Appendix 3

Summary of Professional Accomplishments

1. Name
Ewa Krzemińska

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

2009 –Ph.D. in Natural Sciences –Polish Geological Institute -National Research Institute
Dissertation title *Geochemical record of the Proterozoic geotectonic environment variations based on selected profiles of the crystalline rocks of north-eastern Poland* ",
Promoter dr hab. Janina Wiszniewska,
Reviewers:
prof. dr hab. Andrzej Żelaźniewicz
prof. dr hab. Andrzej Kozłowski

1986 –M.S. in Geology Graduate from Geology Faculty, Warsaw University;- Specialization: Petrology Mineralogy and Geochemistry (metamorphic petrology)
Master's thesis in the field of metamorphic rock petrography " *Metamorphism on the contact of the Kłodzko-Złotystock intrusion in the area of Żelazno-Marcinów-Ołdrzychowice*", under the supervision of doc. dr hab. Janusz Ansilewski/ Bogumił Wierzchołowski,

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

2018 – until today - *senior specialist within laboratory*, head of the MicroArea Analyzes Laboratory;
2017 – reclassification to technical position (obligatory), resulting from the introduction of internal regulations regarding the status of people employed in PIG-NRI laboratories;
2014 – 2016 –assistant professor, head of the Laboratory of Analyzes in the Micro Area;
2011 – 2014 – assistant professor, coordinator of the team for the construction of the ion microprobe laboratory at the PGI-NRI;
2008 – 2011 – assistant professor at the Central Chemical Laboratory at PGI-NRI;
2002 – 2008 – assistant at the Department of Regional Geology;
2001 – 2002 – assistant at the Department of Petrography and Mineralogy;
1997 – 2001 – a break related to the parental leave (1x)
1993– 1996 – specialist in the Laboratory of Electron Microscopy at PGI;
1987 –1993 – a break related to the parental leave (2 x)
1986 – beginning of employment at PGI - intern at the Department of Petrography and Mineralogy

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

As an achievement resulting from Art. 219 paragraph. 1 point 2b. the Act of July 20, 2018 Law on higher education and science (Journal of Laws of 2020, item 85, as amended)

I present, in accordance with Art. 219 section 1 point 2b of the Act
a series of thematically related seven publications under the collective title:

Chronology of the events on the southern edge of the East European Craton: a new dates – updates – revisions

The scientific articles presented here, were published between 2019 and 2022. All works have been prepared in co-authorship. I was a first author in case of four publications [A1, A3, A6, A7], but the second coauthor in the remaining [A2, A4, A5] three. In each of them, I was the leader [A1, A3 and A5] a part relating to U-Pb isotope geochronology, or the sole contractor of analytical works [A2, A4, A6, A7] and the author of interpretations.
Isotope geochronology and its results form the backbone of each publication.

4.1 Scienceometric information

The contributions [A1-A3, A5-A7] have been published in peer-reviewed journals indexed by the Journal Citation Reports, on the "A" list of journals of the Ministry of Education and Science (MEiN). Only the text A4 was included on the "B" list but published in the occasional volume, for the 100th anniversary of PGI, presenting new petrological achievements of PGI-NRI employees.
For the articles of presented cycle that make up the scientific achievement, the sum of MEiN points (publications between 2019 and 2022 e.c. in accordance with the new scoring)
is 990 (990 (4x200 + 100 + 70 + 20).
The sum of the two-year IF impact factors from the year of publication is 20,607 (2x4.142 + 0.826+4.394+4.261+2.742).

4.2. List of publications representing a scientific achievement

The articles as a pdfs and the co-authors' declarations about their participation in the preparation of these publications are presented in Annexes (Pdf) and (Statements)

[A1]
Krzemińska E., Johansson Å., Krzemiński L., Wiszniewska J., Williams I.S., Petecki Z., Salwa, S., 2021. Basement correlation across the southernmost Baltic Sea: Geochemical and geochronological evidence from onshore and offshore deep drill cores, northern Poland. *Precambrian Research,* **362**, 106300 https://doi.org/10.1016/j.precamres.2021.106300.
List "A" MEiN 2021 = 200; IF2021 = 4.142; 4YearIF =4.927; number of citations: 3

[A2]
Wiszniewska J., Krzeminska E., 2021. Advances in geochronology in the Suwałki anorthosite massif and subsequent granite veins, northeastern Poland. *Precambrian Research*, **361** (106265), 1–20. https://doi.org/10.1016/j.precamres.2021.106265
List "A" MEiN 2021 = 200., IF2021 = 4.142; 4YearIF=4.927number of citations 6

[A3] Krzemińska E., Łukawska A., Bagiński B. 2019. U-Pb zircon geochronology of high-grade charnockites -exploration of pre-Mesoproterozoic crust in the Mazury Complex area. *Acta Geologica Polonica,* **69,** 489-511
List "A" MEiN 2021 = 100; IF2019 =0.926; 4YearIF= 1.228 20number of citations: 1

[A4] Krzemiński L., Krzemińska E., Wiszniewska J. 2019. Detrital zircon geochronology and provenance of the Proterozoic quartz-rich metasediments of the Mazowsze domain: Source areas and regional correlation. *Biuletyn - Państwowego Instytutu Geologicznego,* **474**: 59-72
DOI: 10.5604/01.3001.0013.0840
List "B" MEiN 2019=20

[A5] Poprawa P., Krzemińska E., Pacześna J., Amstrong R., 2020. Geochronology of the Volyn volcanic complex at the western slope of the East European Craton – relevance to the Neoproterozoic rifting and the break-up of Rodinia/Pannotia. *Precambrian Research,* **346**, 105817. https://doi.org/10.1016/j.precamres.2020.105817
List "A" MEiN 2021 = 200 pkt., IF2020 = 4.394; 4YearIF = 5.127; number of citations: 26

[A6] Krzemińska E., Poprawa P., Pacześna J., Krzemiński L. 2022. From initiation to termination: The evolution of the Ediacaran Volyn large igneous province (SW East European Craton) constrained by comparative geochemistry of proximal tuffs versus lavas and zircon geochronology *Precambrian Research,* **370** (4):106560
DOI: 10.1016/j.precamres.2022.106560
List "A" MEiN 2021 = 200 pkt., IF2021 = 4.,261; 4YearIF=4.927number of cictations:1

[A7] Krzemińska E., Krzemiński L., Poprawa P., Pacześna J., Nejbert K., 2021 First Evidence of the Post-Variscan Magmatic Pulse on the Western Edge of East European Craton: U-Pb Geochronology and Geochemistry of the Dolerite in the Lublin Podlasie Basin, Eastern Poland. *Minerals* **11**(12):1361DOI: 10.3390/min1112136
List "A" MEiN 2021 = 100 pkt., IF2021 = 2.742; 4Year IF=2.93

4.3. Author's comment

4.3.1. Introduction

After PhD defense, the subject of my scientific and research work focused on geochronological studies of rocks from deep boreholes in the northern and eastern parts of Poland. The aim of the study was systematic verification of the former age determinations obtained a quite a long time ago, often using a low-temperature geochronometers. It was also in a few cases the first geochronological investigation of crystalline rocks.

The analytical works I was carried out on the basis of the U-Pb isotope geochronology method with the use of the zirconium mineral as an exceptionally universal geochronometer. The common goal of the determinations was to define a chronology of the major igneous episodes and geological processes of the complex evolution on the edge of East European Craton near the margin of Teisseyre-Tornquist (TTZ) zone.

In order to reconstruct the regional history of tectonic evolution, especially for the the crystalline basement, s, the age of the rocks is irreplaceable information, apart from a number of geochemical and petrographic aspect, that constitute a main parameter of geological investigations. Without precise reference to the geological timescale, the wealth of other data cannot be fully exploited. In particular the task of regional and stratigraphic correlation cannot be undertaken.

Using even a limited access to crystalline rocks, provided by irregularly spaced deep drillholes, it is possible to reconstruct the geological evolution of basement rocks with the support of U-Pb isotope geochronology, or sedimentary formations in which there are no guide fossils, and to place them correctly into specific time frames. Despite the fragmentary nature of the oldest crystalline basement rocks, a large part of them, which have been strongly deformed, transformed or processed in geological recycling, the of U-Pb geochronology allows us to correlate the various rock suite, and indicate the significant regional connections.

4.3.2. *Methodology*

The U-Pb isotope dating has become a widely used and very effective method in geology, because the system includes two independent pairs of parent-daughter isotopes, giving at least three age variants (i.e. ^{238}U / ^{206}Pb, ^{235}U / ^{207}Pb and ^{207}Pb / ^{206}Pb), which allows to verify an internal consistency of obtained age results.

Among many of minerals containing the uranium element, the zircon has been recognized as the best for U – Pb geochronology due to its generally moderate U content, negligible initial non-radiogenic Pb (common Pb) and its presence in a wide variety of rock types.

In addition, the high close temperature (> 800 ° C) of the U-Pb isotope system confinement has the potential to survive crust annetexis, especially in dry systems. Due to isotope resistance, zircon offers an additional property of preserving a traces of a few episodes of growth prior to the final rock formation stage. This may provides some obstacles in accurately of the age determinations. However, it opens up the possibility to reveal an additional geochronological record relating to the protolith, or inherited or captured material from the surrounding basement rocks during the melt emplacement.

Age studies using zircons as high-temperature geochronometers require a thorough interpretation of the obtained dates, taking into account various aspects of the internal structure of the analyzed zircons. It is necessary to assign correctly the numerical results to the appropriate geological context.

It was my sole responsibility to provide a separate chapter on age studies and interpretation of results in the cycle of contribution submitted for evaluation. In details it included the research strategy an U-Pb isotope measurements on zircon grains, data processing and their geological interpretation, and final discussion of the results. Sometimes it was even the dominant part of the publication.

The investigations were carried out using the Secondary Ion mass spectrometry SIMS technique. The analytical works were performed on the SHRIMP ion microprobe (Sensistive High Resolutuon Ion Microprobe). However, it was not only one device as well as the same laboratory space. After gaining basic methodological practice since 2009, I was able to carried out U-Pb analytics independently.

The presented data set are results of the analytical works that I performed in a few different laboratories, including the prestigious

Research School of Earth Science RSES, Australia National University ANU in Canberra with the SHRIMP RG and SHRIMP II [**A1**, **A4**],

Geological Survey of Australia Geoscience Australia GA at SHRIMP II [part from **A3**], and at my home institution at PGI-NRI in Warsaw at SHRIMP IIe [**A2**, **A6**, **A7** and part from **A3**, part from **A5**].

In all the mentioned laboratories, the main analytical procedure was identical, realized according to methodology written by Williams 1998. The working reference material used during all analytical session was similar. The Temora 2 zircon grains, extracted from the Middledale gabbro diorite massif of New South Wales, Australia, remain a widely used as an age standard for U-Pb isotope geochronology (Black et al., 2003, Iles et al., 2015).

From the methodological point of view, the cycle of articles [**A1 - A7**] presented for evaluation highlights a several different variants / strategies used during U-Pb age study by ion micro probe technique.

From the geological point of view, it presents a wide range of geological problems fro the covered by sediment area of basement that have been solved or taken up using the results of U-Pb isotope analyzes.

4.4 Discussion of the scientific goal of the publication series, the results achieved and their application

The presented a series of thematically related seven publications remain a coherent combination of analytical works performed by me using methodology of U-Pb isotope geochronology accompanied with the interpretation of the obtained data, then used for discussion of geological evolution of this part of the East European craton

4.4.1. Age of the crystalline basement of the Southernmost Baltic Sea

The first of the contribution **[A1]** among evaluated cycle presents the results of the isotopic investigation of the crystalline rocks drilled from the southernmost part of the Baltic Sea. The most of the unique samples derived from the Petrobaltik exploration drilling. Only a few (10 samples) of them pierced the crystalline basement directly.

A significant effect of my investigation as well as a contribution to the regional image of the geological structure of northern Poland and the Baltic zone was determination of the U-Pb zircon age granitogneisses from the fourteen deep boreholes **[A1]**; four from on shore, located in Pomerania and ten from off-shore, penetrating the basement under the bottom of the Baltic Sea, within the Polish Exclusive Economic Zone.

It was the first series of the geochronological studies of the basement rocks from southernmost Baltic Sea area.

These rocks represent the top of the crystalline basement in the Pomeranian region, with the location from Słupsk IG1 in the west to the easternmost borehole Hel IG1 and almost 100 km north of the coast to the B5-1 / 01 borehole, including the basement under the Łeba and the Rozewie blocks (Pokorski, 2010).

The igneous protolith is documented by the internal structure of zircons in all cases.

Inherited cores or grains are rare (1/ 282 results). Most samples show a subtle metamorphic rims. The age of rims slightly differs from magmatic cores with crystallization age of 1750 million years vs 1739 million years (Słupsk IG1:). The traces of sedimentary protolith were not detected gneisses from Słupsk IG1 (80 single spots), hypothetically expected.

The data collected by me indicate two separate periods of magmatic activity: first in the late Paleoproterozoic (Staterian) between 1.79 Ga and 1.75 Ga and in the Mesoproterozoic (late Calymian). The dominant late Palaeoproterozoic igneous episode was associated with a late orogenic deformation at about 1740 Ma. Only in three drill holes (B16, B3, B4) the U-Pb data document an age of crystallization in the range 1.48 - 1.45 Ga, but their location is limited to a narrow belt under the Łeba block.

The obtained age data (protolith) were also important for other co-authors. The geochronology of the rocks allowed to properly group a whole rock geochemical data set, including the geochemistry of trace elements and isotopic geochemistry of Sm-Nd, to better constrain their petrogenetic connections.

The state of knowledge about the age of crust formation processes and their time frame in the in the southernmost Baltic Precambrian basement has changed significantly.

It was necessary to verify the previously constrained sketch of the basement structures, known from the Geological Atlas of the South Baltic (Ryka, Dadlez, 1995), where four structural levels are distinguished, including "an early Proterozoic with archaic relics".

New U-Pb data from the southernmost part of the Baltic Sea and northern Poland were used for construction of the Geological Map of the Crystalline Basement of the Polish part of the East European Platform, scale 1:1,000,000. A similar team of authors with a similar competences (Krzemińska et al., 2017) has been involved in the map preparation works.

These age determination **[A1]** have become a crucial for direct geological correlation within the South Baltic region. Analogous rock formations, including geochemical and isotopic aspects (Nd model age and U-Pb protolith age) are located in the Blekinge area (Johannson et al., 2006, Johannson, 2016) in southern Sweden. Due to such significant similarities and perfect correlation **[A1]** in the area of the Baltic Sea and Pomerania, a new unit was introduced. The Pomorze-Blekinge Domain with age of 1.78 - 1.75 Ga is included on the new map of the crystalline basement of NE Poland (Krzemińska et al., 2017).

It is worth mentioning that igneous rocks from the Trans-Scandinavian Igneous Belt (TIB) also have a similar age of crystallization. One of the three stages of magmatism (TIB1) distinguished there, characteristic for southern Sweden TIB1: 1.81 - 1.76 Ga, coincides with the magmatism of the Blekinge region and magmatic activity in Pomerania and the southern Baltic Sea. However, unlike the granitoids at the southern end of TIB1, the rocks from Blekinge and Pomerania have been deformed. Therefore, taking into account the mesostructural analyzes, there is a close relationship of igneous rocks from Pomerania and the drilling-penetrated southern Baltic zone with the Blekinge area than with TIB1.

A simplified interpretation of the U-Pb age only from fourteen Polish drillings, has been presented as an Abstract and as a lecture at the Nordic Geological Winter Meeting at Lund University (Krzemińska et al., 2014). Then age data were used almost immediately for the regional compilation known from the "*Trans-Baltic Palaeoproterozoic text correlations* *towards the reconstruction of supercontinent Columbia / Nuna"* (Bogdanova et al., 2015). The results of the U-Pb age analyzes **[A1]** have been included in the integrated sketch of the structure of the Earth's crust in the central and southern parts of the Svecofennian orogen across the Baltic Sea (op cit.).

The age results from Pomerania and the southernmost Baltic, perfectly match with almost coevally published results of the age investigation from Gotland island (Sundblad et al., 2021) and Öland, and two drillings located within the Latvian economic zone (Salin et al., 2019, 2021).

4.4.2. A time frame of magmatic activity in the area of Suwałki Anorthosite Massif

A next significant achievement of has been geochronological **[A2]** exploration of rocks from the Suwałki Anorthosite Massif (SAM). They belong to anorthosite-mangerite-charnockite granite (AMCG) sutie as well as to structure known as the Mazury complex, where rapakiwi - texture granitoids are most common.

Modern isotope investigation was initiated twenty years ago, but then it was related to the age of granitoids (rapakivi type), in which the abundance of zircons was guaranteed (Dörr et al., 2002). The initial determination of the age of the deposit related to SAM was realized using Re-Os methodology (Stein et al., 1998; Morgan et al., 2000). This is one of the first applications of the Re-Os geochronology to ore minerals (Fe- sulphides and oxides) in norite. The age study provided however a low accuracy of the result (with an error of ± 37 Ma or ± 94 Ma). The age of ore-bearing anorthosites (1559 - 1556 Ma) remained somewhat overestimated and uncertain in comparison to the age of granitoid crystallization of 1515 ± 3 Ma determined by the TIMS method (Dörr et al. 2002). Nevertheless, in several published regional summaries, the age of SAM was commonly cited as ~ 1.55 Ga (e.g Ashwal, 2010).

For further petrogenetic considerations and geochronological verification of the main components of intrusion, systematic age investigations of a wider collection of rocks e.g, were necessary. In the course of the NCN grant led by prof. dr hab. J Wiszniewska, (# 2015/17 / B / ST10 / 03540: " *The architecture and geological evolution of the Suwałki anorthosite massif determination using three-dimensional modeling of geological and geophysical data"*), my task was to select a proper set of the samples, including never dated before anorthosite drill core samples, prepare and perform analytical part of work on the SHRIMP, analytical data processing and interpretation of age results.

The collection of twenty samples for geochronology was selected from a few litological components e.g. from anorthosite, type A- granite (rapakivi texture) and (post-AMCG) granite veins, mainly aplites and pegmatites commonly cutting all the components of SAM.

The samples represented a few different locations within the SAM: eastern, western and central parts, and different levels (depths) within the igneous body.

The time frame of the SAM emplacement was constrained to about 17 Ma, e.g. between 1516 Ma and 1499 Ma, (previously it was 44 m.y from 1559 Ma to 1515 Ma). The new results **[A2]** obtained in this study (342 single spot analyzes) showed that the main components of AMCG, i.e. anorthosites and type -A granites, crystallized at the same time.

It is consistent with an conclusion of Duchesne et al., 2010, based on the isotope geochemistry of Sm-Nd and Rb-Sr rocks, pointing at least two melts. Moreover U-Pb zircon results confirmed that melts of two separate series were synchronously generated.

The chemically distinct nature of the melts from which the zircons crystallized is shown by diagram of the Th vs U [ppm] contents in zircons from the various AMCG and related rocks Zircons in anorthosite crystallized interstitially in the free spaces left between plagioclases and rare pyroxenes. Two-stage crystallization was common in both rapakivi granite and anorthosite. Firstly, at great depths in the magma chamber and then during decompression in the final stage of the intrusion emplacement, that is recorded as a disturbed pattern of the CL concentric growth zones within larger zircon crystals.

A compilation of the zircon single spot data from anorthosite **[A2]** revealed at least two age peaks at 1515 Ma is dominant in the eastern part of SAM and 1507 Ma in the central and western parts of the massif. They reflect separate igneous impulses or/ and separate intrusions within the SAM. A similar age distribution with two major peaks at 1515 Ma and a minor peak at 1509 Ma is observed on the compilation of the A type granitoids age results

The age of aplite and pegmatite veins marks the time just after SAM consolidation about of 1490–1475 Ma (contact of the veins with SAM rocks is usually sharp). My investigations **[A2]** have directly documented that aplite melt was generated by partial melting of the local source rocks, including the late Palaeoproterozoic protolith of 1.83 Ga, with well-preserved numerous relics of the Svecofennian grain cores, derived from vicinity of SAM. Aplite veins remain a classical example of S-type granites (*sensu* Chappell, White, 1992) in the Mazury Complex.

The updated time frame of magmatic activity within SAM, as well as the new results from the Baltic area, were included in the statistical-paleogeographic compilation "*A geochronological review of magmatism along the external margin of Columbia and in the Grenville-age orogens forming the core of Rodinia* "published in Precambrian Research 371 (2022) 106463. The paper was prepared by an international team led by Åke Johansson, in which I was one of the twenty-three co-authors, representing thirteen countries and five continents.

4.4.3. Relics of a pre-Mesoproterozoic crust in the Mazury complex area.

The U-Pb zircon age of the charnockite rocks presented by publication [**A3**] of the cycle led to the revision of previously published hypotheses (Bagiński et al., 2001) related to the wide range of occurrence of AMCG-suite.

The AMCG rocks, which dominatethe Mazury complex, were emplaced during the Mesoproterozoic time as a series of intrusions located along the E – W line. The charnockites, are one of the main components of the AMCG suite. Therefore, orthopyroxene bearing granitoid, occurring in Łanowicze PIG1 drill hole (only 10 km west of the center of the Krzemianka field) within Mazury Complex were also presented as a AMCG – suite component (Bagiński et al., 2001).

The case of Łanowicze IG1 charnockites the results of the age investigation carried out in the GA laboratory (sample depth 1405 m) were joined with the results of analyzes carried out under my supervision in the PGI laboratory (3 samples from the depth of 1162 m, 1382 m, 1485 m), which were included in the master's thesis of Mrs. Aleksandra Łukawska, (Album No. 309597 "*The genesis of charnockites from Łanowcze PIG-1 drilling in the light of research on zircons and other accessory minerals*". This work was finalized in June 2015).

First age recognition carried out by me in GA, has been confirmed in 2015 by master thesis of Ms A. Łukawska on samples from a few other depths. All data showed that the charnockite protolith from Łanowicze IG1 was undoubtedly Palaeoproterozoic. It differs geochemically from the AMCG component. Therefore, deep drilling in Łanowicze IG1 penetrated older basement hosting AMCG suite.

The coexistence of charnockites at different depths of the same drill hole section and different ages e.g.1836 - 1850 Ma and of 1881 Ma, suggest that in this region on the western edge of SAM the fragments of the crust related to two prominent Lithuanian tectonic domains surround the anorthosite massif from the north.

TheWest Lithuanian WL and the Middle Lithuanian MLD was formed as a continental margin at about 1.86-1.84 Ga. In the East Lithuanian LEL domain, the oldest continental crust was documented at 1.89-1.87 Ga. According to the new model of the geological structure of this part of EEC (Bogdanova et al., 2015), the LEL domain was formed at about 1.89 Ga in the volcanic arc environment, during the early Svecofennian orogeny at 1.89–1.87 Ga. Subsequent accretion on the LEL shore and dynamic events within the MLD volcanic arc led to tectonic "dismemberence" of the older crust. These processes were accompanied by a metamorphism at about 1.80 Ga. Subsequently, the basement was intruded by the anorogenic AMCG formation about 1.52-1.50 Ga.

The evidence of these dynamic stages of the crust evolution have been recorded by the internal pattern of dynamically deformed zircons from Łanowicze PIG1 **[A3]**. The age studies have shown that in this small area, the SAM is surrounded by Middle Lithuanian Domain (MLD) with East Lithuanian relics. They belong to the large Middle Baltic Belt (MBB) distinguished by Bogdanova et al., (2015).

4.4.4. The source of detrital material south of the Mazury complex.

The investigation of the age of the detrital zircons population presented by the fourth **[A4]** contribution is concerned on the mature, quartz-rich meta-sedimentary rocks known from the area south of the Mazury Complex.

The quartzites recognized at the top the crystalline basement of the Mońki IG2 and Zabiele IG1 boreholes were treated as an example of a "quasi-platform" metasedimentary series on the East European craton (Kubicki et al., 1996), or even as the neoproterozoic cover, filling the depressions associated with the "gothian dislocation system" (Ryka, 1998). Usually, quartzites were correlated with the Mesoproterozoic Jotnian formation known from Scandinavia. The Jotnian sediments were deposited in the system of tectonic graben before 1260 Ma. It was assumed the detrital material was derived from the denudation of granitoids from the nearby Mazury complex (Ryka, 1998) dominated by a wide range of Mesoproterozoic igneous rocks (~ 1.5 Ma).

These quartzites were classified as a part of a separate unit of the so-called Biebrza complex (Kubicki et al., 1996; Ryka, 1998). As Jotnian sediments were considered as a younger than rapakivi granites and older than the post-Jotnian diabase dikes of 1260 Ma known from Scandinavia.

The study of the detrital zircon age from the quartzites from Mońki IG2 and Zabiele IG1 as well as their interpretation done by me made, allow to identify the age populations of detritus, including the youngest grains, as an indicator of the maximum deposition age and to estimate the time of metamorphic event, which resulted in significant stratigraphic implications.

None of the earlier hypotheses was confirmed.

As I found out, the detritus came from mostly Paleoproterozoic eroded source rocks, with age in range of 2.11 - 1.68 Ga (^{207}Pb /^{206}Pb age). The dominant age clusters of detrital zircon in quartzites were very similar to those reported in the Late Svecofennian paragneisses in this part of the EEC (Williams et al., 2008). The maximum deposition age of probably did not exceed 1.6 Ga. Thus the sediments were deposited in the terminal stage of Svecofennian orogeny, however before beginning of denudation processes of the Mesoproterozoic AMCG suite of the Mazury Complex.

A thin metamorphic overgrowths and the lack of monazite did not allow for determination of the age of metamorphism. Indirectly, based on the time of the lead loss, it can be assumed that the metamorphic event took place in the late Palaeoproterozoic. The results, prior to publication **[A4]**, were used as part of the chronostratigraphic verification during preparation of the new map of the craton (Krzemińska et al., 2017).

4.4.5. Age of the pyroclastic material and its relationship with the phases of volcanic activity and rifting on the edge of East European Craton

The U-Pb age analyzes of the pyroclastic deposits remain a separate issue of detrital zircon geochronology. Apart from record of the age populations recognized in deposits, the most important remains youngest grains, especially those with a clear volcanic origin, because they can be used to determinations of the age of stratigraphic levels.

As products of volcanic activity, the tuff layers are indicative of immediate deposition and therefore their deposition age, expressed by the crystallization age of the youngest zircons, may be the crucial for pyroclastic horizons correlation. the investigation the volcanic zircon age becomes more and more important.

The petrologic aspect of my knowledge including a previous experience with investigation of basalt and tuffs of the Sławatycze Formation, constituted my original contribution during the work on publication **[A5]**, starting with the concept stage discussed with other co-authors.

For the purposes of this manuscript, I've prepared and illustrated the petrography of the tuffs accompanied with description of geochemical characteristics.

It was great challenge to undertake analytical work with the particularly fine fraction of volcanic grains.

The pyroclastic zircon geochronology is commonly used to determine an age of the tuff or tephra beds. Tephra is proximal pyroclastic deposit, usually consisting of volcanic ash admixed with coarser pyroclastic fractions, that often contain an older generations of volcanic material.

Besides the so-called autocrystals (Miller et al., 2007), which crystallize close to the eruption time, registering the final impulse of a lava or ash flow, pyroclastics always contain slightly older grains, i.e. antecrysts that crystallized during previous magma impulse and were captured by next volcanic flow. Their presence blur a proper age estimation, but they provide broader knowledge about the intensity of previous effusive events.

Pyroclastic zircon geochronology has become my goal, when a draft of the publication [**A5**] was constructed.

The age investigation of four samples of Sławatycze formation as a part of grant 5T12B 05325 (supervised by J. Pacześna) was carried out in 2010, and then initially processed by R. Armstrong (RSES). In one case, the results showed only epiclastic grains documenting the age of the crystalline basement.

It signifocanlty limits a range of the planned interpretation and the possibility of discussing the chronology of volcanic activity in this part of the craton. The sequence of lava flood (basalt) at the end of the Neoproterozoic time is known from deep boreholes in eastern Poland as a widespread Sławatycze Formation and as the Volyn Formation from outcrops and quarries in western Ukraine. Lava flows, alternating with layers of tuff, with a large gap are inconsistently deposited on metamorphic rocks of the crystalline basement or pre-effusive clastic sediments of the Polesie formation.

Due to its unique location in the Orsha-Volyn aulacogen zone, geochronological studies of this area remain a crucial for understand the late Ediacaran rift episode and accompanying volcanic activity. The U-Pb dating so far (Shumlyanskyy et al., 2016) has focused on the basalts from the Volyn outcrops (2 samples) and dolerite, and one tuff (Compston et al., 1995).

The correlation of the tuff beds characteristic for the Sławatycze Formation has never been discussed before. For a broader perspective, it was necessary to extend a number of samples as well as the U-Pb age data.

These complementary analyzes were performed by me on the SHRIMP IIe / MC microprobe at the PGI-NRI. For the first spatial correlation, tuff beds from the northern, central and southern parts of the Lublin-Podlasie basin were selected, e.g. Krzyże IG4 (5 layers), Mielnik IG1 (2 layers), Wisznice IG1 (1 layer) and Kaplonosy IG1 (2 layers) .

Especially in the proximal facies a several generations of volcanic zircon grains are commonly noted in pyroclastic rocks. The syn-eruptive zircon (autocrystals) of Sławatycze Formation were poor in uranium, which always leads to poorer quality results.

Recognition of the youngest grains allowed me to determine the deposition age of individual tuff levels, which ranged from 567.1 ± 4.7 Ma to 553.0 ± 15 Ma. However, the period of the most intense effusion of ashes and tephra lasted between of 567–560 Ma and of 555–557 Ma.

The obtained results showed significant agreement with independently conducted studies of the deposition age of several (distal) tuft layers in Belarus (Paszkowski et al., 2019). These age data were the basis for regional considerations on the final stages of Rodinia rifting and the syneruptive basin evolution [**A5**].

The discussion with one of the reviewers of the manuscript [**A5**] was an inspiration for further investigations in order to determine the time frame of the volcanic activity for the Sławatycze Formation.

Almost the same team of authors attempted to determine [**A6**] the age of the initial and final tuff layers, using the most complete profile of the Sławatycze Formation, with the maximum thickness of the volcanogenic series, which was penetrated by the Kaplonosy IG1drilling .

None of these key layers have been previously dated. The age of the uppermost tuff level within the volcanogenic series profile defines the end of rift activity and the beginning of the development of the passive shore on the western slope of the Baltica.

The significant controversy concerned of the termination of volcanic activity and the rifting process. The alternative was about 551 Ma according to Compston et al. 1995 or 545 Ma according to Paszkowski et al. 2019.

In the first case, it was the date from the one before last tuff layer, and in the second case, the deposition age of the distal tuff (or tuffite) of Kobryn in Belarus (only 3 youngest grains).

My original idea was to supplement the geochronological investigation of the initial and final of tuff layers with the geochemical characteristics of the vocanogenic rocks (tuffs and basalts) in the region, which allow to monitor a nature of the geochemical variation during the evolution of magmatic activity.

The onset of effusive activity in the western part of the rift basin was probably around 580 ± 10 Ma, while the final episode, from the last layer of tuff, was dated at 547 ± 6 Ma. It was a significant adjustment of the first study (Compston et al., 1995), for years cited in context of the final effusive episodes.

The U-Pb age of the terminal phase is recorded by the youngest zircon crystals in the sample (autocrystals) that crystallized directly from the magma just before the eruption. The age of the initial phase was estimated on the basis of the oldest antecrystals preserved as relics. The main phase (approx. 567–551 Ma) was the most widespread and abundant.

To evaluate and present the results of U-Pb analyzes, I've used several alternative statistical methods, including the IsoplotR radial plot to calculate the main age in the youngest population (Vermeesch, 2018, 2021). It is a more appropriate tool for capturing and visualizing a potential data younger than the age of deposition, if they are present.

A new approach for the Sławatycze Formation, which I proposed, was to link an age, and geochemical features with typical phases of volcanic activity identified in the phaerozoic provinces of CFB continental flood basalt (Jerram, Widdowson, 2005) defined on the basis of well exposed architecture and internal structure of volcanic facies.

In the case of the most complete volcanic section of Kaplonosy IG1, the model of three phases, i.e. initial, main and terminal, is well identifiable in relation to U-Pb data obtained from pyroclastic zircon analyzes, geochemistry and frequency of lava and tuff beds and sedimentological features [**A6**].

In the course of the zircon measurements for the above-described publication [**A6**], limited number of grains from one dolerite occurrence, which appear in the Mielnik IG1 profile, were also analyzed. However , rather unexpected age result were obtained. The case of dolerite from Mielnik has been discussed by the last publication [**A7**].

This sub-volcanic rock with a thickness of 18 m (depth 1745 - 1722 m) lies directly on the Palaeoproterozoic crystalline basement.

After the dolerite, there is a layer (6m) of the Polesie Formation sandstones and the main sequence of volcanogenic rocks of the Sławatycze Formation. Dolerite was initially described as Mesoproterozoic or Jotnian (Juskowiakowa et al., 1967) subvolcanic rock. After that, it was commonly linked with late Ediacaran continental volcanism on the edge of the East European Craton (Juskowiakowa, 1971, Bakun-Czubarow et al., 2002, Krzemińska, 2005, Poprawa et al., 2020). This relationship was very credible, because in Ukrainian part of the province, dolerite with age of ~ 567 Ma (Shymlyansky et al., 2016) has been documented, that favored the previous false correlation.

The U-Pb studies of zircon grains from Mielnik dolerite, which I have carried out, have indicated a late Carboniferous age of crystallization i.e. almost 270 Ma less than expected. A numerous inherited grains, including the late Ediacaran, typical for the Sławatycze Formation and Palaeoproterozoic xenocrysts were also detected. The xenocrysts were incorporated into the lava probably just prior to the dolerite intrusion and were not absorbed.

This unexpected result with the age of 299.6 ± 3.6 million years (confirmed on 14 grains) required to recognize a new geological context of this magmatic activity. The late Carboniferous age of numerous dykes and dyke swarms with various thicknesses was commonly recorded in the northern part of Europe.

Neumann et al., 2004 showed that the Late Carboniferous to Permian extensional magmatism, expressed as dyke swarms that appear in a narrow time span from about 300 to 280 Ma, is widespead between northern England, the Oslo Rift in Norway, Skania (Västergötland) in southern Sweden, to Rügen in northern Germany and the Danish island of Bornholm. The age of the Mielnik IG1 dolerite and the older pulse of intrusion of the Skåne swarm coincide with the moment of initial magmatism in the Oslo Rift. This narrow time frame (from 300.4 to 298.9 Ma) is synchronous even with the age (297.4 ± 0.4 Ma) of the Great Whin Sill Dolerite Complex N.E. England (Hamilton, Pearson, 2011).

The age of Mielnik IG1 dolerite remains an excellent example of the crucial role of geochronological study, and thus the failure of a correlation based solely on geochemical or petrographic criteria. In both cases (Ediacaran vs Late Carboniferous / Permian) it is volcanism of the continental flood basalts (CFB) tectonic setting , with similar geochemical features with the mineral complex.

Correlation based solely on geochemical or petrographic criteria can be unreliable. In both options (Ediacaran vs Late Carboniferous / Permian) volcanism is classified as a continental flood basalt (CFB) tectonic setting, characterized by similar geochemical features with the mineral complex.

The most important achievement of the scientific investigations of the presented series of thematically related seven publications under the collective title:

Chronology of the events on the southern edge of the East European Craton: a new dates – updates – revisions

is the final solution to the problem of the uncertain age of rocks from several key regions of the NE crystalline basement of Poland, including the southern Baltic, Suwałki anorthosite massif and its surroundings,

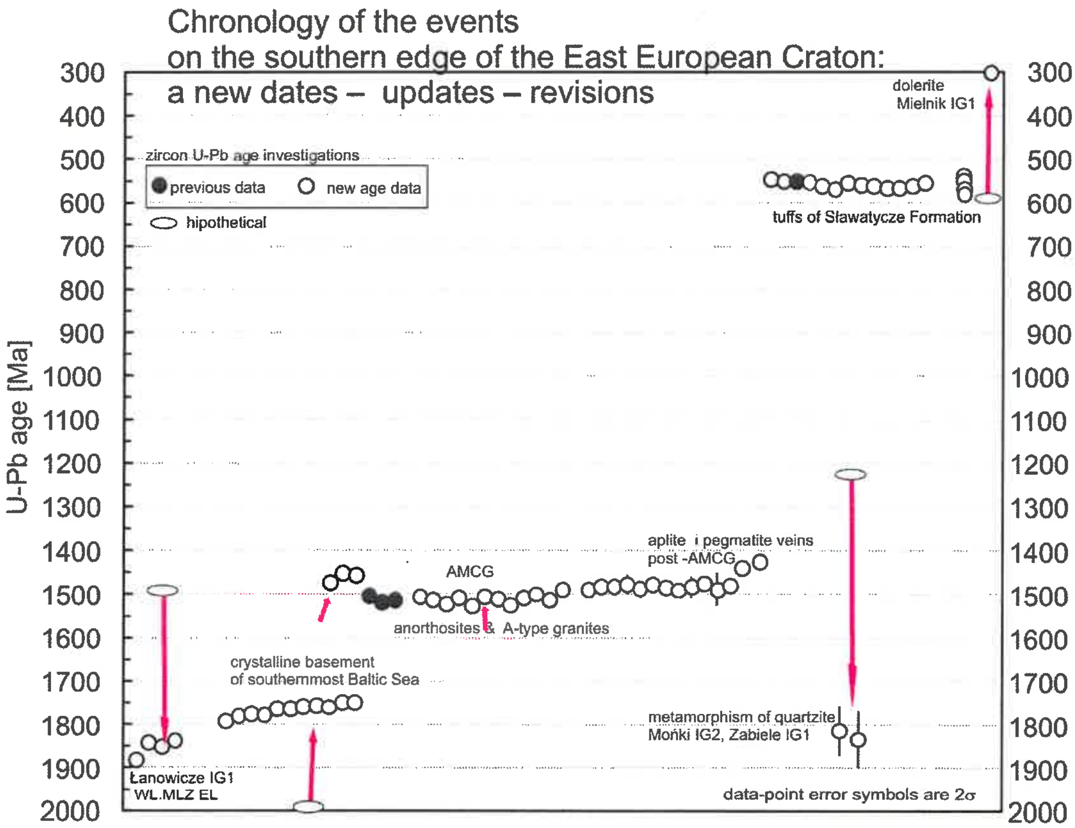
as well as on the basis of isotope bases, the corrected stratigraphic positions of rock formations occurring from the Baltic Sea to the Podlasie region have been indicated. This made it possible to carry out regional correlations giving a consistent image of the evolution of the crust over approximately 1,500 million years, from Orosir to the Late Carboniferous. This is a significant contribution to the advancement of knowledge about the geology of the southwestern part of the East European Craton, which includes:

(1) revision of the age of formation of Palaeo- and Mesoproterozoic rocks of the crystalline basement [**A1, A2, A3**];

(2) correction of the stratigraphic position of pre-Mesoproterozoic mature meta-sediment rocks [**A4**] and late Palaeozoic diabase [**A7**],

(3) determination of the time frame of the Late Ediacaran volcanic activity of the Sławatycze formation [**A5, A6**].

A scope of the introduced chronostratigraphic changes and geochronological supplements is presented by the graphical abstract:



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

5.1. 2015 - 2017 A scientific cooperation with the Department of Bioarchaeology of the Faculty of Archeology at the Warsaw University (Dr. Arkadiusz Sołtysiak) going beyond the NCN Harmonia 5 project 2013/10 / M / HS3 / 00554 *The role of the environment in the urbanization process in Syria in the late Chalcolithic: mass analysis burials from Tell Majnuna*. The aim of the cooperation was to measure the ratio of oxygen isotopes in the enamel layers of mammalian teeth with a precisely defined chronology, that allowed to reconstruct climate variability on a monthly basis and capture the seasonality of the diet and location. The result of this cooperation was the development and implementation of the methodology of isotope studies of enamel (bioapatite), including the performance of double profiles (lingual and cheek side) in accordance with the chronology of incremental zones. The methodology is described and applied in several publications, including:

Krzemińska, E., Sołtysiak, A., Czupyt, Z. J. 2017. Reconstructing seasonality using $\delta^{18}O$ in incremental layers of human enamel: A test of the analytical protocol developed for SHRIMP IIe/MC ion microprobe. Geological Quarterly, 61(2), 370-383. doi: 10.7306/gq.1354
[9 citations including w *Science Advances*: Smith T.M., et al. 2018. Wintertime stress, nursing, and lead exposure in Neanderthal children.]

5.2. 2008 - 2015 A scientific cooperation with the Australian research institute of Earth Sciences: Research School of Earth Sciences (RSES), Australian National University in Canberra under grant 1157 / B / P01 / 2008/35, of which I was a leader. Some of the results are included in the report (http://rses.anu.edu.au/highlights/view.php?article=89&print=1.)

Scientific cooperation within the project of *Development of a model of the geological structure of the base of the sedimentary cover of the Polish part of the East European Platform*, during which at RSES I carried out the main geochronological task including the U-Pb isotope analyzes; The result of this cooperation is a monograph and the first article of the series **[A1]**:

Krzemińska E., Krzemiński L., Petecki Z., Wiszniewska J., Salwa S., Żaba J., Gaidzik K., Williams I.S. (RSES, ANU), Rosowiecka O., Taran L., Johansson Å., Pécskay Z., Demaiffe D., Grabowski J., Zieliński G., 2017. Mapa geologiczna podłoża krystalicznego Polskiej części platformy wschodnioeuropejskiej 1:1 000 000 [Eng. Sum.]. Państwowy Instytut Geologiczny, Warszawa.

Williams I.A., Krzemińska E., Wiszniewska J., 2009. An extension of the Svecofennian orogenic province into NE Poland: evidence from geochemistry and detrital zircon from Palaeoproterozoic paragneisses. *Precambrian Research*, **172**: 234–254 [20 citations]

A distinct stage of cooperation took place after signing the contract for the supply of the SHRIMP Iie/MC-new ion microprobe to PGI-NRI, in which RSES ANU (official agreement on scientific cooperation) and Geoscience Australia were responsible for the part related to the implementation of the methodology and application of isotopic analyzes at PGI-NRI.

5.3. 2010 - 2016 A scientific cooperation with laboratories with a similar equipment and isotopic methodology:
IBERSIMS, Centro de Instrumentaciòn Cientifica, University of Granada,
2012 - training stay - Ion micro probe SHRIMP (IBESIMS),
2016 - co-organizing the VIII SHRIMP Workshop conference (University of Granada and the Polish Geological Institute NRI) https://fciencias.ugr.es/en/34-noticias/2398-viii-shrimp-international-workshop
2013 - 2018 Chinese Academy of Geological Sciences Beijing, and currently SHRIMP Center
2016 - SHRIMP-NIPR National Institute of Polar Research Tachikawa, Tokyo,
2012 and 2020 - Geoscience Australia laboratory, Canberra.

5.4. 1996 - 2014 A Scientific cooperation with research institutions from the countries of the Baltic Sea basin, as part of the international research project EUROBRIDGE. The project aimed to verify the hypotheses concerning the formation of the East European Craton, with particular emphasis on the connection zone between Fennoscandia and Sarmatia. Participation in working meetings aimed at geological correlation of the Polish-Lithuanian border area (University of Vilnius: Prof. Gedyminas Motuza, Dr. Grazina Skridlaite) and Belarusian (Dr. Ludmila Taran).

6. Information about the achievements in teaching, organization and popularizing science or art.

6.1 Educational achievements

Since 2014 (launching the SHRIMP ion microprobe laboratory at the PGI-NRI) I have been dealing with the presentation of theoretical and practical knowledge as part of workshops and individual presentations on the methodology and variants of the isotope ratios measurements and their application.
Until now, the listeners were students:
University of Warsaw, Faculties of Geology, Archeology, Geophysics,
University of Science and Technology AGH,
Jagiellonian University,
University of Silesia.

Every year, as part of the subjects "Geochronology" and "Advanced methods of research of minerals and rocks", in the summer semester I give a lecture for second-year students of master's studies at the Faculty of Geology of the University of Warsaw, combined with classes in the laboratory. It is usually an introduction to the theoretical background and examples of practical application of the SHRIMP IIe / MC ion microprobe.

I take care of scientific supervision and classes as part of student internships, ranging from 1-2 months to one year, each time on the basis of an individually prepared scientific plan. Until now, these were second-cycle students:
The Faculty of Geology, University of Warsaw
[in 2015, 2016, 2019, 2020, 2021];
Of the Faculty of Archeology of the University of Warsaw
[in 2015 from the Department of Archeology of Egypt and Nubia, in 2016 from Université de Montréal, Quebec, Canada / from the Department of Bioarcheology /].
Third-cycle students - doctoral studies: Institute of Geological Sciences of the Polish Academy of Sciences [2015, 2015/2016]
Department of Petrology, Institute of Geochemistry, Mineralogy and Petrology, University of Warsaw: [2019, 2020].

I was the supervisor / co-promoter of master's theses:
Album number 309597 "The genesis of charnockites from the Łanowicze PIG-1 drilling in the light of research on zircon and other accessory minerals" - work completed in 2015.
Album number 324097 "The origin and age of the Bielice granitoids in the vicinity of Bielice, on the basis of isotope studies of zircons" - work completed in 2016.
In the years 2006-2010, I conducted several-week series of classes on the basics of petrography and petrology of igneous rocks for employees of Angolan geological survey.

6.2. Organizational achievements
In 2010, as part of the competition of the Minister of Science and Higher Education and the Research Infrastructure Support Program under the Polish Science and Technology Fund (FNiTP), at the request of the PGI-NRI Director, I was an author of the application (FNiTP 562/2010) to finance an investment called " The Advanced Isotope Microanalysis Laboratory at the PGI-NRI with a high-resolution SHRIMP IIe / MC ion micro probe in a multi-collector version ". The application (FNiTP 562/2010) received a score of 91.67 points out of 100 possible points and was selected for funding as it was ranked number 2 in the FNiTP "natural sciences" ranking. The material scope of the investment task in accordance with the content of the FNiTP 562/2010 application and the agreement No. 661 / FNiTP / 616/2011 concluded on 09/09/2011 between the Ministry of Science and Higher Education and the PGI-NRI, included a formation of an ion micro probe laboratory with auxiliary facilities as well as the laboratory for mineral separation and sample preparation. In the years 2011-2014 at PGI-NRI, I was the coordinator and manager of the team whose task was to perform all activities related to the purchase, installation and then implementation of the ion micro probe facility.

Ewa Krzemińska

.... (the applicant's signature