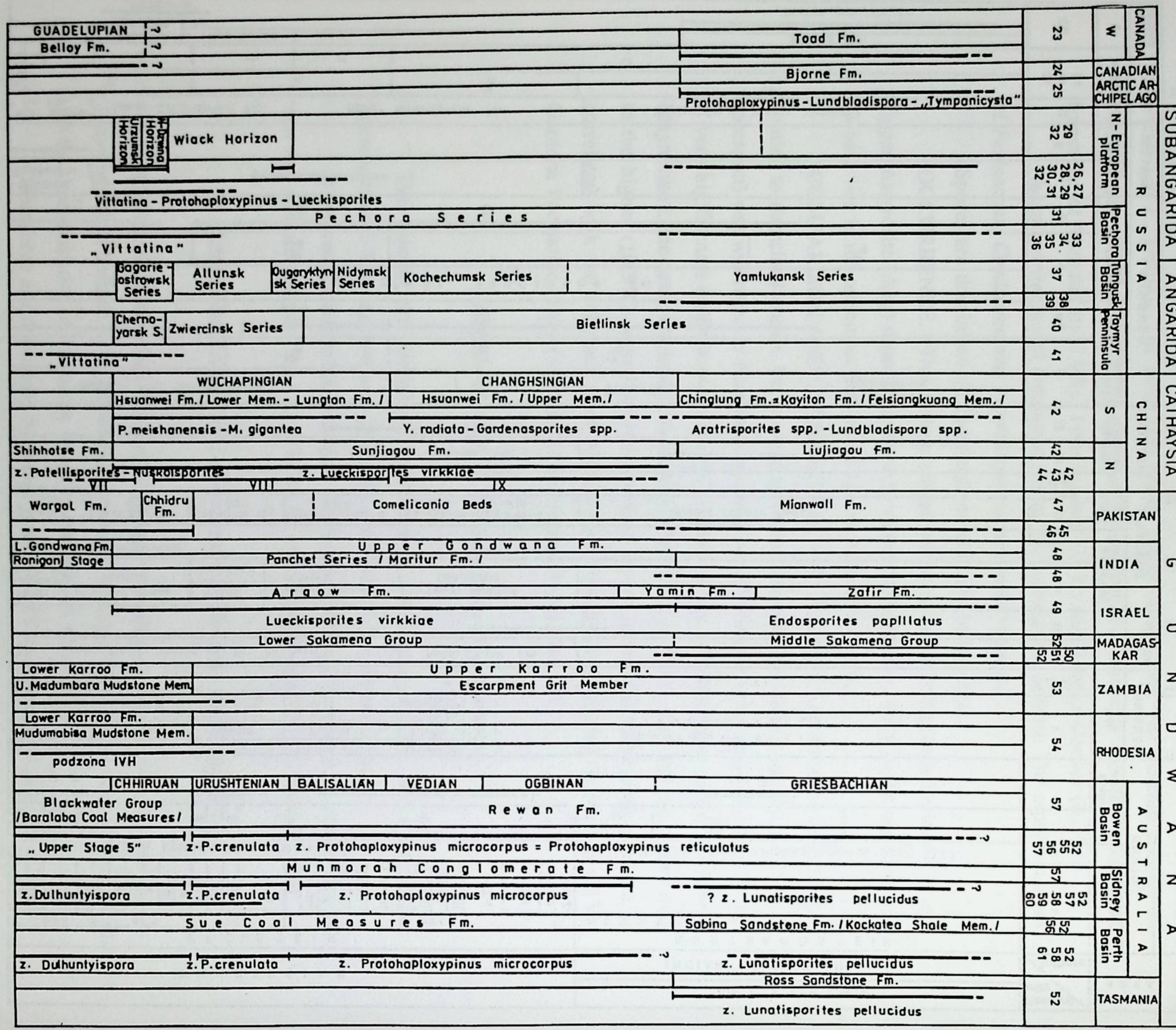
It was recognized in the PZ3 cycle sediments in the eihgt boreholes. It can be divided into two subassemblages: IIa - L. virkkiae Ac and acritarchs and IIb - L. virkkiae Ac.

SUBASSEMBLAGE IIa: Lueckisporites virkkiae Ac and acritarchs

CHARACTERISTICS. -The base of this subassemblage coincides with the assemblage base and top is defined by *Jugasporites parvus* and *Vesicaspora schemeli* last apperance and by the disappearance of acritarchs which make up 2,3% of spectrum.

Miospores are dominated by pollen grains (92,8% in this: Disaccites - 71,7%, 1 - I Ia


THURINGIAN
SCYTHIAN
INDIAN / GRIESBACHIAN /
Standard units
Authors
AREA
ZECHSTEIN
BUNTSANDSTEIN
PZ1
PZ2
PZ3
PZ4
PZ/Tp
LOWER BUNTSANDSTEIN
T1 Ca1 A1d Na1 A1g Ca2 A2 Na2 K2 Na2r A2r T3 Ca3 A3 Na3 T4a Na4a0 A4a1 Na4a1 A4a2 Na4a2 T4b1 Na4b1 T4b2 Na4b2 PZ4c PZ4d PZ4e
zone Lueckisporites virkkiae
zone Lundbladispora obsoleta- Protohaploxypinus pantii / LT1 /
T1r Ca1 A1d T1r A1g T2r T3 Ca3 A3 Pzt
A0
A1
B
Ia Ib Ic IIa IIb III IV
ZECHSTEIN 1
WERRA
ZECHSTEIN 2
STRASSFURT
ZECHSTEIN 3
LEINE
ZECHSTEIN 4
ALLER
ZECHSTEIN5
OHRE
ZECHSTEIN6
Buntsandstein
Bröckelschiefer
T1 Ca1 A1u Na1 A1o Ca2 A2 Na2 K2 Na2r A2r T3 Ca3 A3 Na3 T4 A4 Na4 T5 A5 Na5 A5r
1 2
zone LT1
T1
evaporitic sediments of Z1 - Z4 cycles
Smith Bank Fm.
Bröckelschiefer
Lower Magnesian Limestone
Permian Middle Marls
Upper Magnesian Limestone
Permian Upper Marls
Lower Mottled Sandstone
Bunter Pebble Beds
EZ1 EZ1 EZ2
Don G. EZ1
Aislaby G. EZ2
Teesside G. EZ3
Staintondale G. EZ4
Eskdale G EZ5
Saliferous Marls
Bunter Pebble Beds
Kingscourt Gypsum Fm.
Kingscourt Sandstone Fm.
Balaton Red Sandstone Fm.
Tabajd Evaporite Fm.
Dinnyes Dolomite Fm.
Ad Bd Cd
II1 II2 II3 II4
Kövagószölös Sandstone Fm.
Am Bm Cm Dm
II1 II2 II3 II4
Grödner Sandstein
Bellerophonschichten
Val Gardena Fm.
Lower Bellerophon Fm.
Upper Bellerophon Fm.
Werfen Fm. / Tesero Member /
Aa Ab Ac Bc C
1 2 3 4 5 6 7
Martina Limestone Fm.
Red series
Bijong Fm.
„Vittatina"
„Protohaploxypinus"
1
2
3 4
1
13 14 15 16
16
16
17
17 18
19
19 20
21
21
5
6a
5
6
7
7 8
10
10 11 12
22
NW
Holy Cross Mountains
POLAND
NW
GERMANY
S
NORTH SEA
Nottinghamshire
Yorkshire
ENGLAND
Kingscourt
IRELAND
Transdanubian Central Range
Mecsek Mountains
HUNGARY
Salzgebirges
AUSTRIA
Dolomites
ITALY
E
GREENLAND
EUROAMERICA


GUADELUPIAN ?
Belloy Fm. ?
Toad Fm.
23
W
CANADA
Bjorne Fm.
24 25
CANADIAN ARCTIC ARCHIPELAGO
Protohaploxypinus - Lundbladispora - „Tympanicysta"
Urzumsk Horizon
N. Dzwina Horizon
Wiack Horizon
29 32
26, 27 28, 29 30, 31 32
N - European platform
Vittatina - Protohaploxypinus - Lueckisporites
Pechora Series
31
33 34 35 36
Pechora Basin
„Vittatina"
Gagarie - ostrowsk Series
Allunsk Series
Ougaryktynsk Series
Nidymsk Series
Kochechumsk Series
Yamtukansk Series
37
38 39
Tungusk Basin
Chernoyarsk S.
Zwiercinsk Series
Bietlinsk Series
40
41
Taymyr Peninsula
„Vittatina"
R U S S I A
SUBANGARIDA
ANGARIDA
WUCHAPINGIAN
CHANGHSINGIAN
Hsuanwei Fm. / Lower Mem. - Lungtan Fm. /
Hsuanwei Fm. / Upper Mem. /
Chinglung Fm. = Kayitou Fm. / Felsiangkuang Mem. /
P. meishanensis - M. gigantea
Y. radiata - Gardenasporites spp.
Aratrisporites spp. - Lundbladispora spp.
42
S
Shihhotse Fm.
Sunjiagou Fm.
Liujiagou Fm.
42
z. Patellisporites - Nuskoisporites
z. Lueckisporites virkkiae
VII
VIII
IX
42 43 44
N
C H I N A
CATHAYSIA
Wargal Fm.
Chhidru Fm.
Comelicania Beds
Mianwali Fm.
47
45 46
PAKISTAN
L. Gondwana Fm.
Ranigonj Stage
Upper Gondwana Fm.
Panchet Series / Maritur Fm. /
48
48
INDIA
Argow Fm.
Yamin Fm.
Zafir Fm.
Lueckisporites virkkiae
Endosporites papillatus
49
ISRAEL
Lower Sakamena Group
Middle Sakamena Group
50 51 52
MADAGASKAR
Lower Karroo Fm.
Upper Karroo Fm.
U. Madumbara Mudstone Mem.
Escarpment Grit Member
53
ZAMBIA
Lower Karroo Fm.
Mudumabisa Mudstone Mem.
podzona IVH
54
RHODESIA
CHHIRUAN
URUSHTENIAN
BALISALIAN
VEDIAN
OGBINAN
GRIESBACHIAN
Blackwater Group /Baralaba Coal Measures/
Rewan Fm.
57
„ Upper Stage 5"
z·P.crenulata
z. Protohaploxypinus microcorpus = Protohaploxypinus reticulatus
?
52 55 56 57
Bowen Basin
Munmorah Conglomerate Fm.
57
z. Dulhuntyispora
z. P.crenulata
z. Protohaploxypinus microcorpus
? z. Lunatisporites pellucidus
?
52 57 58 59 60
Sidney Basin
Sue Coal Measures Fm.
Sabina Sandstone Fm. / Kockatea Shale Mem. /
52 56
z. Dulhuntyispora
z. P.crenulata
z. Protohaploxypinus microcorpus
?
z. Lunatisporites pellucidus
52 58 61
Perth Basin
A U S T R A L I A
Ross Sandstone Fm.
z. Lunatisporites pellucidus
52
TASMANIA
G O N D W A N A

Tab. 3.

Correlation of the Late Permian and Early Triassic spore- pollen assemblages.

a - assemblages identified in the Holy Cross Mts; Authors: 1 - Wagner 1987, Wagner et al. 1978, 1981; 2 - Dybova-Jachowicz 1974, 1984a, 1984b, Dybova-Jachowicz et al. 1984, 1987, Jachowicz, Dybova-Jachowicz 1987, Orłowska- Zwolińska 1985; 3 - Kowalczewski, Rup 1989, Rup 1985, Zbroja 1990; 4 - Kuleta 1985, 1990; 5 - Barabas 1990 (unpublished); 6 - Barabas-Stuhl 1990 (unpublished); 7 - Klaus 1955; 8 - Potonié, Klaus 1954; 9 - Massari et al. 1988; 10 - Visscher, Brugman 1988, 11 - Brugman 1983; 12 - Klaus 1963; 13 - Grebe 1957; 14 - Grebe, Schweitzer 1962; 15 - Leschik 1956; 16 - Geiger, Hopping 1968; 17 - Pattison et al. 1973; 18 - Clarke 1965; 19 - Smith, Brunstom 1974; 20 - Smith, Crosby 1979; 21 - Visscher 1971; 22 - Balme 1979; 23 - Jansonius 1962; 24 - Mc Gregor 1965; 25 - Utting 1987; 26 - Luber, Waltz 1941; 27 - Kiuntzel 1965; 28 - Molin, Koloda 1972; 29 - Gomanikov, Meyen 1986; 30 - Severcova 1966; 31 - Molin 1989; 32 - Grausmann et al. 1989; 33 - Chalyshev et al. 1965; 34 - Chalyshev, Wariukhina 1966, 1968; 35 - Waruikhina 1971; 36 - Inosova et al. 1976; 37 - Sadownikow 1989; 38 - Romanowskaya 1963; 39 - Romanowskaya et al. 1973; 40 - Sadownikow 1989; 41 - Dibner 1958; 42 - Shu 1982, 1986; 43 - Shu, Norris 1988; 44 - Zhi, Jiazheng 1987; 45 - Balme 1970; 46 - Visscher 1967; 47 - Maheshwari, Banieryj 1975; 48 - Srivastava et al. 1988; 49 - Eshet 1990; 50 - Jekhowsky, Goubin 1964; 51 - Goubin 1965; 52 - Foster 1979; 53 - Utting 1979; 54 - Falcon 1973; 55 - de Jersey 1970, 1979; 56 - Kremp et al. 1977; 57 - Foster 1982; 58 - Balme, Hennelly 1955; 59 - Grebe 1970; 60 - Helby 1973; 61 - Balme 1963.

Monosaccites 13,1%, Praecolpates - 5,2% and Polysaccites - 0,5%) and spores make up 7,2% of spectrum.

Lueckisporites virkkiae, reprezented by the following norms: Ab (20,0% of species), Ac (20,9%), Ba, Bb (28,4%), Bc (12,0%), C (6,3%), E (3,4%) and form with a "dark body" (9,0%), is the most frequent (20,8% of spectrum). *Klausipollenites* with species: *K. schaubergeri, K. staplini* and *K. minimus*, occurs in the same number (20,0%). *Lunatisporites* is less frequent (14,1%). The striatiti pollens are comparatively abundant.

The monosaccate pollens are dominated by *Nuskoisporites*. The representatives of *Perisaccus* and *Cordaitina* occur singly.

The acritarchas are represented by *Baltisphaeridium* (40,7% of microplankton), *Veryhachium* (38,1%) and *Michrystridium* (21,2%).

OCCURENCE. - This subassemblage was stated in the deposites correspoding to the Grey Pelite (T3) and Platy Dolomite (Ca3) in eight boreholes.

COMPARISON AND CORRELATION is given below, commonly for IIa and IIb subassemblages.

SUBASSEMBLAGE IIb: Lueckisporites virkkiae Ac

CHARACTERISTICS. -The boundaries of this poor subassemblage are diffucult for determination.

The specrum is dominated by *Lueckisporites virkkiae* (29,3%). The representatives of *Lunatisporites* make up 18,7% of spectrum and *Klausipollenites* - 12,0%. The other miospores occur singly.

OCCURENCE. - This subassemblage was distinguished in the deposits corresponding to the Main Anhydrite (A3) and in the lowermost part of the Top Terrigenous Series (Pzt) in the three boreholes.

COMPARISON AND CORRELATION. - Alpine basin: Lueckisporites virkkiae Ac assemblage shows a big similarity to subphaze 5 of Lueckirrkkiae Ac phaze described from the Lower Bellerophon Formation, Dolomites, Italy (Visscher, Brugman, 1988).

ASSEMBLAGE III: Lueckisporites virkkiae Bc

CHARACTERISTICS. - The base of this assemblage is determinated by the first appearance of *Jugasporites lueckoides, J. schaubergeroides* and *Illinites kosankei*. The top is assigned by declination of the most of the Late Permian species with the index taxa *Lueckisporites virkkiae*.

Pollen grains dominated among miospores (93,9% of spectrum), misopres make 6,1%.

Lueckisporites virkkiae represented by following norms: Ab (22,5% of species), Ac (19,8%), Ba, Bb (22,1%), Bc (25,3%), C (6,6%) and E (1,2%) occur the most frequent within pollens 24,3% of spectrum. Reprezentatives of *Lunatisporites* make up 15,9% of assemblage. Such species as *L. labdacus, L. multiplex* and *L. gracilis* are more common than in the older assemblages. The share of *Klausipollenites* equals 14,5% and *Falcisporites* - 5,4%. The other pollens occur rere or scattered.

Monosaccate pollens are dominated by *Perisaccus*.

The genus *Calamospora* is the most frequent among the sproes.

OCCURENCE. - This assemblage was identified in the higher part of the Top Terrigenous Series (Pzt) in the five boreholes.

COMPARISON AND CORRELATION. - Alpine basin: The assemblage which can be correlated to Lueckisporites virkkiae Bc was described as assemblage II3 from the top of Balaton Red Sandstone and lower part of evaporate Tabajd Formations, Transdanubian Central Range, Hungary and to assemblage II3 from the Kővagószőlős Sandstone formation, Mecsek Mountains, Hungary (Barabas-Stuhl, 1981, 1990 (unpublished)). This last differs in the higher contents of *Jugasporites* (24% of assemblage). There exist also a similarity to the phaze Lueckisporites virkkiae Bc distinguished by Visscher and Brugman (1988).

ASSEMBLAGE IV: Protohaploxypinus sp. div. and Densoisporites playfordii

CHARACTERISTICS. - The base of this assemblge is defined by the first apperance of Trassic species: *Lundbladispora brevicula, L.* cf. *obsoleta, Densoipoirites playfordii, Cyclotriletes ologigranifer, C. microgranifer, Punctatisporites triassicus*. The top is assigened by the first apperance of *Densoisporites nejburgii*.

Miospores make up 93,7% of spectrum, acritarchs - 5,0% and so call "Tympanicysta" forms - 1,3%.

The pollen grains still dominated among the miospores (80,3%) whereas the race of spores equals 19,7%.

Dissaccites are the most frequent within the pollens (39,7% of spectrum). They are dominated by striatiti specimens from such genera as: *Protohaploxypinus* (18,5% of spectrum) represented mainly by *P. pantii* and *P. samoilovichii, Lunatisporites* (13,6%) with *L. noviaulensis, L. transversundatus, L. microsaccatus, Striatoabietites* and *Strotersporites* (8,4%). The share of *Klausipollenites* represented by *K. staplinii* and *K. minimus*, equals 8,5%.

Monosaccate pollens (6,0% of spectrum) are dominated by *Endosporites papillatus*.

Cycadopites coxii, C. follicularis and Gnetacaesporites steevesi are the most common within Praecolpates.

Spores are dominated by Densoisporites (10,0% of spectrum) represented by D. playfordii. Lundbladispora and Cyclotriletes occur less frequent. The other spores are single or scattered.

Acritarchs are represented mainly by: Baltisphaeridium (83,2% of acritarchs), Veryhachium (12,3%) and Michrystridium (4,5%).

OCCURENCE. - This spectrum was recognized in the A1 complex deposits of the Lowermost Buntsandstein in the six boreholes.

COMPARISON AND CORRELATION. - The Lowemost Triassic assemblage is known, under the different names, from several localites in Europe and the world (Tab. 3). German basin: The similar assemblage, as a Lundbladispora obsoleta-Protohploxypinus pantii zone, was described from the Lower Buntsandstain of central Poland (Dachów M-24, Otyń IG 1 and Florentyna 2 boreholes) by Orłowska-Zwolińska (1984, 1985). It differs from the Holy Cross assemblage only by luck of acritarchs. The share of individual miospore instead is almost identical. Alpine basin: The Protohaploxypinus sp. div. and Densoisporites playfordii assemblage can probably be correlated to II4 assemblage distinguished in the Tabajd Evaporites formation of Transdanubian Central Range and Upper part of Kövagószólös Sandstone formation of Mecsek Mts in Hungary (Barabas-Stuhl, 1981, 1990 (unpublished)). This last differs from the Holy Cross one by the mixed Late Permian-Early Triassic charcter. The Late Permian elements make up 75% of spectrum and are dominated by Lueckisporites virkkiae Bc and C. There is also a big similarity to Striatiti-Triletes-Tympanicysta assemblage described from the Tessero member of Werfen formation in Dolomites (Massari et al. 1988). Protohaploxypinus sp. div. and Densoisporites playfordii assemblage belongs to LT1 zone of European, palynological scheme proposed by Brugman (1983).

RELATIONS BETWEEN MICROFLORISTICAL ASSEMBLAGES AND LITHOSTRATIGRAPHY

If the Permo-Triassic assemblges are considered in the chronostratigraphic aspect there arises a problem how far palynologic assotiations are environmentally dependent. In the case then lithological units reflect their depositional environment, the possibility of treatment the assemblage boundaries as time-line should be proved by their independence from lithostratigraphic boundaries. Table 2 shows that most of assemblage does not coincide with lithological complexes boundaries: the base of Lueckisporites virkkiae Ab and acritarchs subassemblage is found in most of the boreholes at the lower part of the Zechstein Limestone (Ca1) but it also includes the underlaying basement conglomerate and locally, Copper-Bearing Shale (T1). The top of this subassemblage is stated in the upper part of Zechstein Limestone and in the lowermost part of the Lower Anhydrite (A1d) deposits. Both boundaries of Lueckisporites virkkiae Ab subassemblage lay within the Lower Anhydrites series. The basis of Lueckisporites virkiae Ab and Strotersporites sp. div. subassemblage is usually found at the lower part of the recessive Terrigenous Series (T1r) but, in the case of one borehole, aslo at the uppermost part of the Lower Anhydrite. The top of this subassemblage lies in the upper part of the Upper Anhydrite (A1g) deposits. Lueckisporites virkkiae Ac and acritarchs subasemblage is the only which boundaries coincide with the lithological boundaries of the Grey Pelite (T3) and Plate Dolomite (Ca3) complexes.The base of Lueckisporites virkkiae Ac subassemblage is stated within the Main Anhydrite (A3) series and top - in the upper part of the Main Anhydrite and lower part of the Top Terrigenous Series (Pzt). And Early Triassic Protohaploxypinus sp. div. and Densoisporites playfordii boundaries are found within the A1 lithological complex.

The distingushed assemblages have a relatively consistent occurence throught the studied area both in the shallow zone near the Paleozoic core and deeper one placed far off it. These facts entitle to treatment the assemblage boundaries as the time-lines.

There exsists also a possibility of drawing a correlation between the Holy Cross assemblges and the Late Permian-Early Triassic spectra known from the other regions of Poland which had represent different zones of the sedimentary basen during the Permian-Triassic period.

The microfloristic assemblages very similar to Lueckisporites virkkiae Ab assemblage were recognized in the Lower Zechstein deposits of the Nida basen (south from the Holy Cross Mts) (Dybova-Jachowicz, Laszko, 1978; Fijałkowska, 1990 (unpublished), in the Lower Zechstein in Mielnik borehole (E Poland) (Orłowska-Zwolińska, 1962) and in the Lower Zechstein deposits from afew boreholes on the precambrian platform (NE Poland) (Dybova- Jachowicz, 1981). All these localities together with the Holy Cross Mts area belonged to the shallow, costal part of the basen. The assemblages which can be correlated to Lueckisporites virkkiae Ab spectrum were recognized in the Copper- Bearing Shale and Zechstein Limestone, representing the deeper zones of the basen from the fore-Sudetic monocline (SW Poland) (Kotańska, Krasoń, 1966; Rospondek et al., 1993) and Western Pomerania (NW Poland) (Dybova-Jachowicz, 1981; Jachowicz, 1991).

The assemblages similar to Lueckisporites virkkiae Ac were described from the Plate Dolomite on the fore-Sudetic monocline (Kotańska, Krasoń, 1966; Kotańska, 1970; Górecka, Parka, 1980) and in Western Pomerania (Dybova-Jachowicz, 1981).

The spectra which can be correlated to Lueckisporites virkkiae Bc were identified within the PZ3-PZ4 deposits from the Upper Silesia basin margin (Dybova-Jachowicz et al., 1991) and from central Poland (Dybova-Jachowicz et al. (in press)).

The correlation with the Early Triassic assemblge has been presented in the former chaper.

BOUNDARY PROBLEM

The precise definition of the Permian-Triassic boundary is still an open question in the Holy Cross Mts in spite of fact that is has been a subject of detailed study for last thirty years. The main reason of this situation is a total luck of fossils remains in the boundary beds. Therefore the determination of this boudnary has been grounded only on the lithological premises so far. In the older works (Senkowiczowa, Ślączka, 1962; Rup, 1985; Kuleta, 1985) the boundary between the Zechstein and Buntsandstein deposits was put at the top of the A0 "knobby" complex inculuded then into the Top Terrigenous Series (Pzt). The Buntsandstein deposits begun from A1 sandy complex. The results of current, sedimentological studies (Pieńkowski, 1987, 1989; Kuleta, 1990) improved the principle of loveling this boundary and including the A0 complex to the Triassic. In that case the Zechstein-Buntsandstein boundary would lay at the top of the Top Terrigenous Series. Unfortunatelly any sporomorphs has been found so far in the reddish and mottled mainly mudstone deposits of A0 complex and the first Triassic assemblage appeares only in the next A1 unit. There is then a gap in the palynological scheme comprised the upper part of the Top Terrigenous Series, A0 complex and lower part of A1 complex.

PALEOCLIMATE AND PALEOENVIRONMENT

The suitability of sporomorphs for paleoenvironmental interpretations has been unquestionable since Robinson's (1973), Kremp's (1977), Meyen's (1987) and Visscher and Van Der Zwan's (1981) works.

To evaluate Permian-Triassic paleoenvironments in the Holy Cross Mts, the model of Visscher and Van Der Zwan (1981) was applied to the rocovered assemblages and subassemblages. The 16 morphological groups of sporomorphs were used in the statistical analysis of assemblage compositon. Results are given in the Figure 3, which shows the generalized histograms for all distinguished assemblages and subassemblages.

The significant dominance of the xerophytic elements (Groups H-L) with the striatite pollen grains (Group I) is observed in all assemblages. It indicates generally arid climatic conditions on the studied area during the Late Permian. This suggestion is also confirmed by the lithological data (Wagner et al., 1987; Kowalczewski, Rup, 1989).

Microphytoplankton in the first subassemblage evidences the Zechstein transgression and shallow water conditions during the sedimentation of the Zechstein Limestone. Then the climate became more dry in the Lower Anhydrite period and Lueckisporites virkkiae Ab subassemblage contains almost the same xerophitic forms (88,9% of spectrum). There was marked a short-time increase of humidity during the sedimentation of the recessive Terrigenous Seires and the dry conditions returned in the Upper Anhydrite which is reflected in the incease of striatite pollens race.

Acritarchs in Lueckisporites virkkiae Ac subassemblage evidence the second Zechstein transgression which reached the Holy Cross Mts. A slight increase of humidity is observed in comparizon to the older spectra (11,4% of the hygrophytic elements). The approximate conditions prevailed till the end of Permian.

The significant development of the humid vegetation had place only in Early Triassic that can be inferred from the higher race of hygrophytes in Protohaploxypinus sp. div. and Densoisporites playfordii assemblage (40,9%). The presence of the single acritarchs is connected with the Buntsandstein transsgression. This increase of climate humidy in the Early Triassic is mentioned also in the paleoclimatic interpreatations from other regions of Europe and of the world (Robinson, 1973; Parris et al., 1982).

The reconstruction of the depositional environment, based on a combination of the modified model for the theoretical distribution of organic remains connected with the sedimentation and sedimentary data (Kuleta, 1985; Rup, 1985), is presented on Figure 4. The inferred depositional conditions seem to be comparatively stable, generally in sebkha environment with the three periods of transgression and deposition in the shallow lagoone (the Copper-Bearing Shale, Zechstein Limestone, Grey Pelite, Platy Dolomite and Early Triassic A1 complex). The Uppermost Permian deposits originated in the playa environment and the Lowermost Triassic sandstones have a character of the river deposits (Kuleta, 1985).

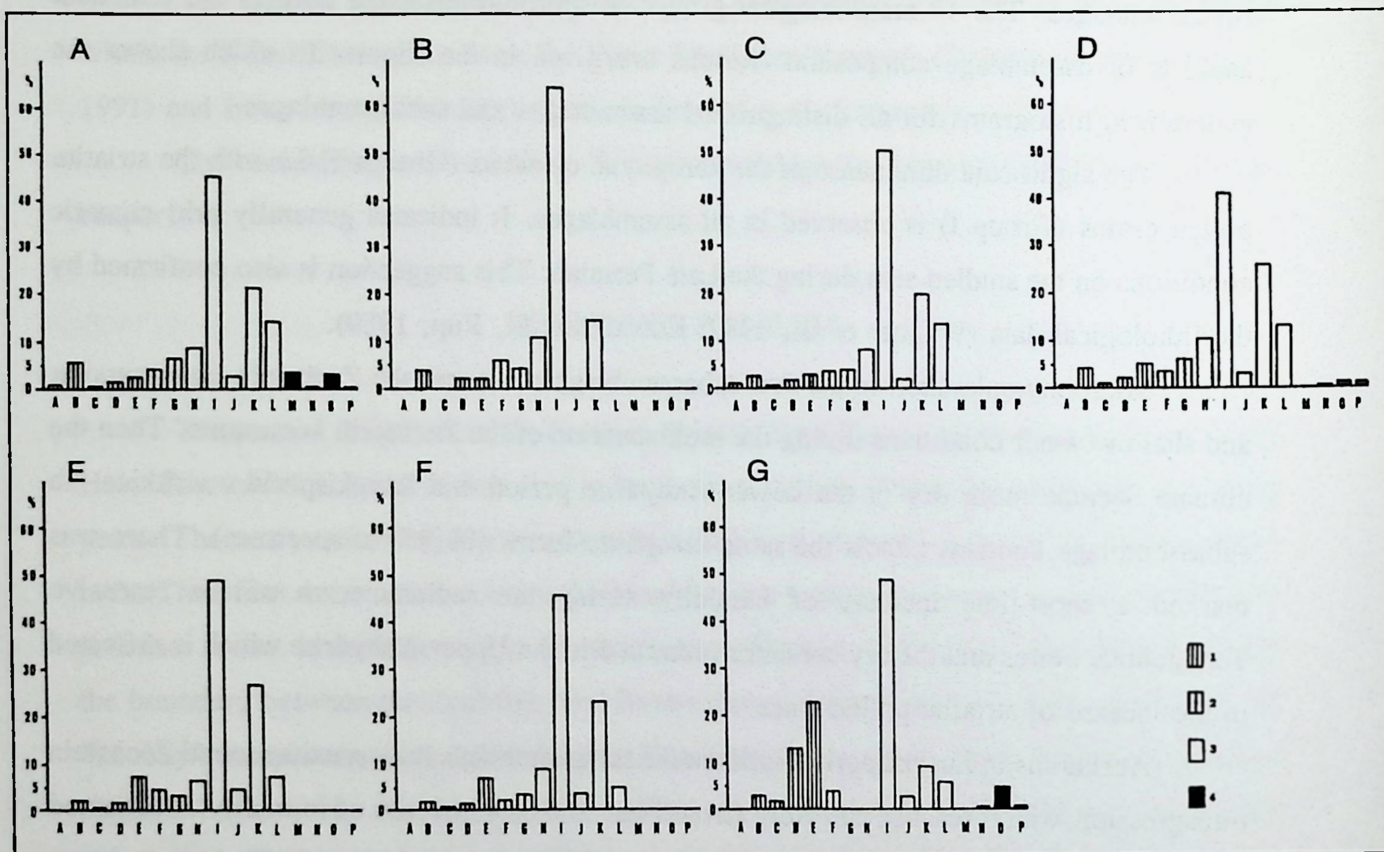


Fig. 3.

Application of the environmental model to the Upper Permian and Lower Triassic samples in the Holy Cross Mts.

1 - hygrofile elements, 2 - mixed elements, 3 - xerofile elements, 4 - microphytoplankton. A - monolete, acavate spores, B - trilete, acavate, laevigate and apiculate spores, C - trilete, acavate and verrucate spores, D - trilete, cingulate and zonotrilete spores, E - monosulcate pollen, F - alete (proto) bisaccate pollen, G - trilete (proto) bisaccate pollen, H - monolete

(proto) bisaccate pollen, I - taeniae (proto) bisaccate pollen, J - Triadispora-complex, K - vesicate pollen, L - (proto) monosaccate pollen, M - Leiosphaeridia, N - Michrystridium, O - Baltisphaeridium, P - Veryhachium. Spore-pollen assemblages: A - Lueckisporites virkkiae Ab and acritarchs, B - L. virkkiae Ab, C - L. virkkiae AB and Strotersporites sp. div., D - L. virkkiae Ac and acritarchs, E - L. virkkiae Ac, F - L. virkkiae Bc, G - Protohaploxypinus sp. div. and Densoisporites playfordii.

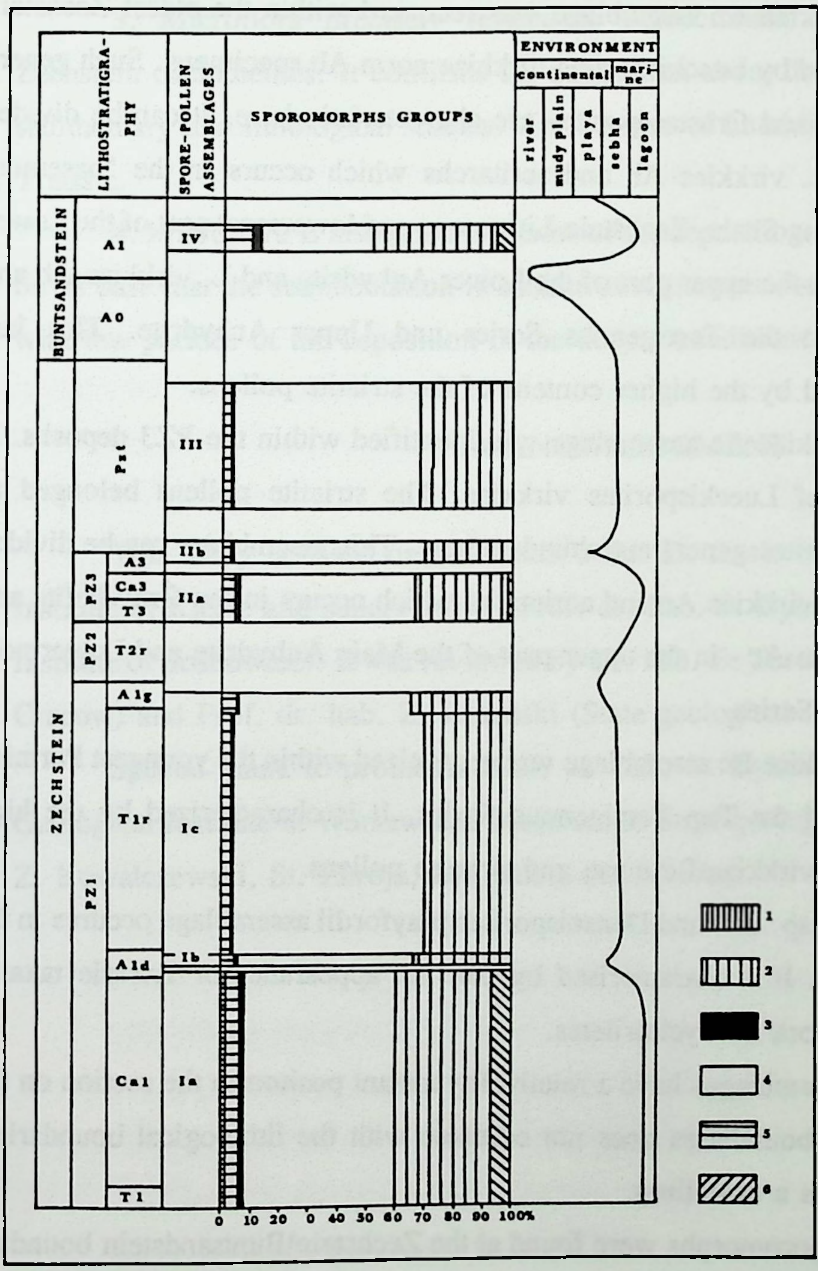


Fig. 4.
Reconstruction of the depositional environment during the Late Permian and Early Triassic in the Holy Cross Mts.
1 - big spores,
2 - middle-size spores,
3 - small spores,
4 - big pollen,
5 - small pollen,
6 - microphytoplankton.

CONCLUSIONS

1. Microflora, as so far, has been a base of the Permian-Triassic biostratigraphy in the Holy Cross Mountains. It allowed to create a comparatively complete palynological scheme which contains three Late Permian and one Early Triassic assemblage. The Late Permian assemblages represent Lueckisporites virkkiae zone and Early Triassic one - LT1 zone. These assemblages (from older to younger) are mentioned below.

1) Lueckisporites virkkiae Ab assemblage was recoverd within the oldest Zechstein deposits (PZ1). It is dominated by Lueckisporites virkkiae norm Ab specimens. Such genera as Hamiapollenites, Vittatina and Crustaesporites are characteristic here. It can be divided into three subassemblages: L. virkkiae Ab and acritarchs which occurs in the "basement conglomerate", Copper-Bearing Shale, Zechstein Limestone and lowermost part of the Lower Anhydrite; L. virkkiae Ba - in the upper part of the Lower Anhydrite and L. virkkiae Ab and Strotersporites sp. div. - in the Terrigenous Series and Upper Anhydrite. This last subassemblage is distingushed by the higher contens of the striatite pollens.

2) Lueckisporites virkkiae Ac assemblage was identified within the PZ3 deposits. It is dominated by Ac norm of Lueckisporites virkkiae. The striatite pollens belonged to Lunatisporites and Strotersporites genera are abundant here. This assemblage can be divided into two subassemblages: L. virkkiae Ac and acritarchs which occurs in the Grey Pelite and Platy dolomite and L. virkkiae Ac - in the upper part of the Main Anhydrite and Lowermost part of the Top Terrigenous Series.

3) Lueckisporites virkkiae Bc assemblage was recognized within the youngest Permian deposits in the upper part of the Top Terrigenous Series. It is characterized by the high frequence of Lueckisporites virkkiae Bc norm and striatite pollens.

4) Protohaploxypinus sp. div. and Densoisporites playfordii assemblage occures in the Lower Triassic A1 complex. It is characterised by the first appearance of Triassic taxa as Densoisporites, Lundbladispora or Cyclotriletes.

The distinguished assemblages have a relativelly costant positon in the section on the studied area. Most of their boundaries does not coincide with the lithological boundaries. These facts let treate them as a time-lines.

Unfortunalelly any sporomorphs were found at the Zechstein\Buntsandstein boundary thus the distinguishing between them still has to be based on the sedimentary criteria.

One should remember, that presented schema has a local character due to geological conditions. The Zechstein-Buntsandstein section contains namely numerous stratigraphical gaps in the Holy Cross Mts.

2. Spore-pollen assemblages, identified in the Holy Cross Mts can be correlated to the contemporaneous spectra refered from the other regions of Europe assigned both to the German basin (Germany, North See Basin, England, Ireland) and to Tetyd (Hungary, Austria, Italy). There is also a similarity to the assemblages known from the other continents.

3. Microflora precisely reflectsthe paleoclimatic changes during the individual Zechstein cuclothemes. It confirms the suggestion about the arid climate obtained from the sedimentary and lithological studies. An increase of humidity is observed only in the Early Triassic.

4. Microflora is also good indicator of the depositional environment. It can be inffered on its base that the sedimentation in sebkha environment dominated during the Late Permian with few periods of the deposition in the deeper conditions of shallow lagoon.

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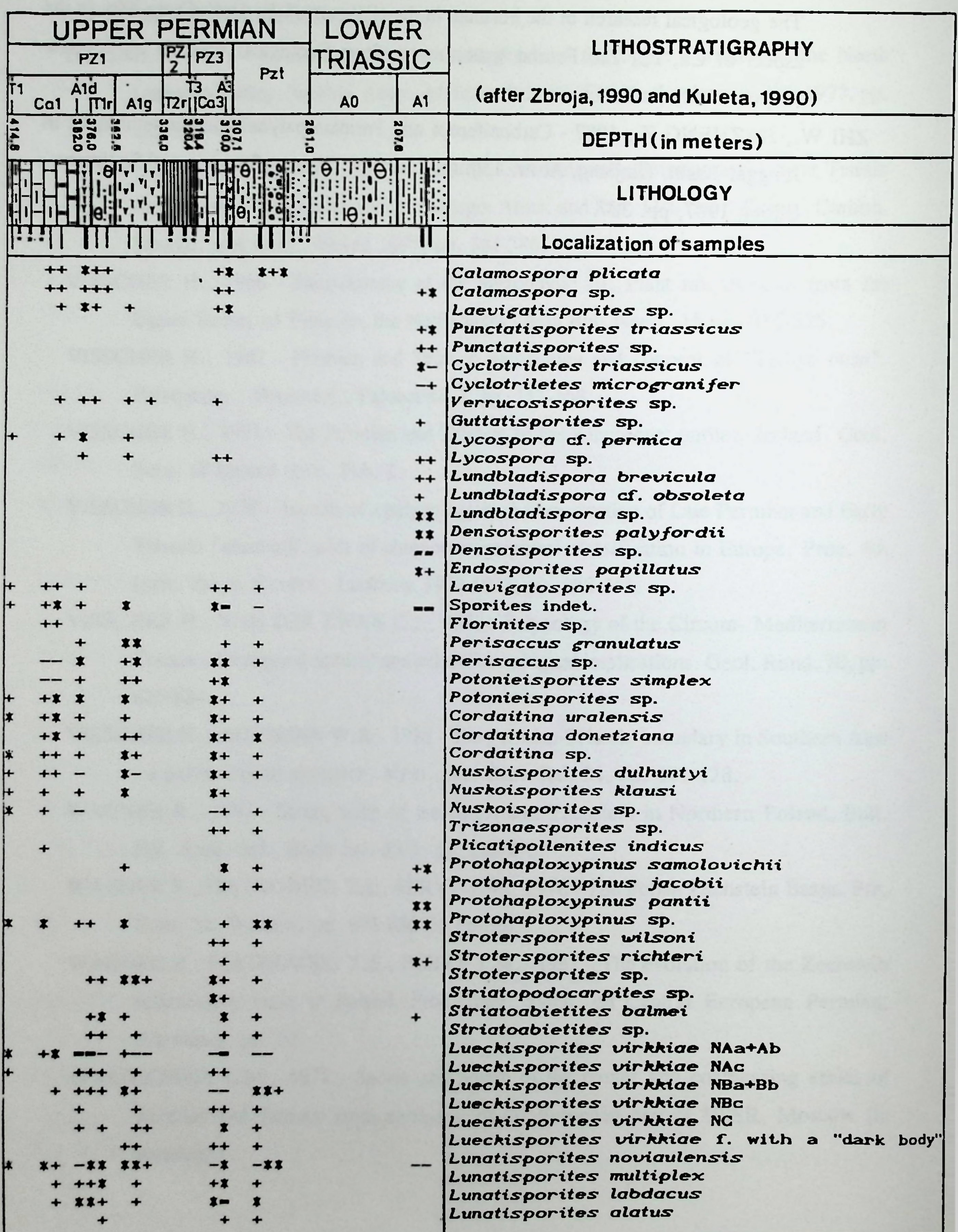
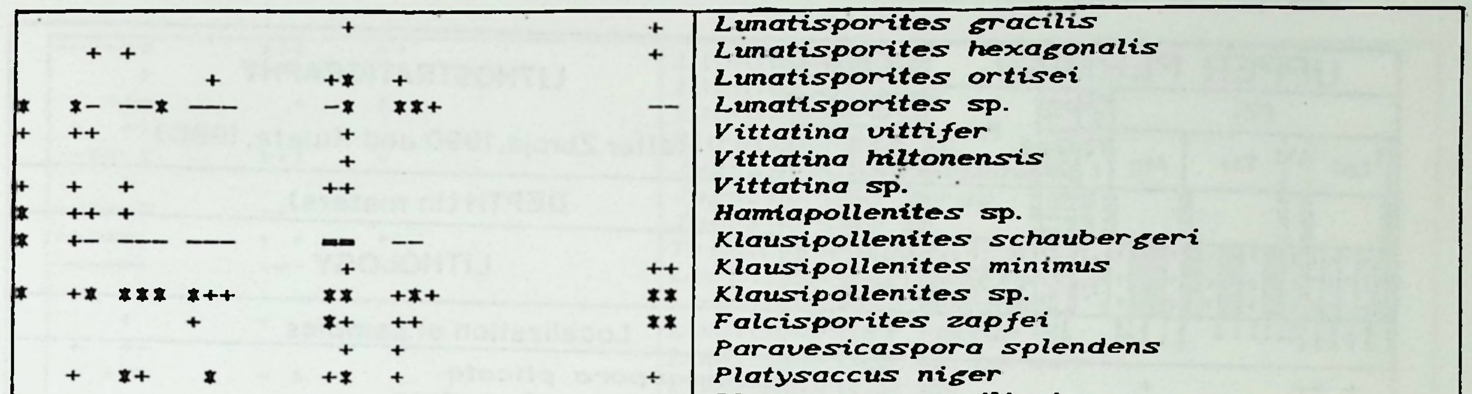
Appendix 1a. Range chart of all taxa in the Tumlin-Podgrodzie IG 1 borehole.

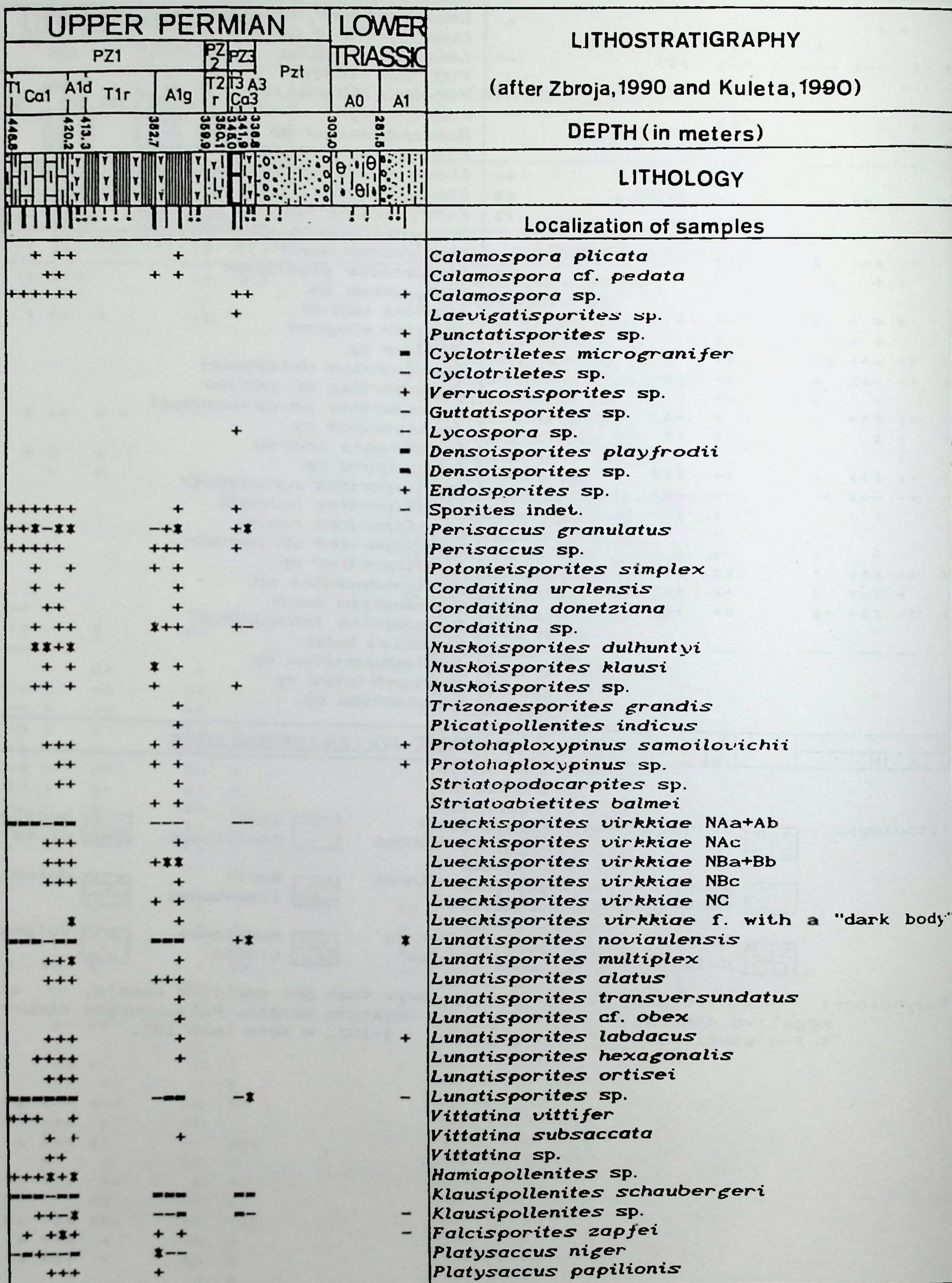




Lithology: conglomerates; coarse sandstones; fine sandstones; mudstones, siltstones; sandy mudstones; limestones; marly limestones; dolomites; marly dolomites; carbonate nodules; mudstones clasts; sulphates

Palynology: — single positive sample, ▬ more than one positive sample, -· single negative sample, ▬· more than one negative sample. Palynomorphs occurrence + 1-4 specimens, * 5-10 specimens, - 1-10%, = more than 10%.

Appendix 1b. Range chart of all taxa in the Jaworze IG 1 borehole.

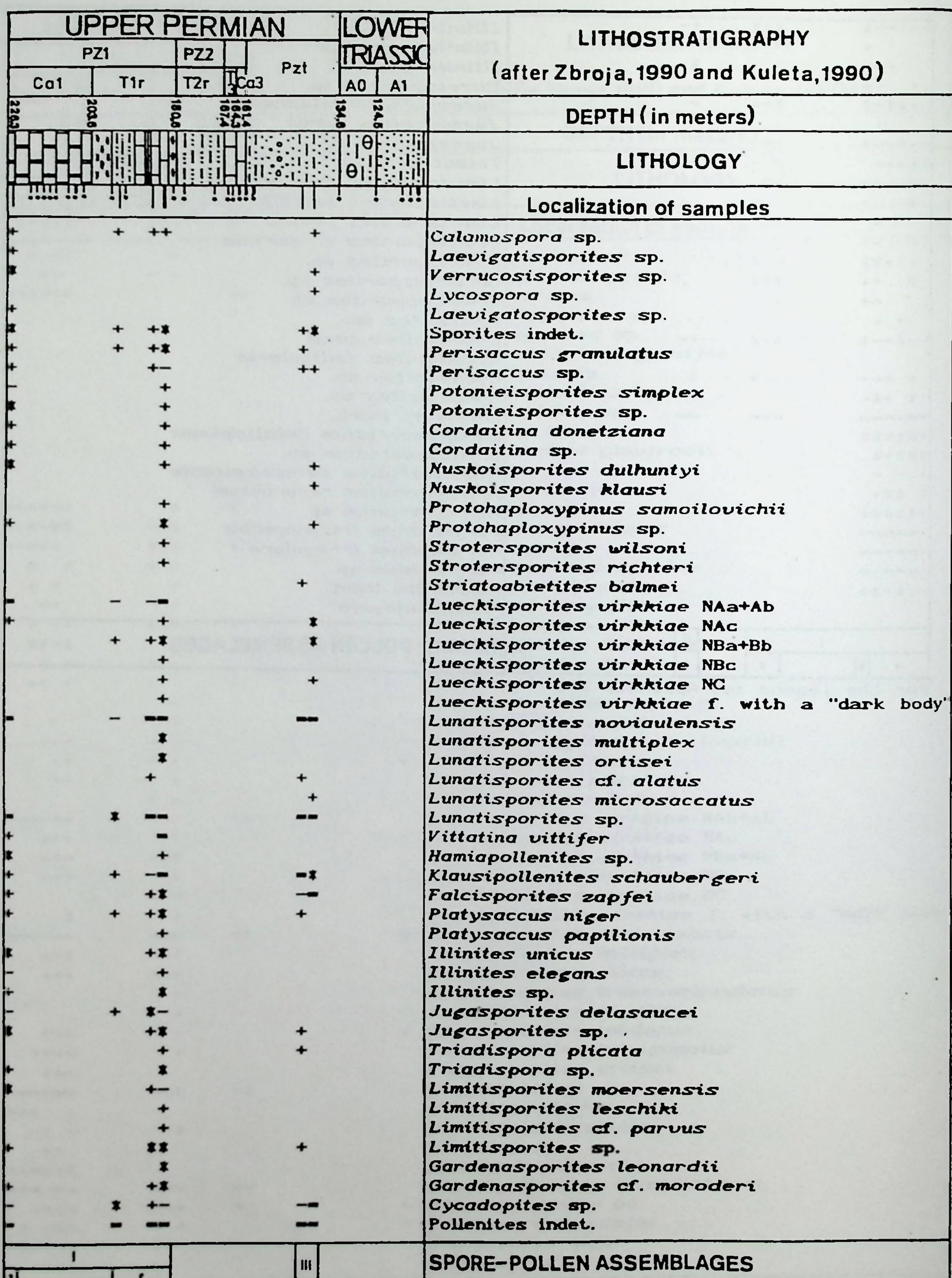


I a, b	I c	II a	IV	
--+-+*	*+*	+-		*Illinites unicus*
+	+			*Illinites elegans*
+++	+	*		*Illinites* sp.
+ ++			+	*Vitreisporites* sp.
--**-*	*+*	+		*Jugasporites delasaucei*
+				*Jugasporites purus*
--*--*	++			*Jugasporites* sp.
+++++	+ +	++		*Triadispora* sp.
------	+--	+*		*Limitisporites moersensis*
+ +				*Limitisporites leschiki*
+	+			*Limitisporites rectus*
+ ++				*Limitisporites* cf. *parvus*
+ +**	+ *			*Limitisporites* sp.
+ ++	+++			*Gardenasporites* sp.
++	+			*Crustaesporites* sp.
+ +				*Pakhapites* sp.
--*--*	*+*	+-	+	*Cycadopites coxii*
			+	*Cycadopites follicularis*
+ +++	+	+	*	*Cycadopites* sp.
* +*+		+		*Monosulcites* sp.
------	---	--	-	Pollenites indet.
+*****			+	*Baltisphaeridium debilispinum*
***+*			*	*Baltisphaeridium* sp.
+ + +				*Micrhystridium setasessitante*
* **+			+	*Micrhystridium recurvatum*
+****+			*	*Micrhystridium* sp.
------			-	*Veryhachium trispinoides*
------			*	*Veryhachium irregulare*
-----			-	*Veryhachium* sp.
-**+*+			-	Acritarcha indet.
			-	"*Thympanicysta*"

I			II	IV	SPORE-POLLEN ASSEMBLAGES
a	b	c	a		

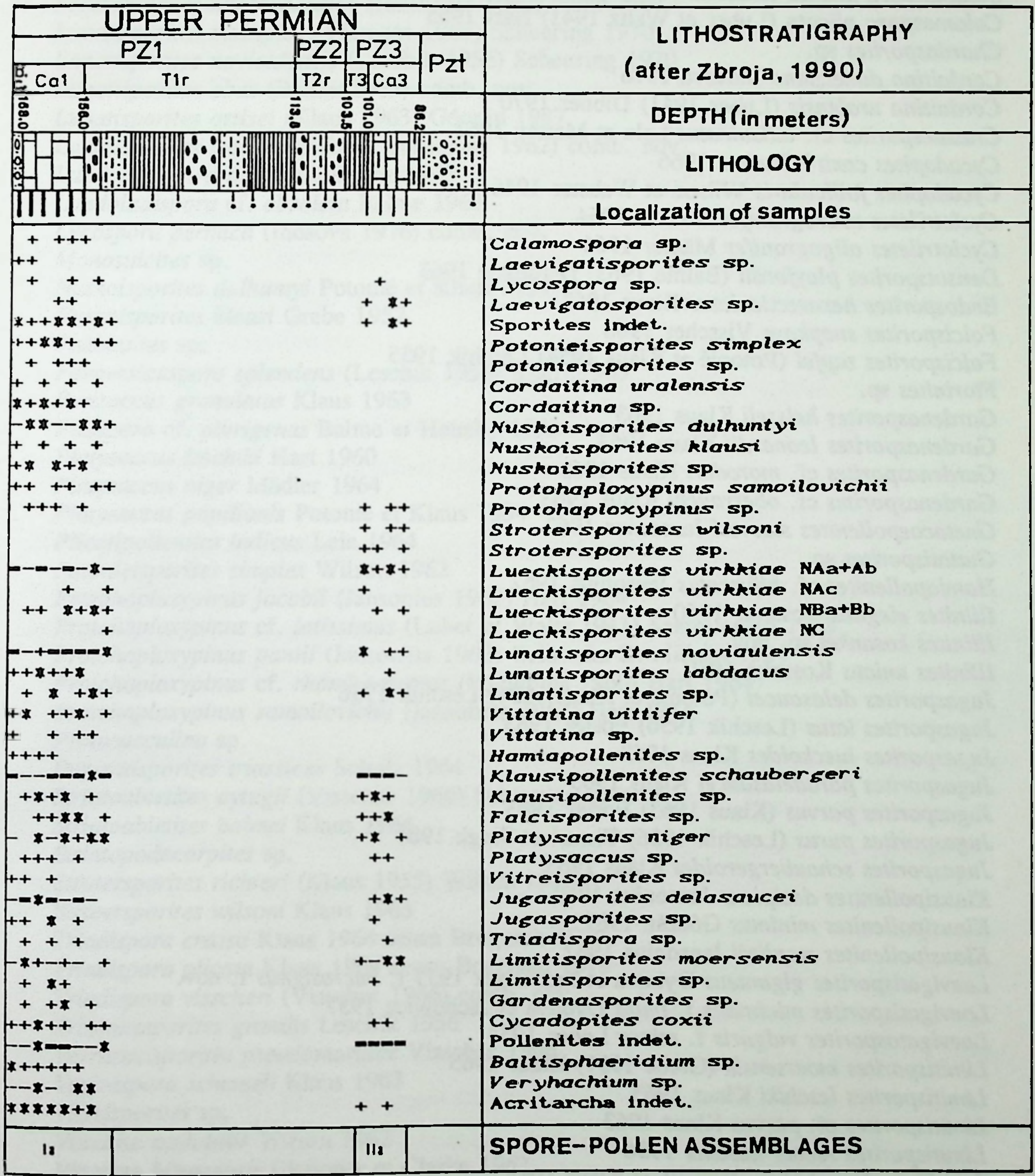
For the legend see Appendix 1a.

Appendix 1c. Range chart of all taxa in the Zachełmie IG 1 borehole.



For the legend see Appendix 1a.

Appendix 1d. Range chart of all taxa in the Zaciszowice IG 1 borehole.



b.c. - basal conglomerate

For the legend see Appendix 1a.

APPENDIX 2. Alphabetical listing of all miospore taxa identified

Apiculatisporites apiculatus f. *media* Dybova et Jachowicz 1957
Calamospora pedata Kosanke 1950
Calamospora plicata (Luber et Waltz 1941) Hart 1965
Chordasporites sp.
Cordaitina donetziana Inosova 1976
Cordaitina uralensis (Luber 1941) Dibner 1970
Crustaesporites cf. *latisulcatus* Lele et Maithy 1963
Cycadopites coxii Visscher 1966
Cycadopites follicularis Wilson et Webster 1946
Cyclotriletes micrograntfer Mädler 1964
Cyclotriletes oligogranifer Mädler 1964
Densoisporites playfordii (Balme 1963) Dettmann 1963
Endosporites hexarecticulatus Klaus 1963
Falcisporites snopkove Visscher 1966
Falcisporites zapfei (Potonié et Klaus 1954) Leschik 1955
Florinites sp.
Gardenasporites heisseli Klaus 1963
Gardenasporites leonardii Klaus 1963
Gardenasporites cf. *moroderi* Klaus 1963
Gardenasporites cf. *oberrauchi* Klaus 1963
Gnetacaepollenites steevesi Jansonius 1962
Guttatisporites sp.
Hamiapollenites cf. *bifurcatus* Jansonius 1962
Illinites elegans Kosanke 1950
Illinites kosankei sp. nov.
Illinites unicus Kosanke 1950
Jugasporites delasaucei (Potonié et Klaus 1954) Leschik 1956
Jugasporites latus (Leschik 1956) Foster 1983
Jugasporites lueckoides Klaus 1963
Jugasporites paradelasaucei Klaus 1963
Jugasporites parvus (Klaus 1963) Foster 1983
Jugasporites purus (Leschik 1956) Tiwari et Singh 1984
Jugasporites schaubergeroides Klaus 1963
Klausipollenites decipiens Jansonius 1962
Klausipollenites minimus Góczán 1987
Klausipollenites staplinii Jansonius 1962
Laevigatisporites giganteus Dybova et Jachowicz 1957 f. *microsignus* f. nov.
Laevigatisporites minimalis f. *pulla* Dybova et Jachowicz 1957
Laevigatosporites vulgaris f. *minor* Loose 1934
Limitisporites moersensis (Grebe 1957) Klaus 1963
Limitisporites leschiki Klaus 1963
Limitisporites cf. *parvus* Klaus 1963
Limitisporites rectus Leschik 1956
Lueckisporites virkkiae Potonié et Klaus 1954
Lunatisporites acutus (Leschik 1956) Scheuring 1970
Lunatisporites alatus (Klaus 1963) comb. nov.

Lunatisporites gracilis (Jansonius 1962) comb. nov.
Lunatisporites hexagonalis (Jansonius 1962) Scheuring 1970
Lunatisporites labdacus (Klaus 1963) comb. nov.
Lunatisporites microsaccatus (Jansonius 1962) comb. nov.
Lunatisporites multiplex (Visscher 1966) Scheuring 1970
Lunatisporites noviaulensis (Leschik 1956) Scheuring 1970
Lunatisporites obex (Balme 1963) comb. nov.
Lunatisporites ortisei (Klaus 1963) Góczán 1987
Lunatisporites transersundatus (Jansonius 1962) comb. nov.
Lundbladispora brevicula Balme 1963
Lundbladispora cf. *obsoleta* Balme 1963
Lycospora permica (Inosova 1976) comb. nov.
Monosulcites sp.
Nuskoisporites dulhuntyi Potonié et Klaus 1954
Nuskoisporites klausi Grebe 1957
Pakhapites sp.
Paravesicaspora splendens (Leschik 1956) Klaus 1963
Perisaccus granulatus Klaus 1963
Pilaspora cf. *plurigenus* Balme et Henelly 1955
Platysaccus leschiki Hart 1960
Platysaccus niger Mädler 1964
Platysaccus papilionis Potonié et Klaus 1954
Plicatipollenites indicus Lele 1964
Potonieisporites simplex Wilson 1962
Protohaploxypinus jacobii (Jansonius 1962) Hart 1964
Protohaploxypinus cf. *latissimus* (Luber et Waltz 1941) Samoilovich 1953
Protohaploxypinus pantii (Jansonius 1962) Orłowska-Zwolińska 1984
Protohaploxypinus cf. *rhomboeformis* (Polukhina 1960) Hart 1964
Protohaploxypinus samoilovichii (Jansonius 1962) Hart 1964
Protosacculina sp.
Punctatisporites triassicus Schulz 1964
Striatoabietites aytugii (Visscher 1966) Scheuring 1970
Striatoabietites balmei Klaus 1964
Striatopodocarpites sp.
Strotersporites richteri (Klaus 1955) Wilson 1962
Strotersporites wilsoni Klaus 1963
Triadispora crassa Klaus 1964 sensu Brugman 1979
Triadispora plicata Klaus 1964 sensu Brugman 1979
Triadispora visscheri (Visscher 1966) comb. nov
Trizonaesporites grandis Leschik 1956
Verrucosisporites pseudomorulae Visscher 1966
Vesicaspora schemeli Klaus 1963
Vitreisporites sp.
Vittatina costabilis Wilson 1962
Vittatina hiltonensis Chaloner et Clarke 1962
Vittatina subsaccata Samoilovich 1953
Vittatina vittifera (Luber et Waltz 1941) Samoilovich 1953

APPENDIX 3. Taxonomy of selected taxa

1. *Cordaitina donetziana* Inosova, 1976 (Pl. I, fig. 19, 20).

DISCUSSION. Circular monosaccate pollen, 22-65 μm in size. Central body (c.b.) circular, saccus narrow on proximal side. Trilete mark usually invisible. C.b. exine thin, smooth or infrapunctate; saccus exine infrarecticulate.

REMARKS. Inosova has distinguished three forms (tenue, crassa and plicata) in this species but it is difficult to recognize them in Holy Cross material due to wors state of preservation.

AGE AND OCCURENCE. Upper Carboniferous - Lower Permian (common), Upper Permian (aundant) in: Poland and Ukraina.

2. *Cordaitina uralensis* (Luber, 1941) Dibner, 1970 (Pl. II, fig. 7).

DISCUSSION. Circular or oval monosaccate pollen, 50-80 μm in size. C.b. circular, saccus very narrow on proximal side. Saccus basis distinct. Tetrade mark invisible. C.b. exine smooth or finegranulate; saccus exine infrareticulate.

REMARKS. It differs from *C. donetziana* by the bigger size and luck of the tetrade mark.

AGE AND OCCURENCE. Middle Carboniferous - Lower Permian (common), Upper Permian (abundant) in: Poland, Ukraina, Russia (European and Asiatic parts) and Australia.

3. *Crustaesporites globosus* Leschik, 1956 (Pl. VI, fig. 4).

DISCUSSION. Rounded trisaccate pollen, 48-75 μm in size. C.b. circular to slighty triangular; sacci small, reniform, may unite laterally. Tetrade mark invisible. C.b. exine divided into 6-8 irregular, smooth ribbs on proximal side; sacci exine reticulate.

AGE AND OCCURENCE. Upper Permian (common) in: Poland, Germany, India and Australia.

4. *Cyclotriletes micrograntfer* Mädler, 1964 (Pl. I, fig. 3).

DISCUSSION. Circular spore, 52-58 μm in size. Trilete mark distinct, 2/3 spore radius lengh. Exine thick, granulate.

AGE AND OCCURENCE. Lower Triassic (abundant), Upper Triassic (rare) in: Poland, Germany and England.

5. *Cyclotriletes oligogranifer* Mädler, 1964 (Pl. I, fig. 7).

DISCUSSION. Circular spore, 72-81 μm in size. Trilete mark distinct, spore radius lengh. Exine thick, granulate with dense distribution of coniform grana.

REMARKS. It differs from *C. microgranulatus* by the bigger size and coarse ornamentation.

AGE AND OCCURENCE. Lower Triassic (abundant), Upper Triassic (rare) in: Poland, Germany, England and Ukraina.

6. *Densoisporites playfordii (*Balme, 1963) Dettmann, 1963 (Pl. I, fig. 17).

DISCUSSION. Circular to slighty triangular, cavate spore, 40-65 μm in size. Wide cingulum in equatorial zone. Trilete mark distinct, extending to inner spore margin. Exine rough, thickned in equatoral margin.

AGE AND OCCURENCE. Upper Permian (rare), Lower Triassic (abundant) in: Poland, Eastern Greenland, Canadian Arctic Archipelago, Russia (Europaen and Asiatic part), Pakistan, India, Israel, Madagaskar, Australia and Tasmania.

7. *Falcisporites zapfei* (Leschik, 1956) Klaus, 1963 (Pl. IV, fig. 16).

DISCUSSION. Haploxylonoidal bisaccate pollen, 30-60 μm in size. C.b. circular, sacci less then hemispherical in shape, with distal inclination. Sacci basis distinc. Narrow, long sulcus on distal side. C.b. exine reticulate more clear on proximal side; sacci exine irregular, reticulate.

AGE AND OCCURENCE. Upper Permian (common), Lower Triassic (rare) in: Europe and Canadian Arctic Archipelago.

8. *Gardenasporites heisseli* Klaus, 1963 (Pl. VI, fig. 3).

DISCUSSION. Slight diploxylonoid bisaccate pollen, 40-80 μm in size. C.b. longitudally oval, sacci hemispherical with distal inclination. Sacci basis convex. Long (40 μm), monolete mark on proximal pole. C.b. exine thin, reticulate; sacci exine finereticulate.

AGE AND OCCURENCE. Upper Permian (common), Lower Triassic (sporadic) in: Poland, Germany, North Sea Basin, Hungary and Italy.

9. *Illinites unicus* Kosanke, 1950 (Pl. V, fig. 6).

DISCUSSION. Haploxylonoid bisaccate pollen, 32-76 μm in size. C.b. circular or longitudally oval. Sacci hemispherical or less then hemispherical with distal inclination. Sacci basis convex or straight, parallel. Small, trilete mark with shorter one arm. C.b. exine fine-granulate, reduced in round mark area; sacci exine reticulate, built from big, sometimes irregular meshes.

AGE AND OCCURENCE. Upper Carboniferous (rare), Upper Permian (abundant), Lower Triassic (sporadic) in: Poland, Germany, England, Italy and USA.

10. *Jugasporites delasaucei* (Potonié et Klaus, 1954) Leschik, 1956 (Pl. V, fig. 4).

DISCUSSION. Diploxylonoid bisaccate pollen, 30-65 μm in size. C.b. transversaly oval, sacci hemispherical, bigger then c.b. Distal zone narrow. Slight convex sacci basis present. Tetrade mark in shape of dilet or trilet with one shorter arm on proximal pole. C.b. exine thick, infrapapillate on proximal side and smooth - on distal one. There is area without exoexine round tetrade mark. Sacci exine fine, reticulate.

AGE AND OCCURENCE. Upper Permian (rare), Upper Permian (abundant), Lower Triassic (sporadic) in: Poland, Western Europa, Italy, Ukraina and China.

11. *Jugasporites lueckoides* Klaus 1963 (Pl. V, fig. 9).

DISCUSSION. Haploxylonoid bisaccate pollen, 30-50 μm in size. C.b. transversaly oval. Sacci small, semilunar in shape. Distal zone widh. Monolete or dilete tetrade mark, 1/3 c.b. radius lengh. C.b. exine infrapapillate or infrarticulate. Area round tetrade mark without exoexine. Sacci exine reticulate.

REMARKS. It differs from other *Jugasporites* species by big, oval area roud tetrade mark, which conforms it to *Lueckisporites*.

AGE AND OCCURENCE. Upper Permian (not numerous) in: Poland, England and Italy.

12. *Jugasporites paradelasaucei* Klaus 1963 (Pl. V, fig. 15).

DISCUSSION. Diploxylonoid bisaccate pollen, 35-82 μm in size. C.b. circular. Sacci less then hemispherical in shape. Distal zone wide. Straight sacci basis present. Dilete or trilete, with one shorter arm, tetrade mark surrounded with area of reduced exoexine. C.b. exine infrapappillate to reticulate; sacci exine reticulate.

REMARKS. It differs from *J. delasaucei* by more circular shape of c.b. and wider distal zone.

AGE AND OCCURENCE. Upper Permian (abundant) in: Poland, England and Italy.

13. *Jugasporites schaubergeroides* Klaus 1963 (Pl. V, fig. 13).

DISCUSSION. Haploxylonoid bisaccate pollen, 26-48 μm in size. C.b. circular or oval. Sacci smaller then c.b., falciform in shape. Convex sacci basis distinct. Distal area of 1/2 c.b. radius widh. Trilete tetrade mark with arms 9-11 μm long surrounded with small area of reduced exine. C.b. exine granulate on proximal side and smooth on distal one. Sacci exine recticulate.

REMARKS. It differs from the other *Jugasporites* species by small size and falciform sacci that conforms it to *Klausipollenites shaubergeri*.

AGE AND OCCURENCE. Upper Permian (not numerous) in: Poland, England, Hungary and Italy.

14. *Klausipollenites schaubergeri* (Potonié et Klaus 1954) Jansonius 1962 (Pl. IV, fig. 8).

DISCCUSION. Haploxylonoidd bisaccate pollen, 20-61 μm in size. C.b. circular or oval. Sacci small, less then hemispherical to semilunar in shape. Sometimes sacci basis united in equatorial zone. Tetrade mark invisible. C.b. exine infragranulate on proximal side and infrareticulate on distal one, conform to sacci exine.

AGE AND OCCURENCE. Lower Permian (regular), Upper Permian (adundant), Lower Triassic (frequent) in: Poland, Western and Southern Europe, Russia (European part), Ukraina, India, Central and Southern Africa and Australia.

15. *Limitisporites moersensis* (Grebe 1957) Klaus 1963 (Pl. V, fig. 18).

DISCUSSION. Haploxylonoid bisaccate pollen, 40-60 μm in size. C.b. circular or transversaly oval. Sacci hemispherical, with distal inclination. Staight or curved monolete mark 3/4 c.b. radius lengh with narrow sutura on proximal pole. C.b. exine fine-granulate to irregular, reticulate. Sacci exine infrareticulate.

AGE AND OCCURENCE. Upper Permian (abundant) in: Poland, Western Europe and Italy.

16. *Limitisporites rectus* Leschik 1956 (Pl. V, fig. 21).

DISCUSSION. Haploxulonoid bisaccate pollen, 25-66 μm in size. C.b. circular or transveraly oval. Sacci hemispherical to semilunar, with distal inclination. Straight or fusiform sacci basis present. Distinct, straight monolete mark of different lengh on proximal pole. C.b. exine fine-punctate to granulate; sacci exine irregular, recticulate.

REMARKS. Comparatively short, straight tetrade mark and characteristic sacci basis distinguish it from other *Limitisporites* species.

AGE AND OCCURENCE. Lower Permian (regular), Upper Permian (frequent) in: Poland, Western Europa, Hungary, Italy, Ukraina, Russia (European part), Tanzania, Australia and Brazil.

17. *Lueckisporites virkkiae* Potonié et Klaus 1954 (Pl. VII, fig. 1-9).

DISCUSSION. Diploxylonoid bisaccate pollen, 40-95 μm in size. C.b. circular or transversaly oval. Sacci less then hemispherical. Sacci basis straight or slighty convex. Distal zone comparatively wide. Monolete tetrade mark 1/3-1/2 c.b. radius lengh on proximal pole. C.b. exine divided in two hemispherical taeniae, with infrareticular ornamentation. Sacci exine reticulate.

REMARKS. Visscher (1971) introduced the "palynodeme" idea and applied it to *Lueckisporites* genus. He distingushed, on the basis of changes in the exoexine structure and the shape of sacci, several palynological norms. Only four of them (A, B, C and E) was recognized in the Holy Cross Mts. It shoud be mentioned that the "palynodeme" concept has been modified last time.

AGE AND OCCURENCE. Lower Permian (sporadic), Upper Permian (abundant), Lower Triassic (sporadic) in: Poland, Western and Southern Europe, Hungary, Russia (European part), China, Pakistan, Madagaskar, Central and Southern Africa.

18. *Lunatisporites noviaulensis* (Leschik 1956) Scheuring 1970 (Pl. IV, fig. 1).

DISCUSSION. Diploxylonoid bisaccate pollen, 60-120 μm in size. C.b. circular or transversaly oval. Sacci hemispherical or bigger in shape. Sacci bassis not always visible. Distal zone broad. Monolete mark on proximal pole. C.b. exine divided into four taeniae: two polar and two equatorial. Surface of taeniae smooth or infrareticulate. Sacci exine reticulate.

AGE AND OCCURENCE. Upper Permian-Lower Triassic (abundant), Middle Triassic (frequent), Upper Triassic (rare) in: Poland, Western and Southern Europe, Hungary, Russia (European part), Ukraina, China, India, Pakistan, Madagaskar, Central Africa and Australia.

19. *Lundbladispora brevicula* Balme 1963 (Pl. I, fig. 13).

DISCUSSION. Cavate, rounded-triangular spore, 32-40 μm in size. Distinct trilete mark accompanied by broad, sometimes undating lips. Exine thick, covered with conical elements, distributed over distal and in marginal part of proximal side.

AGE AND OCCURENCE. Lower Triassic (common) in: Poland, Pakistan and Australia.

20. *Nuskoisporites dulhuntyi* Potonié et Klaus 1954 (Pl. II, fig. 4).

DISCUSSION. Circular to oval monosaccate pollen, 50-200 μm in size. C.b. circular. Saccus width of 1/3-1/2 c.b. radius. Trilete mark with short arms sometimes surrounded with darker, circular area. C.b. exine reticulate, built from big, polygonal meshes. Saccus exina reticulate, radially elongated.

AGE AND OCCURENCE. Upper Permian (common), Lower Traissic (rare) in: Poland, Western and Southern Europe, Hungary, Russia (European part) and China.

21. *Nuskoisporites klausi* Grebe 1957 (Pl. II, fig. 5).

DISCUSSION. Big, circular monosaccate pollen, 150-280 μm in size. C.b. small, circular. Trilete mark with arms 1/2 c.b. radius lengh surrounded by daker area. Exine of c.b. and saccus similar reticulate to infragranulate.

AGE AND OCCURENCE. Upper Permian (common) in: Poland, Germany and England.

22. *Paravesicaspora splendens* Klaus 1963 (Pl. IV, fig. 20).

DISCUSSION. Haploxylonoid bisaccate pollen, 65-89 μm in size. C.b. rhomboidal, longitudally elongated. Sacci hemispherical, with distal inclination. Their basis may unite on distal side. Long, staight, distal sulcus. C.b. exine infrareticulate to infrabaculate on proximal side and fine-infrareticulate on dsital one. Sacci exine reticulate.

AGE AND OCCURENCE. Lower Permian (rare), Upper Permian (frequent) in Poland, Western Europa, Italy and Zair.

23. *Perisaccus granulatus* Klaus 1963 (Pl. I, fig. 16).

DISCUSSION. Circular to oval monosaccate pollen, 40-85 μm in size. C.b. usually circular. Saccus width differentiated from 2/3 c.b radius to 2/3 c.b. diameter. Trilete mark with arms of unequal lengh. C.b. exine fine-punctate to infrareticulate; saccus exine granulate.

AGE AND OCCURENCE. Upper Permian (common) in: Poland, Western Europe and Italy.

24. *Protohaploxypinus pantii* (Jansonius 1962) Orłowska-Zwolińska 1984 (Pl. III, fig. 6).
DISCUSSION. Diploxylonoidal bisaccate pollen, 65-82 μm in size. C.b. circular or oval. Sacci semispherical with distal inclination. Distinct sacci basis. Some specimens have undistinct monolete mark. C.b. exine separated into 6-9 (usually 7) taeniae. Surface of taeniae smooth or infragranulate. Sacci exine infrareticulate.
AGE AND OCCURENCE. Upper Permian (rare), Lower Triassic (abundant), Middle Triassic (rare) in: Poland, England, Italy, Western Canada, India, Pakistan, Madagaskar and Tanzania.

25. *Protohaploxypinus samoilovichii* (Jansonius 1962) Hart 1964 (Pl. III, fig. 1).
DISCUSSION. Diploxylonoid bisaccate pollen, 40-95 μm in size. C.b. circular or longitudally oval. sacci hemispherical or less then hemispherical in shape, with distal inclination. Distal zone narrow. Distinct sacci basis. Monolete mark 2/3 c.b. radius lengh on proximal pole. Exine on proximal side of c.b. divided into 8- 13, rather broad (3-7 μm) taeniae separated by narrow striae. Taeniae are regular, parallel to one another over whole c.b. Sacci exine infrarecticulate, folded in vincinity of sacci attachments.
REMARKS. It is distinguished by the continuos parallel taeniae and distinct sacci basis.
AGE AND OCCURENCE. Lower Permian (rare), Upper Permian (common), Lower Triassic (abundant), Middle Triassic (frequent) in: Poland, Western Europa, Italy, Eastern Greenland, Western Canada, Tanzania, Australia and Tasmania.

26. *Punctatisporites triassicus* Schulz 1964 (Pl. I, fig. 8).
DISCUSSION. Circular spore, 56-60 μm in size. Distinct trilete mark with arms 2/3 spore radius lengh, sometimes divided at ends. Exine thick with fine, punctate ornamentation.
AGE AND OCCURENCE. Lower Triassic (abundant) in: Poland, Germany, Ukraina and Romania.

27. *Striatoabietites balmei* Klaus 1964 (Pl. III, fig. 7).
DISCUSSION. Diploxylonoid to slighty haploxylonoid bisaccate pollen, 45-72 μm in size. C.b. oval. Sacci hemispherical. Distal zone broad. Small, trielete or dilete mark usuallu

invisible. C.b. exine divided to numerous, narrow ribbs with smooth surface which continue over c.b. Sacci exine fine, infrareticulate.

AGE AND OCCURENCE. Upper Permian (not frequent), Lower-Middle Triassic (abundant), Upper Triassic (rare) in: Poland, Western Europe, Italy, Western Canada, Russia (Ural), Australia.

28. *Strotersporites richteri* (Klaus 1955) Wilson 1962 (Pl. III, fig. 8).

DISCUSSION. Diploxylonoid bisaccate pollen, 52-80 μm in size. C.b circular or oval. sacci less then hemispherical in shape. Straight or slight curved monolete mark on proximal pole. C.b. exine divided into numerous, discontinous ribbs with distinc, transverse segmentation. Sacci exine reticulate built from big, polygonal meshes.

REMARKS. It is distinguished by the presence of the transverse segmantation of ribbs exine.

AGE AND OCCURENCE. Upper Permian (common), Lower Triassic (frequent) in: Poland, Western Europe, Hungary, Italy, Eastern Greenland, Western Canada, Canadian Arctic Archipelago, USA.

29. *Strotersporites wilsoni* Klaus 1963 (Pl. III, fig. 11).

DISCUSSION. Slight diploxylonoid bisaccate pollen, 60-115 μm in size. C.b. subcircular. Sacci semilunar, with distal inclination. Distal zone narrow. Monolete mark 1/3 c.b. radius lengh on proximal pole. C.b. exine divided into numerous, narrow ribbs with granulate surface. Sacci exine reticulate built from big, distinct, polygonal meshes.

AGE AND OCCURENCE. Upper Permian (common) in: Poland, England and Italy.

30. *Vittatina vittifera* (Luber et Waltz 1941) Samoilovich 1953 (Pl. IV, fig. 11).

DISCUSSION. Transversaly oval pollen with reduced or without sacci, 40-65 μm in size. Exine of c.b. divided into 12-14 narrow ribbs with smooth surface.

AGE AND OCCURENCE. Lower Permian (common, locally abundant), Upper Permian (frequent), Lower Triassic (sporadic) in: Poland, Russia (European part and Eastern Ural), Italy and Tanzania.

Explanation to the Plates

All specimens x 500 if no other magification is given.

PLATE I

Fig. 1. *Calamospora plicata* (Luber et Waltz) Hart;
the Radwanów IG 1 borehole, 1630,0 m; Zechstein, PZ1 (Ca1).

Fig. 2. *Calamospora pedata* Kosanke;
the Siodła IG 1 borehole, 212,0 m; Zechstein, PZ1 (T1r).

Fig. 3. *Cyclotriletes microgranifer* Mädler;
the Łączna-Zaszosie IG 1 borehole, 329,7 m; Buntsandstein (complex A1).

Fig. 4. *Laevigatisporites minimalis* f. *pulla* Dybova et Jachowicz;
the Radwanów IG 1 borehole, 1630,0 m; Zechstein, PZ1 (Ca1).

Fig. 5. *Laevigatisporites giganteus* Dybova et Jachowicz f. *microsignus* f. nov.;
the Siodła IG 1 borehole, 182,5 m; Zechstein, Pzt.

Fig. 6. *Verrucosisporites pseudomorulae* Visscher;
the Siodła IG 1 borehole, 212,0 m; Zechstein, PZ1 (T1r).

Fig. 7. *Cyclotriletes oligogranifer* Mädler;
the Łączna-Zaszosie IG 1 borehole, 329,7 m; Buntsandstein (complex A1).

Fig. 8. *Punctatisporites triassicus* Schulz;
the Tumlin-Podgrodzie IG 1 borehole, 190,7 m; Buntsandstein (complex A1).

Fig. 9. *Apiculatisporites apiculatus* f. *media* Dybova et Jachowicz;
the Stachura IG 1 borehole, 657,3 m; Zechstein, PZ1 (A1g).

Fig. 10. *Florinites* sp.;
the Podgace IG 1 borehole, 124,7 m; Zechstein, PZ1 (Ca1).

Fig. 11. *Laevigatosporites vulgaris* f. *minor* Loose;
the Siodła IG 1 borehole, 182,5 m; Zechstein, Pzt.

Fig. 12. *Lycospora permica* (Inosova) comb. nov.;
the Radwanów IG 1 borehole, 1630,0 m; Zechstein, PZ1 (Ca1).

Fig. 13. *Lundbladispora brevicula* Balme;
the Łączna-Zaszosie IG 1 borehole, 329,7 m; Buntsandstein (complex A1).

Fig. 14. *Lundbladispora* cf. *obsoleta* Balme;
the Łączna-Zaszosie IG 1 borehole, 329,7 m; Buntsandstein (complex A1).
Fig. 15. *Guttatisporites* sp.;
the Łączna-Zaszosie IG 1 borehole, 329,7 m; Buntsandstein (complex A1).
Fig. 16. *Perisaccus granulatus* Klaus;
the Podgace IG 1 borehole, 124,7 m; Zechstein, PZ1 (Ca1).
Fig. 17. *Densoisporites playfordii* (Balme) Dettmann;
the Łączna-Zaszosie IG 1 borehole, 329,7 m; Buntsandstein (complex A1).
Fig. 18. *Potonieisporites simplex* Wilson;
the Radwanów IG 1 borehole, 1630,5 m; Zechstein, PZ1 (Ca1).
Fig. 19. *Endosporites hexarecticulatus* Klaus;
the Podgace IG 1 borehole, 124,7 m; Zechstein, PZ1 (Ca1).
Fig. 20, 21. *Cordaitina donetziana* Inosova;
the Podgace IG 1 borehole, 124,7 m; Zechstein, PZ1 (Ca1).

PLATE II

Fig. 1, 3. *Trizonaesporites grandis* Leschik;
the Jaworze IG 1 borehole, 369,5 m; Zechstein, PZ1 (A1g) (Fig. 1. - x 1000).
Fig. 2. *Plicatipollenites indicus* Lele;
the Jaworze IG 1 borehole, 369,5 m; Zechstein, PZ1 (A1g).
Fig. 4. *Nuskoisporites dulhuntyi* Potonié et Klaus;
the Łączna-Zaszosie IG 1 borehole, 435,2 m; Zechstein, PZ1 (T1r) (x 750).
Fig. 5. *Nuskoisporites klausi* Grebe;
the Łączna-Zaszosie IG 1 borehole, 435,2 m; Zechstein, PZ1 (T1r) (x 1000).
Fig. 6. *Crucisaccites* cf. *latisulcatus* Lele et Maithy;
the Łopuszno IG 1 borehole, 1761,9 m; Zechstein, PZ1 (Ca1).
Fig. 7. *Cordaitina uralensis* (Luber) Dibner;
the Podgace IG 1 borehole, 124,7 m; Zechstein, PZ1 (Ca1).

PLATE III

Fig. 1. *Protohaploxypinus samoilovichii* (Jansonius) Hart;
the Stachura IG 1 borehole, 665,6 m; Zechstein, PZ1 (A1g).

Fig. 2. *Protohaploxypinus* cf. *latissimus* (Luber et Waltz) Samoilovich;
the Łączna-Zaszosie IG 1 borehole, 435,2 m; Zechstein, PZ1, (T1r) (x 750).

Fig. 3. *Protohaploxypinus jacobii* (Jansonius) Hart;
the Stachura IG 1 borehole, 665,6 m; Zechstein, PZ1 (A1g) (x 750).

Fig. 4. *Protohaploxypinus* cf. *rhomboeformis* (Polukhina) Hart;
the Podgace IG 1 borehole, 124,7 m; Zechstein, PZ1 (Ca1).

Fig. 5. *Striatoabietites aytugii* (Visscher) Scheuring;
the Łączna-Zaszosie IG 1 borehole, 432,5 m; Zechstein, PZ1 (T1r).

Fig. 6. *Protohaploxypinus pantii* (Jansonius) Orłowska-Zwolińska;
the Łączna-Zaszosie IG 1 borehole, 432,5 m; Zechstein, PZ1 (T1r).

Fig. 7. *Striatoabietites balmei* Klaus;
the Stachura IG 1 borehole, 665,4 m; Zechstein, PZ1 (A1g).

Fig. 8. *Strotersporites richteri* (Klaus) Wilson;
the Stachura IG 1 borehole, 665,6 m; Zechstein, PZ1 (A1g).

Fig. 9. *Lunatisporites alatus* (Klaus) comb. nov.;
the Jaworze IG 1 borehole, 369,5 m; Zechstein, PZ1 (A1g).

Fig. 10. *Lunatisporites gracilis* (Jansonius) comb. nov.;
the Łączna-Zaszosie IG 1 borehole, 432,5 m; Zechstein, PZ1 (T1r).

Fig. 11. *Strotersporites wilsoni* Klaus;
the Siodła IG 1 borehole, 183,2 m; Zechstein, Pzt.

Fig. 12. *Lunatisporites obex* (Balme) comb. nov.;
the Podgace IG 1 borehole, 97,7 m; Zechstein, PZ1 (T1r).

Fig. 13. *Striatopodocarpites* sp.;
the Łopuszno IG 1 borehole, 1744,8 m; Zechstein, PZ1 (Ca1).

Fig. 14. *Lunatisporites acutus* Leschik;
the Łączna-Zaszosie IG 1 borehole, 432,5 m; Zechstein, PZ1 (T1r).

Fig. 15. *Lunatisporites hexagonalis* (Jansonius) Scheuring;
the Łopuszno IG 1 borehole, 1744,8 m; Zechstein, PZ1 (Ca1).

Fig. 16. *Lunatisporites labdacus* (Klaus) comb. nov.;
the Radwanów IG 1 borehole, 1630,9 m; Zechstein, PZ1 (Ca1).

Fig. 17. *Lunatisporites microsaccatus* (Jansonius) comb. nov.;
the Zachełmie IG 1 borehole, 185,6 m; Zechstein, PZ1 (T1r).

Fig. 18. *Lunatisporites ortisei* (Klaus) Góczán;
the Stachura IG 1 borehole, 657,9 m; Zechstein, PZ1 (A1g).

PLATE IV

Fig. 1. *Lunatisporites noviaulensis* (Leschik) Scheuring;
the Łopuszno IG 1 borehole, 1761,8 m; Zechstein, PZ1 (Ca1).

Fig 2, 6. *Vittatina subsaccata* Samoilovich;
Fig 2. - the Radwanów IG borehole, 1645,7 m; Zechstein, PZ1 (Ca1); Fig. 6. - the Stachura IG 1 borehole, 665,4 m; Zechstein, PZ1 (A1g).

Fig. 3. *Vittatina costabilis* Wilson;
the Siodła IG 1 borehole, 182,5 m; Zechstein, PZt.

Fig. 4. *Lunatisporites transversundatus* (Jansonius) comb. nov.;
the Łopuszno IG 1 borehole, 1761,9 m; Zechstein, PZ1 (Ca1).

Fig. 5. *Vittatina hiltonensis* Chaloner et Clarke;
the Łopuszno IG 1 borehole, 1735,5 m; Zechstein, PZ1 (Ca1).

Fig. 7. *Lunatisporites multiplex* (Scheuring) comb. nov.;
the Łopuszno IG 1 borehole, 1744,8 m; zechstein, PZ1 (Ca 1).

Fig. 8. *Klausipollenites schaubergeri* (Potonié et Klaus) Jansonius;
the Radwanów IG 1 borehole, 1631,5 m; Zechstein, PZ1 (Ca1).

Fig. 9, 10. *Klausipollenites minimus* Góczán;
the Podgace IG 1 borehole, 97,7 m; Zechstein, PZ1 (T1r);
Fig. 9. - the distal side, Fig. 10. - the proximal side.

Fig. 11. *Vittatina vittifera* (Luber et Waltz) Samoilovich;
the Radwanów IG 1 borehole, 1645,7 m; Zechstein, PZ1 (Ca1).

Fig. 12. *Hamiapollenites* cf. *bifurcatus* Jansonius;
the Tumlin-Węgle IG 1 borehole, 125,7 m; Zechstein, PZ1 (Ca1).

Fig. 13. *Klausipollenites staplinii* Jansonius;

the Stachura IG 1 borehole, 665,4 m; Zechstein, PZ1 (A1g).

Fig. 14. *Protosacculina* sp.;

the Stachura IG 1 borehole, 665,4 m; Zechstein, PZ1 (A1g).

Fig. 15. *Klausipollenites decipiens* Jansonius;

the Podgace IG 1 borehole, 124,7 m; Zechstein, PZ1 (Ca1) (x 1000).

Fig. 16. *Falcisporites zapfei* (Potonié et Klaus) Leschik;

the Siodła IG 1 borehole, 182,5 m; Zechstein, Pzt.

Fig. 17. *Vesicaspora schemeli* Klaus;

the Stachura IG 1 borehole, 665,4 m; Zechstein, PZ1 (A1g).

Fig. 18, 19. *Falcisporites snopkove* Visscher;

the Radwanów IG 1 borehole, 1631,5 m; Zechstein, PZ1 (Ca1);

Fig. 18. - the distal side, Fig. 19. - the proximal side.

Fig. 20. *Paravesicaspora splendens* (Leschik) Klaus;

the Siodła IG 1 borehole, 182,5 m; Zechstein, Pzt (x 750).

PLATE V

Fig. 1. *Platysaccus leschiki* Hart;

the Stachura IG 1 borehole, 602,5 m; Zechstein, PZ3 (Ca3) (x 750).

Fig. 2. *Platysaccus papilionis* Potonié et Klaus;

the Jaworze IG 1 borehole, 369,5 m; Zechstein, PZ1 (A1g).

Fig. 3. *Platysaccus niger* Mädler;

the Radwanów IG 1 borehole, 1630,0 m; Zechstein, PZ1 (Ca1).

Fig. 4. *Jugasporites delasaucei* (Potonié et Klaus) Leschik;

the Łopuszno IG 1 borehole, 1761,5 m; Zechstein, PZ1 (Ca1).

Fig. 5. *Jugasporites parvus* (Klaus) Foster;

the Łopuszno IG 1 borehole, 1744,8 m; Zechstein, PZ1 (Ca1).

Fig. 6. *Illinites unicus* Kosanke;

the Siodła IG 1 borehole, 182,3 m; Zechstein, Pzt (x 750).

Fig. 7. *Jugasporites latus* (Leschik) Foster;

the Radwanów IG 1 borehole, 1631,5 m; Zechstein, PZ1 (Ca1).

Fig. 8. *Illinites elegans* Kosanke;
the Stachura IG 1 borehole, 665,4 m; Zechstein, PZ1 (A1g).
Fig. 9. *Jugasporites lueckoides* Klaus;
the Siodła IG 1 borehole, 183,2 m; Zechstein, Pzt.
Fig. 10. *Illinites kosankei* sp. nov. (holotype);
the Siodła IG 1 borehole, 183,2 m; Zechstein, Pzt.
Fig. 11. *Jugasporites purus* (Leschik) Tiwari et Singh;
the Stachura IG 1 borehole, 665,5 m; Zechstein, PZ1 (T1r).
Fig. 12. *Vitreisporites* sp.;
the Stachura IG 1 borehole, 639,7 m; Zechstein, PZ1 (A1g).
Fig. 13. *Jugasporites schaubergeroides* Klaus;
the Siodła IG 1 borehole, 183,2 m; Zechstein, Pzt.
Fig. 14. *Triadispora visscheri* (Visscher) comb. nov.;
the Radwanów IG 1 borehole, 1630,0 m; Zechstein, PZ1 (Ca1).
Fig. 15. *Jugasporites paradelasaucei* Klaus;
the Siodła IG 1 borehole, 182,5 m; Zechstein, Pzt.
Fig. 16. *Triadispora plicata* Klaus;
the Łopuszno IG 1 borehole, 1761,9 m; Zechstein, PZ1 (Ca1).
Fig. 17, 19. *Triadispora crassa* Klaus;
the Podgace IG 1 borehole, 124,7 m; Zechstein, PZ1 (Ca1).
Fig. 18. *Limitisporites moersensis* (Grebe) Klaus;
the Podgace IG 1 borehole, 124,7 m; Zechstein, PZ1 (Ca1) (x 750).
Fig. 20. *Limitisporites leschiki* Klaus;
the Radwanów IG 1 borehole, 1631,5 m; Zechstein, PZ1 (Ca1).
Fig. 21. *Limitisporites rectus* Leschik;
the Łopuszno IG 1 borehole, 1744,8 m; Zechstein, PZ1 (Ca1).
Fig. 22. *Gardenasporites* cf. *moroderi* Klaus;
the Zachełmie IG 1 borehole, 185,6 m; Zechstein, PZ1 (T1r).
Fig. 23. *Gardenasporites* cf. *oberrauchi* Klaus;
the Siodła IG 1 borehole, 183,2 m; Zechstein, Pzt (x 750).

PLATE VI

Fig. 1. *Gardenasporites leonardii* Klaus;
the Siodła IG 1 borehole, 212,2 m; Zechstein, PZ1 (T1r) (x 750).
Fig. 2. *Limitisporites* cf. *parvus* Klaus;
the Zachełmie IG 1 borehole, 185,6 m; Zechstein, PZ1 (T1r).
Fig. 3. *Gardenasporites heisseli* Klaus;
the Siodła IG 1 borehole, 212,2 m; Zechstein, PZ1 (T1r).
Fig. 4. *Crustaesporites globosus* Leschik;
the Łączna-Zaszosie IG 1 borehole, 435,7 m; Zechstein, PZ1 (T1r).
Fig. 5. *Pakhapites* sp.;
the Podgace IG 1 borehole, 124,7 m; Zechstein, PZ1 (Ca1).
Fig. 6. *Gnetacaepollenites steevesi* Jansonius;
the Ostojów IG 1 borehole, 262,0 m; Buntsandstein (complex A1).
Fig. 7. *Cycadopites coxii* Visscher;
the Siodła IG 1 borehole, 182,5 m; Zechstein, Pzt.
Fig. 8. *Cycadopites follicularis* Wilson et Webster;
the Radwanów IG 1 borehole, 1645,0 m; Zechstein, PZ1 (Ca1).
Fig. 9. *Monosulcites* sp.;
the Łopuszno IG 1 borehole, 1744,8 m; Zechstein, PZ1 (Ca1).
Fig. 10, 22, 25. *Michrystridium* cf. *stellatum* Deflandre;
the Radwanów IG 1 borehole, 1630,0 m; Zechstein, PZ1 (Ca1) (x 750).
Fig. 11. *Leiosphaeridia* sp.;
the Radwanów IG 1 borehole, 1631,5 m; Zechstein, PZ1 (Ca1).
Fig. 12. *Michrystridium recurvatum* Valensi;
the Radwanów IG 1 borehole, 1631,5 m; Zechstein, PZ1 (Ca1).
Fig. 13. *Chordasporites* sp.;
the Radwanów IG 1 borehole, 1630,0 m; Zechstein, PZ1 (Ca1).
Fig. 14. *Michrystridium setasessitante* Jansonius;
the Radwanów IG 1 borehole, 1630,0 m; Zechstein, PZ1 (Ca1).
Fig. 15. *Baltisphaeridium debilispinum* Wall et Downie;
the Radwanów IG 1 borehole, 1631,5 m; Zechstein, PZ1 (Ca1).

Fig. 16. *Baltisphaeridium* sp.;

the Łączna-Zaszosie IG 1 borehole, 329,7 m; Buntsandstein (complex A1) (x 750).

Fig. 17-19. *Veryhachium irregulare* Jekhowsky;

the Radwanów IG 1 borehole, 1630,0 m; Zechstein, PZ1 (Ca1).

Fig. 20. *Veryhachium* sp.;

the Radwanów IG 1 borehole, 1630,0 m; Zechstein, PZ1 (Ca1).

Fig. 21. *Veryhachium trispinoides* (Jekhowsky) comb. nov.;

the Radwanów IG borehole, 1630,0 m; Zechstein, PZ1 (Ca1) (x 750).

Fig. 23. *Baltisphaeridium* sp.;

the Radwanów IG 1 borehole, 1647,0 m; Zechstein, PZ1 (Ca1) (x 750).

Fig. 24. *Pilaspora* cf. *plurigenus* Balme et Hennelly;

the Siodła IG 1 borehole, 182,5 m; Zechstein, Pzt.

Fig. 26. *Michrystridium* sp.;

the Łączna-Zaszosie IG 1 borehole, 329,7 m; Buntsandstein (complex A1) (x 1000).

Fig. 27. *Baltisphaeridium longispinosum* (Eisenack) Eisenack;

the Radwanów IG 1 borehole, 1630,0 m; Zechstein, PZ1 (Ca1) (x 1000).

PLATE VII

Fig. 1. *Lueckisporites virkkiae* Potonié et Klaus norm (N) Aa (after Visscher);

the Radwanów IG 1 borehole, 1630,0 m; Zechstein, PZ1 (Ca1) (x 750).

Fig. 2. *Lueckisporites virkkiae* Potonié et Klaus NAb;

the Łopuszno IG 1 borehole, 1729,7 m; Zechstein, PZ1 (Ca1) (x 1000).

Fig. 3. *Lueckisporites virkkiae* Potonié et Klaus NBb;

the Radwanów IG 1 borehole, 1644,5 m; Zechstein, PZ1 (Ca1) (x 1000).

Fig. 4. *Lueckisporites virkkiae* Potonié et Klaus NBc;

the Radwanów IG 1 borehole, 1660,0 m; Zechstein, PZ1 (Ca1) (x 1000).

Fig. 5. *Lueckisporites virkkiae* Potonié et Klaus NAc;

the Radwanów IG 1 borehole, 1729,7 m; Zechstein, PZ1 (Ca1) (x 1000).

Fig. 6. *Lueckisporites virkkiae* Potonié et Klaus NBa;

the Łopuszno IG 1 borehole, 1744,8 m; Zechstein, PZ1 (Ca1) (x 750).

Fig. 7. *Lueckisporites virkkiae* Potonié et Klaus f. with a "dark body" f. nov.; the Podgace IG 1 borehole, 97,7 m; Zechstein, PZ1 (T1r).

Fig. 8. *Lueckisporites virkkiae* Potonié et Klaus NE;
the Radwanów IG 1 borehole, 1644,5 m; Zechstein, PZ1 (Ca1) (x 1000).

Fig. 9. *Lueckisporites virkkiae* Potonié et Klaus NC (Guttulapollenites);
the Podgace IG 1 borehole, 124,7 m; Zechstein, PZ1 (Ca1) (x 750).

PLATE I

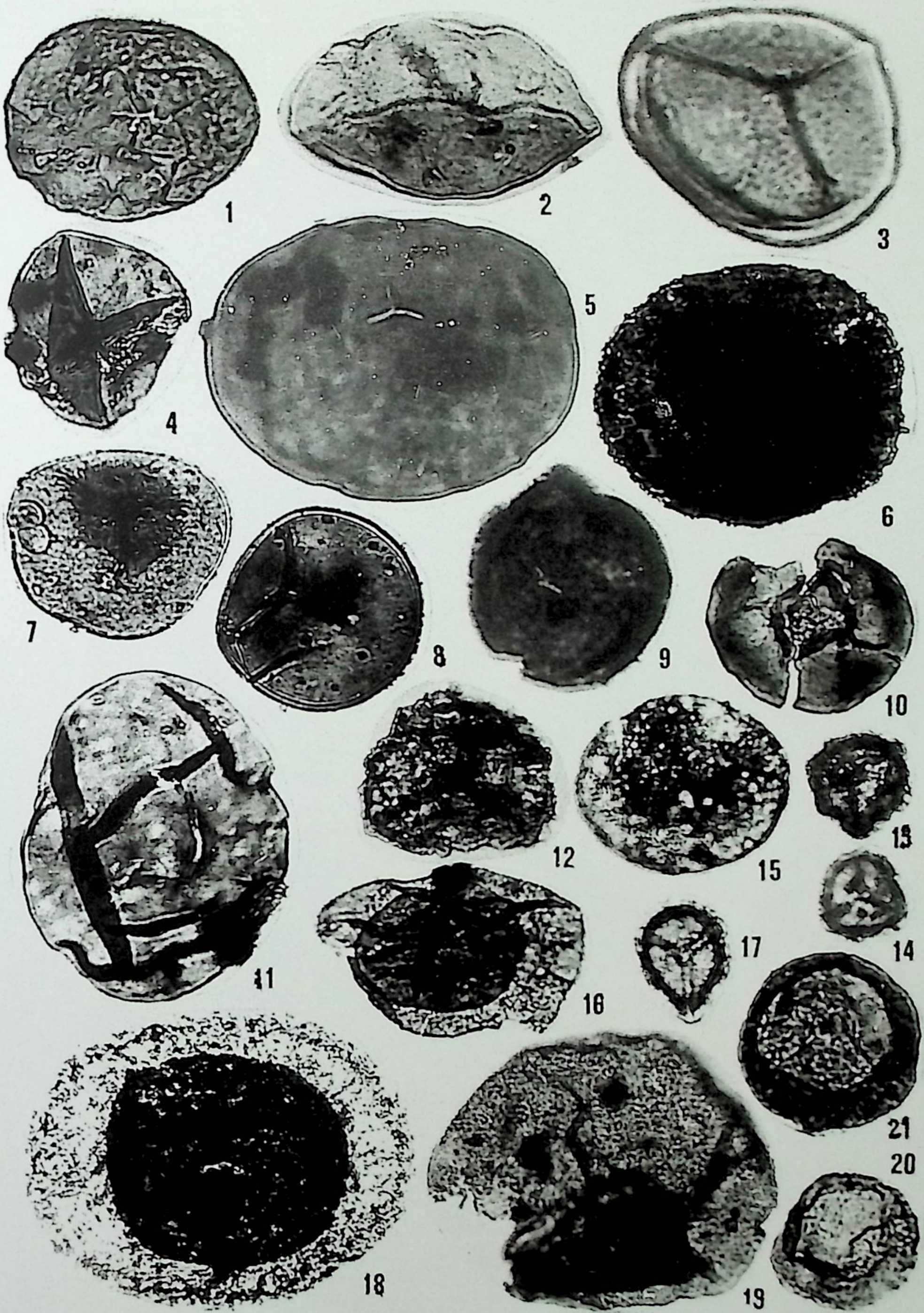
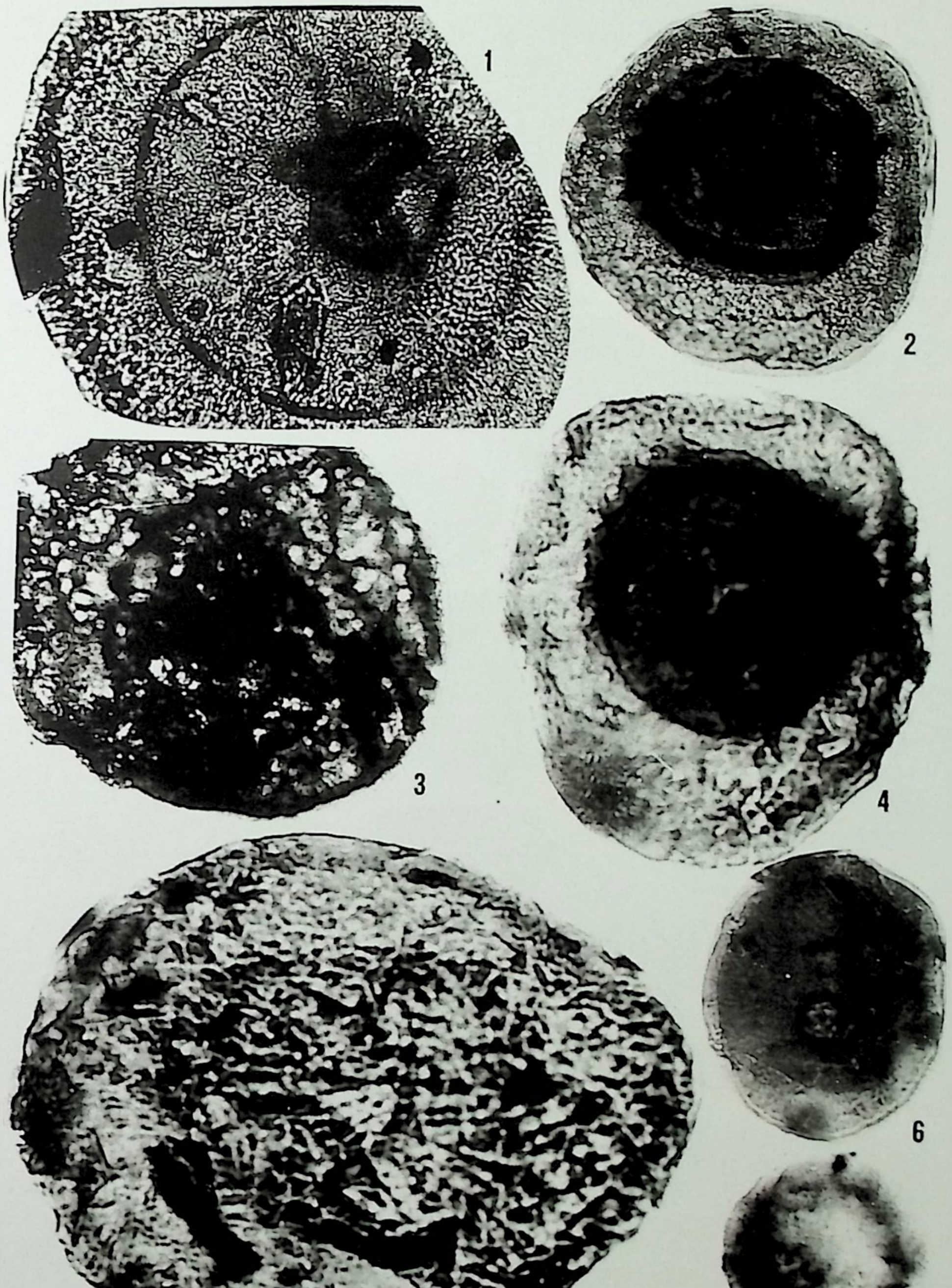


PLATE II



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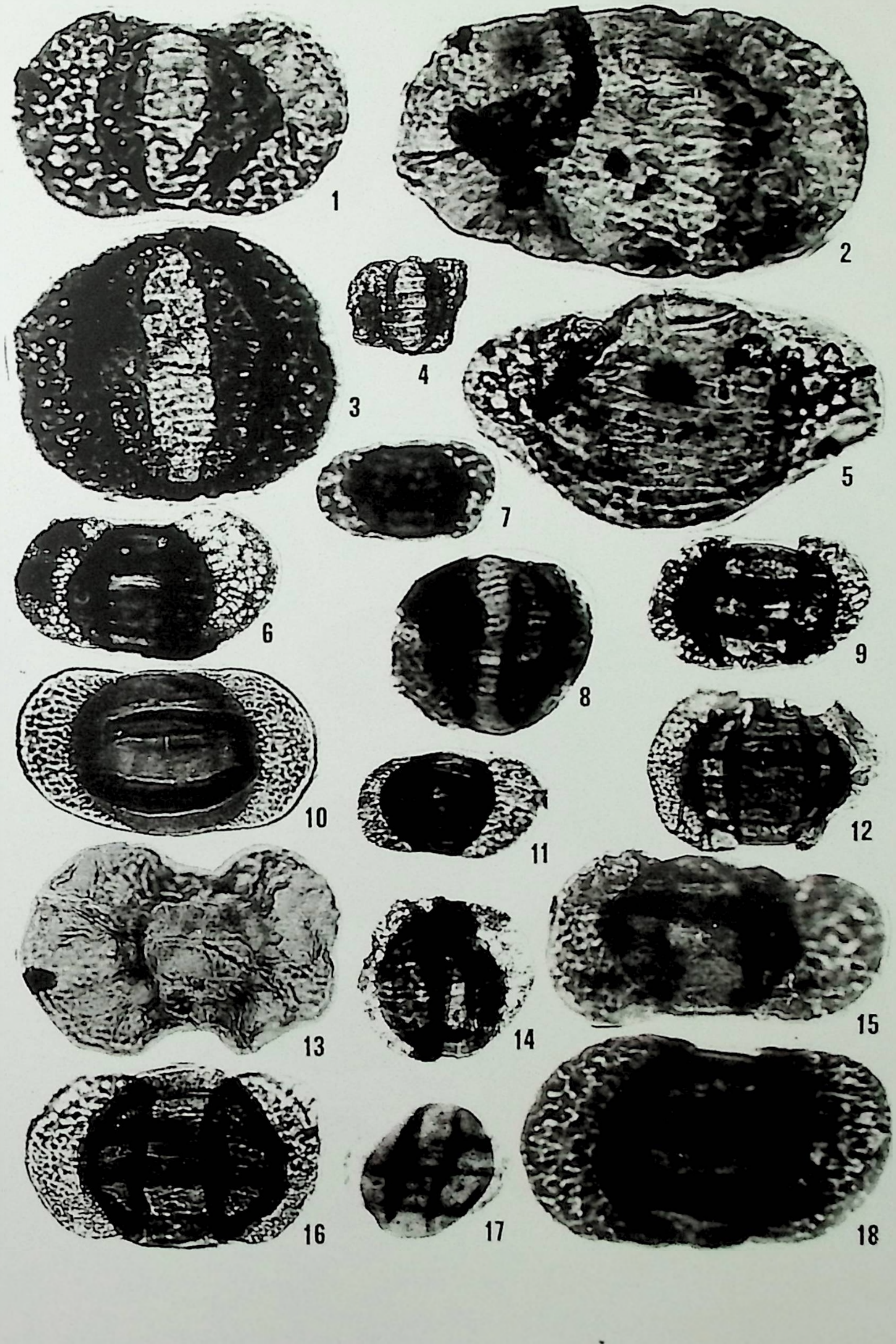

PLATE IV

PLATE V

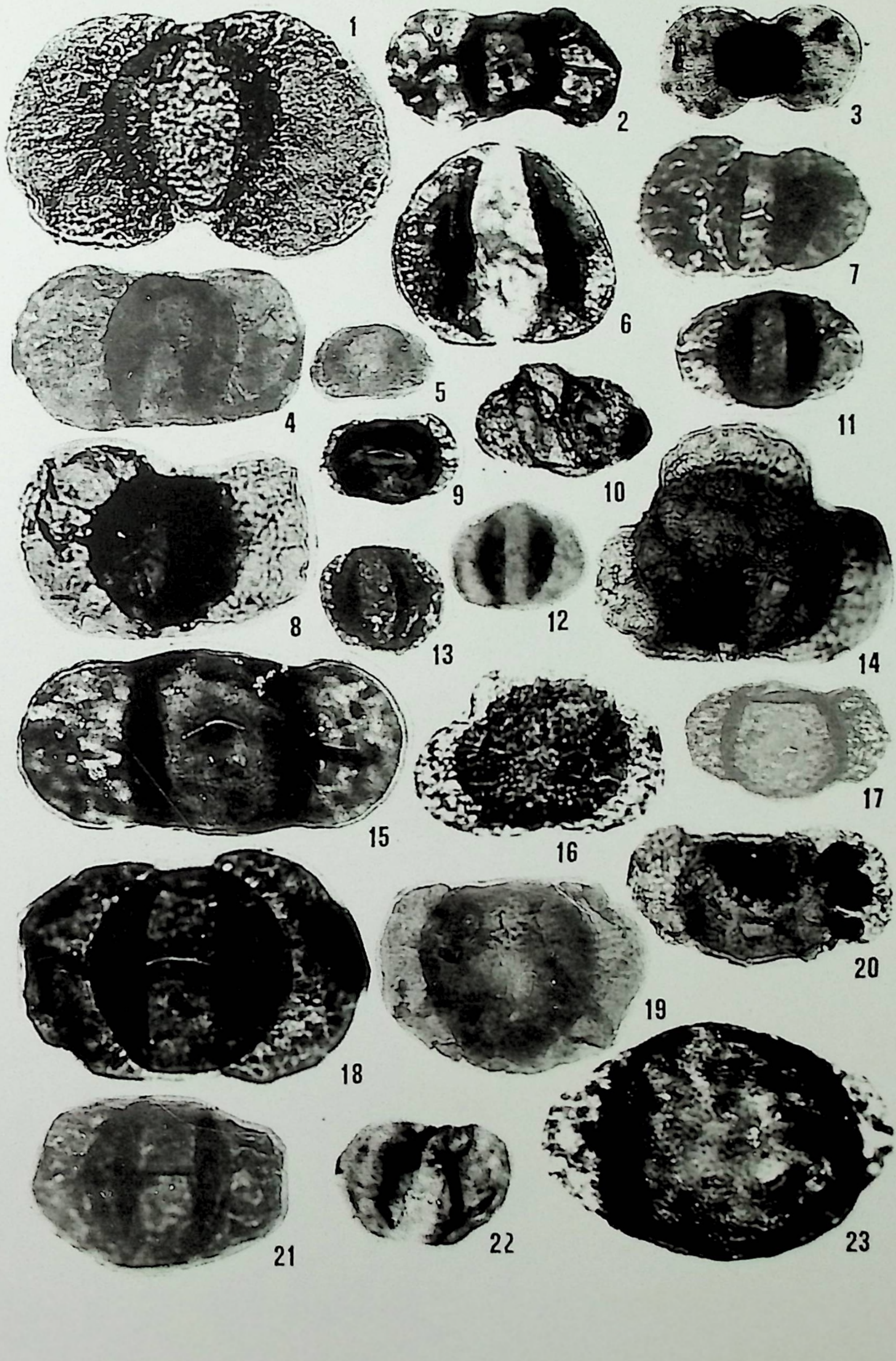

PLATE VI

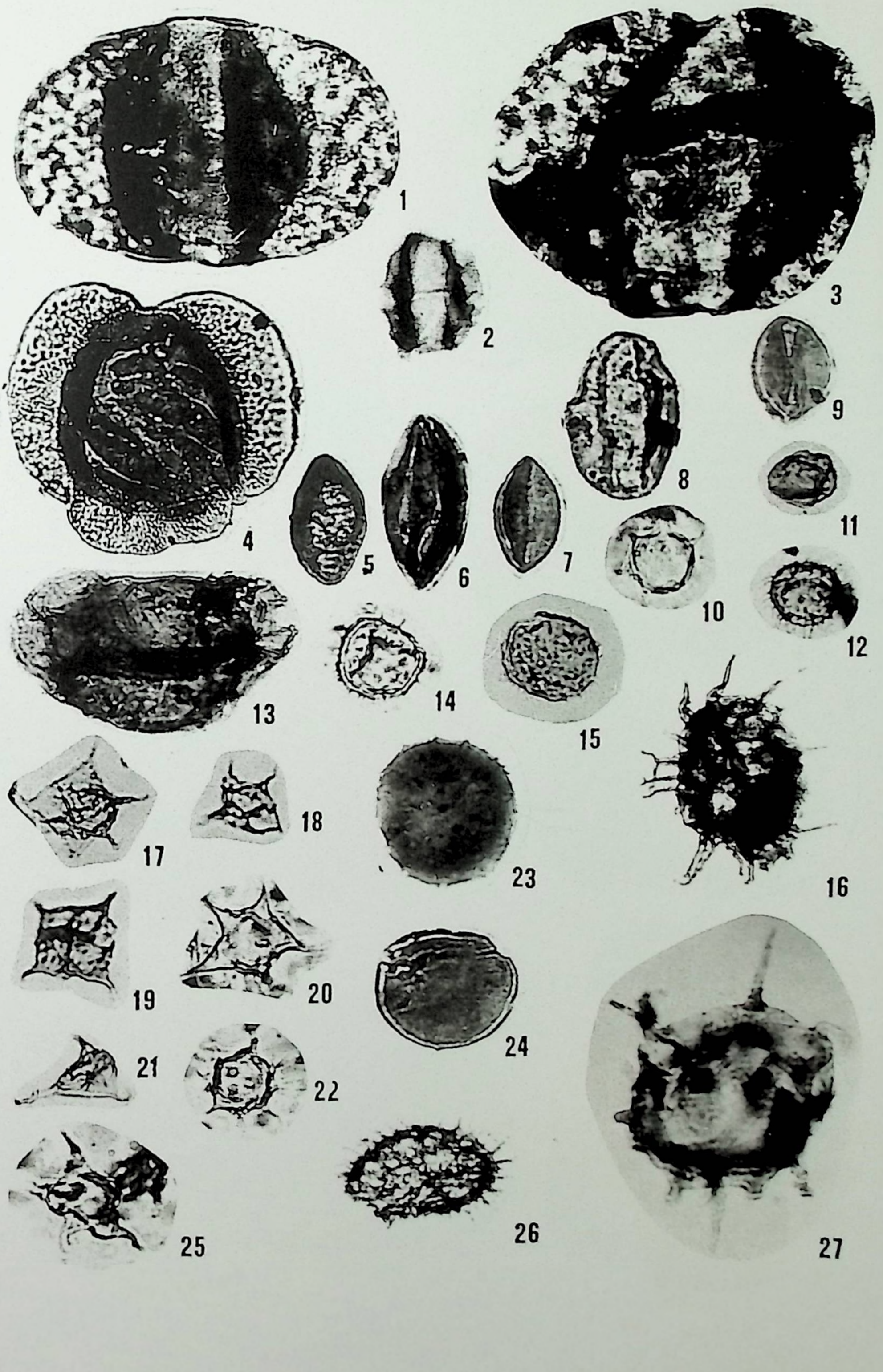

PLATE VII