Summary of Professional Accomplishments

1. Name

Anna Mader

2. Diplomas, degrees conferred in specific areas of science or arts, including the name of the institution which conferred the degree, year of degree conferment, title of the PhD dissertation

1986: Master's degree diploma at the Institute of Geological Sciences of the Jagiellonian University.

1986: Master's degree in geology, Faculty of Biology and Earth Sciences of the Jagiellonian University.

1991: Defense of PhD dissertation "Palynological stratigraphy of Upper Permian and Lower Buntsandstein in the western part of the Holy Cross Mountains" at the Polish Geological Institute

1991: Doctor of Natural Sciences in the field of geology, awarded by the Scientific Council of the Polish Geological Institute

3. Information on employment in research institutes or faculties/departments or school of arts

1986 – 1999	Polish Geological Institute, Holy Cross Branch 25-953 Kielce, ul. Zgoda 21
2010 – 2014	Polish Geological Institute –National Research Institute, Holy Cross Branch, 25-953 Kielce, ul. Zgoda 21
2014 – 2018	Polish Geological Institute –National Research Institute 00-975 Warszawa, ul. Rakowiecka 4
2018 – present day	Polish Geological Institute –National Research Institute, Holy Cross Branch, 25-953 Kielce, ul. Zgoda 21

1986 –1987	Intern
1987 – 1988	Geologist
1989	senior Geologist
1989 – 1990	Assistant
1990 – 1991	senior Assistant
1991 – 1992	Assistant
1992 – 1999	Lecturer (adjunct)
1999 – 2010	*break in work due to family situation*
2010 – 2011	senior specialist in geology
2011 – 2018	Lecturer (adjunct)
2018	senior museum curator
2018 – present day	senior specialist in geology

4. Description of the achievements, set out in art. 219 par. 1 point 2 of the Act

4.1. Title of the academic achievement constituting the basis for the habilitation application

“CLIMATE AND ENVIRONMENTAL CONDITIONS IN THE DEVELOPMENT OF TRIASSIC FLORA IN POLAND BASED ON MICROFLORISTIC RESEARCH”

4.1.1. Thematically related articles that make up the scientific achievement

1. Fijałkowska-Mader A., 1999. Palynostratigraphy, palaeoecology and palaeoclimatology of the Triassic in South-Eastern Poland. *Zentralblatt für Geologie und Paläontologie.* Teil I, 1998, H. 7-8: 601-627.
2. Fijałkowska-Mader A., 2013. Palynostratigraphy, palaeoecology and palaeoclimate of the Late Permian and Triassic of the Nida Basin. *Biuletyn Państwowego Instytutu Geologicznego*, 454: 15-70 (in Polish with English summary).
3. Fijałkowska-Mader A., 2015. A record of climatic changes in the Triassic palynological spectra from Poland. *Geological Quarterly*, 59, 4: 615-653.
   DOI: http://dx.doi.org/10.7306/gq.1239 ($IF_{(2015)}$=0.905).
   The article obtained the Prize of the Director of PGI-NRI for the best article in *Geological Quarterly* for 2015
4. Fijałkowska-Mader A. (70%), Jewuła K., Bodor E., 2020. Record of the Carnian Pluvial Episode in the Polish microflora. *Palaeoworld*, 2020.03.006
   DOI*:* https://doi.org/10.1016/j.palwor.2020.03.006 ($IF_{(2020)}$=1.447)

4.1.2. Discussion of the scientific purpose of the above-mentioned papers and the achieved results

4.1.2.1. Introduction

The aim of the research was to show, based on the differences in the spore-pollen assemblages, how climate change and environmental conditions had influenced the development of the vegetation cover in the Triassic in the area of extra-Carpathian Poland. The determination of the botanical identity of most Triassic miospore species is possible due to long-term studies by palaeobotanists and palynologists in the world. Therefore, despite the influence of a number of external factors, such as transport, environmental conditions or subsequent post-depositional processes, based on microfloral spectra it is possible to quite accurately reconstruct the composition of the original plant communities growing in the areas, from which the material was delivered to the sedimentary basin.

There is a mutual relationship between spore-pollen spectra, palaeoclimate and palaeoenvironment. On one hand, the composition of microfloral communities provides information about climate and the environment. On the other hand, it is possible to infer about the potential types of plant ecosystems based on climatic and environmental conditions resulting from other studies (e.g. clay minerals or oxygen and carbon isotopes). The application of results gained from spore-pollen- analysis for palaeoclimatic and palaeoenvironmental interpretations is a commonly used research tool. It was first applied in 1916 by Lennart von Post for the Holocene peat of southern Sweden (Fries, 1967) and turned out to be most useful for of the study of Quaternary climate (Birks, Björn, 2018). Over time, spore-pollen analysis began to be used to determine the climate of increasingly older geological periods. Visscher and Van der Zwan (1981) were the first to distinguish hygrophytic and xerophytic miospore groups, characterising dry and humid climate, in the spore-pollen communities of the Late Triassic (Carnian). The model was based on the assignment of miospores to specific parent plants and the adoption of climate and environmental preferences of these plants based on the actuality principle. Jelen and Kušej (1982) and Jerenič and Jelen (1991) used an extended version of this model with more types of miospores in Late Triassic assemblages, whereas in one of my earlier papers (Fijałkowska, 1994a, b), I had applied a modified version of the model for the first time to late Permian and Early Triassic spectra. The results of the research conducted by palaeobotanists and palynologists around the world on the botanical affiliation Triassic spores and pollen grains, as well as the environmental preferences of parent plants, enabled me to extend the PPC model to almost all types of miospores, occurring in the Triassic spectra from Poland (**Fijałkowska-Mader, 1999**[1]**, 2013, 2015; Fijałkowska-Mader et al., 2020**, supplementary material) and I called it the 'palyno-palaeoclimatic model – PPC' (**Fijałkowska-Mader, 2015**).

The second model that I applied in my research (**Fijałkowska-Mader, 2015; Fijałkowska-Mader et al., 2020**) was the 'Sporomorph Ecogrup (SEG) model', developed by Abbink (1998; Abbink et al., 2004a, b) to conclude on the ecology of Jurassic plant communities. It is based on the ecological preferences of extinct mother plants, determined on the basis of the principle of actualism, i.e. analogies to the environmental predispositions of contemporary plants, and the characteristics of the deposit. I have used this model to the Triassic miospore assemblages (**Fijałkowska-Mader, 2013, 2015; Fijałkowska-Mader et al., 2020**).

The next step towards refining the interpretation of the climatic and environmental conditions of plants and establishing the mutual relationship between particular plants was the use of the statistical method known as the principal component analysis (PCA) to spore-pollen spectra. This method allows, among others, to monitor the sensitivity of taxa to environmental conditions by limiting the dataset only to those components (factors) that are responsible for taxa differentiation (Verhaegen et al., 2018). In the case of Triassic spectra, it was first applied by Bonis and Kürschner (2012). Their research indicated which types of miospores coexist with each other, i.e. based on the similar environmental preferences of their parent plants, and the factor (temperature, humidity, etc.) that played the decisive role in the distribution of the mother plants. I have applied PCA to the Carnian (**Fijałkowska-Mader et al., 2020**), late Permian and Early Triassic (Fijałkowska-Mader, Jewuła, 2020; Jewuła et al., 2020a) miospore assemblages from Poland. The use of these methods allowed not only to distinguish more humid and drier climate periods in the late Permian and Triassic of Poland, but also to show how vegetation responded to climate change and resulting environmental changes. In palaeoenvironmental reconstructions, I have also applied palynofacies analysis (Fijałkowska, 1994a, 1995; Fijałkowska-Mader et al., 2015a, b), but due to the specific nature of this research method I have not included this aspect of my studies in the discussed scientific achievement

4.1.2.1. Regional setting

In the late Permian and Early Triassic (~259-247 Ma (age according to the International Chronostratigraphic Chart 2020/03, the area of Central Europe and Poland constituted part of the Pangea continent that was located between 18 and 23º N (Scotese, 2014; Map 48, 50), in the convergence zone of the tropical Peritethian domain, and was characterised by monsoon climate with marked seasonality of temperatures and rainfall (Kutzbach, Gallimore, 1989; Roscher, Schneider, 2006). In the Triassic, this area gradually shifted northwards, to reach nearly 30º N (Scotese, 2014; Map 43) in the Rhaetian (201.3-208.5 Ma), but still remained in the monsoon circulation zone (Kutzbach, Gallimore, 1989). Humid climate prevailed in the late Olenkian, Ladinian, middle Carnian, late Norian and Rhaetian, whereas dry climate dominated in the remaining periods of the Triassic (Hochuli, Vigran, 2010; Paul, Pfuff, 2010; Haas et al., 2012; **Fijałkowska-Mader, 2015; Fijałkowska-Mader et al., 2020**). Stressful conditions, both for the animal and plant communities, were caused by a climate with high annual temperature and high precipitation amplitudes (Kiehl, Shields, 2005). These conditions were enhanced during periods of increased tectonic and volcanic activity at the end of the Permian and Triassic. These periods are associated with biotic crises and extinctions (e.g. Wignall, 2007; Hasselbo et al., 2002). However, there is no consensus among researchers regarding the impact of the P/T crisis on terrestrial plant ecosystems. According to some views (e.g. Cascales-Miñana et al.,

[1] Publications that have been included in the scientific achievement are marked in bold

2016), this crisis affected the flora, whereas according to other opinions (cf. Nowak et al., 2020), the crisis did not cause major changes in the floral assemblages. The case is similar with the assessment of the T/J crisis (e.g. Lindström, 2016; Lindström et al., 2019; Li et al., 2020 *versus* Barbacka et al., 2017; Kustatscher et al., 2018). In any case, the microfloral assemblages from deposits across the Permian/Triassic (e.g. Foster, Afonin, 2005; Looy et al., 2005; Fijałkowska-Mader, 2012, 2020) and the Triassic/Jurassic (Lindström, van de Schootbrugge, 2018) boundaries point to severe environmental stress.

In the Triassic, the area of Poland consituted the eastern part of an epicontinental basin that covered the area of central and partly also western Europe, i.e. the Central European Basin, which was connected with the Tethys Ocean throught the East Carpathian, Silesian-Moravian and Burgundy gates (Szyperko-Teller, 1997; Gajewska, 1997; Szulc et al., 2015; Szulc, 2019). The largest subsidence in the Polish part of the basin occurred within the Mid-Polish Trough. During the regressive phases, the sea completely receded from the marginal parts of the basin and sedimentation took place in a continental setting, in river beds, flood plains, deltas, alluvial plains, lakes, and swamps. In such environments originated the terrigeneous deposits of the Lower and Middle Buntsandstein and Keuper (Wagner, 1994; Dadlez et al., 1998).

In the Triassic, the area of Central Europe and Poland belonged to the Euro-American floristic sub-province (Bernardi et al., 2017), also referred to as the Arctic-North Atlantic–Central Europe sub-province (Kustatscher et al., 2018), which was part of the great Laurussia province, covering the Northern Hemisphere. Ziegler (1990) introduced the concept of a biome for a plant–climate zone. The area of Europe belonged to the subtropical biome with a humid summer and a diverse vegetation of lycopods, horsetails, seed ferns, and subordinate Voltziales (Nowak et al., 2020). In the Early Triassic (Induan–Olenekian) plant cover restored after the P/T biotic crisis dominated pioneer forms of the Pleuromeiales producing spores of the genus *Densoisporites* (Grauvogel-Stamm, Ash, 2005). A revival of conifers took place in the early Anisian, mainly Voltziales producing e.g. *Voltizaceaesporites* and *Triadispora* pollen grains; they became the dominant component of the mid-Triassic floristic communities (Dobruskina, 1994; Kürschner & Herngreen, 2010). The conifers were accompanied by seed ferns, cycads/bennettitaleans and ferns (Marattiales, Osmundales; Nowak et al., 2020). A significant change in the plant ecosystems took place in the Ladinian, when the Marattiales hygrophytic ferns, producing e.g. *Leschikisporis* spores, and the Selaginellales lycopods producing *Aratrisporites* spores began to dominate (Kustatscher et al., 2012). Important for the evolution of conifers was the appearance of the Family Chierolepidiaceae, producing characteristic, round, devoid of air sacs *Corollina/Classopollis* pollen grains. Representatives of this family dominated the Norian flora. A short-term pluvial event took place in the Carnian (the so-called Carnian Pluvial Episode), which resulted in a more abundant appearance of hygrophytic forms, such as ferns, horsetails and lycophytes, in the succession of generally xerophytic plant assemblages. An important component of the assemblages was a cycad/beneettitalean producing *Aulisporites* pollen grains. Another significant change of the plant cover from xero- to hygrophytic took place in the Rhaetian, when conifers gave way to the taxonomically diverse Marattiales and Leptosporangiate ferns, seed ferns, Selaginellales lycophytes and horsetails. Cycad/bennettitaleans were numerous at that time (Kustatscher et al., 2018). A characteristic element of the Rhaetian miospore assemblages is the asaccate pollen grain *Riccisporites tuberculatus* Lunblad produced by a ruderal conifer (Rothwell et al., 2000).

4.1.2.3. Research topic and study methods

The subject of the research were microfloral assemblages from the Triassic deposits in extra-Carpathian Poland. The material came from 71 boreholes and two exposures (App. 1). In total, 173 pollen spore spectra were analysed. Among them, 33 assemblages were studied on the basis of T.

Orłowska-Zwolińska's palynological collections from the Geological Museum of the PGI–NRI in Warsaw (App. 1). The remaining groups were analysed in my own palynological, gelatin-glycerine slides, which are part of the collection of the Holy Cross Branch of PGI–NRI in Kielce. In most samples, two slides from a given depth were analysed; 100 sporomorphs were the basis of a quantitative analysis in each of them. In the case of poor samples, all sporomorphs were counted. Later, the results were averaged. The analysis was performed under a Leitz Laborlux S transmitted light biological microscope at 400 × magnification.

The palino-palaeoclimatic (PPC) model and the 'Sporomorph Ecogrups' (SEG) model developed by Abbink (1998; Abbink et al., 2004a, b) were used for all microfloral assemblages. In addition, PCA statistical analysis was applied for the Late Triassic assemblages from Poland, which belong to the *Porcellispora longdonensis* and *Aulisporites astigmosus* palynological zones. The key for these analyses was the relation of spores and pollen grains to the parent plants. For this purpose, I have used extensive literature, which allowed assigning the vast majority of the studied sporomorphs to specific plants or their groups (App. 2).

In the PPC model, sporomorphs are subdivided into the following 19 morphogroups: A – alete and monolete spores, B – trilete laevigate and apiculate spores, C – trilete verrucate, reticulate and murornate spores, D – trilete zonate and cingulate spores (without specimens of *Densoisporites*), E – *Aratrisporites* spp. and F – *Aulisporites* spp., which represent hygrophytic elements; G – *Densoisporites* spp., H – monosulcate pollen, I – *Vitreisporites–Illinites* group and J – asaccate pollen (without circumpollen), which are intermediate elements; K – *Ovalipollis* spp., L – alete bisaccate pollen, M – taeniate bisaccate pollen, N – *Triadispora* spp., O – other trilete bisaccate pollen, P – vesicate pollen, R – monosaccate pollen, S – circumpollen and T – *Porcellispora* spp., which represent xerophytic elements. I have extended the model compared to the original concept of Visscher and van der Zwan (1981) with four morphological groups: F, G, I and O, which came from the fact that my model comprised all Triassic spectra, not only those from the Carnian, on the basis of which the original model was developed.

The SEG model was used for palaeoenvironmental interpretations; it combines dispersed spores and pollen grains with floristic communities occupying specific environmental niches. Four ecogroups were distinguished in the late Permian and Triassic spore-pollen assemblages: upland–hinterland, lowland and river, coastal and undefined. The assignement of miospore types to particular ecogroups (SEGs) is shown in Table 1, which is extended, compared to the original model, to include taxa not present in the Jurassic. Compared to Abbink's (1998) study, I have distinguished more types indicating drier (d) and wetter (w) environmental and climatic conditions within the Lowland and River Ecogroups. Based on the mutual relations of their percentage contribution, the w/d ratio was counted.

Principal component analysis (PCA) was performed in cooperation with Karol Jewuła and Emese Bodor; who applied statistical processing of my database. The database contains information on the content of miospore genera in all tested samples from the late Permian to the Early Triassic (**Fijałkowska-Mader, Jewuła, 2020a**, supplementary materials) and the Carnian (**Fijałkowska-Mader et al., 2020**). To avoid possible statistical bias related to the number of counted miospores, the values of each dataset for PCA have been calculated as percentages of the sum of taxa (see Scott et al., 2012). The dataset was preconditioned and the center log ratio transformation (clr) was applied in order to avoid the constant-sum problem on the closed (i.e., normalised to 100%) dataset and to minimise the spurious autocorrelation problem (Tolosana-Delago, 2012). For filtering purposes, taxa with a minimum of 3% abundance in at least one sample were used for clr-transformation and further statistical analysis. All null values were replaced with 0.01% to allow logarithmic transformation of the dataset. This transformation was performed with application of CoDaPack software (Thió-

Henestrosa, Martín-Fernández, 2005), whereas PCA with the variance-covariance matrix was performed with PAST statistical software (Hammer et al., 2001). Loading and score plots were interpreted using the methodology of Scott et al. (2012).

Tab. 1. Assignement of miospore genera to particular ecogroups (SEGs)

Ecogroup (SEG)	Miospore genera
1.Upland - Hinterland (xerophytic)	*Accinctisporites, Alisporites, Angustisulcites, Brachysaccus, Cedripites, Cordaitina, Corollina, Duplicisporites, Ellispovelatisporites, Enzonalasporites, Falcisporites, Granuloperculatipollis, Heliosacuus, Illinites, Infernopollenites, Klausipollenites, Kugelina, Labiisporites, Limitisporites, Lueckisporites, Lunatisporites, Microcachryidites, Minutosaccus, Nuskoisporites, Ovalipollis, Parillinites, Partitisporites, Perisaccus, Platysaccus, Podosporites, Potonieisporites, Praecirculina, Protohaploxypinus, Rhaetipollis, Striatoabietites, Striatipodocarpites, Strotersporites, Triadispora, Tsugaepollenites, Vesicaspora, Vittatina, Voltziacaesporites*
2.Lowland and River (hygrophytic)	*Acanthotriletes, Anapiculatisporites* (w), *Apiculatisporis* (w), *Aratrisporites, Aulisporites, Baculatisporites* (w), *Calamospora* (w), *Camarozonosporites, Carnisporites, Chasmatosporites* (d), *Concavisporites* (w), *Concentricisporites, Corollina, Cycadopites* (d), *Cyclotriletes* (w), *Cycloverrutriletes* (w), *Deltoidospora* (d), *Densoisporites* (w), *Densosporites* (w), *Duplicisporites, Dictyophyllidites* (d), *Echinitosporites, Endosporites, Equisetumsporites* (w), *Eucommiidites* (d), *Gleicheniidites* (d), *Granuloperculatipollis, Heliosporites* (w), *Keuperisporites, Leschikisporis, Laevigatisporites, Lundbladispora, Lycopodiacidites, Lycopodiumsporites* (w), *Lycospora* (w), *Marattisporites, Monosulcites* (d), *Nevesisporites, Osmundacidites, Palaeospongisporis, Perotriletes, Punctatisporites* (w), *Riccisporites* (d), *Todisporites* (w), *Toroisporis, Trachysporites, Sphagnumsporites* (w), *Verrucosissporites* (w), *Vitreisporites* (w), *Zebrasporites*
3.Coastal	*Aratrisporites, Camerosporites, Corollina, Cycadopites, Densoisporites, Densosporites, Duplicisporites, Granuloperculatipollis, Kraeuselisporites, Lundbladispora, Rhaetipollis*
4. not attributed	*Porcellispora, Sphaeripollenites*

4.1.2.4. Results

The results are discussed for particular palynological zones and subzones distinguished in the Triassic of extra-Carpathian Poland. The palynostratigraphic scheme for the Triassic was developed by Orłowska-Zwolińska (1983, 1984, 1985) and comprises 10 zones and 10 subzones.

4.1.2.4.1. *Lundladispora obsoleta–Protohaploxypinus pantii* Zone (Early Triassic, Induan)

Miospore assemblages, representing the *L. obsoleta–P. pantii* Zone, occur in the Lower Buntsandstein sediments of the Baltic, Sandstone, Jaworzna and Opoczno formations (Orłowska-Zwolińska, 1984, 1985; Fijałkowska, 1994a, b). The use of the PPC model has shown that the contribution of hygrophytic elements from groups D (lycophyte spores *Endosporites*, *Kraeuselisporites* and *Lundbladispora*) and B (fern spores *Cyclotriletes* and *Punctatisporites*) is above 20%. *Densoisporites* (group G), which belong to intermediate elements, together with the cycad/bennettitalean pollen of *Cycadopites* and *Gnetacaepollenites* (group H), have a similar contribution. Striatite pollen of xerophytic conifers and/or peltasmperms from group M

(*Protohaploxypinus*, *Striatoabietites* and *Lunatisporites*) are less numerous. The SEG model points to the significant dominance (averagely above 70%) of the Lowland and River SEG. The contribution of the Coastal SEG varies from 3 to 29% (averagely 12%). The w/d ratio is low, ranging from 0 to 6.1 (averagely 2.5) (**Fijałkowska-Mader, 2015**).

The following picture of the Early Triassic flora of Poland emerges from the analysis of spore-pollen spectra: coniferous shrubs, woody seed ferns and caytoniales (*Sagenopteris*) covered dry upland areas, while lycopodiales (Isoetites, Selaginella), ferns of the Osmundaceae family and horsetails were concentrated in wet and wet areas of the coastal and delta plains and along river banks. Bennettites (*Cycadoides*) dominated the coastal ecosystems (corresponding to modern mangroves). The pioneer lycophytes of *Pleuromeia* grew both in dry and humid places with normal and increased salinity (**Fijałkowska-Mader, 1999, 2013, 2015**). The lack of the described sites with the early Triassic macroflora in Poland (with the exception of the *Equisetites* specimen from the Świętokrzyskie Mountains, mentioned by Czarnocki (1925), makes it difficult to verify this image.

4.1.2.4.2. *Densoisporites nejburgii* Zone (Early Triassic, Olenekian)

Miospore assemblages representing the *D. nejburgii* Zone were found in the Middle Buntsandstein deposits (Pomeranian, Połczyn, Lidzbark, Malbork, Goleniawy, Stachura and Samsonów formations) (Orłowska-Zwolińska, 1984, 1985; Fijałkowska, 1994a; Becker et al., 2020). They belong to three subzones: *D. nejburgii* and acritarchs, *D. nejburgii*, and *Cyclotriletes presselenis*. Spectra of the *D. nejburgii* and acritarchs Subzone are dominated by hygrophilous spores of lycophytes (*Kraeuselispories*, *Endosporites*, *Lundbladispora* and *Uvaesporites*; group D). Spores of *Densoisporites nejburgii* (Schulz) (group G) produced by the lycopsid *Pleuromeia rossica* Neuburg (Yaroshenko, 1975; Orłowska-Zwolińska, 1979) and *Cycadopites* pollen (group H) and representing mixed elements, occur abundantly. There is a clear domination of the Lowland and River SEGs. In the spectra of the *D. nejburgii* Subzone there is a visible differentiation between those from western Poland, with a pronounced domination of hygrophytic elements, and those coming from the Holy Cross Mountains, the Nida Basin and north-eastern Poland, where the hygro- and xerophilic elements occur in similar amounts, averagely above 30%. Lycophyte spores of the genera *Densoisporites*, *Kraeuselisporites* and *Endosporites* dominate among hygrophytic elements, whereas fern spores *Punctatisporites* and *Cyclotriletes* are less abundant. Among xerophytic forms, conifers pollen belonging to *Protohaploxypinus*, *Lunatisporites*, *Angustisulcites* and *Platysaccus* are more numerous. Intermediate elements are represented by *Cycadopites*. In the SEG model, the Lowland and River SEGs prevail and the contributon of the Coastal SEG is relatively high. Values of the w/d ratio range from 1.5 to 8 (averagely 3.2) and are higher from those in the *D. nejburgii* and acritarchs Subzone, which indicates gradual humidity increase. The increase in the contribution of hygrophilous elements is observed in the assemblages of the *C. presselensis* Subzone, occurring in the higher part of the Połczyn Formation and in the Samsonów Formation. They include mainly fern (*Cyclotriletes*, *Punctatisporites*, *Guttatisporites*, *Cycloverrutriletes presselensis*) and lycophyte spores. The gradual decrease in the number of *D. nejburgii* spores is noticeable. Conifer (*Lunatisporites*, *Protohaploxypinus, Alisporites, Brachysaccus*) and caytonialean (*Vitreisporites*) pollen predominates among the xerophytic forms. The SEG model shows the dominance of the Coastal SEG in Western Poland and the Lowland and River SEG in the Holy Cross Mountains. Noteworthy is the increase in the value of the w/d ratio (averagely above 5) in relation to the *D. nejburgii* Subzone, which reflects a pluvial event in the late Olenekian (**Fijałkowska-Mader, 1999, 2013, 2015**). Results of the PCA analysis did not show any major differences in the Smithian (*D. nejburgii* Subzone) and Spathian (*C.*

presselensis Subzone) spectra. On their basis, it can be concluded that factors other than climatic must have had impact on the composition of the microfloral communities (Fijałkowska-Mader, Jewuła, 2020). Lycopsids, mainly from the genera *Pleuromeia* and *Selaginella*, ferns from the Family Osmundaceae (*Neuropteris*, *Cladophlebis*) and *incertae sedis* forms (*Anompopteris*), as well as sphenophytes (*Equisetites*, *Schizoneura*) inhabited wet areas of alluvial and delta plains. Cycads/bennettitales were concentrated in river valleys, and herbaceous conifers, such as Voltziales (*Aetophyllum*), representatives of the Family Albertiaceae (*Albertia*) and *incertae sedis* forms (*Pelourdea*), as well as seed ferns and caytoniales overgrew drier upland areas (Fijałkowska-Mader, 2013*, 2015*). This interpretation is confirmed by sparse finds of macrofloral remains in the Holy Cross Mountains (lycopsid *Pleuromeia* cf. *sternbergii* (Münster), conifer *Voltzia* by Czarnocki, 1931; seed fern *Glossopteridium* by Bocheński, 1957) and from the Fore-Sudetic monocline (*Pleuromeia* by Fuglewicz, 1973). New data on the Spathian vegetation (*C. presselensis* Subzone) in the Holy Cross Mountains was provided by a project in cooperation with the palaeobotanist Z. Wawrzyniak (Fijałkowska-Mader, Wawrzyniak, 2019). A rich group of macrofloral remains, including the conifers *Pelourdea*, *Albertia* and *Carpolithus*, spore ferns (*Anomopteris*, *Cladophlebis*, *Neuropteridium*), lycophytes *Pleuromeia cf. sternbergii* and horsetails (*Equisetites*, *Equisetostachys*, *Schizoneura*), was found in the river sediments of crevasse splays within the Pałęgi clay mine near Mniów (Kuleta et al., 2006).

4.1.2.4.3. *Voltziaceaesporites heteromorphus* Zone (Middle Triassic, early Anisian)

Miospore assemblages representing the *V. heteromorphus* Subzone of the *V. heteromorphus* Zone were found in the Upper Buntsandstein – Lower Röt succession, whereas spectra representing the *Microcachryidites fastidiosus* Subzone of the *V. heteromorphus* Zone were noted in the Upper Röt deposits (Orłowska-Zwolińska, 1984, 1985; **Fijałkowska-Mader, 2013**). The groups characterising both subzones are strongly dominated by xerophytic conifers pollen, most of which are trilete specimens from the genera *Voltziaceaesporites* and *Angustisulcites* (group O) (averagely 20–30%). Vesicate (*Microcachryidites*, *Klausipollenites*; group P), striatite (*Lunatisporites*, *Protohaploxypinus*, *Striatoabietites*; group M), and *Triadispora* conifer pollen (group N) are abundant. The pollen of *Angustisulcites chitonoides* Klaus (group I), produced by the ruderal herbaceous conifer *Aethophyllum stipulare* (Bron.) (Grauvogel-Stamm, 1978; Rothwell et al., 2000), are a characteristic element of the spectrum. Spores of the ferns *Cyclotriletes* (group B), *Verrucosisporites*, *Guttatisporites* and *Baculatisporites* (group C), and the lycophytes *Kraeuselisporites*, *Lapposisporites* (group D) and *Aratrisporites* (group E) predominate among the hygrophytic forms. The SEG model shows a clear dominance of the Upland–Hinterland SEG composed almost entirely of conifers, whose contribution is averagely above 80%. Representatives of the voltzialean taxa were their important component. The Lowland and River SEG is represented by ferns, seed ferns, horsetails, and cycads/bennettitales. Wetter areas were inhabited by lycophytes (*Annalepis*), sphenphytes and ferns. The Coastal SEG includes conifers, lycophytes (*Pleuromeia*, *Annalepis*) and seed ferns. Taxonomically diverse forests and shrubs covered not only dry upland areas, but also coastal, floodplain, and/or tidal areas and deltas. The w/d ratio indicates a characteristic 'dry' peak (0–5, averagely 0.9) in the upper part of the zone (**Fijałkowska-Mader, 1999, 2013, 2015**). Unfortunately, very scarce finds of macroflora in the deposits from Poland (*Calamites* sp. in Samsonowicz, 1929) do not allow to verify this scenario.

Early Anisian assemblages display a larger quantitative and taxonomic diversity in relation to older spectra. A trend of gradual decrease of the dominance of lycophytes in favour of arboresccent gymnosperms, i.e. seed ferns, cycads/bennettitales and caytoniales, can be observed. This phenomenon is global and reflects the revival of diverse plant ecosystems after the late Permian crisis (see Looy et al., 1999; Galfetii et al., 2007; Lindström and McLoughlin, 2007; Hermann et al., 2011).

Strong domination of conifer pollen in the Anisian spectra reflects the first, significant phase of forest development after the late Permian Crisis (cf. Kürschner and Herngreen, 2010).

4.1.2.4.4. *Perotrilites minor* Zone (Middle Triassic, middle Anisian)

Miospore assemblages representing the *P. minor* Zone were found in the Lower Muschelkalk (Orłowska-Zwolińska, 1985; **Fijałkowska-Mader, 2013**). They are strongly dominated by conifer pollen of the genus *Microcachryidites* (group P) (averagely above 20%). Other conifer pollen: *Lunatisporites* and *Striatoabietites* (group M), *Angustisulcites* (group O) and *Triadispora* (group N) are less common. The lycophyte spores *Aratrisporite* (group E), the *Perotriletes* and *Concentricisporites* spores (group D) of unknown botanical affinity, as well as the ferns *Cyclotriletes*, *Microreticulatisporites* and the horsetail spores *Equisetumsporites* (group B) represent hygrophilous elements. The Upland–Hinterland SEG, composed almost exclusively of conifers, dominates the analysed spectra with an average contribution exceeding 80%. An increase of the w/d ratio (averagely above 3), in comparison to the *V. heteromorphus* Zone, proves that the climate became slightly more humid (**Fijałkowska-Mader, 1999, 2013, 2015**).

4.1.2.4.5. *Tsugaepollenites oriens* Zone (Middle Triassic, late Anisian)

Miospore assemblages of the *T. oriens* Zone were recognised in the Middle Muschelkalk (Orłowska-Zwolińska, 1985; **Fijałkowska-Mader, 2013**). They are almost exclusively composed of xerophytic elements, i.e. the conifer pollen *Triadispora* (group N), *Microcachryidites* (group P), *Angustisulcites* (group O), *Illinites* (group I) and *Tsugaepollenites* (group R). The contribution of the Upland–Hinterland SEG is the highest among the analysed Triassic spectra, averagely exceeding 90%. The w/d ratio is very low (averagely below 0.7) and reflects a very dry climate (**Fijałkowska-Mader, 1999, 2013, 2015**).

4.1.2.4.6. *Heliosaccus dimorphus* Zone (Middle Triassic, Ladinian)

Miospore assemblages representing the *Tasmanites* Subzone, distinguished in the lower part of the *H. dimorphus* Zone, occur in the Upper Muschelkalk, whereas spectra of the upper part of this zone were noted in the Lower Keuper Sulechów Beds (Orłowska-Zwolińska, 1983, 1985; Fijałkowska, 1992b, **Fijałkowska-Mader, 2013**). Hygrophytic elements generally dominate in the assemblages of the *Tasmanites* Subzone, except for the southern part of the Nida Basin, where xerophythic forms represented by the lycophytes *Aratrisporites* (group E), *Lycopodiacidites* and *Sellaspora* (group D) prevail and fern spores *Todisporites* (group B), *Converrucosisporites* and *Verrucosisporites* (group C) predominate among the hygrophytic elements. Less numerous are the lycophyte spores *Nevesisporites* and *Asseretospora*. Conifer pollen *Minutosaccus* (group P), *Triadispora* (group N), *Illinites* (group I) and *Heliosaccus* (group R) dominates among xerophytic forms, whereas *Striatoabietites*, *Protohaploxypinus* (group M), *Podosporites* (group P) and *Circulisaccus* (group S) pollen is less common. The Upland–Hinterland SEG dominates in most spectra. The share of the Coastal SEG is high (averagely above 10%). The w/d ratio has very different values: from 11–30 in E and NE Poland and the Nida Basin, to 30–70 in N, NW Poland and the Holy Cross Mountains (**Fijałkowska-Mader, 1999, 2013, 2015).**

Conifers producing the *Minutosaccus gracilis* Scheuring and *Podosporites amicus* Scheuring pollen grains were found not only in the upland–hinterland areas, but were also pioneers of coastal xerophytic palaeobiocenoses. Lycophytes (*Lycostrobus*?, *Cylostrobus* and *Annalepis*), characterised by high environmental tolerance (Grauvogel-Stamm, 1978), dominated in the deltaic and coastal palaeobiocenoses (**Fijałkowska-Mader, 2015**). The only remains of the macroflora, belonging to the spore fern *Pecopteris* sp., were described by Pawłowska (1979) from the Upper Muschelkalk in the Gacki 4 borehole (Nida Basin).

Miospores representing the higher part of the *H. dimorphus* Subzone of the *H. dimorphus* Zone are dominated by hygrophytic elements: spore ferns *Todisporites* and Cyclotriletes (group B) (averagely above 30%) and lycophyte spores from the taxonomically diverse genus *Aratrisporites* (group E) (4–50%). Conifer pollen *Minutosaccus* and *Brachysaccus* (group P) (10–40%) prevail among the xerophytic components. A strong domination of the Lowland and River SEG is visible, reaching even 92%. The share of the Coastal SEG is 4–13%. The value of the w/d ratio changes significantly from 0.5 to 58 (averagely above 20) with a tendency to decrease in the higher part of the zone (Fijałkowska, 1992b; **Fijałkowska-Mader, 1999, 2013, 2015).** Numerous and taxonomically diverse lycophytes (*Selaginella*, *Annalepis*, *Pleuromeia*, *Lycopodites*), ferns (*Anomopteris*, *Neuropteridium*, *Pecopteris*, and others) and horsetails (*Equisetites*, *Neoclamites*) inhabited wetter areas of the delta and flood plain. Sphenophytes also formed rushes along the river and lake banks (cf. Mader, 1990, 1997). Plants of the Coastal SEG also include lycopsids *Lepacyclotes* (*Annnalepis*) *zeilleri* (Fliche) and *Pleuromeia*, seed ferns (*Ptilozamites*), herbaceous conifers (*Elatocladus*) and the voltzilean *Aetophyllum stipilare* (Bronn.). Drier lowlands were covered by herbaceous cycads (*Taeniopteris*), herbaceous and arborescent bennettitales (*Pterophyllum*) and seed ferns (*Pelaspermum*, *Ptilozamites*). Dry upland and inland areas were inhabited by shrubby (*Aetophyllum*, *Albertia*, *Pelourdea*) and arborescent conifers. Such reconstruction of plant ecosystems in Poland was made on the basis of analogies with miospore spectra occurring in Alpine sections and accompanying macrofloral remains (cf. Kustatscher, Van Konijnenburg-van Cittert, 2005; Kustatscher et al., 2012).

4.1.2.4.7. *Porcellispora longdonensis* Zone (Middle–Upper Triassic, late Ladinian–early Carnian)

Miospore assemblages of the *P. longdonensis* Zone were found in the Boundary Dolomite, Lower Gypsum Beds and Chrzanów Beds (Orłowska-Zwolińska, 1983, 1985; Fijałkowska, 1992b; **Fijałkowska-Mader, 2013;** Fijałkowska-Mader et al., 2015). They belong to two subzones: *Echinitosporites iliacoides*, occurring in the Boundary Dolomite and in the lower part of the Lower Gypsum Beds, and *Triadispora verrucata* – in the upper part of the Lower Gypsum Beds. Assemblages of the *E. iliacides* Subzone are strongly dominated by xerophytic elements – *Ovalipollis* (group K), *Brachysaccus*, *Minutosaccus*, *Labiisporites* and *Cedripites* (group P) pollen, whose contribution exceeds 80% in some samples. Conifer pollen *Illinitess* and *Parillinites* (group I), *Perinopollenites* (group J) and araucariacean pollen *Callialasporites* (group R) are less abundant. A characteristic feature of the communities is the appearance of grooved, round pollen of shrubby conifers of the family Cheirolepidaceae – *Duplicisporites*, *Patinasporites*, *Praecirculina* and *Camerosporites* representing the circumpollen group (group S). They are accompanied by moss spores *Porcellispora* (group T). Fern spores *Leschikisporis* (group A), *Apiculatisporis*, *Todisporites* and *Cyclotriletes* (group B), *Verrucosisporites*, *Echinitosporites* (group C), sphenophyte spores *Calamospora* (group B), *Anapiculatisporite*s (group C) and *Aratrisporites* (group E) predominate among the hygrophytic elements. Cycads/bennettitalen pollen (group H) dominates among the intermediate elements. The share of the Upland–Hinterland SEG averagely reaches over 60%. A general decrease in the share of the Coastal SEG is observed in comparison to the *H. dimorphus* Zone. Only in spectra containing acritarchs (in the Boundary Dolomite deposits), the contribution of the Coastal SEG is slightly higher, which reflects a transgression at the Ladinian/Carnian boundary. There is also a noticeable decrease in the value of the w/d ratio (0–7) in comparison to the *H. dimorphus* Zone. The *T. verrucata* Subzone consists almost entirely of xerophytic conifers pollen *Ovalipollis* (group K), Triadispora (group N), *Minutosaccus*, *Labiisporites*, *Cedripites* (group P) and *Infernopollenites* (group M). The SEG model is strongly dominated by the Upland–Hinterland SEG, with an average contribution above 80%. The w/d ratio is very low, below 0.5 (Fijałkowska, 1992b;

Fijałkowska-Mader, 1999, 2013, 2015). PCA allowed to determine the environmental preferences of some parent plants and confirm the previously assumed xero- or hygrophytic nature of the analysed miospore types. PC1, the component responsible for the distribution of xero- and hygrophytic elements, has been interpreted as a climatic factor, i.e. humidity. The genera most sensitive for this factor, i.e. *Triadispora*, *Porcellispora* and *Infernopollenites* appeared. The nature of the second component PC2 cannot not be clearly defined. The biplot for samples and types of miospores confirmed earlier observations that the assemblages of the Boundary Dolomite and the Lower Gypsum Beds consist mainly of xerophytic forms (**Fijałkowska-Mader et al., 2020**). In the early Carnian, there was an increased development of conifers producing *Ovalipollis* and *Triadispora* pollen. Voltziales and cedrales grew inland on dry highlands. Coastal zones were inhabited by cheirolepidacean conifers. Ferns, horsetails and lycophytes were concentrated in the humid zones of the alluvial plains. Liverwort moss producing the spores *Porcellispora longdonensis* was a characteristic plant of the early Carnian ecosystems of Europe, which inhabited shores of periodic lakes (cf. Reinhardt, Ricken, 2000). Areas with increased salinity around the playa and sebkha basins were colonised by the halophyte lycophytes *Annalepis* (Orłowska-Zwolińska, 1983; Mader, 1990, 1997; **Fijałkowska-Mader, 2013, 2015**).

4.1.2.4.8. *Aulisporites astigmosus* Zone (Upper Triassic, middle Carnian)

Miospore assemblages of the *A. astigmosus* Zone occur in the Schilfsandstein sediments (Stuttgart Formation, Bolesław Beds; Orłowska-Zwolińska, 1983, 1985; Fijałkowska, 1992b, **Fijałkowska-Mader, 2013;** Fijałkowska-Mader et al., 2015). They are strongly dominated by hygrophytic elements (39–47%): mainly horsetails *Calamospora*, ferns *Todisporites*, *Deltoidospora* (group B) and *Verrucosisporites* (group C), and lycophyte spores *Aratrisporites* (group E), *Anapiculatisporites*, *Lycopodiacidites* (group C) and *Kraeuselisporites* (group D). Bennettitalen pollen *Aulisporites* (group F) is also abundant (averagely 30%). Xerophytic elements, represented by voltzialean pollen *Ovalipollis* (group K), *Alisporites*, *Brachysaccus*, *Labiisporites* (group P) and *Enzonalasporites* (group R), and conifer pollen *Platysaccus* (group O) are less common. The SEG model shows a strong dominance of the Lowland and River SEG (70–78%) (Fijałkowska, 1992b; **Fijałkowska-Mader, 1999, 2013**). A very high w/d ratio (42–73) reflects the Carnian Pluvial Event (**Fijałkowska-Mader, 2015; Fijałkowska-Mader et al., 2020**). PCA analysis performed for the assemblages of the *P. longdonensis* and *A. astigmosus* zones showed a relatively large number of miospores sensitive to climatic and environmental factors. It also showed a tendency to group together forms with similar environmental preferences: hygrophylous (*Aulisporites*, *Apiculatisporis*, *Leschikisporis*) and xerophylous (*Triadispora*, *Porcellispora*, *Infernopollenites*) pollen and the lack of clear preferences for the genus *Aratrisporites*. A biplot of samples and miospore genera confirmed the affiliation of the taxa to the Upland-Hinterland, as well as the Lowland and River SEGs assumed by Abbink (1998) and by me. Ferns, mainly of the Families Marattiaceae and Dipteridaceae, horsetails (*Neocalamites*, *Equisetites*), sphenophytes (*Isoetites*, *Selaginellites*) and bennettites producing *Aulisporite*s pollen, grew on wet and marshy areas of floodplains, deltas and lake shores. Conifers preferred drier, upland areas (**Fijałkowska-Mader et al., 2020**). It is puzzling that despite the common occurrence of macrofloral remains in the Schilfsandstein deposits, no forms representing the discussed taxa have been described in Polish literature (cf. Reyman, 1979; Pacyna 2014).

4.1.2.4.9. *Corollina meyeriana* Zone (Upper Triassic, Norian)

Three subzones are distinguished within the *C. meyeriana* Zone: *C. meyeriana* a, *C. meyeriana* b, and *C. meyeriana* c. Microfloristic assemblages representing the *C. meyeriana* a Subzone occur in the Upper Gypsum Beds and the Mudstone–Evaporite Ozimek Member of the Grabowa Formation. Spectra of the *C. meyeriana* b Subzone were found in the Jarkowo Beds, in the lower parts of the

Zbąszynek Beds, in the Lower and Middle Studzianna Beds and in the Patoka Member of the Grabowa Formation. The *C. meyeriana* c Subzone occurs in the upper part of the Zbąszynek Beds, in the Upper Studzianna Beds and in the upper part of the Patoka Member (Orłowska-Zwolińska, 1983, 1985; Fijałkowska, 1992b;**Fijałkowska-Mader, 2013**; Fijałkowska-Mader et al., 2015; Fijałkowska-Mader, 2018). Spectra of the *C. meyeriana* a Subzone are strongly dominated by xerophytic elements, mainly pollen of cheirolepidacean conifers *Classopollis*, *Dulicisporites*, *Partitisporites* and *Granuloperculatipollis* (group S), with a contribution of 46% in some spectra. Pollen of other conifers: *Ovalipollis* (group K), *Cedripites*, and *Labiisporites* (group P) are less numerous. Rare xerophytic elements are represented by spores of horsetails, ferns (*Calamospora*, *Todisporites*) and lycophytes (*Lycopodiumsporites*). The SEG model shows a strong dominance of the Upland–Hinterland SEG (53–80%). The share of the Coastal SEG is relatively high (9–25.5%). On the other hand, the w/d ratio decreased in comparison to the *A. astigmosus* Zone and reached 0.2–12 (averagely 3). Cheirolepidacean conifers were drought-resistant trees and shrubs that occurred in a wide range of environments: on lake and river banks, where they formed dense thickets (cf. Abbink, 1998), on floodplains, and possibly also on dry, elevated areas (Alvin, 1982; Abbink, 1998). Arborescent voltziales and cedrales, as well as the shrubby *Pelourdea* and *Elatides* grew in dry zones of uplands and lowlands. Seed ferns preferred dry areas. Ferns, horsetails and lycophytes concentrated on the flood plains (Orłowska-Zwolińska, 1983; **Fijałkowska-Mader, 2013, 2015**).

In the *C. meyeriana* b Subzone, there is a two-fold increase in the abundance of hygrophilous elements – mainly *Densosporites* (group D), *Lycopodiumsporites* (group C) and *Equisetumsporites* (group B) compared to the *C. meyeriana* a Subzone. *Taurocusporites* spores (group D) are more numerous. Nevertheless, conifer pollen *Classopollis* and *Granuloperculatipollis* (group S), *Brachysaccus* and *Cedripites* (group P) remain the dominant elements and contribute to 76.5–79.5% of the spectra, whereas a visible decrease in the amount of *Ovalipollis* (group K) is observed. The SEG model shows an increase in the share of the Lowland and River SEG to 18–21% with a simultaneous decrease of the Coastal SEG below 1. The share of the Upland–Hinterland SEG slightly decreased (58–69%). The w/d ratio increased to an average value of 8 and reflects the Mid-Norian Pluvial Event (cf. Szulc et al., 2015). Damp and wetland areas of the floodplain were inhabited by sphenophytes (*Equisetites*, *Neocalamites*), lycophytes (*Lycopodites, Pleuromeia*), ferns (*Sphenopteris*) and bennettitales (*Pterophyllum*). Drier upland and hinterland areas were overgrown by seed ferns, arborescent voltzialaeans, araucariceans and cedraleans, as well as the shrubby conifer *Elatides*. Cheirolepidaces were concentrated mainly along the banks of rivers and lakes (**Fijałkowska-Mader, 1999, 2013, 2015**). This scenario of plant ecosystems, reconstructed on the basis of miospores, is confirmed by relatively numerous macrofloral finds in Krasiejów and Lipie-Lisowice[2] (cf. Dzik, Sulej, 2007; Pacyna, 2014, 2019). Among them dominates the conifer *Brachyphyllum*, whereas representatives of the genera *Pseudohimerella*, *Pachylepis*, *Stachyotaxus* and the newly described genus and species *Patokaea silesiaca* (Pacyna et al., 2017) are less numerous. They are accompanied by the horsetails *Equisetites*, ferns *Clathropteris*, *Cladophlebis* and *Neuropteris*, as well as cycads/bennettites. In addition, specimens of *Czekanowskia* and the seed fern *Lepidopteris ottonis* (Goepp.) were found (Pacyna, 2014; Kustatscher et al., 2018).

In the assemblages of the *C. meyeriana* c Subzone, a strong dominance of pollen grains from the circumpollen group (group S), accompanied by *Ovalipollis* pollen (group K) and cycads and bennettite

[2] The age of the deposits exposed in the clay pit in Lipie Śląskie - Lisowice is problematic; some authors believe that it is Rhaetian, whereas others suggest a Norian age (see Szulc et al., 2015). I accept a Norian age for these deposits .

pollen (H group), is observed. The w/d ratio is low (0.5–2) and indicates aridisation of the climate after the Mid-Norian Pluvial Event. The Coastal SEG dominates among the ecogroups.

4.1.2.4.10. *Riccisporites tuberculatus* Zone (Upper Triassic, Rhaetian)

Spore-pollen assemblages of the *R. tuberculatus* Zone were found within the Wielichowo Beds, Bartoszyce Beds and Variegated Parszowskie Beds (Orłowska-Zwolińska, 1983, 1985; Fijałkowska, 1992b; **Fijałkowska-Mader, 2013, 2015**). They are rich in hygrophytic elements (36–42%), mainly spores of ferns *Corrugatisporites*, *Marattisporites* (group C), *Deltoidospora*, *Gleicheniidites* and *Todisporites* (group B), horsetails *Calamospora* and *Equisetumsporites*, and lycophytes *Camarozonosporites*, *Anapiculatisporites*, *Densosporites* (group D). Intermediate elements, occurring in similar amounts (averagely 37%), are represented by cycad/bennettitalean pollen: *Cycadopites*, *Eucommiidites*, *Monosulcites* and *Ephedripites.* Rarely the xerophytic elements are represented by cheirolepidacean (group S), volzialean and pineacean pollen (group P) and *Riccisporites* pollen also produced by conifers (Rhotwell et al., 2000). I have noted the presence of malformed spores of the genera *Deltoidospora* and *Toroisporis*, which contribute to 5% in some samples. Similar teratological forms were described from other sites in western and northern Europe (Lindström et al., 2019; Lindström, van de Schootbrugge, 2020). The SEG model shows a clear dominance of the Lowland and River SEG (55–60%) and a relatively high share of the Coastal SEG (over 20%). The value of the w/d ratio varies from 0.1–2 in the lower part of the zone to 8–25 in its upper part. Spore ferns, belonging among others to the Families Dipteridaceae, Mationiaceae and Osmundaceae, horsetails (*Equisetites*, *Nocalamites*) and lycophytes (*Lycopodites*, *Selaginelites*) overgrew the wet and marshy areas of floodplains, delta plains, and river and lake banks. Dry lowlands were inhabited by cycads/bennettitales (*Cycadoides*, *Wielandiella*), gnetales, ferns (mainly from the Families Gleicheniaceae and Cyatheaceae) and seed ferns. Rare pinaces, voltziaces, araucariaces and cheirolepidaces grew in arid inland areas (**Fijałkowska-Mader, 1999, 2015**). The latter also inhabited the coastal zones of lakes (cf. Kürschner, 2010; Bonis, Kürschner, 2012). There is a significant change in the taxonomic composition of the flora in comparison to the Norian ecosystems, dominated by cheirolepidacean plants. Ferns predominated among the Rhaetian communities. A characteristic element of this flora is the herbaceous ruderal conifer of the Family Albertiaceae, producing *Riccisporites tuberculatus* Lundblad pollen (Rhotwell et al., 2000). My reconstruction of the vegetation cover, based on microflora, is confirmed by numerous finds of macrofloral remains, mainly from Upper Silesia (cf. Pacyna, 2014). These remains are dominated by ferns (*Cladophlebis*, *Camptopteris*, *Dicranopteris*), horsetails (*Equisetites*, *Calamites*), as well as cycads/bennettitales (*Pterophyllum*, *Taeniopteris*). Seed ferns (*Lepidopteris*, *Peltaspermum*, *Pecopteris*) and conifers (*Brachyphyllum*, *Pinites*, *Cheirolepis*) are less common (Reyman, 1979; Reymanówna, Barbacka, 1981; Barbacka, 1991; Barbacka et al., 2009).

4.1.3. Conclusions

1. The application of the PPC model and the w/d ratio to miospore assemblages recovered from the upper Permian and Triassic deposits allowed for the reconstruction of climate changes that took place in the late Permian and Triassic in Poland. The research results are generally consistent with the palaeoclimatic reconstructions presented for Europe in the literature.

2. The dominance of xerophytic elements in most of the analysed microflora spectra reflects the conditions of a monsoon climate with a distinct dry season, which prevailed in the late Permian and Triassic in Central Europe. Slight differences in the value of the w/d ratio among the spectra of the *L. virkkiae* Ab Subzone allowed for recording insignificant fluctuations in humidity: an increase during the deposition of the Zechstein Limestone Ca1, a decrease during the sedimentation of the Lower

Anhydrite A1d, a renewed increase during the sedimentation of the Terrigeneous Recessive Series T1r and its time equivalents, and a further decrease during the sedimentation of the Upper Anhydrite A1g. Another increase in humidity was recorded during the sedimentation of the Platy Dolomite Ca3, whereas a decrease during the sedimentation of the Main Anhydrite A3 was recorded in the spore-pollen spectra of the *L. virkkiae* Ac Subzone. In addition, an increase in humidity is observed in the *L. virkkiae* Bc Subzone during the sedimentation of the Podzamcze Formation, Top Terrigeneous Series Pzt and the corresponding PZ4 sediments. Moreover, an increase in the value of the w/d ratio (in relation to the late Permian), documenting periods of more humid climate, is observed in the late Olenekian, Ladinian, middle Carnian, middle Norian and late Rhaetian.

3. Application of the SEG model enabled a tentative reconstruction of the changes in the floristic ecosystems in the study area:

- a pioneer strategy among the lycophytes of the Family Pleuromeiaceae (Lowland and River SEG and Coastal SEG) in colonizing new settings after the P/T crisis is observed in the Induan. Conifers, mainly voltziales, that survived the crisis, formed the Upland–Hinterland SEG;
- a strategy that tolerated environmental stress in coastal ecosystems prevailed in the Olenekian;
- a revival of conifers and the first reforestation after the P/T crisis (strong domination of the Upland–Hinterland SEG) occurred in the early Anisian;
- arid climate in the middle Anisian supported the dominance of the Upland–Hinterland SEG;
- the climate became more humid in the Ladinian, increasing the importance of lycophytes, mainly of the genus *Annalepis*, which was the dominant component in the Lowland and River SEG. At the same time, conifers developed a ruderal strategy in colonizing coastal environments;
- in the early Carnian, lush flora development was hampered by a dry climate change;
- the Carnian Pluvial Event took place in the middle Carnian, causing intensive development of flora and the expansion of horsetails, which became the main component of the Lowland and River SEG;
- in the early Norian the climate became drier and the expansion of xerophytic cheirolepidacean conifers is observed in all environments (Upland–Hinterland, Lowland and River and Coastal SEGs);
- in the middle Norian there was a short-term increase in humidity, the so-called ‘Norian Pluvial Event’, which is recorded by an increased contribution of lycophytes and horsetails in the Lowland and River SEG;
- a gradual increase of humidity is observed in the Rhaetian, favouring the development of ferns, which were an important component of the Lowland River and Coastal SEGs. The marked decline in the abundance of saccate pollen grains in the Rhaetian microfloral spectra and the simultaneous sudden proliferation of a ruderal conifer producing the *Riccisporites tuberculatus* pollen may have been related to the destruction of the environments by the activity of the Central Atlantic Volcanic Province rather than by climate change.

4. The following global events have been recorded in the analysed microfloral assemblages:

- the late Olenekian pluvial event;
- the Carnian Pluvial Event (CPE) in the middle Carnian;
- the Norian Pluvial Event (NPE) in the middle Norian.

4.1.4. References

Abbink O.A., 1998. Palynological investigations in the Jurassic of the North Sea region. *Laboratory of Palaeobot. Palynol. Contrib. Ser.,* 8, Laboratory of Palaeobotany and Palynology Foundation, Utrecht, s. 188.

Abbink O.A., Van Konijnenburg-Van Cittert J.H.A., Visscher H., 2004*a.* A sporomorph ecogroup model for the northwest European Jurassic-Lower Cretaceous I: concepts and framework. *Netherl. Journ. Geosci./Geologie en Mijnbouw,* 83: 17-31.

Abbink O.A., Van Konijnenburg-Van Cittert J.H.A., Visscher H., 2004*b.* A sporomorph ecogroup model for the northwest European Jurassic-Lower Cretaceous II: Application to an exploration well from the Dutch North Sea. *Netherl. Journ. Geosc./Geologie en Mijnbouw,* 83: 81-91.

Balme B.E., 1995. Fossil in situ spores and pollen grains: An annotated catalogue. *Rev. Palaeobot. Palynol.,* 87: 1-323.

Barbacka M., 1981. *Lepidopteris ottonis* (Goepp.) Schimp. and *Peltaspermum* rotula Harris from the Rhaetian of Poland. *Acta Palaeobot.,* 31: 23-47.

Barbacka M., Feldman-Olszewska A., Jarzynka A., Krupnik J., Ociepa A.M., Wcisło-Luraniec E., Ziaja J., 2009. Wstępne wyniki badań paleobotanicznych wiercenia Studzianna (trias-jura) z północnego obrzeżenia Gór Świętokrzyskich. In: Krobicki M. (ed.), Jurassica 8, Vršatec, 09-11.10.2009. *Kwart. AGH Geologia,* 35: 17-19.

Barbacka M., Pacyna G., Kocsis Á.T., Jarzynka A., Ziaja J., Bodor E., 2017. Changes in terrestrial floras at the Triassic-Jurassic Boundary in Europe. *Palaeogeogr., Palaeoclim., Palaeoecol.,* 480: 80-93. http://dx.doi.org/10.1016/j.palaeo.2017.05.024

Bernardi M., Petti F.M., Kustatscher E., Franz M., Hartkopf-Frödder C., Labandeira C.C., Wappler T., van Konijnenburg-van Cittert J.H.A., Peecook B.R., Angielczyk K.D., 2017. Late Permian (Lopingian) terriestrial ecosystems: A global comparison with New data from the low-latitude Bletterbach Biota. *Earth-Sci. Rev.,* 175: 18-43. doi: http://dx.doi.org/10.1016/j.earscrev.2017.10.002

Birks H.J.B., 2018. One hundred years of Quaternary pollen analysis 1916–2016. *Vegetation Hist., Archaeobot.,* 27: 271-309. doi: https://doi.org/10.1007/s00334-017-0630-2

Bocheński T., 1957. tymczasowa wiadomość o występowaniu formy roślinnej typu *Glossopteris: Glossopteridium J. Czarnocki* n. sp. – w pstrym piaskowcu w otworze Radoszyce 3. *Biul. Instyt. Geol.,* 124: 181–191.

Bonis N.R., Kürschner W.M., 2012. Vegetation history, diversity patterns and Climate Change cross the Triassic/Jurassic Boundary. *Paleobiology,* 38: 240–264.

Cascales-Miñana B., Diez J.B., Gerrinne P., Cleal C.J., 2016. A palaeobotanical perspective on the great end-Permian biotic crisis. *Hist. Biol.,* 28: 1066-1074. doi: http://dx.doi.org/10.1080/08912963.2015.1103237

Czarnocki J., 1925. Wyniki badań geologicznych dokonanych w r. 1924 na obszarze mezozoicznym zachodniej części Gór Świętokrzyskich. *Pos. Nauk. Państw. Inst. Geol.,* 11: 11-14.

Czarnocki J., 1931. Sprawozdanie z badań wykonanych w północno-zachodniej części Gór Świętokrzyskich, między Radoszycami a Łączną pod Suchedniowem. *Pos. Nauk. Państw. Inst. Geol.,* 29: 7-10.

Dadlez R., Marek S., Pokorski J., 1998. Atlas paleogeograficzny epikontynentalnego permu i mezozoiku Polski. Państw. Inst. Geol., Warszawa.

Dobruskina I.A., 1994. Triassic Floras of Eurasia. *Österr. Akad. Wissen., Schrift. Erdwiss. Kommiss.,* Bd 10. Springer, Wien – New York, ss. 422.

Dybova-Jachowicz S., Fijałkowska A., Jerzykiewicz J., 2001. Miospory. In*:* Pajchlowa M., Wagner R. (eds.), Budowa geologiczna Polski t. III. Atlas skamieniałości przewodnich i charakterystycznych. cz. 1, z. 3, Młodszy paleozoik, perm: 106-162. Państw. Inst. Geol., Warszawa.

Dzik J., Sulej T., 2007. A review of the early late Triassic Krasiejów biota from Silesia, Poland. *Palaeontol. Pol.,* 64: 1-27.

Fijałkowska A., 1991. Stratygrafia palinologiczna osadów permu i dolnego pstrego piaskowca w zachodniej części Gór Świętokrzyskich. National Geological Archives (NAG) Warszawa, s. 239. (PhD Thesis) (inv. no 84788)

Fijałkowska A., 1992a. Palinostratygrafia osadów cechsztynu i dolnego pstrego piaskowca w NW części Gór Świętokrzyskich. *Prz. Geol.,* 40: 468-473.
Fijałkowska A., 1992b. Palynostratigraphy of the Keuper and Rhaetic in north-western margin of the Holy Cross Mountains. *Geol. Quart.,* 36: 199-220
Fijałkowska A., 1994a. Palynostratigraphy of the Lower and Middle Buntsandstein in NW part of the Holy Cross Mts., Poland. *Geol. Quart.,* 38: 59-96.
Fijałkowska A., 1994b. Palynological aspects of the Permo-Triassic succession in the Holy Cross Mts., *Documenta naturae,* 87, ss. 76, München. ISSN 0723–8428
Fijałkowska A., 1995. Palynostratigraphy and palynofacies of the Permian/Triassic sequence in the Żary Pericline (SW Poland). *Geol. Quart.,* 39: 307-324.
Fijałkowska-Mader A., 1997. Correlation of the Zechstein microflora of Southern Poland. *Pr. Państw. Inst. Geol.,* 157: 229-235.
Fijałkowska-Mader A., 1999. Palynostratigraphy, palaeoecology and palaeoclimatology of the Triassic in South-Eastern Poland. *Zentralbl. Geol. Paläont.,* I, 1998: 601-627.
Fijałkowska-Mader A., 2012. Odzwierciedlenie stresu środowiskowego w palinoflorze późnego permu w Polsce. *Biul. Państw. Inst. Geol.,* 452: 23-32.
Fijałkowska-Mader A., 2018. Regionalne tło geologiczne. In: Fijałkowska-Mader A. (ed.), Nieświń PIG 1. *Prof. Głęb. Otw. Wiertn. Państw. Inst Geol.,* 151: 10–16.
Fijałkowska-Mader A., Heunisch C., Szulc J., 2015a. Palynostratigraphy and palynofacies of the Upper Silesian Keuper (Southern Poland). *Ann. Soc. Geol. Pol.,* 85: 637-661.
Fijałkowska-Mader A., Kuleta M., Zbroja S., 2015b. Litostratygrafia, palinofacjei środowiska sedymentacji utworów triasu w północnej części niecki Nidy. *Biul. Państw. Inst. Geol.,* 462: 83-124.
Fijałkowska-Mader A., Jewuła K., 2020. Odzwierciedlenie globalnych zmian klimatycznych na granicy smitu i spatu (wczesny trias) w mikroflorze Polski. In: 3 Konferencja naukowa pn. Zmiany paleoklimatyczne w przeszłości geologicznej, Warszawa, 9-11 grudnia 2020, Referaty / postery: s. 8-9. Wyd. Państw. Inst. Geol. – Państw. Inst. Bad. ISBN 978-83-66752-82-5 (z)
Fijałkowska-Mader A., Jewuła K., Bodor E., 2020. Record of the Carnian Pluvial Episode in the Polish microflora. *Palaeoworld,* doi*:* https://doi.org/10.1016/j.palwor.2020.03.006
Fijałkowska-Mader A., Kuleta M., Zbroja S., 2015b. Litostratygrafia, palinofacje i środowiska sedymentacji utworów triasu w północnej części niecki Nidy. *Biul. Państw. Inst. Geol.,* 462: 83-124.
Fijałkowska-Mader A., Wawrzyniak Z., 2019. The Early Triassic plant assemblage from Pałęgi (Holy Cross Mts., Poland). 20th Czech-Polish-Slovak Palaeontological Conference, Chęciny, 20-23 October 2019, Abstracts: 20-23. Wyd. UW Warszawa, ISBN 978-83-945216-9-1.
Foster C.B., Afonin S.A., 2005 – Abnormal pollen grains: an outcome of deteriorating atmospheric conditions around the Permian-Triassic boundary. *Journ. Geol. Soc., London,* 122: 253-259.
Fries M., 1967. Lennart von post's pollen diagram series of 1916. *Rev. Palaeobot., Palynol.,* 4: 9-13.
http://www.stratigraphy.org/ICSchart/ChronostratChart2020-03.pdf
Fuglewicz R., 1973. Megaspores of Polish Buntersandstein and their stratigraphical significance. *Acta Palaeont. Pol.,* 18: 401-451.
Gajewska I., 1997. Trias środkowy (wapień muszlowy-kajper dolny). Sedymentacja, paleogeografia i paleotektonika. In: Marek S., Pajchlowa M. (eds.), Epikontynentalny perm i mezozoik w Polsce *Pr. Państw. Inst. Geol.,* 153: 136-150.
Grauvogel-Stamm L., 1978. La flore du Grès á*Voltzia* (Buntsandstein supérieur) des Vosges du Nord (France). Morphologie, anatomie, interpretation phylogénétique et paléogéographie. *Sci. géol.: Mém.,* 50: 1-225.
Grauvogel-Stamm L., Ash S.R., 2005. Recovery of the Triassic land flora from the end-Permian life crisis. *C. R. Paleovol,* 4: 593-608. doi:10.1016/j.crpv.2005.07.002
Haas J., Budai T., Raucsik B., 2012. Climatic controls on sedimentary environments in the Triassic of the Transdanubian Range (Western Hungary). *Palaeogeogr., Palaeoclim., Palaeoecol.,* 353-355: 31-44.
Hammer Ø., Harper D.A.T., Ryan, P.D. 2001. PAST: Paleontological statistics software package for education and data analysis. *Palaeont. Electronica* 4: 9.

Hermann E., Hochuli P.A., Méhay S., Bucher H., Brühwiler T., Hautmann,M., Ware D., Roghi G., 2011. Terrestrial ecosystems on North Gondwana following the end-Permian mass extinction. *Gondwana Research*, 20: 630-637
Hesselbo S.P., Robinson S.A., Surlyk F., Piasecki S., 2002. Terrestrial and marine extinction at the Triassic-Jurassic boundary synchronized with major carbon-cycle perturbation: A link to initiation of massive volcanism? *Geology*, 30: 251-254.
Hochuli P.A., Vigran J.O., 2010. Climate variations in the Boreal Triassic – Inferred from palynological records from the Barents Sea. *Palaeogeogr., Palaeoclim., Palaeoecol.*, 290: 20-42.
Jelen B ., Kušej J., 1982. Quantitative palynological analysis of Julian clastic rocks from the lead-zinc deposits of Mezica. *Geologia - Rozpr. Porocila*, 25: 21-227, Zagreb.
Jerinič G., Jelen B., 1991. Palynostratigraphy, depositional environment and climate of the Upper Triassic in Vlatka-1 off-shore well, SW of Vis Island (Adriatic Sea, Croatia). In: Abstr. 2nd Intern. Symp. Adriatic carbonate platform 1991 in Jadar.
Jewuła K., Trela W., Fijałkowska-Mader A., 2020. Sedimentary and pedogenic record of seasonal humidity during the Permian-Triassic transition on the SE margin of Central European Basin (Holy Cross Mountains, Poland). *Palaeogeography, Palaeoclimatology, Palaeoecology,* 1-25. doi: https://doi.org/10.1016/j.palaeo.2020.110154
Kiehl, J.T., Shields, C.A., 2005. Climate simulation of the latest Permian: Implications for mass extinction. *Geology,* 33, 757-760.
Kuleta M., Niedźwiedzki G., Zbroja S., 2006. Stanowisko z tropami kręgowców z osadów najwyższego środkowego pstrego piaskowca Gór Świętokrzyskich. *Prz. Geol.,* 54: 1081-1088.
Kustatscher E., Ash S.R., Karasev E., Pott C., Vajda V., Yu J., McLoughlin S., 2018. Chapter 13. Flora of the Late Triassic. In*:* Tanne L.H. (ed.), The Late Triassic World, *Topics in Geobiology,* 46: 545-62., Springer Inter. Publ. AG. doi:https://doi.org/10.1007/978-3-319-68009-5_13
Kustatscher E., Heunisch C., Van Konijnenburg-Van Cittert J.H.A., 2012. Taphonomical implication of the Ladinian Megaflora and Palynoflora of the Thale (Germany). *Palaios*, 27: 753-764.
Kustatscher E., Van Konijnenburg-Van Cittert J.H.A., 2005. The Ladinian flora (Middle Triassic) of the Dolomites: palaeoenvironmental reconstructions and palaeoclimatic considerations. *Geo Alp*, 2: 31-51.
Kustatscher E., Van Konijnenburg-Van Cittert J.H.A., Roghi G., 2010. Macrofloras and palynomorphs as possible proxies for palaeoclimatic and palaeoecological studies: A case study from the Pelsonian (Middle Triassic) of Kühwiesenkopf/Monte Prà della Vacca (Olang Dolomites, N-Italy). *Palaeogeogr., Palaeoclim., Palaeoecol.*, 290: 71-80.
Kutzbach J.E., Gallimore R.G., 1989. Pangaean climates: megamonsoons of the megacontinent. *Journ. Geophys. Research*, 94, 3341-3357. doi: https://doi.org/10.1029/JD094iD03p03341
Kürschner W.M., 2010. Vegetation history, diversity patterns, and climate changes across the Triassic-Jurassic boundary. *Labor.f Palaeob. Palynol. Contrib. Ser.*, 29: 140-165.
Kürschner W.M., Herngreen, W.G.F., 2010. Triassic palynology of central and northwestern Europe: a review of palynological diversity patterns and biostratigraphic subdivisions. W*:*Lucas S.G. (red.), The Triassic Timescale. *Geol. Soc. Spec. Publ.,* 334: 263-283.
Li L., Wang Y., Kürschner W.M., Ruhl M., Vajda. V., 2020. Palaeovegetation and palaeoclimate changes across the Triassic-Jurassic transition in the Sichuan Basin, China. Palaeogeography, Palaeoclimatology, Palaeoecology. doi: https://doi.org/10.1016/j.palaeo.2020.109891
Lindström S., 2016. Palynofloral patterns of terrestrial ecosystems change during the end-Triassic event – a review. Geological Magazine, 152 : 223-251. doi:
Lindström S., McLoughlin S., 2007. Synchronous palynofloristic extinction and recovery after the end-Permian event in the Prince Charles Mountains, Antarctica: Implications for palynofloristic turnover across Gondwana. *Rev. Palaeob., Palynol.*, 145: 89-122.
Lindström S., van de Schootbrugge B., 2018. Malformed spores and pollen across the Triassic-Jurassic boundary. Geophysical Research Abstracts, 20, EGU2018-9682.
Lindström S., Sanei H., van de Schootbrugge B., Pedersen G.K., Lesher C.E., Wegner C., Heunisch C., Dybkjær K., Outridge P.M., 2019. Volcanic mercury and mutagenesis in land plants airing the end-Triassic mass extinction. Science Advances, 5 (10): 1-13, doi: https://doi.org/10.1126/sciadv.aaw4018

Lipiarski I., Sarnecka E., 2001. Makroflora. Gromada Telomophyta i Gymnospermae. In: Pajchlowa M., Wagner R. (eds.), Budowa geologiczna Polski, T. 3. Atlas skamieniałości przewodnich i charakterystycznych, cz. 1c – z. 3. Młodszy paleozoik. Perm. Państw. Inst. Geol., Warszawa, s. 162-176.

Looy C.V., Brugman, W.A., Dichler D.L., Visscher H., 1999. The delayed resurgence of equatorial forests after the Permian-Triassic ecologic crisis. *Nat. Acad. Sci. USA Proc.*, 96: 13857-13862.

Looy C.L., Collinson M.E., Van Konijnenburg-Van Cittert J.H.A., Visscher H., Brain A.P.R., 2005. The ultrastructure and botanical affinity of end-Permian spore tetrads. *Inter. Jour. Planet. Sci.*, 166: 875-887.

Mader D.,1990. Palaeoecology of the flora in Buntsandstein and Keuper in the Triassic of Middle Europe. Vol. 2. Keuper and Index. p. 937-1582, Fischer, Stuttgart/New York.

Mader D.,1997. Palaeoenvironmental evolution and bibliography of the Keuper (Upper Triassic) in Germany, Poland and other parts of Europe. pp. 1058, Loga, Köln.

Meyen S.V., 1987. Paleobotany Foundations. Nedra, Moscow, pp. 403.

Nowak H., Vérard Ch., Kustatscher E., 2020. Palaeophytogeographical Patterns Across the Permian-Triassic Boundary. *Frontiers in Earth Science*: 1-16. doi: 10.3389/feart.2020.613350

Orłowska-Zwolińska T., 1979. Miospory. In: Malinowska L. (ed.), Atlas skamieniałości przewodnich i charakterystyczny. Budowa Geol. Polski, t. 3, cz. 2a Mezozoik, Trias: 166-200. Wyd. Geol., Warszawa.

Orłowska-Zwolińska T., 1983. Palinostratygrafia epikontynentalnych osadów wyższego triasu w Polsce. *Pr. Inst. Geol.,* 104:1-89.

Orłowska-Zwolińska T., 1984. Palynostratigraphy of the Buntsandstein in sections of Western Poland. *Acta Palaeont. Pol.*, 29: 161-194.

Orłowska-Zwolińska T., 1985. Palynological zones of the Polish Epicontinental Triassic. *Bull. Acad. Sci., Earth Sci.,* 33: 107-119.

Pacyna G., 2014. Plant remains from the Polish Triassic. Present knowledge and future prospects. *Acta Palaeobot.*, 54: 3-33. doi: 10.2478/acpa-2014-0001.

Pacyna G., 2019. Sphenopsid and fern remains from the Upper Triassic of Krasiejów (SW Poland). *Ann. Soc. Geol., Pol.,* 89: 307-316. doi: https://doi.org/10.14241/aspg.2019.13

Pacyna G., Barbacka M., Zdebska D., Ziaja J., Fijałkowska-Mader **A.**, Bóka K., Sulej T., 2017. A new conifer from the Upper Triassic of Southern Poland linking the advanced voltzialean type of ovuliferous scale with *Brachyphyllum/Pagiophyllum*-like leaves. *Rev. Palaeobot. Palynol.*, 245: 28-54.

Paul, J., Puff, P., 2010. Das Klima im Buntsandstein. W: Deutsche Stratigraphische Kommission (red.), Stratigraphie von Deutschland X. Buntsandstein. *Schrift. deutsch. Gesell. Geowiss.,* 69: 58-69

Reichgelt T., Parker W.G., Martz J.W., Conran J.G., van Konijnenburg-van Cittert J.H.A., Kürschner W.M,. 2013. The palynology of the Sonsela member (Late Triassic, Norian) at Petrified Forest National Park, Arizona, USA. *Rev. Palaeob., Palynol.,* 189: 18-28.

Reyman M., 1979. Makroflora. Gromada Pteridiphyta i Spermophyta. In: Malinowska L. (ed.), Budowa geologiczna Polski t. 3. Atlas skamieniałości przewodnich i charakterystycznych, cz. 2a. Mezozoik. Trias: 222-225. Wyd. Geol., Warszawa.

Reymanówna M., Barbacka M., 1981. *Lepidopteris ottonis* (Goeppert) Schimper z Wyżyny Śląsko-Krakowskiej i obrzeżenia Gór Świętokrzyskich. In: Fauna i flora triasu obrzeżenia Gór Świętokrzyskich i Wyżyny Śląsko-Krakowskiej. Mat. 5 Krajowej Konfer. Paleontologów Kielce-Sosnowiec 1981, s. 79-84.

Rothwell G.W., Grauvogel-Stamm L., Mapes G., 2000. An herbaceous fossil conifer: Gymnospermous ruderals in the evolution of Mesozoic vegetation. *Palaeogeogr., Palaeoclim., Palaeoecol.,* 156: 139-145.

Scotese C.R., 2014. Map 45. Late Triassic. Rhaetian, 201.6 Ma. Map 48. Early Triassic. Induan & Olenekian, 248.5 Ma. Map 50. Late Permian. Lopingian. 255.7 Ma. Transgressive Systems Tract. W: Atlas of Permo-Triassic Paleogeographic Maps (Mollweide Projection), Maps 43-52, Volumes 3 & 4 of the PALEOMAP Atlas for ArcGIS. PALEOMAP Project, Evanston, IL. doi: 10.13140/2.1.2609.9209.

Scott L., Neuman, F.H., Brook, G.A., Bousman, C.B., Norström, E., Metwally, A.A., 2012. Terrestrial fossil-pollen evidence of climate change during the last 26 thousand years in South Africa. *Quarter. Sci. Rev.*, 32:100-118.
Szulc J., 2019. Lower Triassic marine Buntsandstein deposits in the Central European Basin. *Zeit. Deutsch. Gesell. Geowiss.*, 170: 311-320.
Szulc J., Becker A., Fijałkowska-Mader A., 2015. Perm i trias – nowe otwarcie w historii Gór Świętokrzyskich. In: Skompski S, Mizerski W. (eds.), Ekstensja i inwersja powaryscyjskich basenów sedymentacyjnych . 85 Zjazd Polskiego Towarzystwa Geologicznego, Chęciny, 9-11 września 2015 r. Mat. konger.: 11-27. Państw. Inst. Geol. – Państw. Inst. Bad., Warszawa.
Szulc J., Racki G., Jewuła K., Środoń J., 2015. How many Upper Triassic bone-bearing levels are there in Upper Silesia (southern Poland)? A critical overview of stratigraphy and facies. *Ann. Soc. Geol. Pol.*, 85: 587-626.
Szyperko-Teller A., 1997. Trias dolny (pstry piaskowiec). Sedymentacja, paleogeografia i paleotektonika. In: Marek S., Pajchlowa M. (eds.), Epikontynentalny perm i mezozoik w Polsce *Pr. Państw. Inst. Geol.,* 153: 121-132.
Taylor T.N., Taylor E.L., Krings M., 2009. Palaeobotany. The biology and evolution of fossil plants. Elsevier Amsterdam-Tokyo, ss. 1230.
Thió-Henestrosa S., Martín-Fernández J. A., 2005. Dealing with compositional data: the freeware CoDaPack. *Mathemat. Geology*, 37: 773-793.
Verhaegen J., Weltje G. J., Munsterman D., 2018. Workflow for analysis of compositional data in sedimentary petrology: provenance changes in sedimentary basins from spatio-temporal variation in heavy-mineral assemblages. *Geol. Magazine*,156: 1111-1130.
Visscher H., 1971. The Permian and Triassic of the Kingscourt outlier, Ireland. *Geol. Surv. of Ireland., Spec. Publ.*, 1: 1-115.
Ziegler A.M. 1990. Phytogeographic patterns and continental configurations during the Permian Period. *Geol. Soc., London, Mem.*, 12: 363-379.
Visscher H., Van der Zwan C.J., 1981. Palynology of the Circum-Mediterranean Triassic: phytogeographical and palaeoclimatological implications. *Geol. Rund.*,70: 625-634.
Visscher H., Van Houte M., Brugman W.A., Poort R.J.,n1994. Rejection of a Carnian (Late Triassic) “pluvial event” in Europe. *Rev. Palaeobot., Palynol.*, 83: 217-226.
Wagner R., 1994. Stratygrafia osadów i rozwój basenu cechsztyńskiego na Niżu Polskim. *Pr. Państw. Inst. Geol.*, 146, 1-71.
Wignall P. B., 2007. The End-Permian mass extinction – how bad did it get? *Geobiology*, 5: 303–309. doi:10.1111/j.1472-4669.2007.00130.x
Yaroshenko O.P., 1975. Morphology of the spores of *Pleuromeia rossica* and *Densoisporites nejburgii. Paleont. Jour.*, 3: 101-106.

4.2. Other scientific achievements

4.2.1. Palynology

4.2.1.1. Taxonomy

During my research, I have identified 7 new species of spores in the Lower Devonian deposits of the Holy Cross Mountains: *Dibolisporites jakubowskae*, *Dibolisporites rarospinosus*, *Grandispora santaecruciensis*, *Hystricosporites brevispinosus*, *Verrucosisporites rariverrucosus*, *Verruciretusispora dubia* (Eisenack, 1944) Richardson et Rasul, 1978, var. *multituberculata*, and *Dictyotriletes delicatus* (Turnau et al., 2003; Fijałkowska-Mader, Malec, 2011)

In my studies (Fijałkowska, 1995; **Fijałkowska-Mader, 2013**), I have also identified two new taxa of Early Triassic green algae belonging to the order Zygnematales: *Actinastrum stellatum* (emended by Foster and Afonin 2006 as *Syndesmorion stellatum* (Fijałkowska) comb. nov.), aff. *Genicularia zwolinskai* (emended by Foster and Afonin 2006 as *Syndesmorion stellatum*) and a one new type of fungae (Staurosporae Elsik group, 1993) *Stelasporonites* and the species *Stelasporonites nidensis* in the Upper Muschelkalk of the Nida Basin.

I have participated in the determination of pollen grains of the *Enzonalasporites* type, found in the microsporophyll and micropylar canals of the newly described species of conifer plants – *Patokaea silesiaca*, in the Norian deposits from Upper Silesia (Pacyna et al., 2017).

The work by Foster and Afonin (2005) on the occurrence of atypically shaped pollen grains, determined as *Klausipollenites schaubergeri* and *Alisporites* sp., and the possible connection of this aberration with environmental changes across the Permian/Triassic boundary, inspired me to revise the concept of palynodem and morphological norms, introduced by Visscher (1971, 1972) within the late Permian species *Lueckisporites virkkiae* Potnié et Klaus and *Jugasporites delasaucei* (Potnié et Klaus) Leschik. I consider morphological norms as abnormal forms, changed by stressful environmental conditions (Fijałkowska-Mader, 2012, 2020a).

4.2.1.2. Palynostratigraphy

4.2.1.2.1. Palynostratigraphy of the Lower Devonian in the Holy Cross Mountains

For the first time, I have developed a comprehensive palynostratigraphy of the Lower Devonian deposits (late pre–early Eifelian) in the Holy Cross Mountains (Fijałkowska, 1995a, 1996; Fijałkowska-Mader et al., 1997; Fijałkowska-Mader, Malec, 2011) and distinguished 5 zones and 8 subzones of the palynostratigraphical scheme of Streel et al. (1987): PW (Su), AB, FD (Fov, Pra, Min), AP (Cor, Pro, Vel), and AD (Mac). Moreover, I have correlated the T1–T4 tuffite horizons, recognised by Tarnowska (1999), with the PW (Su), AB and AP (Cor, Pro) zones and subzones. This allowed for the comparison of the sections from the Holy Cross Mountains with the succession from the Ardennes–Rhenish regions and the construction of a supra-regional Lower Devonian tefrostratigraphic scheme for Europe. I have also determined the age of the tuffite level exposed on Barcza Hill (where the stratotype of the Barcza Beds is located) as the lower Emsian AB zone (Fijałkowska-Mader, Malec, 2018).

4.2.1.2.2. Palynostratigraphy and lithostratigraphy of the upper Permian in Poland

The detailed palynological zonation for the Zechstein, developed by me (Fijałkowska, 1992a, 1994b) for the NW margin of the Holy Cross Mountains, with the *Lueckisporites virkkiae* Zone subdivided into 4 subzones (*L. virkkiae* Ab, occurring in PZ1, *L. virkkiae* Ac? in PZ2, *L. virkkiae* Ac in the lower part of PZ3, and *L. virkkiae* Bc in the upper part of PZ3 and PZ4, as well as in PZt and the Podzamcze Formation) and 5 assemblages (*L. virkkiae* Ab and acritarchs, *L. virkkiae* Ab, *L. virkkiae* Ab and *Strotersporites* sp. div., *L. virkkiae* Ac and acritarchs and *L. virkkiae* Ac), was applied for other areas of Poland, becoming a supra-regional scheme (**Fijałkowska-Mader**, 1997, 2011, **2013**; Kürschner, Herngreen, 2010).

The palynostratigraphic scheme of the Zechstein, developed by me in the Holy Cross Mountains as part of my doctoral dissertation (Fijałkowska, 1991, 1992a), was extended to the entire territory of Poland (Wagner, 1994; Dybova-Jachowicz et al., 2001). It contains one zone and 4 subzones.

In the case of the North-Sudetic Basin, my studies (Fijałkowska, 1995b; Fijałkowska, Peryt, 1995; Fijałkowska-Mader et al., 2018) have confirmed the presence of PZ2 deposits in its southern part, a feature that has been questioned by some authors (cf. i. a., Wagner, 1986 , 1994; Raczyński, 1997; Raczyński et al. 1998).

In the Nida Basin, my studies (**Fijałkowska, 2013**) have allowed to specify the PZ1 stratigraphy in the Pągów IG 1, Milianów IG 1 and Brzegi IG 1 wells and confirmed the presence of PZ3 and PZt deposits in the Biała Wielka IG 1 well.

Moreover, I have participated in the work of the team (Jewuła et al., 2020b), who presented a proposal for a new, formalised lithostratigraphy of the Permian/Triassic boundary section in the NW margin of the Holy Cross Mountains. The most important change in this scheme, as compared to older studies (e.g. Kuleta, Zbroja, 2006), consists of distiguishing the Podzamcze Formation instead of the Top Terrigenous Series PZt, whereas the stratigraphic range of this formation is much wider and includes even the PZ1 sediments. Moreover, the Siodła Formation was included to the Zechstein, as already suggested in earlier studies (Kowalczewski, Rup, 1989; Trela, Fijałkowska-Mader, 2017).

4.2.1.2.3. Palynostratigraphy and lithostratigraphy of the Triassic in Poland

For the first time, I have presented (Fijałkowska, 1992b, 1994a) a comprehensive palynostratigraphic scheme of the Triassic sediments in the W and NW margin of the Holy Cross Mountains, identifying all 10 zones and 11 subzones distinguished by Orłowska-Zwolińska (1984, 1985) in the Polish Lowlands. My studies were the basis for establishing the stratigraphic position of the lithostratigraphic units distinguished by Kuleta (in Kuleta, Zbroja, 2006) in the Lower Buntsandstein of the NW margin of the Holy Cross Mountains. I recognised miospore assemblages of the *Lundbladispora obsoleta–Protohaploxypinus pantii* Zone in the Jaworzna and Opoczno formations, which allowed to correlate them with the Induan. I identified the spectra in the lower part of the *Densoisporites nejburgii* Zone in the Goleniawy and Stachura formations, which allowed for the correlation of both formations with the Smithian. In the Samsonów Formation, I found assemblages of the *Cycloverrutriletes presselensis* Subzone and on this basis correlated this unit with the Spathian. In the Intergypsum Beds, I identified the spectra of the *Voltziaceaesporites heteromorphus* Zone and correlated them with the early Anisian. However, my main achievement was establishing the boundary between the Norian (*Corollina meyeriana* Zone) and the Rhaetian (*Riccisporites tuberculatus* Zone). It provided the basis for clarifying the stratigraphic scheme of the Upper Triassic in the Holy Cross Mountains region, where the main disorder was caused by the use of chronostratigraphic units as lithostratigraphic ones (cf. Kopik, 1970). I have distinguished the Studzianna Beds in the Middle Keuper (Fijałkowska-Mader, 2018a), which, through the *C. meyeriana* b and c subzones, were correlated respectively with the Jarkowo and Zbąszynek Beds of the Polish Lowlands. In turn, the Variegated Parszów Beds of the Upper Keuper, were correlated with the Wielichowo Beds (comp. Pieńkowski et al., 2014).

In addition, my study of 17 wells in the Nida Basin (Fijałkowska-Mader, 2000, 2013*) allowed to subdivide the Röt Formation into a Lower and Upper part, confirm the problematic occurrence of the Middle Muschelkalk and Schilfsandstein (Stuttgart Formation) (see Jurkiewicz, 1974), and indicate the presence of the Wielichów Beds of Rhaetian age. Following palynostratigraphic analysis, it was possible to set out a detailed stratigraphy of the Triassic sediments in the Nida Basin (cf. Fijałkowska-Mader et al., 2015b).

One of my significant achievements was the development of the palynostratigraphy of the Grabowa Formation in Upper Silesia (Fijałkowska-Mader et al., 2015a). The formation yields two bone levels, Krasiejów and Lisów (Racki, Szulc, 2015), the age of which was considered Carnian, Norian or Rhaetian (cf. Szulc et al., 2015). My palynological study on cores of eight wells and in two exposures (Patoka and Lipie Śląskie–Lisowice) and the determination of the *Corollina meyerian* Zone allowed to define the age of these deposits as Norian.

Moreover, I have identified the Early Triassic *Lundbladispora obsoleta–Protohaploxypinus pantii* Zone in the so-called Transitional Beds spanning the Permian/Triassic boundary in the Żary Pericline (Fore-Sudetic Monocline) (Fijałkowska, 1995).

I have also initiated palynological studies based on miospores of the Triassic deposits in the Polish Tatra Mountains (Fijałkowska, Uchman, 1993). Following my studies, three zones have been determined: the Olenekian *D. nejburgii* Zone (in the Werfenian of the Lower Sub-Tatric Unit), the late Anisian *Tsugaepollenites oriens* Zone (in the Partnach Beds, Upper Sub-Tatric (Strazov) Unit), and the Norian *Corollina meyeriana* Zone (the *C. meyeriana* a Subzone in the Keuper deposits of the Lower Sub-Tatric Unit and the *C. meyeriana* b Subzone in the Tomanowa Beds of the Upper Sub-Tatric Unit). Moreover, *Tsugaepollenites oriens* Klaus, considered a boreal form, was found for the first time within the Alpine facies.

4.2.1.2.3. Palynostratigraphy of the Lower Jurassic in the NW margin of the Holy Cross Mountains

Due to the lack of a current palynostratigraphic scheme for the Polish Jurassic (cf. Marcinkiewicz et al., 2014), I use the levels defined in the North Sea (Lund, 1977) and the Danish straits (Dybkjær, 1991), which – in my opinion – can be easily identified in the Polish Lower Jurassic deposits. In the Zagaje Formation in the Skarżysko-Kamienna IG 2, Opoczno PIG 2 and Nieświń PIG 1 wells and in the Zagaje and Skłoby formations in the Ostałów PIG 2 well, I have identified the *Pinuspollenites–Trachysporites* Zone. In the Ostrowiec Formation of the Ostałów PIG 2 well I have recognised the *Cerebropollenites macroverrucosus* Zone. I have also identified the *Sphaeripollenites–Leptolepidites* Zone in the Gielniów and Drzewica formations of the Ostałów PIG 2 well and in the Ciechocinek Formation of the Mniszków IG 1 well, and the *Leptolepidites–Sphaeripollenites* and *Perinopollenites elatoides* Interval Zone in the Borucice Formation (Fijałkowska, 1988a, b, 2006a, b; Fijałkowska-Mader, 2018b).

4.2.1.3. Palynofacies

I have been conducting palynofacial studies of the Triassic (Fijałkowska, 1994a, 1995; Fijałkowska-Mader, 1999, Fijałkowska-Mader et al., 2015a, b; Becker et al. 2020; Jewuła et al. 2020) and upper Permian (Fijałkowska-Mader, 2011; Jewuła et al. 2020) in Poland in terms of analysis of the sedimentary environment. In the Zechstein , I have distinguished 6 types of palynofacies characteristic of the following settings: shallow-water lagoon, freshwater lake, playa, sebkha and floodplain. In Triassic deposits, I have distinguished one more palynofacies, occurring in river channel settings.

I have also analysed the types of kerogen in the palynofacies of the upper Permian and Triassic deposits in the Nida Basin in terms of hydrocarbon potential (Fijałkowska-Mader, 2020b). I found the presence of mixed kerogen (finely dispersed and ‘fluffy’) of marine origin, and structural kerogen (mainly exinite and vitrinite) of terrigeneous origin, indicating potential oil and oil-gas windows.

4.2.1.4. Palaeoclimate, palaeoenvironment and palaeoecolgy of the late Permian

For the first time I applied the PPC and SEG models to the latePermian microflora assemblages from Poland.In the PPC model I have distinguished 13 morphological groups: A – monolete spores, B – trilete laevigate and apiculate spores, C – trilete verrucate, reticulate and murornate spores, and D – trilete zonate and cingulate spores, which represent hygrophytic elements; E – monosulcate pollen and F – *Vitreisporites–Illinites* group, which are intermediate elements; G – monolete bisaccate pollen, H – other trilete bisaccate pollen, I – taeniate bisaccate pollen, J – *Triadispora* spp., K – vesicate pollen, L – *Jugasporites* spp, and M – monosaccate pollen, which represent xerophytic elements.

I have distinguished four subzones within this zone: *L. virkkiae* Ab, *L. virkkiae* Ab-Ac (*L. virkkiae* Ac? in older literature), *L. virkkiae* Ac and *L. virkkiae* Bc, in the Zechstein (Fijałkowska, 1994b).

Spore-pollen assemblages, belonging to all subzones, are characterized by strong dominance (averagely 70–80%) of xerophytic elements from group I (*Lueckisporites*, *Lunatisporites*, *Protohaploxypinus*, *Strotersporites*), J, K (*Klausipollenites*), L and M (*Nuskoisporites*), which are conifer pollen. There were slight differences at the level of several percent in the content of hygrophytic elements, mainly fern and horsetail spores (groups A, B). In the *L. virkkiae* Ab subzone, their increase was noted in spectra recognised from the Zechstein Limestone (Ca1) (*L. virkkiae* Ab and acritarchs), a decrease – in the Lower Anhydrite (A1d) (*L. virrkiae* Ab), a subsequent increase in the Recessive Terrigeneous Series (T1r) and its time equivalents (*L. virkkiae* Ab and *Strotersporites* sp. div.), and the next decrease in the Upper Anhydrite (A1g) (*L. virkkiae* Ab and *Strotersporites* sp. div.). The next increase in the contribution of hygrophytic forms was noted in the assemblages from the Platy Dolomite (Ca3) (*L. virkkiae* Ac and acritarchs), and a decrease – in the spectra of the Main Anhydrite (A3) belonging to the *L. virkkiae* Ac Subzone. Moreover, an increase in the abundance of hygrophytic elements is observed in the spectra of the *L. virkkiae* Bc Subzone, occurring in the Top Terrigeneous Series (PZt) and its time equivalents of the PZ4 sediments (Fijałkowska-Mader, 1997).

The SEG model, applied to the assemblages from the Nida Basin, shows a clear dominance (averagely above 75%) of the Upland–Hinterland SEG (**Fijałkowska-Mader, 2013**). A slight increase in the share of the Coastal SEG is observed in the spectra of the *L. virkkiae* Ab and acritarchs, and *L. virkkiae* Ac and acritarchs subzones and is connected with a transgressional phase. The w/d ratio is low, ranging from 0 to 1.1 (averagely 0.6). The abundance of abnormal pollen grains within the specimens of the *L. virkkiae* Zone gradually increases in younger assemblages, from 32% in the *L. virkkiae* Ab subzone to 69% in the *L. virkkiae* Bc subzone. In the case of *Jugasporites* and *Triadispora*, the content of abnormal grains increases from 10% to 50% and from a few percent to 10%, respectively (Fijałkowska-Mader, 2012, 2020a).

Based on the results of PPC and SEG analyses, and affiliation of the miospores to the parent plants, I have made an attempt to reconstruct the late Permian plant cover in Poland (**Fijałkowska-Mader**, 1997, **2013**). The dry, elevated areas located beyond the shore of the Zechstein Sea were overgrown by arborescent voltzialean conifers, belonging mainly to the Ullmaniaceae (*Ullmania*) and Majonicaceae (*Pseudovoltzia*). They were accompanied by representatives of the Family Podocarpaceae, herbaceous conifers of unknown systematic position, and peltaspermous seed ferns (types of *Permotheca*, *Tatarina*) and cordaites (*Cardiocarpus*). In younger assemblages, a gradual decrease in the contribution of cordaites and seed ferns is observed, which may be considered as an evolutionary trend (see Taylor et al., 2009) rather than caused by environmental factors. More humid areas, located on the banks of episodic rivers and lakes/playas, were covered with ferns, horsetails and single lycophytes. It is possible that the latter could also inhabit the shores of sebha-type salt basins. Cycads/bennettitales with larger environmental tolerance dominated in the coastal zones. This scenario is confirmed by a few finds of macrofloral remains, mainly from the Zechstein Limestone in the Holy Cross Mountains: seed ferns (*Palmatopteris*, *Sphenopteris*, *Aletopteris*), conifers (*Ullmania bronni* Göppert, *U. frumentaria* (Scloth.), *U. orobiformis* (Schloth.), *Pseudovoltzia libeana* (Geinitz) and cordaites (*Cardiocarpus*), and the North-Sudetic Trough, where ferns (Filicineae) are accompanied by peltasperms and the conifers *Pseudovoltzia* and *Ullmania* (Lipiarski, Sarnecka, 2001).

4.2.2. Rock materials – history of excavation and application

Based on lithological features, I have analysed rock materials (Neogene detritic limestones) used for the construction of Medieval historic buildings in Szydłów: the castle palace, defensive walls, the St. Ladislaus Church, the All Saints Church, and the ruins of the Holy Spirit Church and hospital, pointing to the places of their exploitation, located around the town (Fijałkowska-Mader et al., 2019).

I have also participated in determining the rock material used in the architectural details of the 17th century church and monastery complex on Karczówka Hill in Kielce (Złonkiewicz, Fijałkowska-Mader, 2018), where Lower Triassic and Lower Jurassic sandstones were used apart from the Palaeozoic 'Chęciny marbles'.

I have taken part in the research on the history of rock mining (Middle to Upper Devonian limestones and dolomites) in the Sitkówka area near Kielce (Król et al., 2019) and the history of the exploitation of Lower Devonian sandstones at Barcza Hill near Kielce (Król et al., 2020).

Since 2014, I have been organizing a scientific conference entitled 'Stone in the deposit, landscape and architecture' (earlier names of the conference included 'Interstone' and 'Stone Salon'; until 2020 the conference was co-organized with Targi Kielce) and editing the post-conference papers in *Przegląd Geologiczny*.

4.2.3. Geodiversity of the Holy Cross Mountains area and its popularization

At the beginning of the new millennium, geoparks, i.e. areas containing geological heritage sites of significant scientific significance for geology, as well as unique or beautiful objects, representative of a given region and its geological history, began to appear all over the world. The geodiversity of the Holy Cross Mountains area obviously predestines this area to be called a geopark. The precursor of the geopark idea in the discussed area was Z. Rubinowski, the author of the project 'Chęciny–Kielce Geological Landscape Park' (Rubinowski et al., 1996). Pieńkowski (2004, 2008, 2009) commenced the activities aimed at creating the 'Kamienna Valley' geopark. Together with other employees of the Holy Cross Branch of the PGI-NRI, I have joined him in preparing the documentation for the planned geopark (Pieńkowski, Fijałkowska, 2010; Mader et al., 2011). Unfortunately, due to the lack of interest by the local governments of communites included in the geopark, the project has not been implemented yet.

I have participated in the activities aimed at establishing the Chęciny–Kielce Geopark, which was initially established as the Kielce Geopark, and then as the Świętokrzyski Geopark, aspiring to the List of UNESCO Global Geoparks (Trela et al., 2010; Fijałkowska-Mader, Poros, 2011). I have participated in the study on the concept of the Holy Cross Mountains geoparks network (Trela, Fijałkowska-Mader, 2013), including: the Geopark of the Kamienna Valley, the Chęciny–Kielce Geopark, the Land of Tetrapod and Fossil Dunes, the Łysogóry Geopark, and the Cisów–Orłowiny Geopark. Together with Jan Malec (Mader, Malec, 2012; Fijałkowska-Mader, Malec, 2013), we have developed the project and, with other employees of the Holy Cross Branch of the PGI-NRI (Mader et al., 2013), prepared the documentation of the Łysogóry Geopark. The geopark project has been presented to the management of the Świetokrzyski National Park (Urban et al., 2020), within which most of the planned geopark area is located, but no activities aimed at the implementation of the project have been undertaken yet.

In addition, since 2010, I have been working (independently and in co-authorship) on the geosites from the Holy Cross Mountains area for the Central Register of Polish Geosites. To date, I have developed over 100 of them.

4.3. Plans for the future

I plan to continue the research on the Early Triassic microflora from the clay deposits exposed in Pałęgi (Holy Cross Mountains), a unique exposure on Polish scale, where miospores accompany determinable macrofloral remains (Fijałkowska-Mader, Wawrzyniak, 2019). I also intend to continue research on the Late Triassic microflora from the Kamienica Śląska gravel pit (Upper Silesia) (Fijałkowska-Mader, Paszkowski, 2016). I would like to continue studies on the Triassic stratigraphy in the W and NW margin of the Holy Cross Mountains, as well as on the palynostratigraphy and palynofacies of the Zechstein and Triassic deposits of the North-Sudetic Basin.

5. Presentation of significant scientific or artistic activity carried out at more than one university, scientific or cultural institution, especially at foreign institutions

5.1. Foreign scholarships

During my stay on a three-month scholarship in 1991 in the Laboratory of Palaeobotany and Palinology of the University of Utrecht, I have delivered a series of papers devoted to the palynostratigraphy of the upper Permian, Triassic and Lower Jurassic of the Holy Cross Mountains for students and lecturers. I have also participated in workshops on organic matter and palinofacies, which has resulted in the development of this research in Poland.

During my stay on a monthly scholarship in 1994 in the Institute of Geography, Mineralogy and Geology of the University of Göttingen, I have developed the palynostratigraphic scheme of the Zechstein deposits in the Leucht 2 Baddenhain-Süd wells. The results of the palaeoclimatic analysis of miospore assemblages from these wells were included in the chapter: 'Klima und Klima-Zyklen im Zechstein' (Paul, 2020).

5.2. Participation in the organization of international conferences and scientific workshops

I was the co-organizer of the A4 Fieldtrip (Stop 17; Fijałkowska, 1995c) during the 13th International Carboniferous and Permian Congress, which took place on 25–27th August 1995 in the Upper Silesia and Lublin Coal basins. Apart from the Polish Geological Institute, other universities (AGH, Institute of Botany of the Jagiellonian University, VŠB Technical University in Ostrava, University in Ostrava) and scientific institutions (Museum in Ostrava, Silesian Museum in Opava, Institute of Geological Names of the Polish Academy of Sciences in Krakow) were involed in its organization.

I have been the member of the organizing committee of CIMP (Commission Internationale de Microflore du Paléozoique) Poland 2010 General Meeting conference and presented two excursion sites: 2 and 11 (Fijałkowska-Mader, 2010). Apart from the Polish Geological Institute – National Research Institute, other institutions, i.e. Faculty of Geology of the University of Warsaw, Institute of Geological Sciences of the Polish Academy of Sciences in Warsaw, and the Committee of Geological Sciences of the Polish Academy of Sciences also participated in its organization.

5.3. Participation in the organization of national conferences

I have been the member of the organizing committee of the Sixth Świętokrzyskie Geological and Geomorphological Meetings entitled: 'Reconstruction of sedimentary environments based on sedimentological, geochemical and stratigraphic studies' in Ameliówka near Kielce, 17–18th May 2011, co-organised by the Institute of Geography of the Jan Kochanowski University in Kielce, Association of Polish Gemorphologists, and Geopark Kielce, and the Seventh Świętokrzyskie Geological and Geomorphological Meetings entitled: 'Geodiversity of the Nida Basin in comparison with other areas of the northern part of the Carpathian Foredeep' in Busko-Zdrój, 22–24th May 2013 (Łajczak et al., 2013), co-organized, e.g., by the Institute of Geography of the Jan Kochanowski University in Kielce, Institute of Nature Conservation, Polish Academy of Sciences in Kraków, Department of Geoecology of the University of Warsaw.

In addition, I have been the member of the organizing committee of the 84th Scientific Congress of the Polish Geological Society entitled: 'Extension and inversion of post-Variscian sedimentary basins' in Chęciny on 9–11th September 2015, co-organized by, e.g., by the Faculty of Geology of the University of Warsaw. I have been the member of the organizing committee of the Seventh Workshop on Structural Geomorphology entitled: ‘Structural morphology of the Holy Cross Mountains and the Nida Basin – the state of research and future prospects’, co-organized by the Institute of Nature Conservation of the Polish Academy of Sciences in Kraków, the Institute of Geography of the Jan Kochanowski University in Kielce, the Commission of Structural Geomorphology of the Association of Polish Geomorphologists, and Geopark Kielce. I have participated in the development of field sessions on 26th and 27th September (Fijałkowska-Mader, Złonkiewicz, 2019; Urban, Fijałkowska-Mader, 2019).

5.4. Participation in research and research grants from other universities and scientific institutions

I have conducted and/or still conduct joint research with employees from various universities and scientific institutions, including:

- Institute of Geological Sciences of the Jagiellonian University in the field of: organic matter from the Lower Silesian Zechstein copper-bearing shale (Fijałkowska et al., 1993), palynostratigraphy of the Triassic of the Polish Tatra Mts (Fijałkowska, Uchman, 1993), development and age of Upper Triassic deposits from Upper Silesia (Fijałkowska-Mader, Szluc, 2015) and sedimentation across the Permian/Triassic boundary in the Holy Cross Mountains (Szulc et al., 2015);

- Institute of Geological Sciences of the University of Silesia, grant no. N307117037, in the development of palynostratigraphy of Upper Triassic sediments, including bone horizons, from Upper Silesia (Fijałkowska-Mader et al., 2015; Szulc et al., 2015). As mentioned in subsection 4.2.1.2.3., my research allowed to establish the Carnian age of these horizons; currently I am working on the analysis of Early Triassic microflora from Pałęgi (Fijałkowska-Mader, Wawrzyniak, 2019);

- Institute of Geography and Environmental Sciences of the Jan Kochanowski University in Kielce and National Museum in Kielce in the field of geoeducation and geotourism (Fijałkowska-Mader et al., 2018; Pabian et al., 2017a, b) and the history of rock exploitation (Fijałkowska-Mader et al., 2019; Król et al., 2019, 2021);

- Institute of Geological Sciences of the Polish Academy of Sciences in Kraków in the field of: palynostratigraphy of Lower Devonian deposits in the Holy Cross Mountains (Fijałkowska-Mader et al., 1997), the age of Upper Triassic, coarse-detritic sediments in Upper Silesia (Fijałkowska-Mader, Paszkowski, 2016), stratigraphy and sedimentary development of upper Permian and Lower Triassic deposits in the Holy Cross Mountains (Jewuła et al. 2020a, b), grant no. 2018/29/N/ST10/02028, and the application of PCA statistical analysis to the late Permian and Early Triassic microflora from Poland (**Fijałkowska -Mader et al., 2020**; Fijałkowska-Mader, Jewuła 2020; Jewuła et al. 2020b);

- Institute of Nature Conservation of the Polish Academy of Sciences in Kraków in the field of geomorphology of the Holy Cross Mountains (Urban, Fijałkowska-Mader, 2019) and the protection and promotion of geodiversity of the Holy Cross Mountains area (Urban, Fijałkowska-Mader, 2018; Urban et al., 2020);

- Institute of Botany of the Polish Academy of Sciences in Kraków in the determination of pollen grains of the newly discovered Late Triassic plant *Patokea silesiaca* (Pacyna et al., 2017);

- Research and Development Center KGHM CUPRUM sp. z o.o. in Wrocław in terms of stratigraphy and sedimentary development of the upper Permian and Triassic deposits in the North-Sudetic Basin (Fijałkowska-Mader et al., 2018).

6. Presentation of teaching and organizational achievements as well as achievements in popularization of science or art

6.1. Geoeducation and geotourism

In 2011–2013, I have taken part in the PGI-NRI multi-task project ‘Understanding the Earth’ (the supervisor of the project was G. Pieńkowski; Fijałkowska-Mader et al., 2018). The end result of this project was the development, printing and delivery to educational institutions (probation offices, in-service training centers for teachers and schools) throughout the country of the lesson-exercise outline ‘Understanding the Earth’ (Pieńkowski et al., 2013a). Beside five lesson topics (Structure of the lithosphere, Geological past of Poland, Development of the organic world, The main types of rocks and Polish mineral resources - a topic developed by me, Springs and mineral waters of Poland, Karst processes), the outline includes a field part with an excursion guide ‘Geodiversity of our country’, presenting the geology of the Holy Cross Mountains, Upper Silesia and the Polish Jura Chain, Warsaw, the vicinity of Kłodzko, and the Wigry National Park (Pieńkowski et al. 2013b). I have compiled the ‘Introduction’ to trips to the Holy Cross Mountains and the following excursion sites: Kielce-Karczówka, Gorge of the Lubrzanka river in Mąchocice, Nowa Słupia, “Raj” Cave, Czerwona Góra Quarry.

In 2014–2019, in the Holy Cross Branch of the PGI-NRI I have coordinated a national geological competition ‘Our Earth – the natural environment yesterday, today and tomorrow...’ (organised by the Polish Geological Institute – National Research Institute) for the Świętokrzyskie and Łódź voivodeships. The competition is held in primary and secondary schools, with an art competition in grades IV–VI and a theoretical competition in the higher grades. Every year there is a different competition motto (in 2020 it was: ‘Earth (R)Evolutions’) being the topic of the art works, whereas the theoretical works are written on one of three topics, closely related to the motto. In addition, a test of geological knowledge is performed (at a basic and secondary level); I take part in preparing questions for this test.

As a curator of the Geological Museum in the Holy Cross Branch of the PGI-NRI since 2014, I also conduct museum lessons for primary and secondary school pupils, as well as geology and geography students (Mader, 2016; Mader, Bąk, 2019). In addition, I have participated in the summary of the educational project ‘ABC of a young geologist’, conducted by K. Pabian at the Primary School in Kowala (Pabian et al., 2017b).

I try to popularize geology and geological objects in various forms: through publications (Fijałkowska, Fijałkowski, 1995; Fijałkowska-Mader, Fijałkowski, 2012; Pabian et al., 2017a; Urban, Fijałkowska-Mader, 2018; Złonkiewicz, Mader, 2018), participation in picnics (geological picnic in Bałtów in 2010, V–VII Geological Picnic in Sitkówka-Nowiny in 2012–2014, 22nd and 26th historical picnic ‘Lead melting’ in Tokarnia in 2014 and 2018 with an exhibition entitled: ‘Copper and lead ores in the Holy Cross Mountains’), papers delivered as part of the activities of the Holy Cross Branch of Polish Geological Society, of which I am the president (Pacyna et al., 2016; Złonkiewicz, Mader, 2018; Wawrzyniak et al., 2019), and recently by developing virtual Earth Caches in the Holy Cross Mountains area.

6.2. References not included in chapters 4.1.1

Becker A., Fijałkowska-Mader A., Jasionowski M., 2020. Facies and sedimentary environments of the Lower Triassic of the eastern margin of the Central European Basin (NE Poland). *Geological Quarterly*, 64: 1023-1047. DOI: http://dx.doi.org/10.7306/gq.1566

Dybkjær K., 1991. palynological zonation and palynofacies investigation of the Fjerritslev Formation (Lower Jurassic-basal Middle Jurassic) in the Danish Subbasin. *Geol. Surv. Denmark, DGU Ser. A*, 30: 1-150.
Fijałkowska A., 1988a. Miospory w profilu wiertniczym Skarżysko-Kamienna IG1. *Kwart. Geol.,* 32: 510-511.
Fijałkowska A., 1988b. Wyniki badań sporowo-pyłkowych w profilu wiertniczym Mniszków IG1. *Kwart. Geol.,* 32: 751.
Fijałkowska A., 1995a. Wyniki badań mikrosporowych w osadach dewonu z otworów Tarczek 1A, Tarczek 1 i Tarczek 2 (region łysogórski Gór Świętokrzyskich). W: Malec J. (red.): Korelacje litostratygraficzne, biostratygraficzne i geochemiczne utworów dewonu w Górach Świętokrzyskich. Nar. Arch. Geol., Warszawa, s. 124-131. (NAG Warszawa nr inw. 1330/96)
Fijałkowska A., 1995b. Palynostratigraphy of the Zechstein in the North Sudetic Trough. *Geol. Quart.,* 39: 207-228.
Fijałkowska A., 1995c. Stop 17. Collection of microflora from the Zechstein deposits of the Góry Świętokrzyskie Mountains. *W:* Dybova-Jachowicz S., Fijałkowska A., Hemza P., Kabratova J., Kmiecik H., Knafel S., Kotasowa A., Lipiarski I., Migier T., Musiał Ł., Purkyñova E., Řehoř F., Siweniak-Madej A., Soboń-Podgórska J., Tabor M., Takla G., Tomaś A., Trzepierczyńska A., Turnau E., Zdebska D., Żołdani E.,(red.), Paleontology of the Carboniferous and Permian of the Upper Silesian Coal Basin and the Lublin Coal Basin. Guide to Excursion A4. 13 Inter. Cogr. Carbon-Permian, Aug. 28-Sept. 2, 1995, Kraków. Państw. Inst. Geologiczny, Warszawa, s. 43-44.
Fijałkowska A., 1996. Badania mikroflorystyczne osadów górnego zigenu i emsu w S części Gór Świętokrzyskich ze szczególnym uwzględnieniem problemu granicy między emsem dolnym i górnym. NAG Warszawa, s. 85. NAG Warszawa (nr inw. 86903)
Fijałkowska A., 2006a. Badania palinostratygraficzne permu, triasu i jury. W: Kowalczewski Z. (red.), Opoczno PIG 2. *Prof. Głęb. Otw. Wiertn. Państw. Inst. Geol.,* 111: 59-62. (wersja elektroniczna)
Fijałkowska A., 2006b. Badania palinostratygraficzne permu, triasu i jury. W: Kowalczewski Z. (red.), Ostałów PIG 2. *Prof. Głęb. Otw. Wiertn. Państw. Inst. Geol.,* 112: 63-65. (wersja elektroniczna)
Fijałkowska A., Fijałkowska E., 1994. Surowce skalne użyte przy budowie średniowiecznych (XII?-XVw) zamków w regionie świętokrzyskim. *W:* Skoczylas J. (red.), Użytkowanie surowców skalnych w początkach państwa polskiego. Wyd. UAM Poznań, s. 9-35.
Fijałkowska A., Peryt T.M., 1995. Cykl PZ2 w cechsztynie niecki północnosudeckiej. *Prz. Geol.,* 40, 1: 31-34.
Fijałkowska A., Fijałkowski J., 1995. Occurrence of decorative flints in the Holy Cross Mountains. 7th International Flint Symposium, Warszawa-Ostrowiec Świętokrzyski, 4-8 September, 1995. Proceedings: 71-73.
Fijałkowska A., Rospondek M, Lewandowska A., 1993. The origin of organic matter in Lower Silesian copper-bearing shales. *Ann. Soc. Geol. Pol.,* 63: 85-99.
Fijałkowska A., Uchman A., 1993 Nowe dane do palinostratygrafii triasu Tatr Polskich. *Przegląd Geologiczny*, 41, 5: 373-375
Fijałkowska-Mader A., 2000. Załącznik tekstowy 1. Palinostratygrafia osadów permu i triasu w północnej części Niecki Nidy. W*:* Kuleta M, Zbroja S., Iwanow A., Kiersnowski H. (red), Ropo- i gazonośność osadów permu i triasu w północnej części niecki nidziańskiej, s. 22. NAG Warszawa (nr inw. 60/2002, 142/2005)
Fijałkowska-Mader A., 2010. Stop 2. Kajetanów – The Lower Zechstein black limestones. Stop 11. Czerwona Góra – The Upper Permian conglomerates.*W:* Oliwkiewicz-Miklasińska M., Łaptaś A., Trela W., Stempień-Sałek M., Masiak M. (red.), CIMP Poland 2010 General Meeting, September 16th-19th Guidebook of the Holy Cross Mountains field trip. Instyt Nauk geologicznych PAN, Warszawa.
Fijałkowska-Mader A., 2011. Palinostratygrafia i palinofacje utworów cechsztynu w Polsce. W Trela W., Salwa S. Fijałkowska-Mader A. (red.), 6 Świętokrzyskie Spotkania Geologiczno-Geomorfologiczne, Ameliówka k. Kielc, 17-18 maja 2011. Mat. Konfer.: 24-29. Państw. Inst. Geol. – Państw. Inst. Bad., Odd. Świętokrzyski, Kielce.
Fijałkowska-Mader A., 2018a. Wstęp. W: Fijałkowska-Mader A. (red.), Nieświń PIG 1. *Prof. Głęb. Otw. Wiertn. Państw. Inst. Geol.*, 151: 7-9.

Fijałkowska-Mader A., 2018b. Wyniki badań palinologicznych. W: Fijałkowska-Mader A. (red.), Nieświń PIG 1. *Prof. Głęb. Otw. Wiertn. Państw. Inst. Geol.*, 151: 121-132.

Fijałkowska-Mader A., 2020a. Chapter 3. Impact of the Environmental Stress on the Late Permian Pollen Grains from Zechstein Deposits of Poland. *In:* Guex J., Torday J.S., Miller W.B. (eds.), Morphogenesis, Environmental Stress and Reverse Evolution, Springer Nature, New York, p. 23-35

Fijałkowska-Mader A., 2020b. Zastosowanie wskaźnika TAI (Thermal Alteration Index) i analizy palinologicznej do określenia stopnia dojrzałości termicznej materii organicznej w utworach górnego permu i triasu w północnej części niecki nidziańskiej. *Nafta i Gaz,* 2020, 8: 495-500. DOI: 10.18668/NG.2020.08.01

Fijałkowska-Mader A., Durkowski K., Sokalski D., 2018. Palynological and lithological implications for Zechstein stratigraphy in the marginal part of the North-Sudetic Synclinorium (Lower Silesia, southwestern Poland). *Zeit. Deutsch. Gesell. Geowiss. (German Journ. Geol.),* 169: 495-515.

Fijałkowska-Mader A., Fijałkowski J., 2012. Kamienie dekoracyjne z Gór Świętokrzyskich. W: A. Predygier (red.), Kielecki Festiwal Nauki, 15-20 września 2010. Prezentacje festiwalowe: 47-49. Wyd. Uniw. Jana Kochanowskiego, Kielce.

Fijałkowska-Mader A., Malec J., 2011. Biostratigraphy of the Emsian to Eifelian in the Holy Cross Mountains (Poland). *Geol. Quart.*, 55: 109-138.

Fijałkowska-Mader A., Malec J., 2013. Waloryzacja geostanowisk na obszarze projektowanego Geoparku Łysogórskiego w Górach Świętokrzyskich. *Prz. Geol.*, 61: 165-171.

Fijałkowska-Mader A., Malec J., 2018. Wiek dolnodewońskiego poziomu tufitowego z Barczy (Góry Świętokrzyskie) na podstawie miospor. *Prz. Geol.* ,66: 578-584.

Fijałkowska-Mader A., Malec J., Tarnowska M., Turnau E., 1997. Stratygrafia dolnego dewonu w rejnie Bodzentyna – region łysogórski Gór Świętokrzyskich. *Pos. Nauk. PIG,* 53: 122-125.

Fijałkowska-Mader A., Pabian G., Król P., 2018. Ośrodek Tradycji Garncarstwa w Chałupkach (Góry Świętokrzyskie) jako obiekt geoturystyczny. *Geotourism*, 54-55: 27-36.

Fijałkowska-Mader **A.,** Paszkowski M., 2016. Palynostratigraphy of the Połomia Formation (Southern Poland). W: Szydło A., Krobicki M., Granoszewski W. (red.), 17th Czech-Slovak-Polish Palaeontological Conference, Kraków, 20-21 October 2016, Abstract Volume: 38, Państw. Inst. Geol. – Państw. Inst. Bad., Warszawa, s. 38.

Fijałkowska-Mader A., Pieńkowski G., Salwa S., Szczepanik Z., Złonkiewicz Z., Krzeczyńska M., Pochocka-Szwarc J., Rychel J., Skurczyńska-Garwolińska K., Szrek P., Świło M., Woźniak P., 2018. Projekt PIG-PIB "Zrozumieć Ziemię" – wsparcie dla edukacja geologicznej w szkołach. Kongres Surowcowy 20-23.11-2018, Rytro koło Nowego Sącza, V Konferencja: Złoża kopalin – aktualne problem prac poszukiwawczych, badawczych i dokumentacyjnych, Zeszyt streszczeń 2: 18-19, Wyd. PIG-PIB, Warszawa.

Fijałkowska-Mader A., Poros M., 2011. Dziedzictwo górnicze na obszarze projektowanego Geoparku Chęcińsko-Kieleckiego – inspiracja dla lokalnych inicjatyw i produktów turystycznych. Ogólnopolska Konferencja Naukowa pt: „Geoparki-Georóżnorodność-Geoturystyka", Lublin, 6-8 czerwca 2011. Streszczenia: 25-26.

Fijałkowska-Mader A., Szulc J., 2015. Litho- and palynofacies in the Keuper deposits from Upper Silesia and their environmental implications. 31st IAS Meeting of Sedimentology, 22-25.06.2015. Kraków; http://ims2015.exordo.com; Paper ID 1177.

Fijałkowska-Mader A., Wawrzyniak Z., 2019. The Early Triassic plant assemblage from Pałęgi (Holy Cross Mts., Poland). W: Żylińska A. (red.) 20th Czech-Polish-Slovak Palaeontological Conferecnce, Chęciny, 20-23 October 2019, Abstracts: 22. Wyd. UW Warszawa.

Fijałkowska-Mader A., Złonkiewicz Z., 2019. Sesja terenowa. Uwarunkowania strukturalne, tektoniczne oraz litologiczne rozwoju dolin i grzbietów obszaru trzonu paleozoicznego, a także ewolucji skałek piaskowcowych północnego obrzeżenia Gór Świętokrzyskich. Stanowiska 2.3-2.6. Litostratygrafia dolnego triasu oraz dolnej jury. *W:* Urban J. (red.), Rzeźba strukturalna Gór Świętokrzyskich i Ponidzia – stan badań i perspektywy badawcze. 7 Warsztaty Geomorfologii Strukturalnej, Chęciny 26-28.09.2019, s. 86-89. Wyd. UJK, Kielce.

Fijałkowska-Mader A., Złonkiewicz Z., Król P., 2019. Kamień w architekturze zabytkowej Szydłowa (województwo świętokrzyskie). *Prz. Geol.,* 67: 736-748.

Foster C.B., Afonin S.A., 2006. *Syndesmorion*gen. nov. – A coenobial alga of Chlorococcalean affinity from the Continental Permian-Triassic deposits of Dalangkou section, Xinjiang Province, China. *Rev. Palaeobot. Palynol.,* 138: 1-8.

Jurkiewicz H., 1974. Rozwój triasu na obszarze centralnej części Niecki Nidziańskiej. *Kwart. Geol.,* 18: 90-108.

Kopik J., 1970. Retyk. W: Stratygrafia mezozoiku obrzeżenia Gór Świętokrzyskich. *Pr. Inst. Geol.,* 56: 49-63.

Kowalczewski Z., Rup. M., 1989. Cechsztyn w Górach Świętokrzyskich. *Biul. Państw. Inst. Geol.,* 3632: 5-39.

Król P., Pabian G., Fijałkowska-Mader A., 2019. Zarys historii górnictwa skalnego w rejonie Sitkówki (Góry Świętokrzyskie) w I połowie XX w. *Prz. Geol.,* 67: 758-766.

Król P., Kozak B., Fijałkowska-Mader A., 2020. Historia eksploatacji piaskowców dolnodewońskich na górze Barczy", *Studia Muzealno-Historyczne,* 12: 119-161

Kuleta, M. , Zbroja, S. 2006. Wczesny etap rozwoju pokrywy permsko-mezozoicznej Gór Świętokrzyskich. W: Skompski S., Żylińska, A. (red.), Procesy i Zdarzenia w Historii Geologicznej Gór Świętokrzyskich. 77 Zjazd Naukowy PTG, Ameliówka k. Kielc, 28-30 czerwca 2006 r. Mat. konger: 105–125. Państw. Inst. Geol., Warszawa.

Lund J.J., 1977. Rhaetic to Lower Liassic palynology of the onshore south-eastern North Sea Basin. *Geol. Surv. Denmark, II Ser.,* 109: 1-129.

Łajczak A., Fijałkowska-Mader A., Urban J., Zieliński A. (red.), 2013. Georóżnorodność Ponidzia. Instytut Geografii Uniwersytetu Jaka Kochanowskiego, Kielce. ISBN 987-83-60026-45-8

Mader A., 2016. Działalność Muzeum Geologicznego w Oddziale Świętokrzyskim Państwowego Instytutu Geologicznego-Państwowego Instytutu Badawczego w Kielcach. W: Wojewoda J. (red.), 3 Polski Kongres Geologiczny, Wrocław, 14-16 września, 2016. Wyzwania polskiej geologii. Tom kongresowy: 229. Wyd. Polskie Towarzystwo Geologiczne, ISBN 978-83-942304-2-5. (poster)

Mader A., Bąk E., 2019. Walory edukacyjne Muzeum Geologicznego przy Oddziale Świętokrzyskim Państwowego Instytutu Geologicznego-PIG w Kielcach. W: Geoprodukt. 5 Ogólnopolskie Forum, Popularyzacja geoturystyki, 12 września 2019 r., Zabrze, s. 10-11.

Mader A., Malec J., 2012. Koncepcja funkcjonowania Geoparku Łysogórskiego w Górach Świętokrzyskich. W: Mizerski W., Żbikowska B. (red.), 2 Polski Kongres Geologiczny, Warszawa, 17-19 września, 2012. Abstrakty: 53. Wyd. Państw. Inst. Geol. – Państw. Inst. Bad., Warszawa.

Mader A., Malec J., Wojtyna H., Szrek P., 2013. Koncepcja funkcjonowania Geoparku Łysogórskiego w Górach Świętokrzyskich. NAG Kielce. (nr inw. 2080)

Mader A., Wojtyna H., Szrek D., 2011. Walory geoedukacyjne i geoturystyczne obrzeżenia mezozoicznego Gór Świętokrzyskich między Skarżyskiem a Ostrowcem Świętokrzyskim – projekt Geoparku Dolina Kamiennej. NAG Kielce (nr inw. 1831)

Marcinkiewicz T., Fijałkowska-Mader A., Pieńkowski G., 2014. Poziomy megasporowe epikontynentalnych utworów triasu i jury w Polsce – podsumowanie. *Biul. Państw. Inst. Geol.,* 457: 15-42.

Pabian G., Fijałkowska-Mader A., Urban J., 2017a. Rewitalizacja terenu pogórniczego na przykładzie kamieniołomu Szewce w Górach Świętokrzyskich. *W:* Jawecki B., Tarka R. (red.), Geo-produkt, od geoedukacji do innowacji. Materiały 3 Forum Geo-produkt, Wojsławice 22-24.09.2017., Wyd. Ocean, Wrocław, s. 65-74.

Pabian K., Pabian G., Fijałkowska-Mader A., 2017b. Innowacja pedagogiczna „ABC młodego geologa" jako forma geoedukacji w szkole podstawowej (Kowala, Góry Świętokrzyskie). *W:* Jawecki B., Tarka R. (red.), Geo-produkt, od geoedukacji do innowacji. Materiały 3 Forum Geo-produkt, Wojsławice 22-24.09.2017., Wyd. Ocean, Wrocław, s. 75-83.

Pacyna G., Barbacka M., Zdebska D., Ziaja J., Fijałkowska-Mader A., Bóka K., Sulej T. Nowa, późno triasowa roślina szpilkowa z patoki. Ziarna pyłku *in situ* i w osadzie – tajemnica rodzaju *Enzonalasporites.* Paper delivered on 28.09.2016.

Paul J., 2020. Klima Und Klima-Zyklen im Zechstein. W: Paul J., Heggemann H. (red.), Stratigraphie von Deutschland XII. Zechstein. *Schr. – R. Dt. Ges. Geowiss (ZDGG),* 89: 145-152.

Pieńkowski G., 2004. Najciekawsze treści geologiczne obszaru Doliny Kamiennej i koncepcja utworzenia geoparku. W: Od Ekomuzeum Aglomeracji Staropolskiej do Geoparku Doliny Kamiennej. Materiały Konferencji Starachowice 4–5 czerwca 2004. Wyd. P.U. Campus, s. 50–56.

Pieńkowski G., 2008. The Kamienna Valley Geopark – more than dinosaurs. *Prz. Geol*., 56: 629-638.

Pieńkowski G., 2009. Geopark „Dolina Kamiennej". W: Trela W., Złonkiewicz Z. (red.), Perspektywy rozwoju geoparków w regionie świętokrzyskim, Kielce: 27–30.

Pieńkowski G., Cwojdziński S., Fijałkowska-Mader A., Krzeczyńska M., Krzywicki T., Malec J., Pacuła J., Pochocka-Szwarc K., Rychel J., Salwa S., Szczepanik Z., Szrek P., Wierzbowski A., Woźniak P., Złonkiewicz Z., 2013a. Zrozumieć Ziemię. Konspekt lekcyjno-ćwiczeniowy z wprowadzeniem do wycieczek. pomoc dydaktyczna dla nauczycieli geografii szkół gimnazjalnych i ponadgimnazjalnych. Wyd. PIG-PIB Warszawa, pp. 246.

Pieńkowski G., Cwojdziński S., Fijałkowska-Mader A., Krzeczyńska M., Krzywicki T., Malec J., Pacuła J., Pochocka-Szwarc K., Rychel J., Salwa S., Szczepanik Z., Szrek P., Wierzbowski A., Woźniak P., Złonkiewicz Z., 2013b. Georóżnorodność naszego kraju. Przewodnik wycieczkowy (płyta DVD). Wyd. PIG-PIB Warszawa, pp. 388.

Pieńkowski G., Mader A**.** 2010. The Kamienna Valley Geopark (Holy Cross Mts., Poland) – a unique geoeducational area. 9th European Geoparks Conference 2010 Lesvos Island, Greece, 1-5 October, 2010. Abstracts: 127.

Pieńkowski G., niedźwiedzki G., Brański P., 2014. Climatic reversals related to the Central Atlantic mamgatic province caused the end-Triassic biotic crisis – evidence from Continental strata in Poland. Geol. Soc. Amer. Spec Pap., 505: 263-286

Racki G., Szulc J., 2015. The bone-bearing Upper Triassic of Upper Silesia, southern Poland: integrated stratigraphy, facies and events – introductory remarks. *Ann. Soc. Geol. Pol.,* 85: 553-556.

Raczyński P., 1997. Warunki sedymentacji osadów cechsztynu w niecce północnosudeckiej. *Prz. Geol.,* 45: 693-699.

Raczyński P., Kurowski L., Mastalerz K., 1998. Litostratygrafia i ewolucja basenu północnosudeckiego na przełomie paleozoiku i mezozoiku. Wycieczka 2. W: Wojewoda J. (red.), Ekologiczne aspekty sedymentologii. Mat. 7 Kraj. Spotkań Sedyment., Wojcieszów, 2-4 lipiec, 19887, T. 1: 75-100. WIND, Wrocław.

Rubinowski Z., Wróblerwski T., Nowak M., Gągol J., 1996. Funkcjonowanie Chęcińsko-Kieleckiego Geologicznego Parku Krajobrazowego w systemie obszarów chronionych w Górach swiętokrzyskich. Mat. 8 Konf. Sozologicznej, Kielce, 16-17 maj 1996. Kielce.

Streel M., Higgs K., Loboziak S., Riegel W., Steemans Ph., 1987. Spore stratigraphy and correlation with faunas and floras in the type marine Devonian of the Ardenne-Rhenisch regions. *Rev. Palaeobot. Palynol.,* 50: 211-229.

Szulc J., Becker A., Mader A., 2015. Perm i trias – nowe otwarcie Gór Świętokrzyskich. 84 Zjazd Naukowy PTG, Chęciny, 9-11. 09. 2015 r. Materiały: 11-27 Wyd. PIG-PIB, Warszawa.

Szulc J., Racki G., Jewuła K., Środoń J., 2015. How many Upper Triassic bone-bearing levels are ther in Upper Silesia (southern Poland)? A critical overview of stratigraphy and facies. *Ann. Soc. Geol. Pol.,* 85: 557-626.

Tarnowska M., 1999. Schemat dewońskiego wulkanizmu piroklastycznego w Górach Świętokrzyskich. W: 10 Konferencja sozologiczna, Geologia i sozologia w regionie świętokrzyskim. Oddział Świętokrzyski I Sekcja Sozologiczna PTG, Oddział Świętokrzyski PIG, Kielce, 20 października 1999, s. 43-54.

Trela W., Fijałkowska-Mader A., 2013. Geoparki na horyzoncie. *Sur. i maszyny budowl.,* 562: 92-96.

Trela W., Fijałkowska-Mader A., 2017. Paleogleby w zapisie sedymentacyjnym formacji z Siodeł w Górach Świętokrzyskich (perm górny-trias dolny). *Prz. Geol*., 65: 227-233.

Trela W., Mader A., Złonkiewicz Z., Czajkowska E., Poros M. 2010. Inicjatywa powołania Geoparku Chęcińsko-Kieleckiego – wstępne założenia i koncepcja. Sympozjum popularno-naukowe pt: "Zagospodarowanie geoturystyczne okolic Miedzianki – perspektywy, możliwości i koncepcje", Miedzianka k. Chęcin 4. 09. 2010. Streszczenia: 7.

Turnau E., Fijałkowska-Mader A., Filipiak P., Stempień-Sałek M., 2003. Miospory. W*:* Malinowska L. (red.), Budowa geologiczna Polski t. III. Atlas skamieniałości przewodnich i charakterystycznych. cz. 1b, z. 1, Dewon: 623-678, Państw. Inst. Geol., Warszawa.

Urban J., Fijałkowska-Mader A., 2018. Brama Piekło oczami (nie tylko) geologów. *Skarżyskie Zeszyty Ligi Ochrony Przyrody*, Zeszyt 16. Piękne, rzadkie i chronione, część VII. Wyd. Powiat Skarżyski, Skarżysko-Kamienna: 98–105.

Urban J., Fijałkowska-Mader A., 2019. Sesja terenowa. Główne cechy rzeźby strukturalnej Gór Świętokrzyskich. Stanowisko 1.1. Chęciny, zamek: rzeźba strukturalna południowo-zachodniej części Gór Świętokrzyskich widziana z wież chęcińskiego zamku. *W:* Urban J. (red.), Rzeźba strukturalna Gór Świętokrzyskich i Ponidzia – stan badań i perspektywy badawcze. 7 Warsztaty Geomorfologii Strukturalnej, Chęciny 26-28.09.2019, s. 63-73. Wyd. UJK, Kielce.

Urban J., Fijałkowska-Mader A., Malec J., 2020. Waloryzacja dziedzictwa geologicznego oraz ocena potencjału turystycznego. W: Buchholz L., Jóźwiak M., Reklewski J., Szczepaniak P. (red.), Świętokrzyski Park Narodowy. Przyroda i Człowiek, s. 171-175. Świętokrzyski Park Narodowy – Uniwersytet Jana Kochanowskiego, Bodzentyn – Kielce.

Wagner R., 1986. Problemy formalnej litostratygrafii cyklotemów ewaporatowych na przykładzie cechsztynu. *Prz. Geol.*, 35: 250-254.

Wagner R., 1994. Stratygrafia osadów i rozwój basenu cechsztyńskiego na Niżu Polskim. *Pr. Państw. Inst. Geol.*, 146: 1-71.

Wawrzyniak Z., Kustatscher E., Mader A., Filipiak P. Zapis wczesnotriasowego ekosystemu lądowego w gliniance Pałęgi koło Mniowa. Paper delivered on 27.11.2019.

Złonkiewicz Z., Fijałkowska-Mader A., 2018. Kamień w architekturze zespołu kościelno-klasztornego na Karczówce w Kielcach (Góry Świętokrzyskie). *Prz. Geol*., 66: 421-435.

Złonkiewicz Z., Mader A., 2018. Walory geoedukacyjne kamieniołomu Zachełmie w Górach Świętokrzyskich (Polska Południowa). *Geotourism*, 54-55: 11-26.

Złonkiewicz Z., Mader A. Kamieniarka zespołu klasztorno-kościelnego na Karczówce w Kielcach. Paper delivered on 21.03.2018.

7. Apart from information set out in 1-6 above, the applicant may include other information about his/her professional career, which he/she deems important

7.1. Scholarships and awards

1991: Three-month research scholarship at the Laboratory of Palaeobotany and Palynology at the University of Utrecht (The Netherlands);

1994: Monthly research scholarship at the Institute of Geology, University of Göttingen (Germany);

1994: State award for young Polish scientists and research grant from the Foundation for the Development of Polish Science;

2015: Award of the Director of PGI-NRI for the best article in 'Geological Quarterly' for 2015;

2017: Badge of honor 'Meritorious for Polish geology'.

7.2. Review of articles

I have acted as the reviewer of numerous scientific articles both in the field of palynology (*Review of Palaeobotany and Palynology, Acta Palaeobotanica, Journal of the Palaeontological Society of India, German Journal of Geosciences, Annales Societatis Geologorum Poloniae, Biuletyn Państwowego Instytutu Geologicznego*) and the use of rock raw materials in historical and contemporary buildings (*Przegląd Geologiczny)*, as well as Poland's geodiversity and its popularization (*Geotourism, Przegląd Geologiczny*, geoeducation and geotourism (*Geoheritage, Przegląd Geologiczny*).

……Anna Mader……

(Applicant's signature)

App. 1.

No. Location		Number of assemblages	PPC	Analyzes SEG	PCA
NIDA BASIN					
1. Biała wielka IG 1		3	3	3	0
2. Brzegi IG 1		5	5	5	0
3. Gidle 2		3	3	3	0
4. Gomunice 13		2	2	2	0
5. Gomunice 15		2	2	2	0
6. Jaronowice IG 1		2	2	2	0
7. Jędrzejów IG 1		4	4	4	0
8. Książ Wielki IG 1		1	1	1	0
9. Milianów IG 1		7	7	7	0
10. Pągów IG 1		6	6	6	0
11. Potok Mały IG 1		3	3	3	0
12. Secemin IG 1		1	1	1	0
13. Węgleszyn IG 1		3	3	3	1
14. Włoszczowa IG 1		7	7	7	1
15. Zamoście IG 1		2	2	2	0
HOLY CROSS MTS					
16. Boża Wola IG 1		4	4	4	2
17. Cierchy IG 1		1	1	1	0
18. Eugeniów-Korytków IG 1		4	4	4	1
19. Goleniawy IG 1		1	1	1	0
20. Mniszków IG 1		4	4	4	1
21. Momina *		1	1	1	0
22. Nieświń PIG 1		7	7	7	3
23. Oblęgor PIG 1		1	1	1	0
24. Opoczno PIG 2		13	13	13	2
25. Ostałów PIG 2		8	8	8	3
26. Promnik IG 1		2	2	2	0
27. Radwanów IG 1		6	6	6	0
28. Studzianna IG 2		3	3	3	0
FORE-SUDETIC MONOCLINE					
29. Bronków M 27		1	1	1	0
30. Dachów M 24		1	1	1	0
31. Dychów M 26		1	1	0	0
32. Jasień P 4		1	1	0	0
33. Kosierz M 25		1	1	1	0
34. Lubiatów M 20		1	1	1	0
35. Łazy P 7		1	1	0	0
36. Nowa Wieś P 1		1	1	1	0
37. Otyń IG 1		1	1	1	0
NE POLAND					
38. Bartoszyce IG 1		3	3	3	0
39. Marianka IG 1	a	4	4	4	0
40. Morski Las IG 2	a	1	1	1	0
41. Ptaszkowo IG 3	a	3	3	3	0
42. Przylesie	a	1	1	1	0
43. Nidzica IG 1	a	1	1	1	1
44. Płońsk IG 2	a	2	2	2	2

No. Location	Number of assemblages		Analyzes PPC	SEG	PCA
45. Raducz IG 1	a	1	1	1	0
NW POLAND					
46. Bobolice 3	a	1	1	1	1
47. Czaplinek IG 2	a	1	1	1	0
48. Jamno IG 2	a	1	1	1	0
49. Kamień Pom. IG 1	a	1	1	1	0
50. Połczyn IG 1	a	1	1	1	0
W POLAND					
51. Drawno GEO 2	a	1	1	1	0
52. Gorzów Wlkp. IG 1	a	1	1	1	0
53. Książ IG 2	a	1	1	1	1
54. Łagów Lub. IG 1	a	1	1	1	0
55. Międzychód IG 1	a	1	1	1	0
56. Ośno IG 1	a	1	1	1	1
57. Ośno IG 2	a	2	2	2	2
58. Sulechów IG 1	a	3	3	1	3
59. Środa IG 2	a	3	3	3	0
60. Wągrowiec IG 1	a	3	3	3	3
61. Wielichowo IG 1	a	1	1	1	0
62. Zbąszynek IG 1	a	2	2	2	0
S POLAND					
63. Odra 1	a	1	1	1	0
64. Odra 3	a	3	3	3	3
65. Wieluń KW 1	a	3	3	3	3
66. Wołczyn IG 1	a	1	1	1	0
67. Św. Anna*		1	1	1	0
UPPER SILESIA					
68. BPH 142	a	1	1	1	0
69. N 216	a	1	1	1	0
70. WB 12	a	1	1	1	0
71. Woźniki K 1		3	3	0	3
72. Zł 7 4	a	1	1	1	0
73. ZM 6 6	a	1	1	1	0
sum:		**173**	**173**	**165**	**37**

71 boreholes
2 outcrops

* - outcrops
a - assemblages analyzed on the basis of T. Orłowska-Zwolińska' collections stored in the Geological Museum of the Polish Geological Institute-NRI in Warsaw

App. 2. Botanical affinity of miospore genera

Genus	Mother plants
SPORES:	
Acanthotriletes	Paprocie zarodnikowe incerte sedis: *Sphenopteris* (Balme, 1995)
Anapiculatisporites	Widłaki różnozarodnikowe: poryblinowce: *Isoetites* (Balme, 1995; Kustatscher i in., 2012)
Apiculatisporites	Paprocie zarodnikowe: Marattiaceae (Balme, 1995)
Aratrisporites	Widłaki różnozarodnikowe: poryblinowce: *Isoetites*, pleuromejowce: *Cyclostrobus;* widliczki: *Selaginellites* (Helby i Martin, 1965; Grauvogel-Stamm, 1978; Grauvogel-Stamm i Duringer, 1983; Orłowska-Zwolińska, 1979, 1983; Mader, 1990, 1997; Ruckwied, 2009; Kürschner i Herngreen, 2010; Kustatscher i in., 2012)
Asseretospora	Widłaki różnozarodnikowe: poryblinowce: *Isoetites* (Visscher i in., 1994)
Baculatisporites	Paprocie zarodnikowe: Dipteridaceae: *Thaumatopteris* (Balme, 1995; Van Konijnenburg-Van Cittert, 2002)
Calamospora	Skrzypy: *Neocalamites* (Orłowska-Zwolińska, 1979; Kelber i Van Konijnenburg-Van Cittert, 1998)
Camarozonosporites	Widłaki jednakozarodnikowe: widłakowce: *Lycopodites* (Orłowska-Zwolińska, 1979)
Carnisporites	Paprocie zarodnikowe: Schizeaceae (Roghi, 2004)
Conbaculatisporites	Paprocie zarodnikowe: Dipteridaceae: *Thaumatopteris* (Pedersen i Lund, 1980; Roghi, 2004)
Concavisporites	Paprocie zarodnikowe: Dicksoniaceae, Mationiaceae: *Phlebopteris* (Balme, 1995; Kustatscher i in., 2012), Matoniaceae (Van Konijnenburg-Van Cittert, 1993; Roghi, 2004),
Concentricisporites	Paprocie zarodnikowe (Kustatscher i in., 2010)
Converrusosisporites	Paprocie zarodnikowe: Marattiaceae: *Rhinipteris* (Roghi, 2004)
Convolutispora	Paprocie zarodnikowe (Roghi, 2004)
Corrugatisporites	Paprocie zarodnikowe (Roghi, 2004)
Cyclotriletes	Paprocie zarodnikowe: Osmundaceae: *Neuropteris* (Mädler, 1964; Orłowska-Zwolińska, 1979, 1983)
Cycloverrutriletes	Paprocie zarodnikowe: Osmundaceae: *Neuropteris* (Orłowska-Zwolińska, 1979)
Deltoidospora (Cyathidites)	Paprocie zarodnikowe: Cyathaeacae, (Douglas, 1973; Van Konijnenburg-Van Cittert, 1989, 1993; Balme, 1995)
Densoisporites	Widłaki różnozarodnikowe: pleuromejowce: *Pleuromeia*, widliczki: *Selaginellites* (Knox, 1950; Lundblad, 1950, Yaroshenko, 1975; Orłowska-Zwolińska, 1979; Meyen, 1987; Looy i in., 1999, 2005)
Densosporites	Widłaki różnozarodnikowe: widliczki: *Selaginellites* (Balme, 1995)
Dictyophyllidites	Paprocie zarodnikowe: Dipteridaceae: *Dictyophyllum,* Matoniaceae: *Matonia* (Van Konijnen Van Cittert, 1989,1993; Balme, 1995; Barbacka i in., 2016)
Echinitosporites	Paprocie zarodnikowe incerte sedis: *Chiropteris* (Scheuring, 1970)
Endosporites	Widłaki (Kürschner i Waldemaar Herngreen, 2010): Selaginellaceae (Looy i in., 1999)
Equisetumsporites	Skrzypy: *Equisetites* (Balme, 1995)
Gleicheniidites	Paprocie zarodnikowe: Gleicheniaceae: *Gleichenia* (Potonié, 1967)
Heliosporites	Widłaki różnozarodnikowe: Selaginellaceae (Orłowska-Zwolińska, 1979)
Kraeuselisporites	Widłaki różnozarodnikowe: Selaginellaceae (Balme, 1995; Roghi, 2004; Kürschner i Herngreen, 2010; Kustatchser i in., 2012)
Laevigatisporites	Widłaki różnozarodnikowe: Selaginellaceae (Balme, 1995)
Laevigatosporites	Skrzypy: *Bowmanites* (Balme, 1995)
Leschikisporis	Paprocie zarodnikowe: Marattiaceae: *Danaeopsis* (Orłowska-Zwolińska, 1983; Balme, 1995)
Lundbladispora	Widłaki różnozarodnikowe: Selaginellaceae (Yaroshenko, 1975; Orłowska-Zwolińska, 1979; Kürschner i Herngreen, 2010; Looy i in., 2005)
Lycopodiacidites	Widłaki jednakozarodnikowe: *Lycopodites* (Filatoff, 1975; Abbink, 1998)
Lycopodiumsporites	Widłaki jednakozarodnikowe: *Lycopodium* (Filatoff, 1975)
Lycospora	Widłaki: Lepidocarpaceae (Balme, 1995)
Marattisporites	Paprocie zarodnikowe: Marattiaceae: *Marattiopsis* (Orłowska-Zwolińska, 1983)
Nevesisporites	Widłaki różnozarodnikowe: Selaginellaceae (Kustatscher i in., 2010),
Osmundacidites	Paprocie zarodnikowe: Osmundaceae: *Osmundopsis* (Van Konijnenburg-Van Cittert, 1978; Balme, 1995; Kustatscher i in., 2012)
Polypodiumsporites	Paprocie zarodnikowe: Polypodiaceae (Balme, 1995)
Porcellispora	Mchy (Mader, 1997; Reinhardt i Ricken, 2000; Roghi, 2004)
Puntatisporites	Paprocie zarodnikowe: Osmundaceae: *Neuropteris* (Grauvogel-Stamm i Grauvogel, 1980)

Reticulatisporites	Paprocie zarodnikowe: Dipteridaceae (Roghi, 2004)
Sphagnumsporites	Mchy (Filatoff, 1975)
Todisporites	Paprocie zarodnikowe: Osmundaceae: *Todites* (Orłowska-Zwolińska, 1983; Balme, 1995), Marattiaceae (Pott i in., 2018)
Toroisporis	Paprocie zarodnikowe: Osmundaceae: *Todites* (Roghi, 2004)
Trachysporites	Paprocie zarodnikowe Osmundaceae (Bonis, 2010), Dipterideceae (Pott i in., 2018)
Uvaesporites	Paprocie zarodnikowe: Osmundaceae: *Cladophlebis* (Roghi, 2004); widłaki: Selaginellaceae (Balme, 1995; Kustatscher i in., 2012), Pleuromeiceae (Looy i in., 2005)
Verrucosisporites	Paprocie zarodnikowe: Marattiaceae (Orłowska-Zwolińska, 1979; Balme, 1995)
Zebrasporites	Paprocie zarodnikowe: Mationiaceae: *Phlebopteris* (Petersen i in., 2013)
POLLEN GRAINS:	
Alisporites	Iglaste: wolcjowe: Ullmaniacae, Podocarpaceae (Grauvogel-Stamm, 1978; Balme, 1995); paprocie nasienne (Jersey de, 1964; Van Konijnenburg-Van Cittert, 1971; Balme, 1995; Reichgelt i in., 2013), Corystospermales (Taylor i in., 2009); miłorzębowe (Larsson, 2009)
Angustisulcites	Iglaste (Kürschner i Herngreen, 2010), wolcjowe (Reichgelt i in., 2013), Aethophyllaceae (Looy i in., 1999)
Araucariacites	Iglaste: Araucariaceae (Roghi, 2004; Reichgelt i in., 2013)
Aulisporites	Sagowcowe (Kräusel et Schaarschmidt, 1966; Balme, 1995; Kustatscher i in., 2012); benetyty (Visscher i in., 1994); skrzypy (Orłowska-Zwolińska, 1983);
Brachysaccus	Iglaste: wolcjowe (Orłowska-Zwolińska, 1979)
Callialasporites	Iglaste: Araucariaceae (Roghi, 2004; Reichgelt i in., 2013)
Camerosporites	Iglaste: Cheirolepidiaceae (Scheuring, 1970; Visscher i in., 1994; Roghi, 2004); paprocie nasienne (Balme, 1995);
Cedripites	Iglaste: Cedraceae; *Cedrus* (Potonié, 1967)
Cerebropollenites	Iglaste: Taxodiaceae: *Taxus* (Larsson, 2009)
Chasmatosporites	Benetyty: *Wielandiella* (Tralau, 1968; Kürschner i in., 2014), miłorzębowe (Balme, 1995)
Classopollis (Corollina)	Iglaste: Cheirolepidiaceae (Van Konijnenburg-Van Cittert, 1987; Balme, 1995)
Cycadopites	Benetyty: *Cycadoides* (Kürschner i in., 2014); sagowce, paprocie nasienne: Peltaspermales (Balme, 1995);
Duplicisporites	Iglaste: Cheirolepidiaceae (Visscher i in., 1994; Roghi, 2004)
Ellipsovelatisporites	Iglaste: *Pelourdea* (Mader, 1997)
Enzonalasporites	Iglaste (Balme, 1995; Visscher i in., 1994; Roghi, 2004), wolcjowe (Reichgelt i in.,2013)
Eucommiidites	Benetyty: *Wielandiella* (Van Konijnenburg-Van Cittert, 1987; Balme, 1995), Erdtmannithecales (Petersen i in., 2013), gniotowce (Pedersen i in., 1989)
Granuloperculatipollis	Iglaste: Cheirolepidiaceae (Orłowska-Zwolińska, 1983; Roghi, 2004)
Heliosaccus	Iglaste: Cheirolepidaceae (Orłowska-Zwolińska, 1979)
Illinites (Succinctisporites)	Iglaste: Utrechtiaceae: *Lebachia* (Orłowska-Zwolińska, 1979, 1983; Balme, 1995), wolcjowe (Grauvogel-Stamm i Grauvogel, 1973; Kustatchser i in., 2012); paprocie nasienne (Kürschner i Herngreen, 2010)
Infernopollenites	Iglaste incerte sedis (Visscher i in., 1994; Roghi, 2004)
Klausipollenites	Iglaste: wolcjowe: Majonicaceae (Potonié, 1967; Reichgelt i in., 2013): *Pseudovoltzia* Visscher, 1971)
Kugelina	Iglaste: Cheirolepidaceae (Balme, 1995)
Labiisporites	Iglaste: wolcjowe (Orłowska-Zwolińska, 1983)
Limitisporites	Iglaste: wolcjowe: *Ullmania* (Balme, 1995)
Lueckisporites	Iglaste: wolcjowe: *Ullmania* (Visscher, 1971); Majonicaceae (Balme, 1995)
Lunatisporites	Iglaste: Podocarpaceae (Clement-Westerhof, 1974; Visscher i in., 1994; Balme, 1995; Roghi, 2004), paprocie nasienne: Peltaspermales, benetyty: *Pterophyllum* (Looy i in., 2005)
Microcachryidites	Iglaste: Podocarpaceae (Balme, 1964, 1995)
Minutosaccus (Protodiploxypinus)	Iglaste (Samoilovich, 1953): Pineaceae lub Podocarpaceae (Scheuring, 1970; Kustatscher i in., 2012), wolcjowe (Kürschner i Herngreen, 2010), paprocie nasienne (Reichgelt i in., 2013)
Monosulcites	Benetyty: *Cycadoides* (Potonié, 1967; Van Konijnenburg-Van Cittert, 1971; Boutler i Windle, 1993), miłorzębowe (Van Konijnenburg-Van Cittert, 1971)
Ovalipollis	Iglaste: wolcjowe (Scheuring, 1976; Orłowska-Zwolińska, 1979; Roghi, 2004)
Parillinites	Iglaste
Partitisporites	Iglaste: Cheirolepidaceae (Orłowska-Zwolińska, 1979, 1983; Visscher i in., 1994; Roghi, 2004)

(Paracirculina)	
Patinasporites	Iglaste: Majoniceaceae (Axsmith i in., 1998, Reichgelt i in., 2013)
Perinopollenites	Iglaste: Taxodiaceae/Cupressaceae (Balme, 1985; Van Konijnenburg-Van Cittert i Van der Burgh, 1989; Van Konijnenburg-Van Cittert 2002; Larsson, 2009)
Platysaccus	Iglaste: Podocarpaceae (Balme, 1995); paprocie nasienne: Corystospermales (Traverse, 1988; Kustatscher i in., 2012)
Podosporites	Iglaste: Podocarpaceae (Orłowska-Zwolińska, 1983; Balme, 1995; Kürschner i Herngreen, 2010; Kustascher i in., 2012; Reichgelt i in., 2013)
Praecirculina	Iglaste: Cheirolepidacae (Cornet, 1977; Visscher i in., 1994; Roghi, 2004; Kürschner i Herngreen, 2010)
Protohaploxypinus	Iglaste (Orłowska-Zwolińska, 1983; Visscher i in., 1994), wolcjowe (Balme, 1995); paprocie nasienne: Peltaspermales: *Permotheca, Tatarina?* (Balme, 1995; Reichgelt i in., 2013); miłorzębowe: Glossopteridales: *Arberiella* (Balme, 1995)
Rhaetipollis	Iglaste (Larsson, 2009)
Riccisporites	Iglaste: Albertiaceae (Rhotwell i in. 2000; Vajda i in., 2013); mchy: Marchanteacae (Lundblad, 1954; Balme, 1995), nagozalążkowe (Orłowska-Zwolińska, 1979, 1983), ?benetyty (Mander i in., 2012; Kürschner i in., 2014)
Spheripollenites	Igalste: Taxodiaceae (Abbink, 1998; Roghi, 2004)
Striatoabietites	Iglaste incerte sedis (Scheuring, 1970; Meyen, 1981, 1987; Visscher i in., 1994), ?paprocie nasienne (Kustatscher i in., 2010)
Striatopodocarpites	Miłorzębowe: Glossopteridales: *Arberiella* (Balme, 1995)
Triadispora	Iglaste: wolcjowe, Albertiaceae: *Albertia* (Grauvogel-Stamm, 1969, 1978; Scheuring, 1976; Orłowska-Zwolińska, 1979, 1983; Balme, 1995; Brugman, 1986; Visscher i in., 1994; Kürschner i Herngreen, 2010; Reichgelt i in., 2013)
Tsugaepollenites	Paprocie nasienne: Peltaspermales (Kürschner i Herngreen, 2010); iglaste: Podocarpaceae (Taylor i in., 2009)
Vallasporites	Iglaste: wolcjowe (Visscher i in., 1994; Roghi, 2004; Reichgelt i in., 2013), paprocie nasienne (Kürschner i Herngreen, 2010)
Vesicaspora	Paprocie nasienne: Peltaspermales (Balme, 1995)
Vitreisporites	Kajtonie: *Sagenopteris* (Van Konijnenburg-Van Cittert, 1971; Balme, 1995; Mander i in., 2014), *Caytonanthus* (Taylor i in., 2009); benetyty (Van Konijnenburg-Van Cittert, 2008)
Voltziacaesporites	Iglaste: wolcjowe (Balme, 1995; Reichgelt i in., 2013), Yuccites (Looy i in., 1999)

Literature not included in the „Summary of Professional Accomplishments"

Balme B.E., 1964. The age of the Wagina Sandstone, Irwin River District, Western Australia. *Austral. Journ. Sci.*, 27: 1-82.

Barbacka M., Pacyna G., Pieńkowski G., Ziaja J., 2016. New data about *Matonia braunii* (Göppert) Harris from the Early Jurassic of Poland and its ecology. *geol. Quart.,* 60: 857-868.

Bonis N.R., 2010. Palaeoenvironmental changes and vegetation history during the Triassic-Jurassic transition. *Lab. Palaeobot. Palynol. Contrib. Ser.*, 29: 1-216.

Boutler M.C., Windle T., 1993. A reconstruction of some Middle Jurassic vegetationin Northern Europe. *Spec. Pap. Palaeont*., 49: 125-154.

Brugman W.M., 1986. A palynological characterization of the Upper Scythian and Anisian of the Transsadanubian Central Range (Hungary) and thr Vincentinian Alps (Italy). PhD Thesis Univ. Utrecht.

Filatoff J., 1975. Jurassic palynology of the Perth Basin, Western Australia. *Palaeontograph. B.*, 154: 1-113.

Grauvogel-Stamm L., 1969. Nouveaux types d`organes reproducteurs mâles de coniferes du Grès á *Voltzia* (Trias inférieur) des Vosges. *Bul. Serv. Carte Geol. d' Alsace et de Lorraine*, 22: 93-120, 355-357

Grauvogel-Stamm L., Duringer J., 1983. *Annalepis zeilleri* Fliche 1910 emend., un organe reproducteur de lycophyte de la Lettenkohle de l'est de la France. Morphologie, spores in situ et paléoécologie. *Geol. Rundsch.,* 72: 23-51.

Grauvogel-Stamm L., Grauvogel L., 1973. *Masculostrobus acuminatus* nom.nov., un nouvel organe reproducteur mâle de gymnosperme du grès á *Voltzia* (Trias inférieur) des Vosges (France). *Geobios*, 6: 101-114.

Grauvogel-Stamm L., Grauvogel L., 1980. Morphologie et anatomie d' *Anomopteris mougetii* Brogniart (synonymie: *Pecopteris sulziana* Brogniart) unefougère du Buntsandstein Supérieur des Vosges (France). *Univ. Louis Pasteur Strasbourg Inst. Géol. Sci. Bull.,* 33: 153-166.

Helby R.J., Martin A.R.H., 1965. *Cyclostrobus* gen. nov. cones of lycopsidean plants from the Narrabeen Group (Triassic) of New South Wales. *Austral. Journ. Bot.,* 13: 389-404.

Jersey de N.J., 1964. Triassic spores and pollen grains from the Bundamba Group. *Geol. Surv. Queensland*, 321: 1-21.

Kelber K.P., Van Konijnenburg-Van Cittert J.H.A., 1998. *Equisetites arenaceus* from the Upper Triassic of Germany with evidence for reproductive strategies. *Rev. Palaeobot. Palynol.*, 100: 1-26.

Klaus W., 1963. Sporen aus dem südalpinen Perm. *Jb. Geol. B.A.,* 106: 229-361.

Knox E.M., 1950. The spores of *Lycopsidium, Phylloglossum, Selaginella* and *Isoëtes* and their value in the study of microfossils of Palaeozoic origin. *Trans. Proc. Botan. Soc. Edinburgh*, 35: 209-357.

Kürschner W.M., Mander L., McElwain J.C., 2014. A gymnosperm affinity of *Riccisporites tuberculatus* Lundblad: implications for vegetation and environmental reconstructions in the Late Triassic. *Palaeobiodiver. Palaeoenvir.*, 94: 29-305. doi: 10.1007/s12549-014-0163y

Larsson L.M., 2009. Palynostratigraphy of the Triassic-Jurassic transition in southern Sweden. *Geol. Fören. Förhandl.*, 131:147-163.

Looy C. V., Brugman W.A., Dichler D.L., Visscher H., 1999. The delayed resurgence of equatorial forests after the Permian-Triassic ecologic crisis. *Nat. Acad. Sci. USA Proc.*, 96: 13857-13862.

Lundblad B., 1950. Studies in the Rhaeto-Liassic floras of Sweden. *Kong. Sven. Veten. Akad. Hand.*,1: 1-82.

Lundblad B., 1954. Contributions to the geological history of the Hepaticae. Fossil Marchiantiales from the Rhaetic-Liassic coal mines of Skromberga (Prov. of Scania). Sweden. *Sven. Bot. Tids.*, 48: 381-417.

Mader D., 1990. Palaeoecology of the flora in Buntsandstein and Keuper in the Triassic of Middle Europe. Vol. 2. Keuper and Index: 937-1582, Fischer, Stuttgart/New York

Mader D., 1997. Palaeoenvironmental evolution and bibliography of the Keuper (Upper Triassic) in Germany, Poland and other parts of Europe. ss. 1058, Loga, Köln

Mädler K., 1964. Die geologische Verbreitung von Sporen und Pollen in der Deutschen Trias. *Beih. geol. Jb.,* 65: 3-147.

Mander L., Kürschner W.M., McElwain J.C., 2013. Palynostratigraphy and vegetation history of the Triassic-Jurassic transition in East Greenland. *Jour. Geol. Soc.,* 170: 37-46.

Meyen S.V., 1981. Some true and alleged Permotriassic conifers of Siberia and the Russian Platform and their alliance. *Palaeobotanist*, 28-29: 161-176.

Pedersen K.R., Crane P.R., Friis E.M., 1989. Pollen organs and seeds with *Eucommiidites* pollen. *Grana*, 28: 279-294.

Pedersen K.R., Lund J.J., 1980. Palynology of the plant-bearing Rhaetian to Hettangian Kap Stewrt Formation, Scoresby Sund, East Greenland. *Rev. Palaeobot. Palynol.,* 31: 1-69.

Petersen H.I., Lindström S., Therkelsen J., Pedersen G.K., 2013. Deposition, floral composition and sequence stratigraphy of uppermost Triassic (Rhaetian) coastel coals, southern Sweden. *Inter. Jour. Coal Geol.*, 116-117: 117-134.

Potonié R., 1967. Versuch der Einordnung der fossilen Sporae dispersae in das phylogenetischen System der Pflanzenfamilien. *Forschung. Landes Nordrhein-Westfalen*, 1761: 1-310.

Pott C., Bouchal J.M., Choo T.Y.S., Yousif R., Bomfleur B., 2018. Ferns and fern allies from the Carnian (Upper Triassic) of Lunz am See, Lower Austria: A melting pot of Mesozoic fern vegetation. *Palaeontograph. B*: *Palaeobot. Palaeophyt*, 297: 1-101.

Reinhardt L., Ricken W., 2000. Climate cycles documented in a playa system: comparison of geochemical signatures derived from subbasins (Triassic, Middle Keuper, German Basin). *Zentralbl. Geol. Paläont.,* 1: 315-340.

Roghi G., 2004. Palynological investigations in the Carnian of the Cave del Predil area (Julian Alps, NE Italy). *Rev. Palaeob. Palynol.*, 132: 1-35.

Ruckwied K., 2009. Palynology of Triassic/Jurassic boundary key sections of the NW Tethyan Realm (Hungary and Slovakia). Doctor Thesis TU Darmstadt, D17, pp. 95, tuprints.ulb.tu-darmstadt.de/1359/4/RuckwiedDiss-Teil4.

Scheuring B.W., 1970. Palynologische und palyno-stratigraphische Utersuschungen des Keupers im Bölchentunnel (Solothurner Jura). *Schweitz. Paläont. Abh.*, 88: 1-187.

Tralau H., 1968. Some middle Jurassic miospores of southern Sweden. *Geol. Fören. Stockholm Förhand.*, 89: 469-472.

Traverse A., 1988. Paleopalynology. Boston, London, Sydney, Wellington.

Vajda V., Calner M., Ahlberg A., 2013. Palynostratigraphy of dinosaur footprint-bearing deposits from the Triassic-Jurassic boundary interval of Sweden. *Geol. Fören. Förhand.*, 135: 120-130.

Van Konijnenburg-Van Cittert J.H.A., 1971. In situ gymnosperm pollen from the Middle Jurassic of Yorkshire. *Acta Bot. Neerl.*, 20: 1-97.

Van Konijnenburg-Van Cittert J.H.A., 1987. New data on *Pagiophyllum maculosum* Kendall and its male cone from the Jurassic of North Yorkshire. *Rev. Palaeobot. Palynol.*, 51: 95-105.

Van Konijnenburg-Van Cittert J.H.A., 1989. Dicksoniaceous spores in situ from the Jurassic of Yorkshire, England. *Rev. Palaeobot. Palynol.*, 61: 273-301.

Van Konijnenburg-Van Cittert J.H.A., 1993. A review of the Matoniaceae based on in situ spores. *Rev. Palaeoot. Palynol.*, 78: 235-267.

Van Konijnenburg-Van Cittert J.H.A., 2002. Ecology of some Late Triassic to Early Cretaceous ferns in Eurasia. *Rev. Palaeobot. Palynol.*, 119: 113-124.

Van Konijnenburg-Van Cittert J.H.A., 2008. The Jurassic fossil plant record of the UK area. *Proc. Geol. Assoc.*, 119: 59-72.

Van Konijnenburg-Van Cittert J.H.A., Van der Burgh J., 1989. The flora from the Kimmeridgian (Upper Jurassic) of Culwoger, Sutherland, Scotland. *Rev. Palaeobot. Palynol.*, 61: 1-51.

Budapest, 11.09.2020.

Ernese Bodor

Research Centre for Astronomy and Earth Sciences,
Hungary-9400 Sopron, Csatkai Endre street 6-8, Hungary
Eötvös Loránd University, Palaeontology Department
Hungary-1114, Pázmány Péter avenue 1/C, Hungary

CO-AUTHOR'S STATEMENT

I declare that in the work of A. Fijałkowska-Mader, K. Jewuła, E. Bodor, 2020. Record of the Carnian Pluvial Episode in the Polish microflora. *Palaeoworld*, doi:https://doi.org/10.1016/j.palwor.2020.03.006 my participation consisted in elaborating statistic analysis PCA in terms of principial component loadings and presenting the results in form of the Figure 9.

I define my participation in the work as 10%.

Bodor Emese

Siganture

Kraków, 15.09.2020.

Karol Jewuła

Instytut Nauk Geologicznych
Polska Akademia Nauk
ul. Senacka 1, 31-002 Kraków

OŚWIADCZENIE

Oświadczam, że w pracy A. Fijałkowska-Mader, K. Jewuła, E. Bodor, 2020. Record of the Carnian Pluvial Episode in the Polish microflora. *Palaeoworld*, doi:https://doi.org/10.1016/j.palwor.2020.03.006 mój udział polegał na:

1. analizie statystycznej PCA danych dotyczących procentowego udziału palinomorf w zespołach sporowo-pyłkowych w zakresie zależności miedzy rodzajami miospor i próbkami oraz trendami głównych komponentów w czasie,
2. opracowaniu wyników analizy w postaci podrozdziału „5.2. PCA" oraz rysunków: Fig.10 i Fig. 11,
3. opracowaniu części rozdziału „6. Discussion", dotyczącej interpretacji wyników analizy PCA.

Swój udział w artykule określam na 30%.

Karol Jewuła
Podpis
15/09/2020