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CORRELATION OF THE TOURNAISIAN MIOSPORE ZONATIONS OF POLAND AND THE BRITISH ISLES

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Abstract: Many stratigraphically important Tournaisian miospore taxa occur in both Poland and Western Europe, permitting correlation of the miospore zonations in both regions at several stratigraphic levels, especially in the lower Tournaisian. Rather poor sample coverage in the middle part of the Polish Tournaisian, and rare occurrence of some late Tournaisian species of zonal importance make comparison with Western Europe difficult, though some tentative correlations are suggested.

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INTRODUCTION

Turnau (1975) described five succesive miospore assemblages from the Famennian, Strunian and Dinantian in two borehole sections from Western Pomerania (Fig. 1). In the same year, Krawczyńska-Grocholska published a short note on an upper Vissean miospore assemblage from the same region. In 1978 and 1979, Turnau formally established a miospore zonal scheme for the (?) Frasnian — Westphalian B interval in Western Pomerania comprising 10 oppel zones, one of which was divided into 3 subzones.

Subsequent investigations in Western Pomerania by one of the authors (E.T.) has resulted in improved knowledge of the ranges of many miospore taxa. This work, and recent publication of the results of numerous investigations in Western Europe now permits correlation at several stratigraphic levels between the miospore successions in the two regions. Joint studies by the authors of material from Poland and the British Isles have elucidated the taxonomic relationships between many of the more important miospore taxa. Together with the recently published comparative work by Avkhimowitch *et al.* (1988), this has enabled a more confident review of the Tournaisian palynostratigraphy of the two regions.

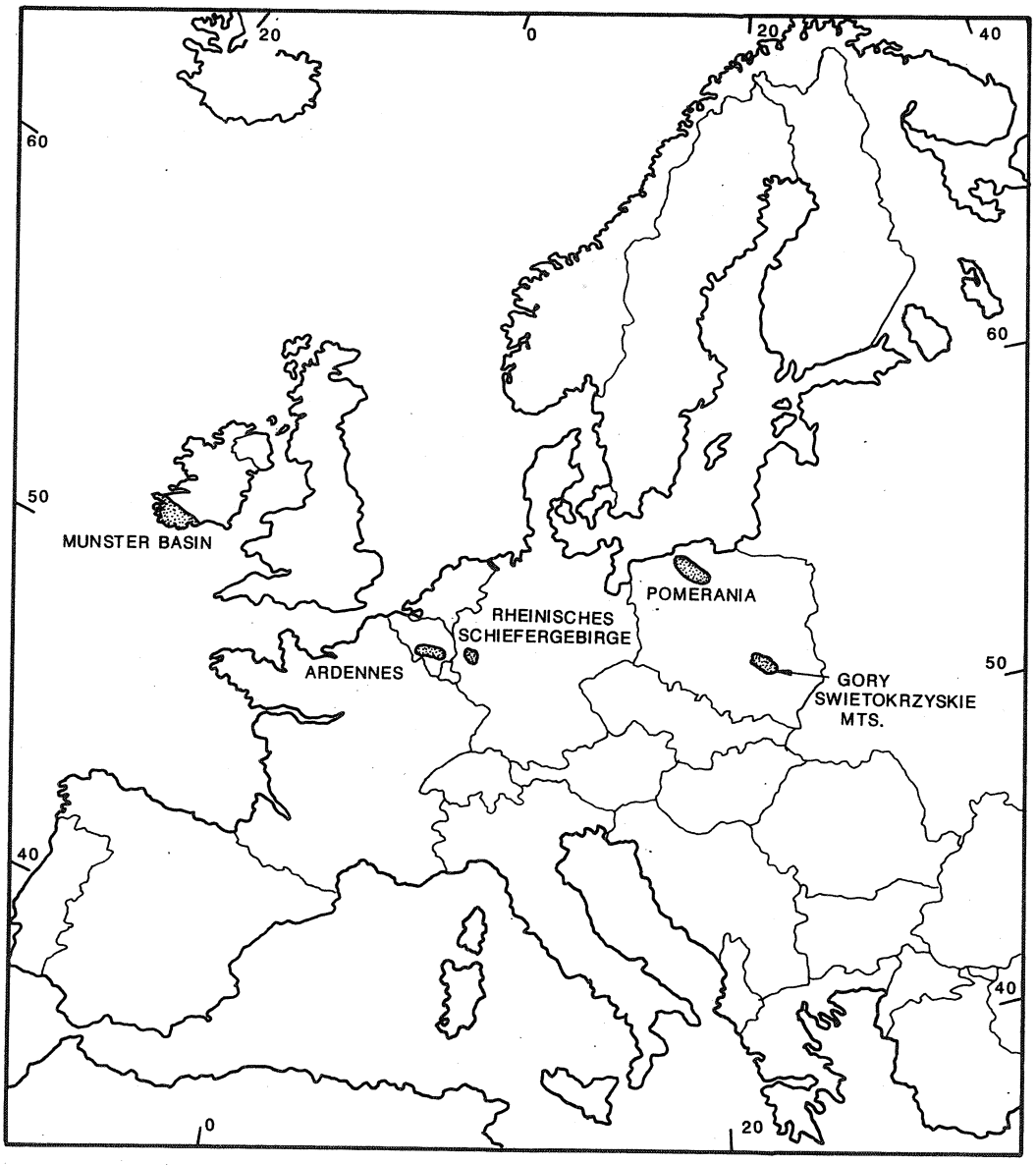

Fig. 1. Map showing position of areas discussed in text

Jachowicz (1962, 1967) published an account of Visean and problematic Tournaisian miospore assemblages from the Góry Świętokrzyskie (Holy Cross) Mountains. More recent work in this structurally complex area has resulted in the publication of details of Famennian, Strunian and lowermost Dinantian miospore assemblages (Turnau, *in press*). However, the

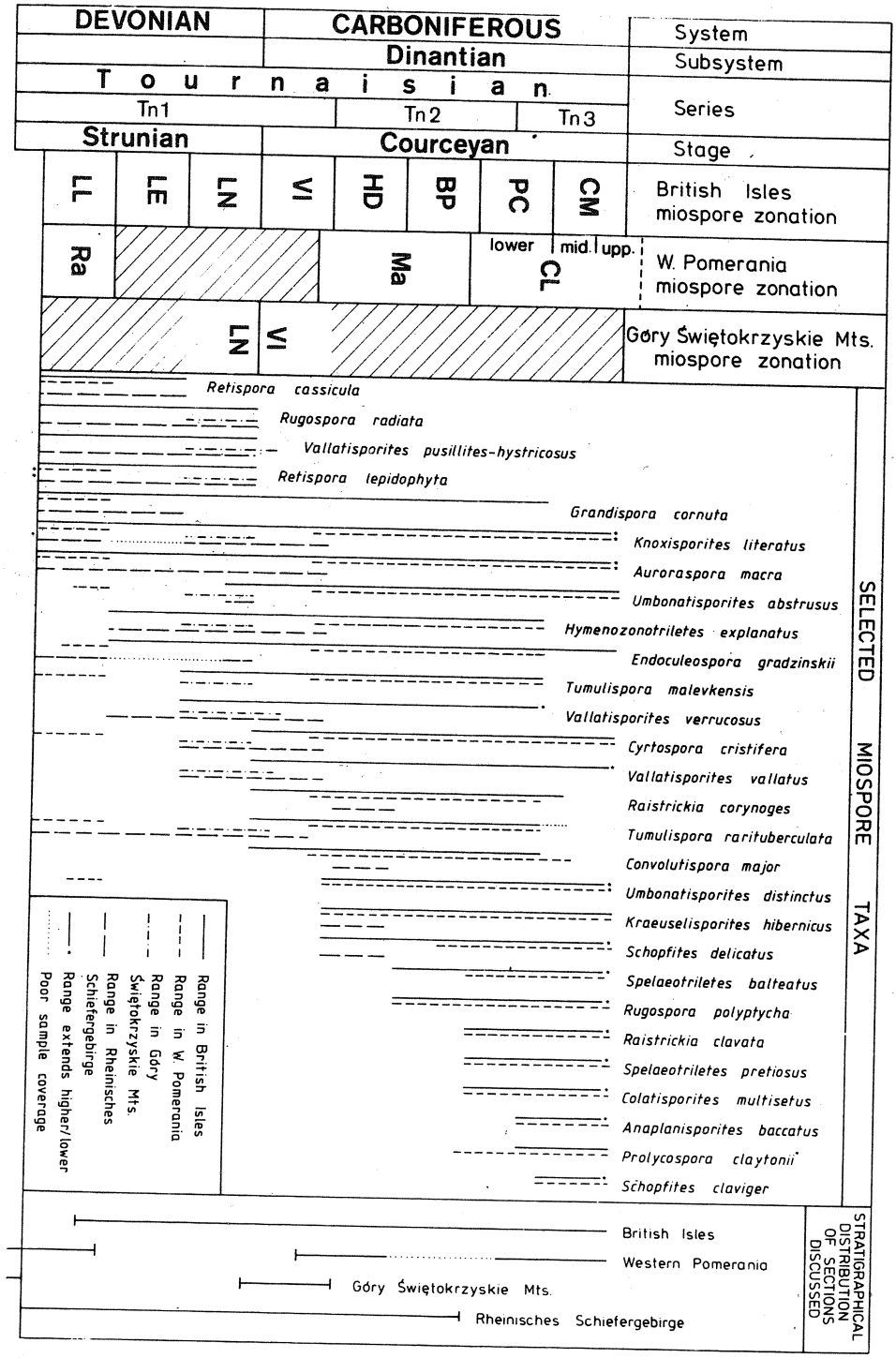

Fig. 2. Correlation of Tournaisian miospore zonations of Poland and the British Isles and stratigraphical ranges of selected spore species.

palynological succession contains gaps caused by unfavourable lithology through several intervals.

The Tournaisian assemblages obtained from the Góry Świętokrzyskie Mountains resemble those from Western Europe, permitting correlation with the British Isles zonal scheme (Higgs *et. al.*, 1988). However, the Famennian assemblages can neither be satisfactorily accomodated in the zonal scheme established by Richardson & McGregor (1986) nor in that proposed by Streel *et al.* (1987). This is due to the lack of many species of zonal importance, and, on the basis of conodont evidence, to the diachronous apperance of some taxa in the Góry Świętokrzyskie Mountains, north-west Europe and North America.

The earliest attempt to establish a miospore zonation for the Tournaisian of the British Isles was made by Neves *et al.* (1973). Subsequently, numerous authors published detailed palynological accounts of sections in this region, and the original zonal scheme was gradually refined on the basis of these new studies. No attempt to review the evolution of this zonation is made here, but a full discussion may be found in Higgs *et al.* (1988).

CORRELATION BETWEEN POLAND AND THE BRITISH ISLES

Stratigraphic ranges of selected miospore species in the Tournaisian of the British Isles, Pomerania, the Góry Świętokrzyskie Mountains and the Rhenisches Schiefergebirge are shown in Figure 2.

The *Retispora lepidophyta* — *Knoxisporites literatus* (LL) Biozone can be recognised in Western Pomerania. It corresponds to the local *Tumulispora rarituberculata* (Ra) Biozone the base of which is defined by the first apperance of *Knoxisporites literatus* (Waltz) Playford and *Tumulispora rarituberculata* (Luber) Potonié

The *Retispora lepidophyta* — *Hymenozonotriletes explanatus* (LE) biozone has not been recognized in Poland. Corresponding deposits appear on current evidence absent in Western Pomerania, and are palynologically barren or not present in the Góry Świętokrzyskie Mountains.

The *Retispora lepidophyta* — *Verrucosisporites nitidus* (LN) Biozone has also not been recognized in Western Pomerania (see *V. mesogrumosus* in the „Systematic comments") but it has been recognized in the Góry Świętokrzyskie Mountains. LN assemblages from this area contain, among other species, *Verrucosisporites nitidus* (Naumova) Playford and *Vallatisporites verrucosus* Haquebard.

Spores belonging to *Vallatisporites hystricosus* — *Vallatisporites pusillites* complex disappear at the base of the *Vallatisporites verrucosus* — *Retusotriletes incohatus* (VI) Biozone everywhere in the British Isles, but their range extends higher in the Góry Świętokrzyskie Mountains, into strata assigned to the VI Biozone which contain the trilobite *Belgibole (Waribole)*

abruptirhachis (Richter & Richter) G. Hahn & Brauckman indicating stratigraphical position not older than basal Carboniferous (Żakowa *et. al.*, 1975). The disapperance of *Retisphora lepidophyta* (Kedo) Playford which defines the base of the VI Biozone is the most prominent feature of the Tournaisian miospore succession, and can be recognized in both regions considered within Poland, and in the British Isles.

Correlation between Pomerania and the British Isles is difficult in the mid-Tournaisian. It is not possible at this stage to recognize either the *Kraeuselisporites hibernicus — Umbonatisporites distinctus* (HD) or the *Spelaeotriletes balteatus — Rugospora polyptycha* (BP) Biozones within the rather broad *Convolutispora major* (Ma) Biozone of Pomerania. However, *Kraeuselisporites hibernicus* Higgs and *Rugospora polyptycha* Neves & Ioannides have been recorded sporadically in Pomerania, and new drilling with closer sample spacing may permit more detailed correlation in the future.

Colatisporites denticulatus Neville, *Raistrickia clavata* (Haquebard) Playford, Spelaeotriletes balteatus (Playford) Higgs and *S. pretiosus* (Playford) Neves & Belt first appear close above the base of the Cl Biozone which is defined by the first appearance of *Prolycospora claytonii* Turnau. The base of this zone is considered to correlate with a level within the BP Biozone in Western Europe. The base of the middle subzone of the Cl Biozone, characterized by the disapperance of *Tumulispora* spp. and of *Hymenozonotriletes explanatus* Kedo may be correlated with the base of the *Schopfites claviger — Auroraspora macra* (CM) Biozone in Western Europe, defined by the first apperance of *Schopfites claviger.* This species appears only sporadically within the Cl Biozone in Western Pomerania, and its range is not firmly established. A single specimen of *Lycospora pusilla* (Ibrahim) Somers has also been recorded high in the Cl Biozone. The first appearance of this taxon defines the base of the *Lycospora pusilla* (Pu) Biozone in Western Europe, which is tentatively correlated with the Tournaisian/Visean boundary.

CORRELATION OF POLISH MIOSPORE BIOZONATION AND OTHER BIOSTRATIGRAPHIC SCHEMES

Many parts of Tournaisian section in Western Pomerania and the Góry Świętokrzyskie Mountains contain other groups of fossils which permit independent confirmation of the miospore correlations at certain levels. The base of the LL Biozone in Western Pomerania is younger than the base of the Upper *expansa* (conodont) Zone while the highest miospore assemblages of this zone are found in association with *costatus* conodont faunas (Matyja & Turnau, *in press*). The uppermost Devonian trilobite *Phacops accipitrinus* (Phillips) occurs together with Strunian brachiopods in strata assigned

to the LL (Ra) Biozone (Korejwo, 1975).

In the Rheinisches Schiefergebirge, the lowest VI Biozone assemblage occurs slightly below the lowest sulcata Zone conodont fauna (Higgs & Streel, 1984). In Western Pomerania, the lowest Ma Biozone assemblages are found in association with *sandbergi* Zone conodont suggesting break in the succession. According to Korejwo (1979), the early Dinantian goniatite, *Pseudoarietites dorsoplanus dorsoplanus* H. Schmidt also occurs in strata assigned to the basal part of the Ma Biozone. In the Góry Świętokrzyskie Mountains the VI Biozone assemblage occurs within strata including trilobite *Belgibole (Waribole) abruptirhachis* (Richter & Richter) G. Hahn & Brauckmann (Żakowa *et al.*, 1985).

Conodont faunas from several sections containing upper Ma Biozone assemblages include *Siphonodella isosticha* Cooper and *Polygnathus dentilineatus* Branson, indicating a Tn2 age. Faunas from immediately below the boundary between the Ma and Cl Biozones include *Polygnathus communis carina* Hass and *Siphonodella* sp., suggesting position within Tn2, rather than Tn3 as stated in Matyja (1976) and Turnau (1978). *Avonia nigra* (Gosselet) and *Polygnathus* cf. *purus purus* Voges found within the lower part of the Cl Biozone indicate a position not higher than Tn2. A bivalve-gastropod fauna from the base of this zone was considered by Korejwo (1979) to indicate a position within the upper part of Tn2 or the lower part of Tn3.

Acknowledgments

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SYSTEMATIC COMMENTS

In the following section, we are concerned mainly with the specific identity of some species which occur in Poland and in the British Isles, but have been recorded under different names. Some species, whose concept varies from author to author are described and discussed to avoid ambiguity. No attempt has been made to present full synonimy lists. These lists concern, first of all, the material examined by the authors, and in a lesser degree some suggestions on synonimity based on illustrated and described material.

The micrographs presented in Plates I and II, and the spore descriptions concern Polish material, which is housed in the Institute of Geological Sciences in Kraków.

Genus *Anaplanisporites* Jansonius, 1962

Anaplanisporites baccatus (Hoffmeister, Staplin & Malloy) Smith & Butterworth, 1967
Pl. I: 1

1977 *Anaplanisporites delicatus* Neves & Ioannides, p. 76, pl. 5: 2 — 4.
1977 *Anaplanisporites delicatus* Neves & Ioannides; Owens, Guennel & Cameron, pl. 1: 9.
1978 *Anaplanisporites delicatus* Neves & Ioannides; Turnau, p. 7, pl. 1: 25.

Description: An *Anaplanisporites* with an ornament of discrete coni, densely set, with pointed or blunt apices, about 0.5 μm high and wide at base. Trilete rays, accompanied by narrow lips, extend to spore margin. Curvaturae may be present. Distal secondary folds common. Size range 24 (30) 34.5 μm (25 specimens).

Genus *Colatisporites* Williams, in Neves *et al.*, 1973

Colatisporites denticulatus Neville, in Neves *et al.*, 1973
Pl. I: 2, 3

1978 *Apiculiretusispora multiseta* (Luber) Butterworth & Spinner; Turnau, p. 6, pl. 1: 22, 23.

Description: A *Colatisporites* with a dense, uniform ornament of gradually tapering, acute or truncated spines and bacula 1 — 2 μm long confined to distal, equatorial, and proximo-equatorial regions. Intexine distinct to obscure, comprising about 4/5 of spore diameter. Trilete rays simple, 1/2 to 1/3 radius long, often indistinct. Size range 41 (48) 56 μm (28 specimens).

Genus *Schopfites* Kosanke, 1950

Schopfites delicatus Higgs emend Higgs, Clayton & Keegan, 1988
Pl. I: 5

1978 *Schopfites claviger* Sullivan; Turnau (*partim*)

Description: A *Schopfites* with an ornament of closely spaced bacula and rare pila, 0.5 to 2 μm wide and 1 to 2.5 μm long. Intexine indistinct. Sutures accompanied by ray folds, extending almost to equator. Size range 48 (50) 56 μm (6 specimens).

Remarks: Most specimens determined by Turnau (1978) as *S. claviger* have fine ornament and are considered now to represent *S. delicatus*.

Genus *Tumulispora* Staplin & Jansonius, 1964

Remarks: *Tumulispora* has been established to accomodate cingulate spores having a coarse tuberculate sculpture. Potonié (1966) included in this genus *Zonotriletes raritu-berculatus* Luber while Turnau (1978) included in it *Lophozonotriletes malevkensis* Kedo. Some authors still use *Lophozonotriletes* because, as suggested by Playford (1976), the morphography of the type species of *Lophozonotriletes* has not been clarified yet. The present authors disagree with this opinion. The type species of *Lophozonotriletes, L. lebe-dianensis* Naumova, as illustrated by Soviet palynologists, is clearly an azonate spore (cf. Avkhimovitch, 1974, pl. 27: 14, pl. 28: 15; Kedo, 1974, pl. 20: 5, pl. 21: 10). The genus

Lophozonotriletes has been included by Byvsheva (1985) to *Azonotriletes* Luber 1938. For this reasons we prefer to use *Tumulispora.*

Tumulispora rarituberculata (Luber) Potonié, 1966
Pl. I: 7

1988 *Lophozonotriletes triangulatus* (Ishchenko) Playford; Higgs *et al.*, p. 67, pl. 8: 16 — 19, and synonyms.

Size range: 54 (74) 100 μm (thirteen specimens).

Remarks: *T. rarituberculata* is distinguished from *T. malevkensis* solely on the basis of spore size. According to Kedo (1963) *T. malevkensis* ranges from 33 to 50 μm, and *T. rarituberculata* from 53 to 65 μm. Byvsheva (1985) gives the size ranges of these two species as 30 to 40 μm and 55 to 70 μm. The respective figures given by Turnau (1978) are 32.5 to 52 and 54 to 100 μm, and by Higgs *et al.* (1988) 32 to 50 and 52 to 64 μm. Thus, the size limit between the two species is arbitrary, but, nevertheless, we prefer to keep them separate because this is stratigraphically useful in the British Isles where *T. malevkensis* appears lower in stratigraphical sequence.

Tumulispora malevkensis (Kedo) Turnau, 1978
Pl. I: 6

Size range: 32.5 (42.5) 52 μm (20 specimens).

Genus *Vallatisporites* Haquebard, 1957

Vallatisporites pusillites (Kedo) Dolby & Neves, 1970
Pl. II: 1, 2

1962 *Cirratriradites hystoricosus* Winslow, p. 41, pl. 18: 5.
1962 *Cirratriradites sp. A* Winslow, p. 41, pl. 18: 1 — 2.
1988 *Vallatisporites pusillites* (Kedo) Dolby & Neves; Higgs *et al.*, p. 80, pl. 16: 13 — 15.

Description: A *Vallatisporites* having a distal ornament of spines and galeae 2 to 7.5 μm long, 1.5 to 6 μm wide at base, 2 to 4 μm apart. Over the cingulum, these elements are smaller and more widely spaced. Cingulum 1/4 to 1/3 radius of spore, bearing along the inner margin a row of radially aligned vacuoles 3 to 6 μm in radial length. Sutures bordered by ray folds which extend to spore margin. Size range 52 (61) 81 μm (10 specimens).

Remarks: Avkhimowitch *et al.* (1988) suggested that *V. pusillites* (Kedo) Dolby & Neves emend Byvsheva (1985) and *V. hystricosus* (Winslow) Byvsheva (1985) were two distinct species differing in the size and nature of ornamentation elements. In this paper we use the broader concept of *V. pusillites.*

Genus *Verrucosisporites* Ibrahim emend. Smith, 1971

Verrucosisporites mesogrumosus (Kedo) Byvsheva, 1985
Pl. II: 4, 6.

1975 *Verrucosisporites nitidus* (Naumova) Playford; Turnau, pl. 2: 5.
1978 *Verrucosisporites nitidus* (Naumova) Playford; Turnau, pl. 1: 12.
1979 *Verrucosisporites nitidus* (Naumova) Playford; Turnau, pl. 1: 10., non pl. 1: 14.

Remarks: As stated in Avkhimowitch *et al.* (1988) *Verrucosisporites mesogrumosus* differs from *V. nitidus* (Naumova) Playford (1964) in having more widely spaced verrucae which are usually more irregular in shape and variable in size on each specimen. Also the exine wall is in *V. mesogrumosus* more prominently defined. The specimens of *V. mesogrumosus* from the lower Tournaisian of Western Pomerania, assigned preciously to *V. nitidus*, have well defined wall and verrucae which vary considerably in size on each specimen.

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Streszczenie

KORELACJE ZON MIOSPOROWYCH TURNEJU POLSKI I WYSP BRYTYJSKICH

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Korelację zon sporowych Polski i Wysp Brytyjskich (Fig. 1) wraz z zasięgami stratygraficznymi wybranych gatunków spor, przedstawiono na Figurze 2.

Pierwsza próba stworzenia miosporowego schematu stratygraficznego dla turneju Wysp Brytyjskich przedstawiona została w pracy Neves *et al.* (1973). Dzięki późniejszym badaniom wielu autorów schemat ten był doskonalony. Dyskusję nad jego ewolucją przedstawiono w pracy Higgs *et al.* (1988).

W latach 1978 i 1979 Turnau ustanowiła lokalny miosporowy schemat stratygraficzny dla turneju (oraz nadległych i niżej leżących utworów) Pomorza Zachodniego. Dzięki dalszym badaniom palinologicznym na tym terenie uściślono dane dotyczące zasięgów stratygraficznych wielu gatunków.

Wspólne badania autorów niniejszej pracy nad materiałem z Polski i Wysp Brytyjskich pozwoliły na wyjaśnienie związków taksonomicznych pomiędzy wieloma ważnymi stratygraficznie gatunkami. To oraz wyniki podobnych badań opublikowanych w wieloautorskiej pracy Avkhimowitch *et al.* (1988) pozwalają obecnie na pewniejsze niż dotychczas przeprowadzenie korelacji sukcesji sporowych turneju Pomorza Zachodniego i Wysp Brytyjskich.

Turnejskie zespoły sporowe występują również na terenie Gór Świętokrzyskich, gdzie wyróżniono dwie zony sporowe schematu brytyjskiego, stosowanego w całej Europie północno-zachodniej.

Biozonę *Retispora lepidophyta — Knoxisporites literatus* (LL) można wyróżnić na Pomorzu Zachodnim. Odpowiada ona lokalnej zonie *Tumulispora rarituberculata* (Ra), której dolną granicę określa pierwsze pojawienie się gatunków *T. rarituberculata* i *Knoxisporites literatus.*

Zespołów spor biozony *Retispora lepidophyta — Hymenozonotriletes explanatus* (LE) do tej pory w Polsce nie stwierdzono. Na Pomorzu Zachodnim, w dotychczas zbadanych profilach, utwory odpowiadające tej zonie, oraz kolejnej zonie *Retispora lepidophyta — Verrucosisporites nitidus* (LN) są nieobecne, co wynika także z wyników badań konodontowych (Matyja & Turnau, w druku).

Obecność zespołów spor najwyższej zony dewonu *Retispora lepidophyta — Verrucosisporites nitidus* (LN) stwierdzono w Górach Świętokrzyskich w profilu Kowala 1 (Turnau, w druku). W zespołach tej zony występują m.in. gatunki *Verrucosisporites nitidus* i *Vallatisporites verrucosus.*

Zespoły sporowe biozony *Vallatisporites verrucosus — Retusotriletes incohatus* (VI) stwierdzono również w wyżej wymienionym profilu. Charakteryzują się one brakiem spor *R. lepidophyta*, którego zanik jest charakterystyczny dla utworów najniższego karbonu również i w innych regionach Europy i poza nią.

Korelacje utworów środkowego turneju pomiędzy Pomorzem Zachodnim i Wyspami Brytyjskimi są trudne z uwagi na słabe rozpoznanie palinologii tych utworów na Pomorzu. Podstawa lokalnej zony sporowej *Convolutispora major* (Ma) odpowiada poziomowi stratygraficznemu w obrębie zony konodontowej *Simphonodella sandbergi.* W obrębie zony Ma pojawiają się gatunki *Kraeuselisporites hibernicus* i *Rugospora polyptycha.* Należy więc sądzić, że zona Ma obejmuje część zony VI *Vallatisporites verrucosus — Retusotriletes incohatus* (VI), zonę *Kraeuselisporites hibernicus — Umbonatisporites distinctus* (HD) oraz część zony *Spelaeotriletes balteatus — Rugospora polyptycha* (BP).

Kolejna zona sporowa turneju Pomorza Zachodniego jest zoną zasięgu gatunku *Prolycospora claytenii.* W obrębie dolnej części tej zony pojawiają się po raz pierwszy gatunki *Spelaeotriletes pretiosus, Raistrickia clavata* i *Colatisporites denticulatus.* Należy zatem sądzić, że dolna granica zony Cl odpowiada poziomowi stratygraficznemu poniżej granicy zon *Spelaeotriletes*

balteatus — *Rugospora polyptycha* (BP) i *Spelaeotriletes pretiosus* — *Raistrickia clavata* (PC).

Dolna granica środkowej podzony *P. claytonii* powyżej której brak już gatunków *Hymenozonotriletes explanatus*, *Tumulispora rarituberculata* i *Tumulispora malevkensis* odpowiada zapewne dolnej granicy biozony *Schopfites claviger* — *Auroraspora macra* (CM). Na Wyspach Brytyjskich podstawę tej zony wyznacza pierwsze pojawienie się gatunku *Schopfites claviger*. Na Pomorzu Zachodnim gatunek ten występuje rzadko i jego zasięg stratygraficzny nie jest dobrze określony.

W zespołach spor górnej części zony Cl napotkano jeden egzemplarz gatunku *Lycospora pusilla*. Pierwsze pojawienie się tego gatunku określa w Europie zachodniej podstawę zony *Lycospora pusilla* (Pu) korelowanej tymczasowo z granicą turnej/wizen.

Utwory turneju Pomorza Zachodniego i Gór Świętokrzyskich, w których wyróżniono zony sporowe są dość dobrze datowane na podstawie morskiej fauny. Dane faunistyczne potwierdzają prawidłowość przedstawionej korelacji.

EXPLANATIONS OF PLATES

Plate I

All photographs ×1000.

1 — *Anaplanisporites baccatus* (Hoffmeister, Staplin & Malloy) Butterworth & Smith. Karsina 1 at 2535.3 m, Upper Cl Biozone.

2, 3 — *Colatisporites denticulatus* Neville. Wierzchowo 9 at 3323.0 m, Middle Cl Biozone.

4 — *Schopfites* cf. *delicatus* Higgs. Karsina 1 at 2242.1 m, Upper Cl Biozone.

5 — *Schopfites delicatus* Higgs. Biesiekierz 1 at 2907.1 m, Lower Cl Biozone.

6 — *Tumulispora malevkensis* (Kedo) Turnau. Babilon 1 at 2629.5 m, Ra Biozone.

7 — *Tumulispora rarituberculata* (Luber) Potonié. Babilon 1 at 2629.5 m, Ra Biozone.

Plate II

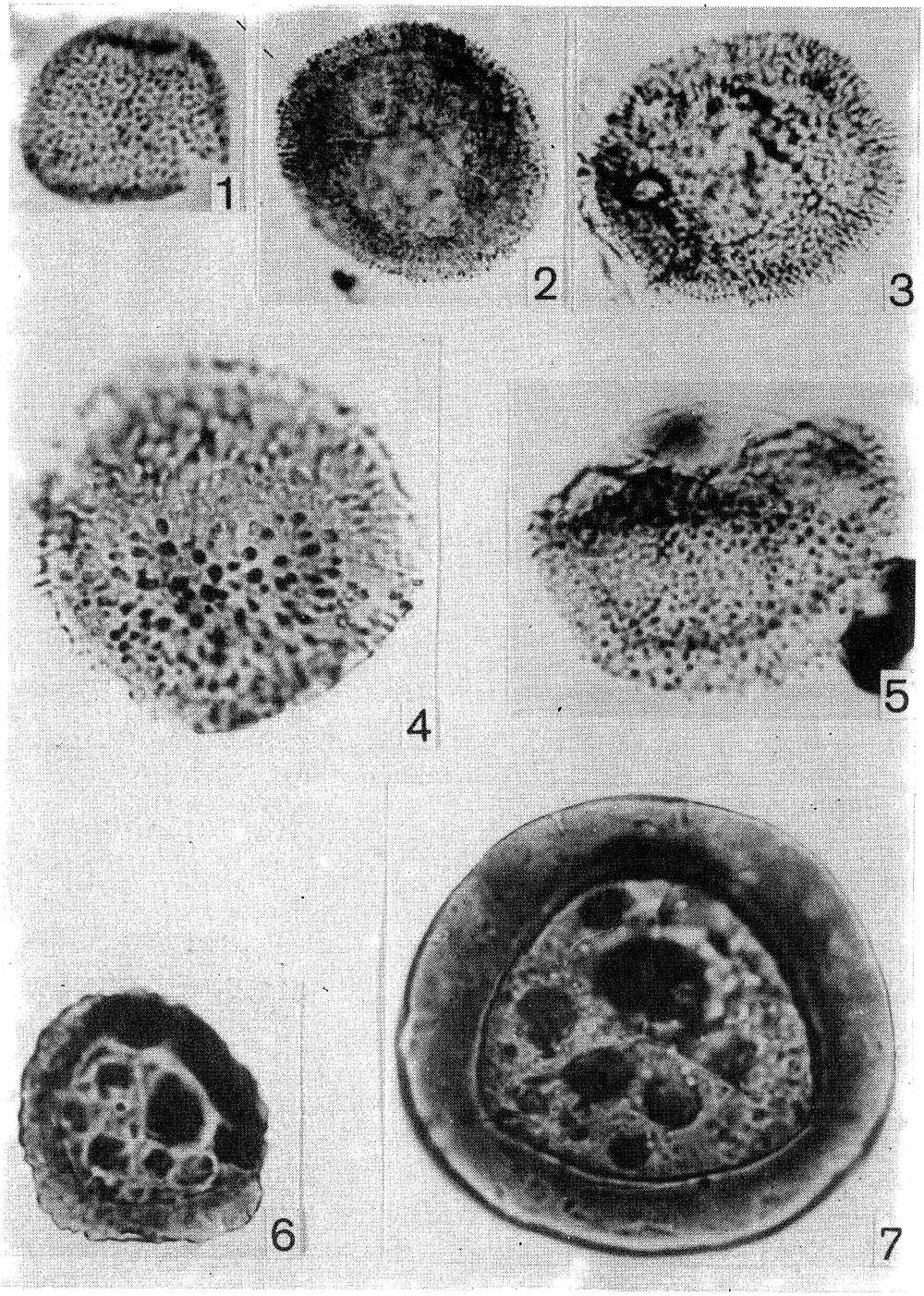
All photographs ×1000.

1, 2 — *Vallatisporites pusillites* (Kedo) Dolby & Neves. Kowala 1 at 7.2 — 7.6 m, VI Biozone

3 — *Vallatisporites verrucosus* Haquebard. Kowala 1 at 7.2 — 7.6 m, VI Biozone

4, 6 — *Verrucosisporites mesogrumosus* (Kedo) Byvsheva. *4* — Rzeczenica 1 at 2920.7 m, VI Biozone; *6* — Babilon 1 at 2629.5 m, Ra Biozone

5 — *Vallatisporites vallatus* Haquebard. Kowala 1 at 7.2 — 7.6 m, VI Biozone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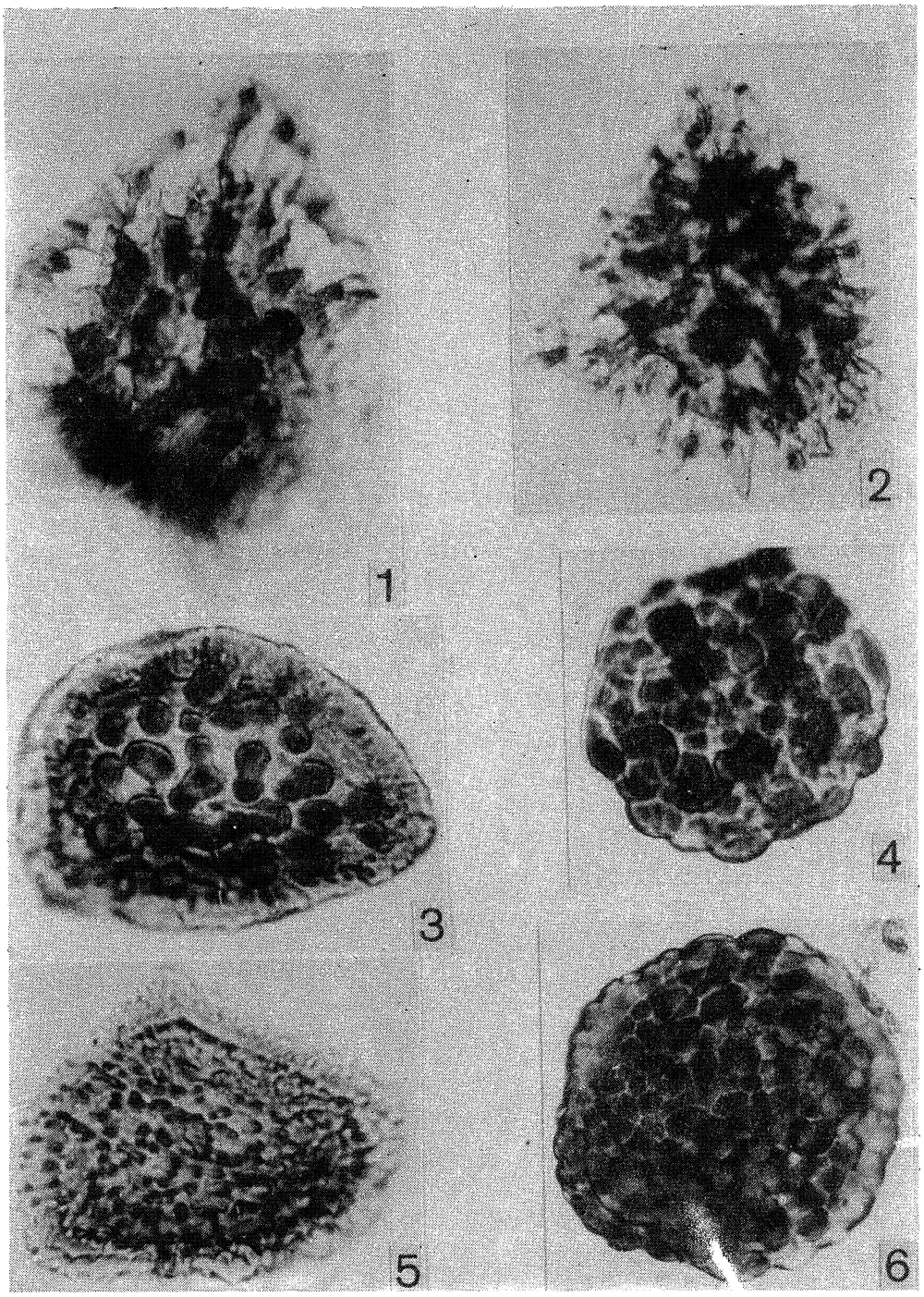
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