Appendix No. 3

Academic portfolio

I. Personal information

1. Name and surname: Anna Weronika Hrynowiecka

2. Diplomas, scientific/artistic degree – provide the name of the institution where graduated, place, year of graduation and title of PhD dissertation.

2004: Master of Science in Environmental Protection, Nicolaus Copernicus University in Toruń. Title of thesis: Contemporary pollen fall and actual vegetation in Tuchola Forest, Supervised by. dr hab. Andrzej Nienartowicz.

2008: Doctor of Earth Science in Biology, W. Szafer Institute of Botany Polish Academy of Science in Cracow. Title of the doctoral dissertation: History of vegetation and climate of the Mazovian (Holstein) Interglacial and Liviecian (Saalian) glaciation on the basis of pollen analysis of palaeolake sediments from Nowiny Żukowskie, SE Poland. Supervised by prof. dr hab. Kazimiera Mamakowa and prof. dr hab. Magdalena Ralska-Jasiewiczowa. Reviewed by prof. dr hab. Kazimierz Tobolski, Department of Geographic and Geological Sciences, Adam Mickiewicz University in Poznań, and prof. dr hab Leszek Lindner, Faculty of Geology, University of Warsaw.

3. Information on previous academic employment.

Adjunct in W. Szafer Institute of Botany Polish Academy of Science from 2008 to end of 2012
Senior Specialist in Polish Geological Institute – National Research Institute - 2013
Adjunct in Polish Geological Institute – National Research Institute from beginning of 2014 to 2018.
Senior Specialist in Polish Geological Institute – National Research Institute – from 2018.

II. The scientific achievement

1. Presentation of scientific achievement pursuant to Art.16 Paragraph 2 the Act from 14th March 2003 on scientific degrees and titles and on degrees and titles in art] (Dz. U. 2016 r. poz. 882 ze zm. w Dz. U. z 2016 r. poz. 1311.)

The scientific achievement consists of five scientific publications.

The academic achievement composed of a series of five thematically coherent reviewed scientific publications [A1] - [A5] (Appendix No. 5), which were prepared and published upon receipt of a doctoral degree. The two papers included in the scientific achievement were published in journals on the "JCR List" - Web of Science. I am the first author all five papers.

a) Title of the scientific achievement

Reconstruction of vegetation changes and hydroclimatic conditions during MIS 11c in eastern Poland based on palaeobotanical analyses

b) (author/authors, title/titles of papers, year of publishing, name of the publishing house)

[A1] Hrynowiecka, A., Obidowicz, A. 2011. The attempt of define of referential terms for Mazovian (Holstein) Interglacial peat bog from Nowiny Żukowskie (SE Poland). Studia Limnologica et Telmatologica, Vol. 5(1): 13–22.

[A2] Hrynowiecka A., Szymczyk, A. 2011. Preliminary results of comprehensive palaeobotanical studies of peat bog sediments from the Mazovian (Holstein) interglacial at the site of Nowiny Żukowskie (SE Poland). Bulletin of Geography, Physical Geography Series. 4/2011: 21-47.

[A3] Hrynowiecka, A., Żarski, M., Winter, H. 2014. Palaeobotanical and stratigraphic interpretation of the Mazovian (Holsteinian) interglacial profile from Dobropol and other new sites in the Western Polesie Region (SE Poland). Studia Quaternaria 31(1): 17-30.

[A4] Hrynowiecka, A., Winter, H. 2016. Palaeoclimatic changes in the Holsteinian Interglacial (Middle Pleistocene) on the basis of indicator-species method - Palynological and macrofossils remains from Nowiny Żukowskie site (SE Poland), Quaternary International, 409 (Part B): 255-269; http://dx.doi.org/10.1016/j.quaint.2015.08.036.

[A5] Hrynowiecka, A., Pidek, I.A. 2017. Older and Younger Holsteinian climate oscillations in the palaeobotanical record of the Brus profile (SE Poland). Geological Quarterly, 61 (4): 723–737, DOI: http://dx.doi.org/10.7306/gq.1358.

The co-authors statements on their contribution to particular works can be found in Appendix No. 4

2. Description of scientific/artistic aim(s) of the listed above paper(s) and achieved results including their potential applications.

[A] – publication included in the scientific achievement, [B] – other scientific publication, monography etc. (from JCR list, B list), [C] – conference abstract (Appx no 5)

Description of scientific aim of the works constituted the scientific achievement:

A series of five scientific publications entitled: " Vegetation and climate changes in MIS 11c from E Poland based on palaeobotanical analyses " contains the results of palaeobotanical studies of the peat bog and lacustrine sediments of the Mazovian Interglacial (MIS 11c) of three sites located in the Lublin Upland and Western Polesie Region.

Mazovian Interglacial (Holsteinian, MIS 11c), its age is estimated at approx. 400,000 years, is rated for the longest (16 - 25 ka) and the warmest (even by 2 - 4 ° C more than today) interglacial in the Pleistocene. The sites of the Mazovian Interglacial in Poland are not frequent. Their greatest concentration is observed in eastern Poland, where even the existence of the "fossil Mazovian Lakeland" is mentioned (Appx 5: C50). The sediments of this age were most often subjected only to expertise palynological analysis, which enabled a fairly superficial reconstruction of vegetation changes assigning a given profile to a chronostratigraphic unit. High resolution palaeobotanical analysis: palynological analysis and extremely rarely used for this period analysis of plant macro remains, the results of which show a series of selected five publications, enable a comprehensive reconstructions of environmental changes in terrestrial vegetation and evolution of peat bog and lake ecosystems with changes in plant communities, trophies and water levels of water reservoirs of the studied area during the Mazovian Interglacial. The obtained detailed results allowed for the reconstruction of climate changes, taking into account the key climate-related oscillations for MIS

11c and, what is very important from the point of view of the Holocene, climate changes occurring without human impact.

In the publications included in the scientific achievement I undertook a detailed reconstruction of the development of lakes and peat bogs of Mazovian Interglacial in eastern Poland on the basis of changes in pollen composition, including non-pollen palinomorphs and macroscopic plant remains preserved in sediments. Particular attention was focused on the reconstruction of the environment's response to climatic oscillations (OHO and YHO) and early-glacial cooling in the light of the preserved plant indicators.

Method

The presented series of habilitation achievement is based on detailed palynological studies and macroscopic plant remains of three Mazovian Interglacial profiles (Holsteinian, MIS 11c): Nowiny Żukowskie, Dobropol and Brus. Changes in climatic and hydrological conditions were determined on the basis of indicator-species method.

All samples meant for pollen analysis were acetolized according to the Erdtman's method (1960). Before acetolysis, one tablet of *Lycopodium* was added per 1 cm^3 of each sample (Stockmar 1971, Berglund & Ralska-Jasiewiczowa 1986), in order to determine the absolute concentration of sporomorphs.

Samples meant for plant macroremains analysis were taken in strict correlation with ones meant for pollen analysis. All samples were subjected to maceration using a 10% solution of KOH and detergents. 150 ml of sediment was soaked in water for ca. 24h and then boiled with an addition of KOH. After the sediment was boiled to a pulp, the samples were subjected to wet sieve analysis using a 0.2 mm-mesh sieve. The material remaining on the sieve was sorted under a magnifying binocular glass. All plant remains qualifying for identification were isolated and placed in a mixture of glycerine, water and ethyl alcohol in ratio of 1:1:1, with an addition of thymol. The determined material was stored in separate small "boxes". The isolated plant remains were determined to the rank of species, as far as was possible, considering the state of preservation of the material.

The indicator-species method is one of the commonly used methods provides basis for reconstructions of climatic changes in geological history. Based on palaeobotanical data climatic parameters are estimated according to the presence of plant species tolerating specific climatic conditions (temperature, humidity, light requirements), assuming that these requirements were invariable in the past.

The use of data obtained by pollen analysis and macro remains analysis allows for more precise reconstruction of paleoclimate parameters. In particular, macro remains of plants permit the determination of different taxa, frequently to the level of species. The occurrence of plant macro remains confirms the presence of taxa on site in the case of sporadic appearance of pollen taxa, and reduces the possibility of origin from a distant source. Particularly useful is the use of this approach in the absence of climate modern analogs. In the indicator-species method, only the presence/absence of a particular taxon is considered. The combination of both methods (palynological and macro remains analysis) allows not only reconstruction of paleotemperatures of

the warmest and coldest month, average rainfall, and the climatic conditions for the spring months based on the requirements of specific species.

Reconstruction of the evolution three palaeoreservoirs from the Mazovian Interglacial from E Poland based on the palaeobotanical analyzes results

The results of comprehensive palynological studies, rich plant macro remains (especially seeds, fruits, needles and woods) and peat-forming deposits from **Nowiny Żukowskie** gave an extremely accurate view of the continuous transformation of the Mazovian Interglacial palaeoenvironment and early Liwiec Glaciation (MIS 10) and allowed to determine the species composition of the forests of that time, evolution of aquatic, reed swamp and peat-forming plant communities, as well as changes of the trophies and water level of shallow palaeoreservoir (Appx 5: A1, A2, A4, C30, C31, C33, C34, C50).

During the Late Sanian 2 Glaciation (MIS 12) the landscape in the area of Nowiny Żukowskie was dominated by a diversified mosaic of open steppe-tundra communities. *Betula*, *Pinus* and *Larix* occurred infrequently as single trees or in small clusters. *Betula nana* and *Juniperus* attained high values. Dry habitats were presumably covered by steppe-like grasses communities with admixtures of *Artemisia*, *Juniperus*, and *Hippophaë rhamnoides* that is usually found on sandy, poor soils, also. On humid areas communities were predominated by Cyperaceae, with *Thalictrum*, *Filipendula*, *Caltha*, *Trollius europaeus*, *Mentha*, and tundra-like communities with a high proportion of *Betula nana* accompanied by infrequent *Salix herbacea*, *Polygonum viviparum*, *Equisetum*, and mosses. The belt of littoral reed-swamps surrounding the lake was most likely overgrown by communities dominated by Cyperaceae and *Phragmites* accompanied by *Equisetum*, and some species of Ranunculaceae, Brassicaceae, and Apiaceae. *Sphagnum* and other mosses occurred abundantly. In standing water within lakes, *Botryococcus* algae were present.

At the beginning of the Mazovian Interglacial (MIS 11c) the water basin in Nowiny Żukowskie was surrounded by boreal birch-pine forests with admixture of *Larix*. *Betula nana*, *B. humilis*, and *Juniperus* indicated the recent prevalence of cool climate. Communities of herbaceous plants, mainly with Poaceae and Cyperaceae, as well as with Apiaceae and *Thalictrum*, were still often present. The basin was overgrown by phytocenoses of poor species composition, including *Potamogeton natans*, *P. pectinatus*, *P. filiformis*, *P. rutilus*, and *Myriophyllum spicatum*. Occurrence of *Potamogeton* species, suggests that the basin was relatively shallow. *P. filiformis* in phytocenoses evidences that the water in the lake was cool, mesotrophic, very clear, marked by the presence of $CaCO_3$ and pH > 7. The mesotrophic of the water basin is confirmed also by the appearance of *P. rutilus*. Poorly developed swamps of the older part of the zone were inhabited mainly by *Phragmites australis* (pollen) and *Carex rostrata* fruits. Peat bogs with *Scheuchzeria palustris* were most likely of an initial type. The entry of i.a. *Carex lasiocarpa* and the formation of communities with *Scheuchzeria palustris* and *Andromeda polifonia* indicates the gradual decrease in pH.

The younger part of the zone is characterized by more in forestation. The growth of swamps with *Schoenoplectus lacustris* and the spreading of nympheids (*Nymphaea alba*, *N. Candida*, and *Nuphar lutea*), suggest the shallowing of the basin. Physico-chemical properties of water were also

gradual changing. The development of peat bog with *Andromeda polifolia* and occurrence of *Comarum palustre*, not tolerating calcium carbonate and prefer acidic water species, suggests that the decrease in pH was associated with the dystrophication of the basin. This trend is confirmed by *Nymphaea candida*, presently attaining its optimum in humotrophic basins poor in calcium, and *Isoëtes lacustris*, which was numerous in this time.

The variability of ecological requirements of terrestrial plants represented in macro remains indicates that the basin was surrounded by a mosaic of habitats, from fertile and humid herb communities with *Urtica dioica*, to thermophilous communities with *Fragaria vesca* and *Potentilla alba*, typical of dry areas.

The improving climatic conditions and increasing humidity were advantageous to the development of forests with high proportions of *Fraxinus*, *Ulmus*, and *Tilia*. *Picea* became dominant in the landscape and shaded occurrence of *Taxus baccata*. The development of forests with *Picea abies*, which has a competitional advantage when growing in climate with a rapid transition between winter and summer, suggests increased seasonality during this zone. *Taxus baccata*, shadow-tolerant taxa grow below *Picea* crowns, is sensitive on severe and prolonged frost. *Alnus glutinosa* formed small patches of riparian forests and accompanied by nitrophylous species such as *Sambucus nigra* and *Urtica dioica*. In this zone, the lowest trophy and lack of calcium carbonate was recorded in the lake. In such conditions *Isoëtes lacustris* attained optimum growth. They were accompanied only *Najas flexilis*, while the occurrence of nympheids was limited to the littoral. Swamp communities nearly completely disappeared. Peat bogs adjacent to the basin were poorly developed as well. Dry habitats were diminishing, covered by i.a. *Fragaria vesca*, was also observed, what supports the hypothesis of an increase in humidity. On the end of this zone *Txus baccata* withdrawal what it was connect with cooling climate.

During intra-interglacial climatic oscillation (OHO) occurred climatic changes, particularly the decrease in temperatures and humidity expressed an increase in the amount of *Pinus sylvestris* and *Betula alba* as well as by the appearance of *Larix* and even *Betula humilis*. It was a regressive phase with gradual shallowing of the water, what is documented by intensive development of phytocenoses with *Schoenoplectus lacustris* and as the expansion of nympheids (*Nuphar lutea*, *Nymphaea alba*, *N. candida*, and *N. cinera*). Swamps with *Carex gracilis* and *C. rostrata* were gradually restored. Peat bog was also well developed and marked by *Eriophorum vaginatum*, *Scheuchzeria palustris*, *Menyanthes trifoliata* and *Andromeda polifolia*. Disappearance of *Isoëtes lacustris* phytocenoses evidence of an increasing water trophy. Nevertheless, the water were still rather low pH and were devoid of carbonates (*N. candida*). Due to the development of peat bog and high content of *Pinus* in catchment, the palaeobasin may have been gradual dystrophication.

The structure of forests was modified under the influence of improved climatic conditions– they were dominated alternatively by *Abies* and *Carpinus*, with a small admixture of *Corylus* and *Quercus*. *Abies* is a thermophilous tree, requiring a high humidity of both air and soil, preferring an oceanic climate, poorly tolerating frosts and not tolerating high fluctuations of temperature between summer and winter. *Corylus* is sensitive to severe and prolonged frost. Initially, boggy habitats were

disappearing what was resulted from overdrying, caused by the decline of water level and deterioration of climatic conditions. After that palaeoreservoir became deeper but devoid of habitats enabling the development of submerged vegetation and promptly dominated by swamp vegetation. It was composed mainly of the extinct species - *Aracites interglacialis*, associated with the littoral zone only in Mazovian Interglacial, and *Dulichium arundinaceum*, a thermophilous species not found in the present-day in Europe. Patches of peat bogs were redeveloped, with dominant component *Eriophorum vaginatum*, highly resistant to periodic fluctuations in the water level.

The climate was more warmed. Forest communities were still predominated by *Abies* and *Carpinus*. Humid and periodically flooded habitats surrounding the basin were covered by *Pterocarya fraxinifolia* and *Alnus glutinsa*. Dry habitats, located on elevations or slopes, were inhabited by i.a. *Buxus sempervirens*. Water level of the lake increased. Reed swamps were composed mostly by *Aracites interglacialis* and peat bogs by *Eriophorum vaginatum*. The trees directly surrounded the basin and were likely to limit the growth of swamps. The reservoir was acidic, humotrophic and very shallow, as indicated by remains of plants - *Brasenia borysthenica*, *Aldrovanda dokturovskyi* and *Potamogeton natans*.

The surroundings of basin were again overgrown mostly by boreal pine-birch forests with *Larix*, and, initially, with *Picea*. Appearance of *Betula humilis* was also recorded. The climatic changes resulted also in the increasing of the water table. The belt of swamp was still comprising mainly *Aracites interglacialis*, became enriched by *Sparganium hyperboreum* and *Carex rostrata*. Peat bogs with *Eriophorum vaginatum*, *Menyanthes trifoliata* and *Andromeda polifolia* continued their increase in area. Into deeper basin was entered also *Potamogeton rutilus*, *P. dorofeevi*, *P. filiformis*, and infrequent *Isoëtes lacustris*. *P. rutilus* and *P. filiformis* prefer mesotrophic conditions and *Isoëtes lacustris* - oligotrophic, what shows that trophy of the reservoir was still poor.

The next zone is conformable with the “birch oscillation” and is marked by an increase in the proportion of *Betula* and *Larix* and decrease of *Pinus*. The basin repeatedly passed into a shallow overflow land, surrounded by swamp, still dominated by *Aracites interglacialis* with *Carex rostrata*. Regression was observed in peat bogs accompanying the basin and also in aquatic vegetation. *Isoëtes lacustris* due to the increasing trophy and accumulation of sediments, was withdrawn from the water, while *Brasenia borysthenica* reappeared. The regression of peat bogs suggests that the shallowing of basin was rather a consequence of the declining water level than of the infill with sediments.

After this episode *Pinus sylvestris* was again the most important in of landscape. The water level of the basin reincreased, what resulted in a noticeable improvement in its conditions, including the increase pH and trophy, what is evidenced by *Potamogeton obtusifolius*, known to prefer eutrophic water with a thick layer of organic sediments. This improvement allowed the growth of phytocenoses with *Batrachium* sp., *Potamogeton natans*, *P. rutilus*, *P. filiformis* and *P. pusillus*. Such a species composition suggests the mesotrophic water. In well developed swamp communities, enriched with i.a. *Cicuta virosa* and *Hippuris vulgaris*, the content of *Aracites interglacialis* was

decreased. Due to the gradual diminishing of peat bogs, taxa forming these communities, are represented only by *Eriophorum vaginatum*.

Just as much detailed, thanks to the correlation of macrofossils remains, palynological and diatomological analysis, I presented the evolution of the palaeoreservoir in **Brus**, Western Polesie Region (Appx 5: A5, C35, IIK3). Brus is the first site of Mazovian Interglacial (Holsteinian, MIS 11c) in Western Polesie Region analyzed in terms of plant macrofossils. Results of this analysis supported by palynological and diatomological investigations allowed to reconstruct in detail the vegetation and paleoclimate changes in the region and brought new information on the functioning of the lake in the past. The deposits of the fossil lake in Brus cover the whole interglacial and partly also glaciations preceding and following it. In the Late Sanian 2 Glaciation (Elsterian, MIS 12) the lake began its functioning in the steppe-tundra landscape as an eutrophic/mezotrophic and shallow, as evidenced by the presence of *Nuphar*, surrounded by bogs and rushes with *Carex*.

The beginning of Mazovian Interglacial the palaeolake was surrounded by *Betula alba* and *Pinus sylvestris* communities and was characterized by numerous *Betula nana* and *B. humilis* macroremains points to initially cool climate. The edges were covered with *Phragmites australis* and *Typha* reed. The lake was still shallow, easily warmed in the summer, which enabled the growth of bryozoa *Cristatella mucedo*. This species in Norway prefers warm clear water of a temperature above 11 - 16˚C, and at least an average content of $CaCO_3$ and pH above 5.4. *Chara* which also is an indicator of high $CaCO_3$ content and higher acidity confirms these water parameters. The peat bog developed. *Cenococcum* algae were numerous, perhaps as a result of still unstable substrate in the catchment area of the lake. Increase of water level is observable in the disappearance of rushes, absence of *Sphagnum* and a marked reduction in the occurrence of *Cristatella mucedo*. In the younger part of early interglacial, the conditions stabilized. Number of statoblasts of *C. mucedo* increased and *Chara* appeared. Edges of the lake were very shallow. Silty littoral allowed for the development of *Eleocharis palustris* and *Carex bohemica*.

The climate became warmer and humid. Terrestrial vegetation was initially dominated by *Picea abies* and *Alnus glutinosa*. In the middle part, high values of *Taxus baccata* were very important signal of oceanic features of the climate. The optimum phase was dominated by *Abies alba* and *Carpinus betulus* communities. In the older part of period the lake was rather meso/eutrophic, which is indicated by the presence of *Najas flexilis* – species with the optimum in mesotrophic water. In the younger part the trophy increased, marked by *Najas marina, Nuphar* and thermophilous *Najas minor* with the optimum development in eutrophic water. Intensive development of alder carrs with *Alnus glutinosa*, *Urtica dioica*, *Ranunculus sceleratus*, *R. gailensis, Thelypteris palustris* and *Viola palustris*, is evidenced by their macroremains and may be related to the presence of exposed, periodically flooded banks. In the shallow littoral rushes appeared with *Typha*, *Carex rostrata*, *C. gracilis*, *Schoenoplectus lacustris* and nympheids. Shallowing of water level is marked by abundant occurrence of *Lemna trisulca* – species tolerant to shallow and mesotrophic conditions and the appearance of *Azolla filiculoides* - characteristic of shallow, warm lakes of the Middle Pleistocene.

In the end of Mazovian Interglacial the pine forests dominated the landscape and the lake was still shallow as indicated by nympheids and *Batrachium*. Rushes with *Typha* and *C. rostrata* were no longer abundant. Alder still overgrown the edges, probably together with *Betula* communities. Peat deposits formed during this period provided fruits and seed scales of *Betula nana* and *B. humilis*. Lake was rather mesotrophic, as can be deduced from the presence of *Myriophyllum verticillatum*, *Cladium mariscus*, *Potamogeton filiformis*. The water was probably cold with high transparency, rich in $CaCO_3$ and pH>7.

In the Early Liviecian Glaciation (Saalian, MIS 10) was a slight increase in water level, evidenced by the return of *Chara* and communities with *Cristatella*. However, *Callitriche autumnalis* and *Batrachium* may indicate still fairly shallow water. Peat bogs developed again, as evidenced by numerous Sphagnum leaves.

The third profile, the age of which, as a result of detailed palynological analysis, I estimated at Mazovian Interglacial, is the **Dobropol** site in Western Polesie Region. Sedimentation in the basin was initiated in the period predominated by *Betula* with a small admixture of *Pinus sylvestris*. The basin was relatively deep, with meso/eutrophic water, as indicated by numerous macrofossils of *Najas flexilis* and *Najas marina*, however with local shallowings, as suggested by presence of *Nuphar* and *Scirpus kreczetowiczii*.

Afterwards, humid and water-logged areas were dominated by riparian forest with *Alnus glutinosa*, *Ulmus*, *Fraxinus excelsior*, *Sambucus nigra* and *Hedera helix*. These and slightly drier habitats also supported development of communities with *Picea abies* and *Taxus baccata*. Areas of greater aridity were overgrown by *Pinus sylvestris* and gradually colonized by *Quercus*, *Corylus* and *Carpinus*, forming oak-hornbeam forests. As a result of successive environmental changes, *Carpinus* became dominant. This fertile, relatively humid forest created also the habitat of *Abies*, *Quercus* and *Corylus*. Drier and insolated habitats were covered by *Buxus sempervirens*, while humid ones – by *Alnus glutinosa*, *Pterocarya fraxinifolia* and *Frangula alnus*. The reservoir was probably relatively shallow, as indicated by a number of trichosclereids of Nympheaceae. Subsequent cooling and climate continentalization resulted in disappearance of thermophilous trees and dominance of boreal forest with *Pinus sylvestris* and *Betula*. In these time the basin became shallower. Communities with *Carex vesicaria*, *C. caespitosa* and *Aracites interglacialis* (characteristic species of the Mazovian Interglacial) developed intensely. The shores were covered by a peat bog with *Menyanthes trifoliate* and, most likely, *Betula humilis*. However, there was still a deep-water in the basin, inhabited by *Najas flexilis*, *Stratiotes aloides*, *Potamogeton*, thermophilous *Brasenia borysthenica* and other numerous aquatic plants. Dominance of *Pinus* in the landscape was confirmed by abundant Pinaceae remains. Surroundings of the lake were also overgrown by *Betula*, *Ranunculus sceleratus* and *Mentha aquatica*. The end of Mazovian Interglacial was still predominated by arboreal pine forest, however with a notably lower content of *Betula*. Among terrestrial plants, *Andromeda polifonia* indicated still intense development of a peat bog. The belt of swamp was noticeably diminished, as well as aquatic plants that most likely disappeared as the basin became much shallower. Pine forest encroached onto peat bog. At the onset of the early Liviecian Glaciation

(MIS-10), *Pinus sylvestris* and *Betula* were replaced by herbaceous plants, mainly Poaceae, Cyperaceae and *Artemisia*, forming steppe-like communities. *Betula nana* and numerous mosses, inhabiting patches of dwarf shrub tundra, appeared as well. Possibly, swamps disappeared and the water level could have risen again. The occurrence of aquatic plants, such as *Stratiotes aloides*, *Potamogeton*, *Callitriche autumnalis*, *Batrachium* and other taxa, supported this assumption.

Conclusions

The most important achievement of the publication cycle is the application of palynological analyzes and macroscopic plant remains for studies of the Mazovian Interglacial (MIS 11c) and Early Liwiecian Glaciation (MIS 10) sediments, which contributed to a more complete understanding of lake evolution and vegetation changes without human impact.

Comparing the results of palaeobotanical analysis of Mazovian Interglacial profiles analyzed by me (Nowiny Żukowskie, Brus, Dobropol and Hermanów being under review), I have observed the connecting of characteristics plant succession, climate change and hydrological conditions that I have presented in the table below.

The name of the regional pollen assemblages zones (R PAZ)		**Description of dominant vegetation, climate changes and hydrological conditions**
EG EP 2	*Pinus*-NAP	Interstadial rare pine forests. Slight improvement of climatic conditions. Raising the water level.
EG EP 1	NAP-*Betula*/*Betula*-NAP	Stadial open steppe-tundra communities, pioneer birch forests. Cold, continental climate. Lowering of the water level.
M EP 6 b	*Pinus*	Boreal pine forests. Continental climate. A slight increase in the water level.
M EP 6 a	*Pinus-Picea*	Pine-spruce forests. Gradual cooling of the climate, increasing influence of continental climate. The reservoir was shallow.
M EP 5 b	*Carpinus-Abies*-(*Picea*)	Deciduous hornbeam and coniferous forest communities with fir and spruce. Marine climate. The reservoir was shallow.
M EP 5 a	*Carpinus-Abies*-(*Pterocarya-Buxus*)	Hornbeam deciduous forest and coniferous forest communities with fir. Alder forests with Pterocarya. Optimum climate - Marine climate. The reservoir was shallow.
M EP 4	*Pinus-Betula*	The communities of pine forests with an admixture of birch. Cooling climate, continental climate. Shallowing of the reservoir.
M EP 3 b	*Picea-Alnus*-(*Taxus*)	Spruce forests with a yew and alder forests. Marine climate. Lowering the water level.
M EP 3 a	*Picea-Alnus*-(*Fraxinus-Ulmus-Tilia*)	Spruce forests, deciduous forest with ash, elm and lime and alder riparian forests. Marine climate. Raising the water level.
M EP 2	*Betula-Pinus*	The communities of boreal birch and pine forests. Continental climate. The reservoir was shallow.
M EP 1	*Betula*	Rare pioneer communities of birch forests. The climate still quite cold, continental. The reservoir was shallow.
LG EP	NAP-*Betula nana-Juniperus*	Open steppe-tundra communities. Cold, continental climate. The initial phase of a shallow water reservoir.

It should be emphasized that the detailed results of palynological analyzes of the age of the Mazovian Interglacial (MIS 11c) comprehensively elaborated in correlation with macroremains analysis based on modern methods belong to the only ones in Poland and are a very valuable source

of knowledge about climate and environmental changes, with fluctuations in levels and water parameters in palaereservoirs, with species composition, fire potential and the presence of foreign taxa in the contemporary Polish flora.

Thanks to the applied palynological analyzes and fossil plant macroremains, I reconstructed history of vegetation and history of three palaeoreservoirs development, which functioned from Late Sanian 2 Glaciation (MIS 12) by Mazovian Interglacjal (MIS 11c) to Early Liwiecian Glaciation (MIS 10). In each of the analyzed profiles, the occurrence of analogous stages of development was found, which were reflected in changes in the composition of pollen zones (L PAZ), which were the result of regional climate changes. General climate trends marked in the studied palaeoreservoirs overlap local differences in the composition of macroremains changing (L MAZ), which is the result of local palaeolimnological conditions, lake morphometry and geological structure, including mineral composition and vegetation of the catchment.

III. Overview of other scientific – research achievements

Outline of scientific work and research areas undertaken before doctorate

In 2004, I graduated the Faculty of Environmental Protection at the Nicolaus Copernicus University in Toruń. My supervisor was dr. hab. Andrzej Nienartowicz, professor UMK. The subject of the master's thesis was "Contemporary pollen fall and actual vegetation in Tuchola Forest", which proves that I became interested in the method of palynological analysis at the beginning of my scientific path. The preparation of this work was related to the self-collection of surface pollen samples from various ecosystems in the Tuchola Forest NP, laboratory preparation and pollen determination, analysis and conclusions that related to the correlation of results of pollen analysis and observation of natural forest vegetation ecosystems (mainly coniferous forests), meadow, forest edges and heathlands.

The results of these studies, apart from the MA thesis, were published - Filbrandt-Czaja et al., 2007 (Appx 5: B16) and presented at the scientific conference (Appx 5: C20).

Studies of Environmental Protection, gave me the basics of biological, botanical and phytosociological knowledge. However, thanks to a wide geological and geomorphological subject matter, I now have knowledge about the processes occurring during deposition, post-deposition, land surface formation, mechanisms related to the sliding of ice sheets and a number of phenomena that affect the final construction of organic sediments (starting material for palynological and plant macrofossils analysis), and in particular their geological context.

In 2004, at the Nicolaus Copernicus University in Toruń, I obtained the right to teach biology. The knowledge gained at that time is used by me to organize and conduct didactic classes, among others for elementary school students in Gdańsk (Appx 5).

In the same year, I began doctoral studies in International Doctoral Studies of Natural Sciences of Polish Academy of Sciences in Krakow (2004-2008). Under the supervisor prof. dr hab. Kazimiera Mamakowa, I had an intense palynological course, which deepened my knowledge in this area. I learned to recognize acetolized pollen grains with particular reference to Pleistocene taxa - interglacial, glacial, Holocene indicators and the most common rebedded taxa. As part of this course,

I analyzed Pleistocene sediments from different periods using materials from the Paleobotanical Museum of Botany Institute Polish Academy of Sciences in Kraków. I analyzed palynologically Holocene materials from different periods of vegetation succession and colonization periods; I have completed training in the field of laboratory preparation of samples for pollen analysis and I had preparing comparative preparations for the collection of the Palaeobotany Department of PAS in Kraków. In addition, in November 2006 I had training by prof. dr hab. J. Nawrocki (PIG-PIB) in the field of paleomagnetic research and magnetic susceptibility, the results of which were included in the PhD thesis being prepared in this period.

I obtained the degree of doctor of biological sciences in 2008 at the Institute of Botany W. Szafer PAS on the basis of the dissertation entitled "Palinostratigraphy and the history of vegetation and climate of Mazovian Interglacial based on the profile from Nowiny Żukowskie on the Lublin Upland," which I initially prepared under the direction of prof. dr hab. Kazimiera Mamakowa and in the final stage - prof. dr hab. Magdalena Ralska-Jasiewiczowa. The PhD thesis was devoted to the profile of 13m thickness drilled with my participation in 2005, adapted to the current requirements of palynology. The first studies of the material from Nowiny Żukowskie using pollen analysis and plant macroremains were carried out at the Institute of Botany of the Jagiellonian University by Dyakowska (1952). Nowiny Żukowskie was one of the first researched sites with the recognition of the Mazovian Interglacial in the area of south-eastern Poland. This position was recognized by Prof. W. Szafer for the stratotype of this interglacial (Szafer, 1953).

In the 1950s, not recognized herbaceous, aquatic and reed swamp plants, most shrubs (except *Corylus*), dwarf shrubs and numerous tree species, which could be crucial for the reconstruction of vegetation and climate history during this period (eg *Taxus, Pterocarya, Juglans*). For this reason, I decided to repeat the palynological examination in this position. I presented their detailed results in the description of the series of works included in the habilitation achievement, because they are an important part of it.

The results of these studies have been described in great detail and published after the PhD - Hrynowiecka-Czmielewska, 2010 (Appx 5: B17) and presented at scientific conferences (Appx 5: C19, C21, C22, C27).

During my doctorate, I started cooperation in a project financed by MNiSW 139/UKR/2006/01 "Geological research in Starunia (Eastern Carpathians) - identification of possible sites for wooly rhinoceros in Quaternary formations" (2006-2008, head: prof. dr hab. Maciej Kotarba, AGH), where I performed pollen analysis.

Unique in the world character of the site, where in 1909 the remains of the wooly mammoth were found, and in 1929, the wooly rhinoceros started to undertake comprehensive interdisciplinary research after many years using modern geochemical, geophysical, lithological, sedymentological, radiocarbon, microbiological and paleobotanical methods (palynological and macroremains analysis) and malacological. To undertake the next comprehensive paleobotanical studies prompted the authors of the project incomplete identification of the history of Pleistocene and Holocene vegetation in this area. The research undertaken played a significant role in the detailed

reconstruction of the palaeoenvironment, the succession of local vegetation, the assessment of the climate prevailing at that time, and the ecological conditions of the reservoir in which the remains of megafauna were found. The role of developed, among others profiles are extremely important because, along with other comprehensively developed research results, they allowed for the selection of an optimal area in which the chance to find other well-preserved specimens of large mammals is the largest.

Three profiles: St 4', St 22, St 28 and two exposures VL 1 and VL 3 were examined by pollen analysis. Sediments examined palynologically contain the record of stages of vegetation development during the Plenivistulian, Late Glacial and Holocene. In the Plenivistulian (34 000 ± 500 BP, 43 100 ± 1 100 BP) the communities of open vegetation predominated - grassland with *Artemisia* and other herbaceous plants and shrubby tundra with *Betula nana* and Cyperaceae on more humid habitats. There occurred also different species of *Ephedra*. Trees occurred probably only in small groups. Only in the Hengelo/Denekamp interstadial forest-steppe with *Pinus sylvestris* and *Picea* appeared.

The presence of shrubs *Juniperus*, *Ephedra fragilis*, E. *distachya*, E. *strobilacea* and *Hippopheë rhamnoides* indicates considerable openness of landscape in the Alleröd. The dominance of Poaceae, *Artemisia*, and Cyperaceae and the occurrence of plants from family Asteraceae and *Helianthemum nummularium* suggest the prevail continental climate. Caryophyllacae, *Plantago lanceolata*, *Viola palustris*, and *Potentilla erecta* appeared. Quite often occurrence of *Betula nana*, the appearance of *Selaginella selaginoides*, and *S*. cf. *helvetica* as well as exceptionally numerous Poaceae indicate of steppe-tundra communities existence. Rarely *Pinus*, *Betula*, *Larix*, *Alnus viridis*, and *P. cembra* occurred in open landscape.

The cooling of climate brought about in the Younger Dryas (10 190 ± 50 BP, 11 430 ± 60 BP, 12 240 ± 60 BP), wider spread of steppe and steppe-tundra communities with the domination of Poaceae, Cyperaceae, *Artemisia*, and Chenopodiaceae. *Elymus*, *Helianthemum nummularium*, plants from Asteraceae family (pollen of *Ambrosia*, *Aster* t., *Anthemis* t., Cichorioideae) and the patches of shrubby tundra often occurred. *Larix*, *Alnus viridis*, *Pinus cembra*, and *Juniperus* could occur rarely.

The improvement of climatical conditions, at the beginning of Holocene in the Preboreal period brought about the development of forest communities with *Pinus*, *Picea*, and *Larix*. The communities of open vegetation were still common. The plants growing in shore zone of water reservoir were represented in exceptionally great number. The domination of forest assemblages with *Corylus* and *Tilia cordata* in Boreal/Atlantic period (4 505 ± 35 BP) suggest considerable warming of climate. *Ulmus*, *Fagus*, *Quercus* and *Carpinus* accompanied them in admixture – these were probably open multispecies mixed forests. Considerable participation of *Alnus glutinosa* and *Picea* suggest increased humidity. They formed alder forests with spruce and *Filipendula*, Cyperaceae and Filicales monolete in undergrowth. Boreal pine forests with birch grew on drier habitats. The area of open vegetation diminished, however Poaceae and *Artemisia* were still present.

In the Subboreal/Subatlantic period (3250 ± 30 BP, 3655 ± 35 BP) the communities of multispecies mixed forests with *Fagus* began to domination in the landscape. *Carpinus*, *Tilia cordata*, *Corylus*, *Quercus*, *Ulmus* as well as *Acer* and *Tilia* cf. *platyphyllos* grew in these forest in addition to

Betula. In the undergrowth there occurred *Sambucus nigra* and, *Frangula alnus* and in trees crowns *Viscum*. *Taxus baccata*, *Fraxinus*, *Salix*, and probably *Picea* grew in alder forests. In the herb layer of these forests grew Filicales monolete, *Filipendula*, *Caltha*, and Cyperaceae. Frequent were spruce forests, probably with the admixture of *Abies* and *Pinus*, with Poaceae in the undergrowth.

The results of these studies were published after the doctoral degree - Stachowicz-Rybka et al., 2009 (Appx 5: B6) and presented at scientific conferences (Appx 5: C25, C26).

While I was still a doctoral student, I attempted to systematize knowledge about Polish quaternary paleobotanical research in the Tatra, Pieniny and Podhale. To this end, I undertook a review of available and archival literature. The result of these activities was the reconstruction of the vegetation history of the Tatra and Podhale terrains from the early Vistulian to Holocene in correlation to the changes occurring in these periods in Polish Lowland.

The Vistulian coolings in the Tatras were characterized by the dominance of arctic-mountain vegetation communities, treeless shrubby tundra with *Betula nana* and steppe communities and warming of Bölling and Alleröd - park tundra with boreal *Pinus* and *Picea* forests and *Pinus cembra*, *Larix* and *Betula*. During the Preboreal period of the Holocene, the *Picea* forests dominated in the upper floor, above which developed the *Pinus mugo* floor, above the alpine floor with mountain vegetation and grasslands, which gradually retreated to increasing heights. In the Boreal period, mixed forests with *Ulmus*, *Corylus*, *Tilia* and *Alnus* grew on the lower floor. The upper floor was dominated by *Picea* forests. In the Atlantic period, the lower floor is up to 1700 amsl formed mixed forests with *Ulmus*, *Tilia* and *Quercus*, enriched with *Abies*, *Fagus* and *Carpinus*. The upper floor was dominated by *Picea* forest. In the Subboreal period in the lower floor, the share of *Ulmus* under the influence of neolithic human activity declined and the *Picea* forests of the upper floor reached the maximum spread. In the Subatlantic period, under the influence of human activities and climate change, the expansion of *Abies* and *Fagus* forests in the lower floor occurred. Above the Preboreal period, a mountain pine floor has appeared above the spruce forests, and above it a mountain vegetation floor.

Conclusions related to the history of vegetation in the Tatra and Podhale region, the age of the studied reservoirs, mainly peat bogs, development of plant floors in the Tatras and the development of colonization resulted in the publication after the PhD - Hrynowiecka-Czmielewska, 2009 (Appx 5: B13) and were presented at the conference scientific (Appx 5: C24).

IV. Research areas undertaken after doctorate. Outline of research achievements not proposed as the basis for application for the academic degree of habilitation

1. Palynological and plant macroremains analysis of the Mazovian Interglacial (MIS 11c) and the accompanying glaciation

Just after the doctorate I continued palynological research of the Mazovian Interglacial sediments, however, originating from the area of Pieniny. Huba site presents a profile containing a fragment of Mazovian succession from the end of the climatic optimum (pollen period III) with wet *Betula* and *Alnus* forests involving *Pterocarya*, *Ulmus* and *Salix* to the end of the interglacial (pollen period IV) with dominant boreal *Pinus* forests with *Picea* admixture. This is the first site of the

Mazovian Interglacial in the Polish Carpathians, and slightly different course of vegetation succession is caused by the geographical location and geomorphological conditions of the site.

The results of studied of the Huba sediments were published - Birkenmajer et al., 2010 (Appx 5: B18) and presented at scientific conferences (Appx 5: C28, C29).

The wealth of various remains found in the profile from Nowiny Żukowskie inspired me to continue working on this material. I received grant N N307 155538 "Reconstruction of local paleoecological conditions of the Mazovian Interglacial from Nowiny Żukowskie (Lublin Upland, SE Poland) on the basis of comprehensive palaeobotanical research in correlation to palynostratigraphy" (2010-2012) and I began study to preparation and recognition of Holocene and fossil Pleistocene seeds, fruit, needles and other vegetative remains of plants collected in the comparative collection of Botany Institute W. Szafer PAS in Kraków. The vast majority of the effects of my actions in this field were included in the publication cycle being the basis for applying for the postdoctoral degree.

My other activities regarding the Mazovian Interglacial and not included in the cycle of publications included in the habilitation achievement was cooperation with dr hab. Sławomir Terpiłowski, prof. UMCS under grant N N306 198739 "Climatic cycles of the Middle Pleistocene in the record of sediment succession in the region of Łuków (E Poland)" (2010-2013). The Mazovian age of the biogenic series of the studied oxbow lake sediments was determined based on pollen analysis performed by dr hab. A. I. Pidek. My task was macroremains of plant analysis from these sediments. Recognised plant remains in the oldest layers indicate the end of glaciation with *Betula nana* and *B. humil*is fruits and numerous *Cenococcum geophillum* cenobias. Higher located samples contains numerous *Betula* and *Pinaceae* fruits and seeds that indicate the beginning of the interglacial. The shore of the oxbow was boggy and subject to variable water levels, which contributed to the development of the community with *Ranunculus sceleartus* and *Urtica dioica*. The rushes with *Carex rostrata* and *Typha* sp. played an important role. The Middle Pleistocene age may be indicated by the numerous macrospores of *Salvinia natans* and *Azolla filiculoides* at the youngest layer, which could massively overgrowing the reservoirs and which indicate to eutrophication.

The results of these studies were published - Terpiłowski et al., 2014 (Appx 5: B7) and presented at scientific conferences (Appx 5: C32, C41, C43).

Subsequent analysis of Mazovian interglacial sediments that I conducted, which have not been included in the publication cycle of the habilitation achievement, is the Hermanów profile on the Łuków Plain. They are the result of cooperation with dr Marcin Żarski in SMGP Adamów in 1:50 000 scale and the implementation of research topic 61.3601.1302.00.0 in PIG-PIB (Appx 5).

The results of the Hermanów profile research were presented at scientific conferences (Appx 5: C50, C60, C61). The manuscript describing the research entitled "The rank of intra interglacial (OHO and YHO in MIS 11c) and post interglacial (MIS 11b) cooling in E Poland" by: Hrynowiecka, A., Żarski, M., Drzewicki, W. was given to reviews in Geological Quarterly in December 2018.

In 2018, I was included by prof. dr hab. Leszek Marks (PIG-PIB, UW) to carry out the grant 2017/27/B/ST10/00165 "Revision of stratigraphic division and ranges of Middle Pleistocene

Glaciations in Western Polesie (Polish-Belarusian-Ukrainian borderland)". My task in this project is to review the results of palynological analyzes of profiles from the area of the Polish-Belarusian-Ukrainian borderland and to analyze new profiles obtained in order to determine the ranges of Central Poland Glaciations. So far, I have conducted a review of the available literature and selected the positions of the Mazovian Interglacial (Alexandrian in Belarus, Likhwinian in Ukraine), which should be reviewed. I also carried out a preliminary palynological analysis of new profiles: Włodawa-Cegielnia, Korolówka and Wyryki from eastern Poland (Garb Włodawski), in which I confirmed the age of the Mazovian Interglacial. The results of my work in this area were presented at the working meeting of the participants of the grant in Okuninka in September 2018.

2. Palynological analysis of sediments younger than MIS 10 and older than MIS 5e (Eemian Interglacjal)

Thanks to the cooperation with Dr. Robert Sokołowski (UG), I analyzed the fluvial organic sediments from the Mrzezino site near Puck, which age was determined by the IR-OSL method on MIS 7. The analyzed profile consists of two series: Mrz I (younger) and Mrz II (older). Frequency of pollen was very low. In both series, sporomorphs of trees occur in proportions indicating sever climatic conditions (about 50% and below). Damaged and redeposited elements: Dinophyceae cysts, rebedded sporomorphs, both tertiary and Pleistocene origin, occur in considerable quantities and are significantly damaged, which indicates their water transport and poorly stabilized soil environmental conditions. The results of the research from the Mrzezino sediments were published: Sokołowski et al., 2018 (Appx 5: B12).

3. Palynological analysis of the Eemian Interglacial and Vistulian Glaciation

I started researching Eemian sediments in 2011 thanks to cooperation with Dr. Andreas Börner from the State Geological Survey of Mecklenburg-Vorpommern (Germany).

The profiles of Banzin I (B I) and Banzin II (B II, NE Germany) situated approx. 25 km south of the maximum range of the Vistula ice sheet were discovered thanks to the construction of the North German gas pipeline (NEL). Both profiles present the course of succession from the Late Saalian Glaciation (MIS 6) with a mosaic of herbaceous plant communities, among which Poaceae, *Artemisia*, Cyperaceae, *Rumex acetosella* and heliophytes such as *Helianthemum nummularium* and *Jasione montana* and many other herbaceous plants. *Betula nana* and numerous mosses point to the occurrence of tundra communities, which underlines the prevailing cold climate. The trees were few, but there were often *Hippophaë rhamnoides*, *Juniperus* and *Salix* shrubs. The beginning of the Eemian Interglacial was dominated by the relatively rare forests of *Betula* with the admixture of *Pinus*, which was accompanied by *Juniperus* and *Calluna vulgaris*. Gradual warming led to dominating of *Betula* and *Pinus* forests with a small share of *Quercus* and *Corylus*. Subsequent climatic changes caused the development of oak forests with *Pinus* and a significant admixture of *Corylus* up to its dominance, with a small share of *Tilia cordata* and *Picea abies*. *Alnus glutinosa*, *Salix*, *Ulmus*, *Fraxinus*, *Viburnum* and *Taxus baccata* appeared along with the expansion of riparian forests. From the palynological and macroremains premises, it appears that the reservoir could become shallow and overgrown even in the optimum climate of the Eemian Interglacial.

The next Eemian profile, Hinterste Mühle (NE Germany), also comes from the outcrop and this time it presents a complete record of the late-glacial-interglacial and early-glacial succession.
The terrestrial environment around the mesotrophic lake was dominated by open heliophilous steppe communities with Poaceae, Cyperaceae and Artemisia and dwarf-moss tundra with *Betula nana* and *Salix herbacea* imply cold climate conditions. The frequent occurrence of *Hippophaë rhamnoides* and *Juniperus* indicates poor soil conditions prior to the ending of the glaciation.

Eemian peat accumulation began in the second half of the pine-rich phase. In spite of the progressive alluviation of the lake, areas of open water (mire pools) still remained - they permitted the spread of submerged and floating water plants. The beginning of Middle Eemian was characterized by the development of thermophilic communities initially dominated by *Quercus* and accompanying *Ulmus*, *Fraxinus* and *Corylus*. Already at that time warm climate indicators like *Hedera helix* and *Viscum* occurred. The tree vegetation of *Corylus* with accompanying *Quercus* began to dominate. *Alnus* together with *Fraxinus* and *Ulmus* began creating riparian forest communities on lakeshore and floodplains. Furthermore, the appearance of *Typha latifolia* in large numbers indicates a shallowing of the lake. Further changes led to the development of mixed deciduous forest type *Quercetum mixtum* with *Corylus*, *Quercus*, *Tilia cordata*, *Ulmus* and *Fraxinus* with significant climatic requirements as well as *Carpinus*. Peaty sites in depressions by the lakeshores were still colonised by riparian forests with *Alnus*, and communities with *Picea* and *Taxus* appeared. Aquatic and reed swamp plants still occurred, but in small numbers.

The end of Eemian Interglacial was beginning of the appearance of communities with *Pinus* and *Betula* and still persisting hornbeam and spruce in regress, indicating a gradual deterioration of the climatic conditions.

Further cooperation with Dr. Andreas Börner resulted in a palynological analysis of the outcrop eemian sediments from Beckentin (NE Germany). The Beckentin pollen sequence begins with which contains very few pollen with a large proportion of damaged sporomorphs (Crumpled). The landscape was dominated by herbs such as Poaceae and Chenopodiaceae and rare trees *Pinus* and *Betula* appears. The lower portion of the peat unit showing the pioneer bright forests with *Pinus* and expanding *Betula*. The upper part of the peat, continues to yield high proportions of *Pinus* but with a large contribution of *Quercus* and rising percentages of *Tilia* and *Corylus*. The riparian forests are represented by the spread of *Ulmus* and *Fraxinus*. Next was expansion of mixed deciduous forest elements with high proportions of *Corylus* and a decline of *Pinus* and *Betula*. On nearby floodplains, riparian forests developed containing *Alnus*, *Salix*, *Ulmus*, *Fraxinus*, *Taxus baccata* and *Humulus lupulus. Tilia* becomes increasingly important in the local forest communities. The further climatically changes led to the expansion of *Carpinus* and *Picea*, accompanied by the spread of *Ilex aquifolium*, *Buxus sempervirens*, and *Abies*, while many elements of the *Quercetum mixtum* and riparian forests (except *Alnus*) gradually retreated. Deterioration of climatic conditions led to the dominating of *Pinus-Betula* forests and the decline of thermophilic *Carpinus*. The sedimentation in the palaeoreservoir ended in the Early Vistulian (MIS 4), when the steppe-tundra communities and especially heathlands were once again dominant in the landscape. Most plants have disappeared in

the lake. The oligotrophy is confirmed by the numerous spores of *Isöetes lacustris* and peat bog by *Sphagnum*.

The results of Eemian sediment from Germany analysis were published - Börner et al., 2015, 2018; Rother et al., 2018 (Appx 5: B8, B9, B11) and presented at scientific conferences (Appx 5: including C42, C44, C48, C49, C51, IIK4).

In the area of the South Podlasie Lowland, where about 100 sites with the record of the Eemian succession were discovered. One of this was Ławy site with numerous remains of four representatives of the "*Mammuthus - Coelodonta*" fauna complex: *Mammuthus primigenius*, *Coelodonta antiquitatis*, *Bison priscus* and *Equus ferus*. Well preserved mammalian remains were accompanied by organic sediment, which was subjected to pollen analysis. Its results indicate the interstadial character of plant communities in which megafauna representatives lived. At the time, there were rare pine forests in the park tundra type with quite numerous herbaceous vegetation forming the steppe-tundra communities. Radiocarbon dating of the mammoth jaw at 39.8 cal ka BP allowed determining the chronological time in which megafauna representatives lived, to the beginning of Interstadiał Hengelo.

At the Ławy palaeolake pollen succession is a reflection of climate change from the Eemian to the Vistulian. At the end of the Eemian Climatic Optimum (older sediments could not be reached), the area was dominated by deciduous forests mixed with *Carpinus* and *Corylus* (E5). The gradual cooling resulted in the spread of *Picea* and *Pinus* forests (E6) to total domination of *Pinus* at the end of the interglacial (E7). From the beginning of Vistulian retreated communities of forest and open areas communities was dominated. Because of probable sedimentary gaps we cannot attribute all zones to a specific succession phase definitively. Probably just the Herning Stadial (EV1, GS-26) is in chronological accordance.

The results of the "Ławy" sediments analysis were published - Hrynowiecka et al., 2018 (Appx 5: B10) and presented at scientific conferences (Appx 5: C52, IIK5).

One of the tasks of the Polish Geological Survey (PIG-PIB) was, and still is, the mapping of exposures arising during the construction of "linear infrastructure facilities". During such work on the construction of a gas pipeline near Łęczyce (near Lębork), Leszek Jurys (PIG-PIB) found a significant thickness of organic sediments, which together with Dr. Robert Sokołowski (UG) we took and analyzed. I determined the age of these sediments at Eemian Interglacial. So far, this is the only Eemian profile in this part of Pomerania.

The lake sedimentation began at the time when *Betula* was dominated in the landscape with a slight admixture of *Pinus* and *Larix* - pioneer, luminous communities with numerous herbaceous plants. The improvement of climatic conditions enabled the development of communities with *Quercus*, *Ulmus* and *Fraxinus*. The communities with *Corylus*, *Quercus* and *Tilia* have spread in the climatic optimum. Numerous *Alnus* appeared, which may indicate a well-developed water system, probably lakeland, allowing to develop of riparian azonal communities with *Alnus*, *Fraxinus* and *Ulmus*. Next in the vicinity of the reservoir *Carpinus* and *Picea* began to dominate with still numerous *Corylus* and riparian communities with *Alnus*. *Abies* did not appear. The reservoir has been deep so

far, which is indicated by the almost complete lack of aquatic and rushes plants pollen, perhaps with flowing water – only few colonies of *Botryococcus*. In the final phase of the interglacial, the deterioration of climatic conditions led to the domination of *Pinus* and *Betula* and the growing importance of herbaceous plants. The reservoir became shallow - numerous pollen of *Ranunculus trichophyllus*, decreased of trophy - spores of *Isoëtes*, and overgrew with peat bog - *Sphagnum* spores. However, the colonies of *Botryococcus* and *Pediastrum* indicate lake conditions.

The results of the Łęczyce profile research were presented at scientific conferences (Appx 5: C46, C47). The manuscript concerning the results of paleobotanical, sedimentological and isotopic analyzes of organic sediments from Łęczyce is being prepared.

Currently, I am preparing a palynological analysis of the Eemian profile from the vicinity of Gorzów Wielkopolski under Grant No. 0201/2048/18 "Life and death of an extinct rhinoceros (*Stephanorhinus* sp.) from western Poland in the light of interdisciplinary palaeoenvironmental studies" (2018-2020), implemented by the University of Wroclaw, Faculty of Biological Sciences, head is dr hab. Krzysztof Stefaniak.

During the monitoring and mapping of the outcrop created during the construction of the expressway, organic deposits were discovered, the age of which, after the preliminary palynological analysis, I determined on Eemian interglacial. In these sediments an almost complete skeleton of an extinct rhino "forest" - *Stephanorhinus kirchbergensis* - was deposited. The results of pollen analysis of 6 sediment samples directly adjacent to the jaw show the dominance of *Carpinus* and *Corylus* communities as a rhinoceros living environment. This species composition allows to determine the rhinoceros' life time on the end of the Middle Eemian Interglacial defined for the terrain of Poland as *Carpinus-Corylus-Alnus* R PAZ (E5), the climatic optimum of this interglacial.

Whereas pollen analysis of 11 samples of sediment extracted from cavern teeth indicates that the majority (7 samples) is a lake sediment that penetrated into the spaces inside the teeth *post mortem* and also suggest the species composition of *Carpinus* and *Corylus*. Only 4 samples differ in their pollen composition. They indicate mainly on *Betula* and *Corylus*, as the source of food *Stephanorhinus kirchbergensis.* The intriguing discovery turned out to be *Taxodium* sp. pollen in amounts up to 4%. This species has so far not been found in Eemian Interglacial.

The results of these studies were presented at scientific conferences (Appx 5: C56, C57, C58). During the preparation there are three publications on the preliminary results of multidisciplinary research on the main profile from Gorzów Wielkopolski, a smaller side profile and on the diet and rhinoceros living environment.

Also as part of the research on the sediments of Eemian Interglacial, I was invited to participate in the NCN Grant No. 2017/27/B/ST10/01905 "Intra-Eemian climate oscillations. Reconstruction based on multidisciplinary research on fossil sediments of the Garwolin Plain (Central Poland)" (2018 -2021), the head is dr hab. Irena Agnieszka Pidek, prof. UMCS, and the project is carried out at the Maria Curie-Skłodowska University in Lublin, Faculty of Earth Sciences and Spatial Management. My task is a detailed palynological analysis of three selected profiles with full Eemian succession from the Garwolin Plain: Kozłów (profile with a large thickness of the hornbeam phase -

E5), Żabieniec (profile from a large thickness of the post-interglacial phase) and Puznówka (profile from a large thickness of the late-glacial MIS 6 sediments), for palaeoecological reconstruction, localization of climate oscillations and then explanation of their causes. The preliminary results of my participation in this venture were presented at scientific conferences (Appx 5: C53, C55, C59).

4. Palynological studies of LGM and Holocene

Thanks to cooperation with Dr. Robert Sokołowski (UG), I subjected palynological analysis of the Vistulian organic fluvial sediments from Reda site (N Poland). The aim of the research was to determine the genesis of exposed sediments and palaeoenvironmental conditions during their deposition. The age of sediments was determined based on OSL analyzes. The results of the pollen analysis allow to divide the analyzed profile into three parts. The oldest part of the profile was sedimented in climatic conditions similar to the shrubby tundra and steppe communities. This is indicated by the preserved *Betula nana* pollen and spores of mosses as well as numerous pollen of Poaceae and *Artemisia*. The few pollen grains of the *Pinus* and *Betula* trees probably originate from the clumps rarely scattered in this area, however, in the vast majority of distant transport.

Containing the largest amount of organic matter, the central part of the Reda profile was formed in slightly more stable conditions, both climate and hydrological. It was probably the peaty shore of the reservoir (*Sphagnum* spores). Slight improvement of climatic conditions allowed the development of park tundra with *Pinus* and *Betula* trees as well as heliophyte *Hippophaë rhamnoides*. The area was still dominated by steppe-tundra communities with *Betula nana*, Musci, *Selaginella selaginoides*, Poaceae, *Aertemisia, Calluna vulgaris* and other herbaceous plants. On the shore of the reservoir grew rushes with Cyperaceae, *Typha latifolia*, *Ranunculus acris* and ferns.

Deterioration of climatic conditions was recorded in the youngest part of the profile. Few pollen grains of trees indicate almost complete their withdrawal. The landscape resembled a mosaic of steppe meadows with dominance of Poaceae, with shrubby tundra patches.

The results of these studies were presented at the scientific conference (Appx 5: C40). The publication regarding the results of the unveiling in Reda is being prepared.

A continuation of my research on the Holocene deposits in Podhale was the palynological analysis of peat and lake sediments from the open-gravel mine in Długopole, which were discovered by Dr. Marcin Żarski (PIG-PIB) during works on the sheet Czarny Dunajec SMGP in scale 1:50 000. Results of pollen analysis of the samples from Długopole, a very important site for the reconstruction of the Podhale palaeoenvironment, indicate the Late Vistulian-Holocene age of the studied sediments. The bottom of the profile is represented by the Younger Dryas, characterized by the dominance of open communities with numerous herbaceous and shrubby vegetation. The area was overgrown by steppe communities with Poaceae and Cyperaceae, *Hippophaë rhamnoides*, *Salix herbacea* and *Juniperus* shrubs as well as by tundra with *Betula nana*. *Pinus* was rare.

During the Preboreal period of the Holocene, the *Pinus* forests developed with a small admixture of *Picea* and *Larix*. Poaceae were still numerous indicating rare crowns of trees. In the Boreal period, *Picea* forests dominated, with *Pinus* and *Corylus* appearing. Wetlands located in the vicinity of the reservoir were dominated by riparian forests with *Alnus*, *Ulmus* and numerous ferns

and herbaceous plants characteristic of exposed shores. The boreal age of sediments confirms ^{14}C dating at 9555 ± 60 and 9928 ± 80 years cal BP at the border between peat and lying above silt. The Atlantic period is characterized by the further development of *Picea* forests in this area. The communities with *Tilia* and *Corylus* developed stronger in the younger part. The floodplain forests with *Alnus*, *Ulmus* and numerous ferns continued to strong developed. Particularly noteworthy is the small thickness of peat deposits (about 20cm) and the peaty-silt sediments (about 20cm) that contain the record from the Younger Dryas to the Atlantic.

The results of these studies have been presented at scientific conferences (Appx 5: C39, C54). The publication with the results of the outcrop Długopole analysis is being prepared.

As part of the IODP-347 Baltic Sea Paleoenvironment program, which aimed at obtaining numerous cores of the Baltic seabed and conducting multidisciplinary analyzes of sediments, I analyzed the palynological two profiles: Ba-60 from Kattegat and Ba-65 from around Bornholm. The sedimentation of Holocene deposits in the analyzed profiles began in the Preboreal period, where *Pinus* pollen was completely dominant. In the Boreal period *Corylus* and *Alnus* reached the highest values with a high share of *Ulmus*. In the Atlantic period, *Quercus*, *Tilia* and *Ulmus* pollen dominated with high proportions of *Corylus* and *Pinus*. *Quercus* pollen still dominated in the Subboreal, but with a higher share of *Corylus* and *Alnus*. The Subatlantic period was characterized by an increase in the value of *Pinus* pollen, with a still high proportion of *Quercus*, *Corylus* and *Alnus* as well as the appearance of low-percentage continuous *Carpinus* and *Fagus* curves and higher values of Poaceae. The publication on the results of the Baltic core research is being prepared.

I became interested in the cyclical nature of the occurrence of interglacials and glaciations, especially changes in the Earth's orbit parameters and solar activity, and their impact on climate change in the Mazovian Interglacial (MIS 11c) and Holocene.

In the history of the Earth, multiple climate changes have been documented and the last of them occurred with the end of Vistulian and the ice sheets' disappearance of about 11000 years ago. On a current basis, we observe multidirectional, fluctuating or quasicyclic fluctuations in the state of the atmosphere, which can be interpreted as a continuous correction of the balance of the climate system. However, astronomical factors have the greatest and long-term impact on our climate. In 1941, Milutin Milanković described the relation of cyclical climate changes with periodic changes in the Earth's orbit parameters in the "Canon of Insolation and the Ice-Age Problem" (in 1867, J. Croll was the first to observe them). According to Milankovic, the eccentricity of the orbit (eccentric changes every 100,000 years), the inclination of the Earth's axis, precession and changes in the Sun's activity due to its strong and unstable magnetic field are responsible for cyclical global climate changes and so the climate of the Earth is controlled by the Sun's energy.

The correlation of the astronomical parameters MIS 1 (Holocene) and MIS 11c (Mazovian Interglacial) allows to state significant similarity of these two geological periods. Comparison of other parameters, i.e. time of climate oscillation after forest entry, duration of climate and vegetation regression, and its regeneration (based on pollen analysis of laminated deposits) confirms the thesis about the twin similarity of the most important climate changes that took place in MIS 11c and MIS 1

- OHO (Older Holsteinian Oscillation) and 8.2 ka events (Koutsodendris et al., 2012). The ability to trace the predictable course of the astronomical parameters curves allows us to answer the question of whether we can predict the duration of the Holocene.

The results of these studies have been published - Hrynowiecka, 2016 (Annex 5: B15) and presented at scientific conferences (Appx 5: including C45, IIK5).

5. Modern times - Melisopalynology

Pollen analysis is not just palaeobotany. Their melisopalinological aspect seemed very interesting to me and in 2005 I made an intensive training in Apipol-Kraków company from Brzączowice, which deals in buying, packaging and selling versatile bee products. I had the opportunity to get to know the honeys pollen view, beebread and pollen baskets from Europe, Asia, Americas and even Africa and Australia. It gave me a lot of experience in recognizing non-acetolized pollen grains that I used in non-commercial recognition of honeys and honey blends on the Polish market.

At that time I started cooperation with prof. dr hab. Kazimierz Tobolski (Adam Mickiewicz University in Poznań), which also interested in this subject and propagating knowledge on this subject. This resulted in the chapter "Melisopalinological analysis of the honeys from the southern Kociewie and the Lower Vistula Valley" in the monograph "Kociewie Kraina nad Wisłą" (Kociewie Land on the Vistula) edited by K. Tobolski and M. Pająkowska-Kensik (Appx.5: B14) and participation in international conferences: VIIIth International Workshop on the landscape architecture and regional planning "Beans in the landscape" and "Lanscape conservation and bees or why bees from rural areas". Tuczno - Poland (30/04 - 3/05/2009) - papers: "The honey in microscopic view" and "Classification and geography of honey based on content of pollen"; and national events: Hrynowiecka-Czmielewska A. 2011. Melisopalinology of Lower Vistula Valley on the background of Poland's honeys. Festival of Taste, 20-21 August 2011, Gruczno.

6. Summary of scientific achievements

Total impact factor of my post-doctoral publications on the Journal Citation Reports (JCR) list (as of December 20, 2018):

- according to the year of publication: 15,670
- five-year: 17,596
- current: 16,536

Total number of MNiSW points:

- for the publication year: 295
- currently: 353

Number of publication citation by:

- WoS - 39 (with self-citations - 42)
- SCOPUS - 48 (with self-citations - 54)
- Google Scholar - 80 (with self-citations)

Hirsch index by base:

- WoS - 4

- SCOPUS - 5
- Google Scholar – 6

For my scientific achievements consists of 61 publications (including 5 indicated as a habilitation achievement), mostly in English, published in domestic and foreign journals. This is: 1 chapter in the monograph, 17 original scientific articles in magazines included in the lists of the Ministry of Science and Higher Education, including 10 published in JCR journals, 42 abstracts and conference reports, 3 publications in conference tour guides. In addition, I made about 15 expert opinions in the field of palynology from various geological age mainly within the framework of the PIG-PIB tasks.

I consider the Special Award of the PIG-PIB Director for the best publication of young employees to be a great distinction and a positive assessment of my work: Börner, A., Hrynowiecka, A., Stachowicz-Rybka, R., Kuznetsov, V., Maksimov, F., Grigoriev, V, Niska, M., Moskal-del Hoyo, M. 2014. Palaeoecological investigations and 230Th / U dating of Eemian interglacial peat sequence of Banzin (Mecklenburg-Western Pomerania, NE-Germany). Quaternary International 386: 122-136. doi: 10.1016 / j.quaint.2014.10.022.

The results of my research were presented at 19 international conferences (10 with my active participation) and 28 national conferences (16 with my active participation).

I was the head of 2 grants, one doctoral grant and one multidisciplinary grant, contractor or main contractor in 6 national grants. I was also the head of three research topics at PIG-PIG and a contractor in at least 8 research topics at PIG-PIB and in many PSH tasks.

I was co-organizer of two conferences: VI POLISH CONFERENCE OF PALAEOBOTANY of QUAERNARY Sea sediments, lagoon and coastal bogs as a source of information about paleoenvironments and climate, 10-13 June 2013, Krynica Morska and 86 Scientific Congress of the Polish Geological Society in Łuków, 20-5.09.2018.

I was a member of the editorial board of Acta Palaeobotanica in 2008-2009. I reviewed 4 scientific articles in magazines from the JCR and Ministry of Science and Higher Education lists.

I took care of and helped a PhD student Aleksandra Jurochnik MA in 2008-2012, at the Institute of Botany W. Szafer PAS in Kraków, doctoral dissertation: "Late-glacial and Holocene vegetation in Węgliny (Ziemia Lubuska); Supervisor: prof. dr hab. Dorota Nalepka.

Detailed information is included in Appendix No. 5.

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