



Państwowy Instytut Geologiczny
Państwowy Instytut Badawczy

państwowa służba geologiczna
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Załącznik 3b

Summary of Professional Accomplishments

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1. Name.

Aleksandra Kozłowska

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.

2002 – PhD in Earth Sciences, Geology – Polish Geological Institute – National Research Institute

Title of Doctor's Thesis: *Diogeneza piaskowców górnego karbonu w północno-zachodniej części rowu lubelskiego*;

Supervisor Prof. Dr Hab. Anna Maliszewska;

Reviewers: Prof. Dr Hab. Anna Langer-Kuźniar and Dr Hab. Andrzej Barczuk

1986 – Master's degree in geology (specialty: stratigraphy and exploration geology) – Faculty of Geology, University of Warsaw

Title of Master's Thesis: *Mineralizacja kruszcowa w rejonie Udrynia na masywie Suwalskim (na podstawie wierceń)*;

Supervisor: Doc. Dr Eugenia Zimnoch.

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

2002 – Present Assistant Professor at the Polish Geological Institute – National Research Institute

1991 – 2002 Research Assistant at the Polish Geological Institute

1990 – 1991 Senior Research Assistant at the Polish Geological Institute

1987 – 1990 Research Assistant at the Polish Geological Institute

1987 – 1987 Petrographer at the Polish Geological Institute

1986 – 1987 Intern at the Polish Geological Institute

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

4.1. Cycle of scientific articles related thematically, pursuant to art. 219 para 1. point 2b of the Act. Title of scientific achievement:

Diagenesis of Upper Jurassic sideritic rocks in Poland

4.2. Publications included in the scientific achievement.

Electronic versions of publications submitted as the scientific achievement are included in **Załącznik 5**, while the co-authors' statements on individual contributions to the publications are provided in **Załącznik 6**.

[A1] **Kozłowska A.**, Maliszewska A., 2015. Berthierine in the Middle Jurassic sideritic rocks from southern Poland. *Geological Quarterly*, 59, 3: 551-564.

Indexed in the Journal Citation Report

List A MNiSW; Scoring for the year of publication: 20 points; 2019 Score:70

IF for the year of publication 0.858; 5-year IF 0.918

My participation in the preparation of the publication consisted in: 1) managing the research projects covering the study described in this work, 2) collecting research material, 3) developing research concepts and methodology, 4) literature studies, 5) performing petrographic and cathodoluminescence research, 6) selecting and preparing samples for studies in a scanning electron microscope with an energy dispersive X-ray analyser and the conversion of the results of quantitative analyses of carbonates into molecular composition, 7) selection and preparation of samples for X-ray analysis, and interpretation of the obtained results, 8) compilation of the research results in Tables 1-6, 9) taking photomicrographs for presentation in Figure 5, 10) manuscript preparation, 11) participation in the preparation of responses to reviews, 12) preparation of the final version of the manuscript.

[A2] Jarmołowicz-Szulc K., **Kozłowska A.**, 2016. Temperature and isotopic relations in carbonate minerals in the Middle Jurassic sideritic rocks of central and southern Poland. *Geological Quarterly*, 60, 4: 881-892.

Indexed in the Journal Citation Report

List A MNiSW; Scoring for the year of publication: 20 points; 2019 Score:70

IF for the year of publication 0.833; 5-year IF 0.950

My participation in the preparation of the publication consisted in: 1) managing the research projects covering the studies described in the paper, 2) collecting research material, 3) participation in the

development of research concepts and methodology, 4) literature studies, 5) conducting petrographic and cathodoluminescence research, 6) selection and preparation samples for study in a scanning electron microscope with an energy dispersive X-ray analyser and the conversion of the results of quantitative analyses of carbonates into molecular composition, 7) performing most of the homogenization temperature measurements in two-phase inclusions in Mg-siderite from the Gutwin borehole and the Wąglany near Opoczno borehole, 8) selection and preparation of samples for isotopic studies and analysis of $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ determinations in carbonate minerals, 9) compilation of the research results in Tables 1, 2 and in Attachment 1, 10) taking photomicrographs under a polarizing microscope for presentation in Figures 3 and 4,) construction of Figures 4 and 5 that contain the results of isotopic research, 12) manuscript preparation (except chapters on fluid inclusion research), 13) participation in the preparation of responses to reviews, 14) participation in the preparation of the final version of the manuscript.

[A3] Maliszewska A., **Kozłowska A.**, Kuberska M., 2018. Skały syderytowe jury środkowej Kujaw - studium petrologiczne. *Przegląd Geologiczny*, 66, 4: 240-251.

Scoring for the year of publication: 12 points; 2019 Score: 40 points

My participation in the preparation of the publication consisted in: 1) collecting part of the research material, 2) participation in the development of research concepts and methodology, 3) literature studies, 4) participation in conducting petrographic and cathodoluminescence research, 5) participation in selecting and preparing samples for study in a scanning electron microscope with an energy dispersive X-ray analyser and converting the results of quantitative analyses of carbonates into molecular composition, 6) performing studies of fluid inclusions, 7) presentation of the chemical composition of carbonate minerals on triangle diagrams – Figures 9 and 10, 8) compilation of the results of isotopic analyses in Table 1, 9) compilation of the results of fluid inclusion studies in Table 2, 10) interpretation of the results of isotopic and fluid inclusion studies, 11) participation in the manuscript preparation, 12) participation in the preparation of responses to reviews, 13) preparation of the final version of the manuscript.

[A4] **Kozłowska A.**, 2019. Instrumental methods applied in the investigations of carbonate minerals in the Middle Jurassic sideritic rocks with respect to diagenetic processes. *Biuletyn PIG*, 474: 31-42.

Scoring for the year of publication: 20 points

My participation in the preparation of the publication consisted in: 1) managing the research projects covering most of the studies described in the paper, 2) collecting research material, 3) developing research concepts and methodology, 4) literature studies, 5) conducting petrographic and cathodoluminescence research, 6) selection and preparation of samples for examination in a scanning

electron microscope with an energy dispersive X-ray analyser and conversion of the results of quantitative analyses of carbonates into molecular composition, 6) selection and preparation of samples for isotope analyses and determinations of $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values in carbonate minerals, 7) taking photomicrographs in a polarizing microscope and cathodoluminescence for presentation in Figures 2 and 3, 8) manuscript preparation, 9) preparation of the final version of the manuscript.

4.3. Projects directly related to a scientific achievement.

The work carried out within the framework of two research grants financed by the Ministry of Science and Higher Education and the National Science Centre, and two statutory research projects financed by the Ministry of Science and Higher Education, carried out at the Polish Geological Institute - NRI, enabled conducting scientific research and obtain results published in the papers [A1] to [A4].

In the period 2004–2007, I was one of the three major participants in the research grant [N2] entitled *Petrologia jurajskich skał sydereitowych na Nizinie Polskiej* and in a statutory research project [S8] entitled *Syderyty jurajskie Kujaw i Wielkopolski: studium petrologiczne*. Prof. Dr Hab. A. Maliszewska was the leader of both projects. The research results were presented at national [K12; K25] and international [L6; L9; L10] scientific conferences, as well as in publications [A3; A4].

The research on sideritic rocks was continued with subsequent projects conducted in the years 2006-2013: a statutory project [S12] titled: *Skały sydereitowe jury środkowej w północnym obrzeżeniu Gór Świętokrzyskich a warunki ich sedymentacji i diagenety*, and the research grant [N4] titled: *Diagenety sydereitowych rud żelaza jury środkowej z północnego obrzeżenia Gór Świętokrzyskich i obszaru częstochowsko-wieluńskiego*. I was the leader of the projects. The research results of these projects were presented at national [K14; K20] and international [L15, L24, L26, L28] conferences, as well as in publications [A1; A2; A4].

4.4. Overview of achievements.

4.4.1. Introduction.

Research on Middle Jurassic sideritic iron ores in the outskirts of the Holy Cross Mountains margin were started by Kuźniar (1924, 1925). His most extensive contribution covers the results of research on a sideritic iron ore deposit in Parczew (Kuźniar, 1928). In the same year, an extensive work by Jaskólski (1928) was published, which describes the results of studies of Doggerian ore-bearing clays in the Częstochowa region. Those studies were

continued by Jaskólski in association with Sawicka-Ekiert after World War II (Jaskólski, Sawicka-Ekiert, 1955). In 1966, Ekiert performed a petrographic study of Doggerian iron ores from eight boreholes in the vicinity of Wieluń, Olsztyn and Zawiercie. The most interesting and important in the field of iron ore petrography in Poland is the study of the Łęczyca ore-bearing deposits of the Upper Vesulian (currently the Lower Bathonian) in the Kujawy region, published by Turnau-Morawska (1961). Petrographic characteristics of Middle Jurassic iron ores from the Kamień Pomorski region were presented by Dadlez in 1963 and 1964. Due to the limited instrumental methods at that time, petrographic studies were limited mainly to the mineral composition identification and determination of iron content in rocks.

With the emergence of new analytical possibilities, which allowed better characterization of the mineral composition and determination of the origin of sediment mineralization, studies of sideritic rocks at the Polish Geological Institute-National Research Institute were resumed. The work started in 2004 and was carried out in four research projects [N2], [S8], [S12] and [N4]. As a result, sideritic rocks were investigated in the Polish Lowlands [K12; K25], [L6; L9; L10], [A3; A4], and then in the north-eastern margin of the Holy Cross Mountains and in the Częstochowa region [K14; K20], [L15; L24; L26; L28], [A1, A2, A4].

The aim of the research was to identify thoroughly the mineral composition of Middle Jurassic sideritic rocks and to determine the conditions of siderite formation against the background of the diagenetic history of Middle Jurassic deposits. The usefulness of currently used instrumental methods for the interpretation of the origin of sideritic rocks was also presented.

4.4.2. Research methods

Sideritic rocks were tested on 64 samples from 35 boreholes in the Polish Lowlands (Kujawy, Wielkopolska, Western Pomerania), 156 samples from 11 boreholes in the north-eastern margin of the Holy Cross Mountains, and 116 samples from 6 boreholes in the Częstochowa region (Fig. 1).



Fig. 1. (Fig. 1 in the article [A4]) Location of the studied boreholes; grey area – extent of the Middle Jurassic in Poland after Lott et al. (2010).

Microscopic investigations of uncovered, polished thin sections were carried out on a Nikon Optiphot 2 polarizing microscope. The percentage content (vol.%) of the mineral composition of the analyzed sideritic rocks was obtained from planimetric analysis using the point count method, counting up to 300 grains, on the integration stage produced by the British company Prior, or determined as an estimated percentage.

All analyzed thin sections were stained with Evamy's solution to determine the type of carbonate cement.

Cathodoluminescence analyses (CL) were performed at the PGI-NRI on an English device, the so-called cold cathode, models CCL 8,200 mk3 and CITL MK5 (equipped with EDX), both from Cambridge Image Technology Ltd, which are mounted on a Nikon polarizing microscope. The cathodoluminescent method is useful in distinguishing carbonate cements because some types of carbonate show different luminescence.

Scanning electron microscopy (SEM) examinations were performed with the use of two microscopes: the JSM-35 type from JEOL and the LEO 1430 type, combined with the EDS ISIS energy microprobes manufactured by Oxford Instruments. Uncovered, polished and carbon-sputtered thin sections were analyzed to identify the chemical composition of mainly carbonate minerals. The SEM Quant software was used in the quantitative X-ray analysis of microareas. All the results of quantitative carbonate analyses were converted to molecular composition.

The study of fluid inclusions was carried out under a microscope, in special double-side polished thin sections, mainly with the use of both a Linkam freezing and heating apparatus mounted on a Leitz Orthoplane polarizing microscope and a Nikon fluorescence filter set (ultraviolet and blue light). Heating and freezing of samples was carried out generally in the temperature range from room temperature (19-29°C) to +100°C and to -70°C. The accuracy of the measurements against the commonly used SynFline standards is 1°C at temperatures above zero, and 0.1°C at freezing temperatures. The complex FLUIDS package (Bakker, Brown, 2003) and the FLINCOR software (Brown, 1989), covering less complex chemical systems, were used to calculate the values of isochores, salinity and other parameters.

X-ray examinations were performed on an X'Pert PW 3020 X-ray diffractometer from Philips. The mineral composition of the clay fraction was examined on air-dry oriented preparations, after glycolization and heating to 550°C for one hour.

Isotope studies of oxygen and carbon in carbonate minerals were carried out on CO₂ obtained from carbonate samples according to standard procedures for the reaction with phosphate acid (McCrea, 1950; Al-Aasm et al., 1990). Measurements were made on a modified MI1305 spectrometer (Hałas, 1979; Hałas, Skorzyński, 1980; Durakiewicz, Hałas, 1994; Durakiewicz, 1996). The accuracy of the measurements is ± 0.1 ‰.

Of research methods used in the analysis of sideritic rocks, I carried out polarizing microscope and cathodoluminescence research together with Prof. dr hab. A. Maliszewska and dr M. Kuberska. I participated in the research on fluid inclusions conducted by dr hab. K. Jarmolowicz-Szulc. Scanning electron microscopy studies were carried out by L. Giro (PGI-NRI), X-ray analysis by W. Narkiewicz (PGI-NRI), and isotope studies by Prof. S. Hałas and his team (Mass Spectrometry Laboratory of the Institute of Physics at the Maria Curie-Skłodowska University in Lublin).

4.4.3. Research results

4.4.3.1. Sideritic rocks

The Middle Jurassic sideritic rocks are represented by clayey siderites (also include muddy and sandy varieties), sideritic sandstones and sideritic coquinas, which are the most common among them (Fig. 2, 3). Sideritic conglomerates and sideritic claystones and mudstones are less common. Sideritic rocks occur in the form of layers and concretions. In the Polish Lowlands, siderites were formed mainly in Lower and Upper Bajocian and Lower Bathonian deposits. The main types distinguished are clayey siderites and sideritic coquinas (Łęczyca region), less frequent are sideritic sandstones (Maliszewska et al., 2007a [N2], b [K12]; [A3]). In the northern margin of the Holy Cross Mountains, siderites are found in Lower Aalenian, Lower and Upper Bajocian, and Lower and Middle Bathonian deposits. The dominant rock types in that area are clayey siderites and sideritic sandstones; there are also sideritic coquinas, conglomerates and mudstones (Kozłowska et al., 2008 [S12]; 2013 [N4]). In the Częstochowa region, siderites occur in the Upper Bajocian and Bathonian (predominantly Lower and Middle Bathonian). In that area, clayey siderites are more common than sideritic sandstones, while sideritic coquinas and mudstones are observed on a local scale (Kozłowska et al., 2013 [N4]).

Sideritic rocks are composed of iron carbonate, mainly Mg-siderite and less frequent siderite. Mg-siderite is represented by sideroplesite, which is a mineral of the isomorphic siderite-magnesite series, containing 70-95% FeCO_3 and 5-30% MgCO_3 (Bolewski, 1982). Pistomesite appears quite often and contains 50-70% FeCO_3 and 30-50% MgCO_3 (Bolewski, 1982). The mineral that shows a siderite composition ($\text{FeCO}_3 > 95\%$, Bolewski, 1982) is rare (Maliszewska et al., 2006 [L9]; Maliszewska et al., 2007a [N2], b [K12]; Kozłowska et al., 2008 [S12]; 2013 [N4]; [A1]; [A2]; [A3]).

Clayey siderites are dark brown, compact rocks. They are composed mainly of sideroplesite (Fig. 2A) of micrite- and microspar-sized crystals, occasionally spar-sized. The sideroplesite content ranges from 50 to 98 vol.% of rock. It is accompanied by clay minerals (kaolinite, illite, berthierine) that account for 0-35 vol.%. The contents of quartz grains of aleurite and psammite size are variable, with a maximum of about 40 vol.% of rock. The content of bioclasts and ooids does not usually exceed 4 vol.% of rock. The accessory constituents include feldspar, mica, zircon, pyrite, hematite and organic matter. In places, clayey siderites are cut with veins filled with calcite, ankerite and pyrite.

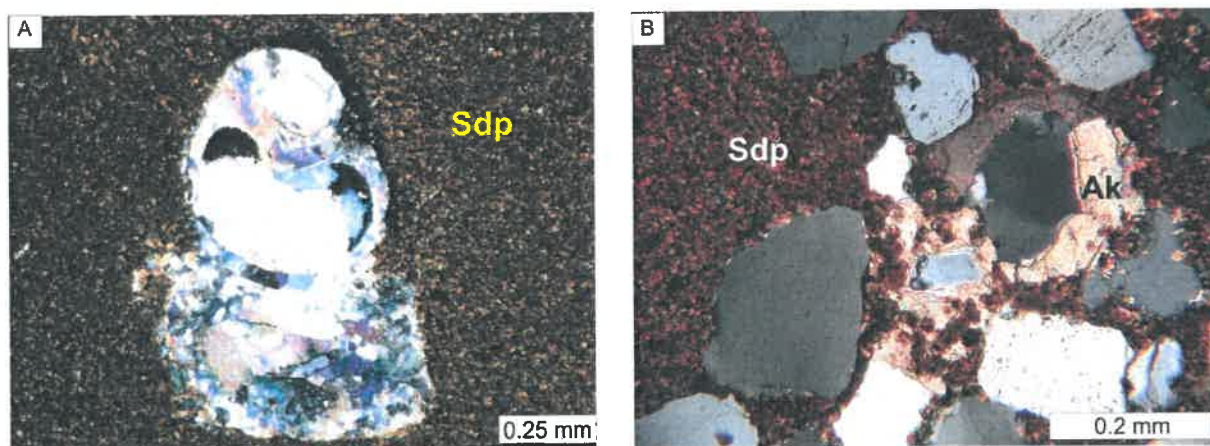


Fig. 2. A. (Fig. 2A in the article [A4]) Clayey siderite composed with micritic sideroplesite (Sdp) with gastropoda calcite shell. Goszczynno 4/III borehole, depth 66.4 m, crossed polars. B. (Fig. 2G in article [A4]) Micrite sideroplesite (Sdp) and ankerite (Ak) cements in siderite sandstone. Mniszków IG 1 borehole, depth 962.0 m, crossed polars.

Sideritic sandstones are usually fine and medium-grained quartz arenites (Fig. 2B), compact, grey-brown in colour. Quartz grains account for 16-80 vol.% of rock, while the content of feldspars, micas and zircons is minor. The amounts of bioclasts and ooids (Fig. 3B; mainly berthierine and carbonates in composition) are variable, and the maximum content of each of these components can reach about 18 vol.% of rock. The cement in the sandstones is composed of carbonate minerals: micrite and microsparite sideroplesite, sparite sideroplesite, pistomesite, ankerite, calcite and clay minerals (kaolinite, illite, berthierine, chlorites). Locally, the rock is cut with veins filled with calcite, ankerite, sideroplesite and pistomesite.

Sideritic coquinas are generally compact rocks, brown or grey-brown in colour. They are characterized by organodetrital structure and mostly directional texture, emphasized by the arrangement of bioclasts. The main components of the coquinas are bioclasts (Fig. 3A), mainly fragments of shells of bivalves, brachiopods, foraminifera, gastropods, skeletal elements of echinoderms, and serpulid tubes. The least frequent are fragments of bryozoans and algae colonies. Their content ranges from 20 to 80 vol. % of rock. Additional components are quartz grains, berthierine, carbonate and phosphate ooids, and small amounts of feldspar, rock fragments and phosphates. The grain material is cemented with micrite and microsparite sideroplesite, sparite ankerite, calcite, pistomesite and clay minerals (berthierine, illite, kaolinite). In coquinas, veins filled with calcite, dolomite, sideroplesite, pistomesite, kaolinite and ores were observed.

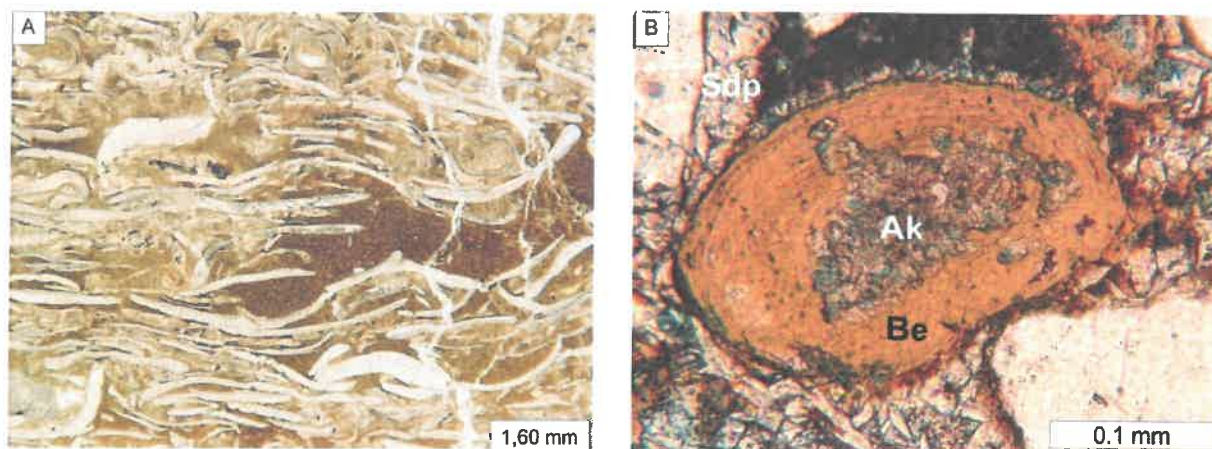


Fig. 3. A. (Fig. 2A in the article [A3]) Dense packing of shell fragments in sideritic coquina; brownish sideroplesite concentration. Borszyn 1/XIX borehole, depth 184.0 m, one polar. B. (Fig. 3D in the article [A4]) Berthierine (Be) ooids replaced by ankerite (Ak) in sideritic sandstone cemented by sideroplesite (Sdp) spar (rhombhedrons) and ankerite (blue colour by Evamy's solution). Omięcin XI/3 borehole, depth 172.8 m, one polar.

Sideritic conglomerates are represented in several samples. They are referred to as poly- and oligomictic paraconglomerates due to the nature of psephitic clasts [A1].

Psephite grains of polymictic paraconglomerates are represented by clasts of clayey siderite, sideritic claystone, sandstones cemented with ankerite, calcite or berthierine, carbonate rocks and mono- and polycrystalline quartz. The groundmass of the conglomerates is a sandy matrix, locally with bioclasts and ooids, as well as cements: sideroplesite (micrite, microspar), calcite and berthierine.

The oligomictic paraconglomerate is composed of psephitic clasts of calcite-sideritic sandstone cemented with micritic sideroplesite.

Sideritic mudstones and claystones are brown rocks showing a pelite-aleurite structure and directional texture, manifested by the arrangement of micas, siderite and organic matter. They contain from 20 to 30 vol. % of rock of carbonate minerals represented only by micritic sideroplesite. The detrital material includes quartz silt and sand, micas (mainly muscovite) and clay minerals. Fossil plant debris is common.

4.4.3.2. Carbonate minerals

The major carbonate mineral in sideritic rocks is iron carbonate (Mg-siderite) – sideroplesite. Pistomesite occurs in places, while siderite is sporadic. They are accompanied by variable amounts of calcite and ankerite [A2; A3; A4].

Siderite, sideroplesite and pistomesite in sideritic rocks occur as the groundmass, cement filling pore spaces in the rock, and minerals replacing clay minerals in ooids. In places, they fill the voids in bioclasts and form veinlets. These minerals occur as micrite, microspar and spar, often forming rhombohedral crystals. The Evamy's solution does not stain iron carbonates; in cathodoluminescence, they do not show fluorescence. Based on microscopic observations, two sideroplesite generations have been identified: early and late (Fig. 4; [A2]), like in the Carboniferous sandstones of the Lublin Graben (Kozłowska, 1997 [C3]; 2001 [D10]; 2004 [H1]). Siderite represents only the early generation, while pistomesite represents only the late generation. Within the early generation, micrite and microsparitic sideroplesite, locally siderite, have been distinguished. Sideroplesite of the late generation, compared to that of the early one, is characterized by larger crystals and higher magnesium content. It is represented by sparitic sideroplesite, less frequently by pistomesite. The chemical composition of sideroplesite and pistomesite individuals, based on the chemical analysis in an electron microscope, is as follows: 63.9-91.4 mol% FeCO_3 , 5.2-32.1 mol% MgCO_3 , 1.9-18.7 mol% CaCO_3 , and 0.0-4.2 mol% MnCO_3 (Fig. 5) (Kozłowska et al., 2008 [S12]; 2013 [N4]; [A2]; [A3]; [A4]). Within the rhombohedral crystals of sideroplesite and pistomesite, a zonal structure is often observed, which is related to the variable content of iron and magnesium. It is very well visible in backscattered (BSE) electron images (Fig. 4B) [A2]. Rhombohedral crystals in sideritic rocks are more common in the northern margin of the Holy Cross Mountains than in the Częstochowa region and the Polish Lowlands. Temperature studies were performed in spar-sized sideroplesite and pistomesite individuals (some were rhombohedrons) that contained fluid inclusions large enough for analysis. The obtained homogenization temperatures ranged from 48.5 to 139.0°C, the freezing temperatures were from -10.0 to -3.4 °C, and the eutectic temperatures varied from -40 to -30°C (Kozłowska, 2014 [K20]; [A2]; [A3]). The carbon and oxygen isotope determinations were performed mostly for the early generation sideroplesite and pistomesite. The $\delta^{13}\text{C}$ PDB values range from -29.76 ‰ to 1.60 ‰, and the $\delta^{18}\text{O}$ PDB values from -7.84 ‰ to 1.86‰ (Maliszewska et al., 2007a [N2]; Kozłowska et al., 2008 [S12]; 2013 [N4]; [A2]; [A3]; [A4]). Two samples were tested for isotopes in the late generation sideroplesite and pistomesite. The $\delta^{13}\text{C}$ PDB values are -10.83 ‰ and 9.58 ‰, and the $\delta^{18}\text{O}$ PDB values are 8.82 ‰ and -10.45 ‰, respectively (Kozłowska et al., 2008 [S12]; 2013 [N4]; [A2]; [A4]).

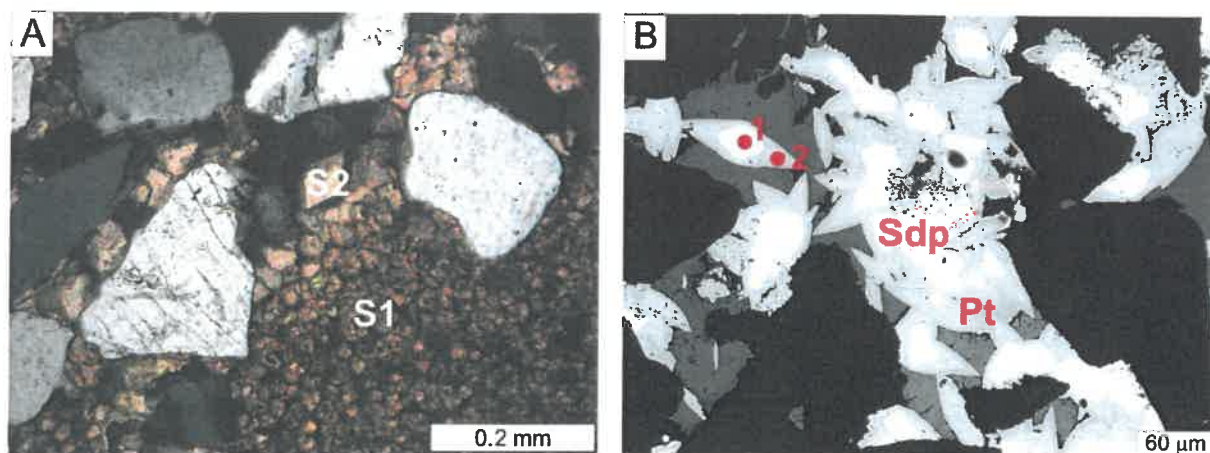


Fig. 4. A. (Fig. 4A in the article [A2]) Two generations of siderite – the early generation (S1 – microsparitic sideroplesite and late generation (S2 – sparitic sideroplesite) in clayey siderite. Łutowiec 135Ż borehole, depth 178.9 m, crossed polars. B. (Fig. 4B in the article [A2]) Zonal structure in rhombohedral crystals of sideroplesite (Sdp) and pistomesite (Pt) which form cement in siderite sandstone; 1, 2 – numbers of points of analysis (Appendix 1). Gutwin borehole, depth 201.6, BSE image.

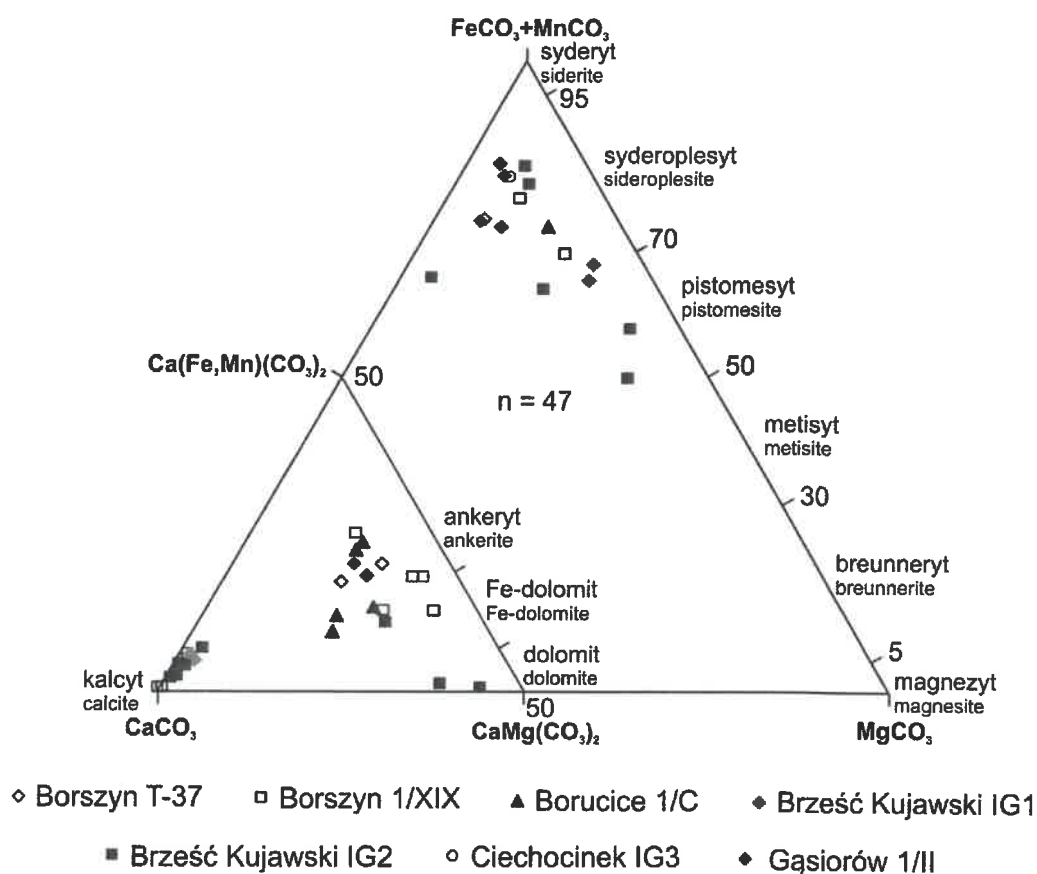


Fig. 5. (Fig. 9 in the article [A3]) Carbonate cements of Middle Jurassic sideritic rocks in the $\text{FeCO}_3 + \text{MnCO}_3 - \text{CaCO}_3 - \text{MgCO}_3$ triangular diagram.

Calcite not only occurs in bioclasts, but also forms a cement in sideritic rocks, fills veinlets and replaces minerals (berthierine, phosphates) that are components of ooids. It forms micrite-sized and spar-sized crystals. Treated with Evamy's solution, it stains red (calcite) or pink-violet (Fe-calcite). In cathodoluminescence studies, it is yellow, yellow-orange, red and brown-orange, or shows no luminescence. The luminescence effect is due to the content of iron and manganese in calcite. Chemical analyses in an electron microscope showed the following chemical composition of calcite: 0.0-5.7 mol% FeCO₃, 0.1-4.2 mol% MgCO₃, 90.0-99.6 mol% CaCO₃, and 0.0-4.1 mol% MnCO₃ (Maliszewska et al., 2007a [N2]; Kozłowska et al., 2008 [S12]; 2013 [N4]; [A4]). The studies show that it most often represents Fe-calcite or Fe/Mn-calcite. Calcite contains numerous fluid inclusions, but temperature measurements could have been performed only in one sample [A2]. The homogenization temperature of calcite in a veinlet is between 59.8 and 67.8°C. The $\delta^{13}\text{C}$ PDB values range from -19.48‰ to -2.01‰, and the $\delta^{18}\text{O}$ PDB values from -8.11‰ to -1.22‰ (Kozłowska et al., 2008 [S12]; 2013 [N4]; [A2]; [A4]).

Ankerite and Fe-dolomite are the cement in sideritic rocks, fill veinlets, occur in bioclasts, and replace berthierine of ooids. **Dolomite** was found locally, only in veinlets. Ankerite and Fe-dolomite crystallize in the form of microspar and spar. Treated with Evamy's solution, dolomite does not stain, Fe-dolomite turns light blue, and ankerite is blue. In cathodoluminescence studies, dolomite is red, while Fe-dolomite and ankerite do not show luminescence due to the high iron content. The chemical composition of Fe-dolomite and ankerite identified in an electron microscope is as follows: 11.0-24.9 mol% FeCO₃, 14.6-27.5 mol% MgCO₃, 50.5-71.2 mol% CaCO₃, and 0, 0-2.7 mol% MnCO₃ (Maliszewska et al., 2007a [N2]; Kozłowska et al., 2008 [S12]; 2013 [N4]; [A4]). Fe-dolomite and ankerite contain numerous fluid inclusions. In some of them, homogenization temperatures were measured ([A2]; [A3]), obtaining the values ranging from 75.9 to 185.3°C. Isotope determinations were made for two samples that contained ankerite. The $\delta^{13}\text{C}$ PDB values are -7.04‰ and -6.54‰, and the $\delta^{18}\text{O}$ PDB values are -10.63‰ and -10.01‰ (Kozłowska et al., 2008 [S12]; 2013 [N4]; [A4]).

4.4.3.3. Clay minerals

X-ray examinations and point chemical analyses of clay minerals confirmed the presence of berthierine [A1]. In some samples, kaolinite, illite and traces of chlorites were also identified [A1].

Berthierine occurs mainly in sideritic sandstones, less often in clayey siderites, and sideritic conglomerates and coquinas. In thin sections, this mineral is green or yellowish-brown in colour and was previously described as chamosite. Berthierine composes ooids, is the cement in sideritic rocks, and fills the interior of bioclasts. Ooid grains are oval, less frequently spherical, and are 0.1-1.2 mm in average diameter. Their cores commonly contain quartz grains or small bioclasts. The ooid cortex shows a delicately marked concentric structure. The chemical composition of berthierine in ooids is as follows: 20.78-35.41 wt% SiO₂, 20.80-28.40 wt.% Al₂O₃, 25.59-38.05 wt% FeO, 0.00-0.44 wt% MnO, 0.00-1.13 wt% CaO, 0.00-5.44 wt% MgO, 0.00-0.29 wt% K₂O, and 0.00-1.36 wt% P₂O₅ [A1; A3]. Berthierine ooids in the Middle Jurassic rocks represent class B according to the classification of Kearsley (1989). There are numerous ooids of subclass B2, composed of berthierine with well-developed concentric laminae. Some of the ooids, in which the dominant minerals are berthierine and kaolinite, are included in subclass B4. They form flattened grains that are the effect of mechanical compaction. In addition, there are also ooids of subclass B5, which represent flattened berthierine ooids whose nucleus is made up of bioclasts composed of berthierine.

The commonly observed process is the replacement of berthierine by siderite and sideroplesite, which are subsequently replaced by Fe-calcite and ankerite. Ooid-composing berthierine is replaced by sideroplesite, pistomesite, Fe-calcite, ankerite and pyrite, and transformed into kaolinite and phosphates. According to the classification of Kearsley (1989), carbonate ooids belong to class C and subclasses C1 to C4. They represent carbonate ooids (siderite and calcite) that formed as a result of replacement of ooids composed of phyllosilicates. The studied rocks contain ooids in which berthierine was replaced by sideroplesite, pistomesite, Fe-calcite and ankerite. Sometimes, this process leads to the complete replacement of berthierine by carbonate minerals.

Berthierine was found in deposits that accumulated in marine and deltaic environments, in the period from the Early Bajocian to Late Bathonian. The presence of berthierine in the investigated rocks, both marine and deltaic, at places of freshwater and seawater mixing, may indicate sea level changes in the basin and the presence of warm waters. Water salinity in the basin is an important factor during berthierine crystallization.

In the studied sideritic rocks, berthierine ooids in the Bathonian deposits are characterized by a better state of preservation than those in the Bajocian and Aalenian rocks ([A1]). Diagenetic processes of replacement and alteration of berthierine are developed most strongly in clayey siderites. In the Bathonian of the north-eastern margin of the Holy Cross

Mountains, marine deposits, mainly nearshore, contain ooids in which berthierine is replaced by Fe-calcite and sideroplesite, rarely by ankerite. In the Bathonian deltaic deposits, berthierine ooids are usually well preserved. In the Upper Bajocian nearshore deposits, the most common ooids are those in which berthierine has been in places completely replaced by sideroplesite, pistomesite, Fe-calcite, ankerite and pyrite, and altered into kaolinite. These processes are less developed in the Częstochowa region compared to the north-eastern margin of the Holy Cross Mountains. Similar differences in the effects of diagenetic processes between both study areas were noticed in the Lower Bajocian deltaic deposits. In the Aalenian of the north-eastern margin of the Holy Cross Mountains, sideritic rocks that developed in various environments contain only ooids composed of kaolinite, pyrite, sideroplesite and pistomesite.

Other clay minerals identified in the sideritic rocks are kaolinite and illite, and locally chlorites. In the north-eastern margin of the Holy Cross Mountains, in addition to berthierine, also kaolinite, illite and trace amounts of chlorites were found in the Lower and Middle Bathonian, and kaolinite in the Upper Bajocian and Upper Aalenian. In the Częstochowa region, apart from berthierine, there is also illite (Lower Bajocian). Dudek's (2012) research showed that the content of illite in claystones of this area is greater than the contents of kaolinite and chlorite. The variability in the composition of clay minerals in deposits of different ages may indicate changes in the climate and sedimentary conditions during the Middle Jurassic.

4.4.4. Interpretation and discussion

The presence of siderites in the form of layers and concretions prompted some researchers to consider them syngenetic with the host deposits (Berg, 1944; Taylor, 1949). However, most researchers have long believed that these rocks were formed during diagenesis (e.g. Correns, 1942; 1952; Taupitz, 1954; Krajewski et al., 2001; Mücke, 2006; Stel, 2009). Studies of siderites from fossil deposits indicate their crystallization in various environments: marine, brackish and freshwater (including Weber et al., 1964; Matsumoto, Iijima, 1981; Krajewski et al., 2001). Similarly, the formation of siderites at present may be associated with various conditions, such as marine (Gautier, Claypool, 1984; Hałas, Chlebowski, 2004), brackish (Pye, 1981) or freshwater (Postma, 1969).

Sedimentological analysis performed by Dr. A. Feldman-Olszewska (Feldman-Olszewska, 2005; Kozłowska et al., 2008 [S12]; 2013 [N4]) showed that most of the studied siderites were formed in a low-oxygenated marine environment, mainly in the transition zone

between the fairweather and storm wave base and in the shoreface zones, which is mostly supported by the results of petrographic, mineralogical and geochemical studies.

There are three stages in the history of diagenesis of sideritic rocks: eodiagenesis, mesodiagenesis and telodiagenesis (according to the scheme of Choquette, Pray, 1970).

Eodiagenesis (early diagenesis) is the stage when physical and chemical processes operate under conditions of shallow sediment burial, in association with surface processes. This stage is strongly related to sedimentary conditions, especially with the degree of oxygenation or hypoxia in the sediment.

The earliest authigenic mineral in sideritic rocks is berthierine. Early precipitation of berthierine in the sediment, before or at the beginning of the action of mechanical compaction, is evidenced by the fact that this mineral fills large spaces between the grains. Also, the presence of berthierine in the inner parts of bioclasts indicates its early formation. This mineral crystallizes at 25-45°C (Hornibrook, Longstaffe, 1996) under tropical conditions, in a marine and deltaic environments, where fresh and sea waters mix (Worden, Morad, 2003; Wilson, 2013). Taylor (1998) and García-Frank et al. (2012) suggest the precipitation of berthierine under suboxic conditions. Berthierine uses reduced iron (Fe^{2+}) in the methanogenic zone at a low sedimentation rate (Odin, 1988). The most likely source of iron for berthierine in the study area seems to be freshwater of rivers carrying material from land weathering. As a result of contact of freshwater with the sea, the salinity of the former increases, causing the iron to flocculate and deposit mainly in a highly reactive amorphous state (Ehrenberg, 1993). Berthierine is formed by diagenetic recrystallization of odinite or other precursor minerals similar to it (Odin et al., 1988). The formation of berthierine requires reducing conditions where the activity of sulfides and bicarbonate is low (Taylor, 1990; Fritz, Toth, 1997; Sheldon, Retallack, 2002). Additionally, Fritz and Toth (1997) report that the precipitation of berthierine is associated with low activity of silica in solution, otherwise kaolinite is formed.

In a hypoxic environment, in sediments rich in reactive iron-containing minerals and at a low concentration of dissolved sulfates, berthierine is replaced by precipitating siderite (Brown, Kingston, 1993; Morad, 1998). In the studied rocks, it is mostly Mg-siderite - sideroplesite, locally siderite (Kozłowska et al., 2008 [S12], 2011 [L25], 2013 [N4]; Witkowska, 2012). The source of iron for sideroplesite and siderite, could be continental waters supplied to the sediment (Woodland, Stenstrom, 1979 fide Zymela, 1996; Blatt et al., 1980 fide Zymela, 1996) and clay and sulfide minerals brought to sedimentary basins from land (Pearson, 1979; Price, Sellwood, 1997). According to Narębski (1957), iron is also

brought in the form of colloidal suspension of $\text{Fe}(\text{OH})_3$, and the dissolution of this compound takes place as a result of the action of CO_2 -rich waters under the conditions of fermentation of organic residues on the seabed. The activity of microorganisms that decompose the organic matter contained in the sediment played a very important role in the precipitation of sideroplesite and siderite. It is assumed that siderite and sideroplesite were formed at relatively low temperatures ($<75^\circ\text{C}$, Morad, 1998) and at shallow depths.

Sideroplesite forms crystals of various sizes, which is related to the type of sideritic rock and the diameter of the network of channels and pores in the intergranular space, which allow the solutions to circulate. In clayey siderites, sideroplesite is most often represented by a very finely crystalline form (micrite, microspar), with a predominance of anhedral or subhedral crystals. In contrast, in sideritic sandstones and clayey-sandy siderites, sideroplesite forms crystals that are usually larger (microspar, spar) and better crystallized, locally euhedral.

Sideroplesites in the Middle Jurassic sideritic rocks are characterized by not only a high content of FeCO_3 , significant contents of MgCO_3 and CaCO_3 , and a small content of MnCO_3 ([A4]). According to Mozley (1989), significant amounts of MgCO_3 (up to 41 mol%) and CaCO_3 (up to 15 mol%), and less than 1 mol% MnCO_3 indicate the precipitation of siderites from seawater.

The results of determinations of carbon isotopic composition $\delta^{13}\text{C}$ PDB of Middle Jurassic sideroplesites suggest that they were formed under anoxic or suboxic conditions in the microbial methanogenesis zone (Irvin et al., 1977; Morad, 1998). The isotopic composition of oxygen $\delta^{18}\text{O}$ PDB in sideroplesites, assuming its crystallization temperature of 20°C (Baker et al., 1995; Rezaee, Schulz-Rojahn, 1998), indicates that the values of $\delta^{18}\text{O}$ SMOW of pore water, from which they precipitated, ranges from -6.00 to -1.00 ‰. This proves both the presence of pore water of marine origin and a share of seawater mixed with freshwater. The study of fluid inclusions shows, based on the freezing temperature, that the salinity of the solution in the inclusions ranges from 1.7 to 16.9wt% and its density is about 1 g/cm^3 ([A2]). The eutectic temperature values indicate the presence of calcium and magnesium ions in the brines ([A2]).

Locally, due to an increase in the activity of silica in solution (Fritz, Toth, 1997), berthierine in ooids was altered into kaolinite. Kaolinite is formed in an acidic environment (Osborn et al., 1994), in which meteoric waters play an important role, slightly acidic due to the dissolution of CO_2 and organic acids (Giles, de Boer, 1990).

Under anoxic conditions, pyrite crystallized in the sulfate reduction zone. Under the conditions of freshwater inflow, methanogenic bacteria rework organic matter and produce CO₂ and CH₄ (Claypool, Kaplan, 1974).

Mechanical compaction occurs almost from the beginning of eodiagenesis, and its effects are best visible in coquinas and sandstones. This is evidenced by the dense packing of detrital material, reduction in primary porosity, cracking of skeletal elements of fauna and grains, flattening or crushing of ooids, deformation of clay-mud laminae, and bending of mica plates in some places.

Mesodiagenesis was poorly marked in the clayey siderites, probably due to their compactness and limited permeability of formation solutions. In contrast, in porous sandstones and coquinas, there was an active circulation of fluids.

In mesodiagenesis, the development of sideroplesite continued and pistomesite precipitated. These minerals form spar-sized crystals, often rhombohedral. In rhombohedral crystals of sideroplesites and pistomesites, we often observe a zonal structure with a significant enrichment in magnesium in their outer parts, compared to the middle part that is richer in iron ([A2; A3; A4]). The zonation in the crystals indicates changes in the chemistry of pore water during crystallization. The increase in magnesium content in the crystals may be related to high concentration of Mg in formation waters (Morad et al., 1994). Rhombohedral forms of sideroplesite and pistomesite were observed in pore spaces, mainly in sideritic sandstones and clayey-sandy siderites, in which these minerals crystallized from solution. In places they fill the voids in bioclasts. In addition, they occur in ooids of sideritic rocks as a result of replacement of primary minerals. Isotope determination values for the late generation of sideroplesite and pistomesite, assuming their crystallization temperature most often above 60°C (based on fluid inclusion studies), indicate the formation of late sideroplesite and pistomesite from pore water enriched in the ¹⁸O isotope compared to water from which the early siderite precipitated (Fig. 6) (Kozłowska et al., 2008 [S12]; [A2]).

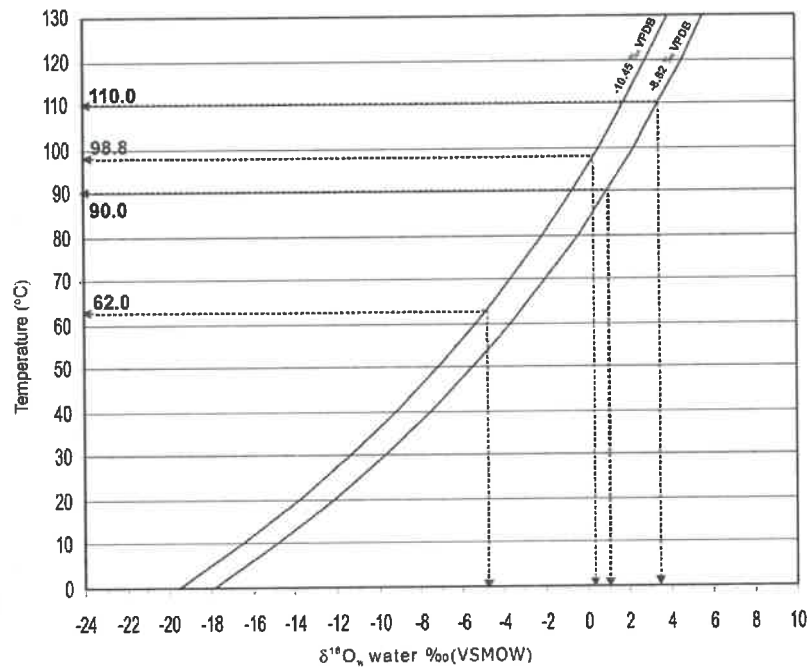


Fig. 6. (Fig. 7 in the article [A2]) Plot of $\delta^{18}\text{O}$ pore water versus temperature for the late generation of siderite (Carothers et al., 1988)

Next, calcite cement was formed, which often fills the space between siderite and sideroplesite crystals, voids in skeletal elements, and veinlets. It also occurs as a secondary mineral in ooids. This calcite represents the ferruginous variety that contains magnesium and, in places, is enriched with manganese. It is characteristic of later generations of this mineral (e.g. Mozley, Hoernle, 1990). Crystallization of Fe-calcite after sideroplesite is probably caused by a reduction in the Fe/Ca ratio in pore water, or its depletion in iron due to the precipitation of pyrite and siderite, or its removal by migrating waters (Zymela, 1996). Biogenic carbonates could be the source of calcium for calcite. The results of determinations of $\delta^{13}\text{C}$ PDB carbon isotopic composition of Fe-calcites correspond to the values obtained for siderites and sideroplesites, which are characteristic for the microbial methanogenesis zone (Morad, 1998). The values of $\delta^{18}\text{O}$ PDB, assuming its crystallization temperature of about 60°C (based on fluid inclusion studies), indicate that Fe-calcite precipitated from $\delta^{18}\text{O}$ SMOW pore water with positive values, which corresponds to sea water or pore water that reacted with the surrounding rocks.

Fe-dolomite and ankerite crystallized as the last of the carbonate cements in the Middle Jurassic sediments. Earlier, dolomite probably formed. Fe-dolomite and ankerite fill the voids in pores after the crystallization of rhombohedral crystals of sideroplesite and pistomesite, or replace berthierine in ooids or calcite in bioclasts. They also fill veinlets. The

values of isotope determinations for ankerite correspond to the data obtained for ankerite in Upper Jurassic deposits of Spitsbergen (Krajewski et al., 2001). According to these authors, cementation with ankerite was late diagenetic, under conditions of deep burial and elevated temperature (80-100°C) in an environment dominated by abiotic kerogen decarboxylation processes. The analysis of fluid inclusions of ankerite indicates the temperature of its crystallization in the range of about 70-160°C. In connection with the values of $\delta^{18}\text{O}$ PDB of ankerite, it suggests its precipitation either from pore water composed of seawater or from pore water that reacted with the surrounding rocks. The sources of calcium, magnesium and iron for ankerite could be minerals transformed and dissolved during the process of sediment burial. The high temperature of ankerite formation may indicate significant sediment burial or a contact with hydrothermal waters.

In mesodiagenesis, we observe replacement effects. Berthierine ooids were replaced partially or completely by carbonate minerals, which penetrated the grains from the outside and blurred their internal structure. The original concentric structure of numerous ooids was destroyed by the replacement of berthierine by sideroplesite, pistomesite, Fe-calcite or ankerite. In bioclasts, the original unstable calcite or aragonite has been replaced by Fe/Mn-calcite. The replacement of the original component of bioclasts often took place without changing their internal structure. In turn, the replacement of calcite and aragonite by ankerite and sideroplesite often blurred the internal structure of bioclasts.

Early diagenetic berthierine is chemically and structurally unstable. As the temperature and depth of burial increase, this mineral is gradually altered into chlorite through a transitional stage representing the chlorite/serpentine mixed-layered mineral (Wilson, 2013). Berthierine is altered into chamosite as a result of a dissolution-precipitation process, in a closed or semi-closed system, at a temperature of about 70°C (Jahren, Aagard, 1989; Aagard et al. 2000).

Of the remaining diagenetic processes, numerous traces of dissolution of ankerite have been noticed in coquinas. The effects of chemical compaction in the form of push-up texture in bioclasts have also remained in places.

Telodiagenesis is a set of processes that operate in sediment after it is uplifted or exposed. In the case of Jurassic rocks, this stage was associated with tectonic inversion of the Mid-Polish Trough in the Late Cretaceous (Dadlez, Marek, 1969). This could have caused the increased activity of pore solutions with the chemical composition of meteoric waters, or the inflow of deep waters of hydrothermal origin. Veinlets filled with, e.g., carbonate minerals: calcite, ankerite and sideroplesite, sometimes sulfides, may have formed at that time. In

addition, iron oxidation in ooid berthierines and in sideroplesite may have taken place. Meteoric waters could have also influenced the process of alteration of berthierine into kaolinite.

4.4.5. Conclusions

1. Middle Jurassic sideritic rocks are represented mainly by clayey siderites (including also muddy and sandy varieties), sideritic sandstones and sideritic coquinas. Sideritic conglomerates, claystones and mudstones occur on a local scale.
2. The main mineral composing the sideritic rocks is iron carbonate (Mg-siderite), representing sideroplesite, less frequently pistomesite. Siderite is found sporadically. It is accompanied by varying amounts of clay minerals, mainly berthierine, kaolinite, illite, and locally chlorites. In addition, there are other carbonate minerals: Fe-calcite, Fe-dolomite and ankerite, occasionally dolomite.
3. Berthierine occurs commonly in the form of ooids or a cement, and it fills the interior of bioclasts. This mineral rarely occurs in clayey and clayey-sandy siderites, while it is frequently found in sideritic sandstones and coquinas.
4. Iron carbonates are represented by micrite, microspar and spar. Mg-siderites (sideroplesite and pistomesite) form in places rhombohedral crystals that are often characterized by a zonal structure, with a distinct enrichment in magnesium in their outer parts, compared to the middle part that is richer in iron. This is due to the increasing supply of magnesium in the solution from which they crystallized.
5. There are three stages in the history of diagenesis of sideritic rocks: eodiagenesis, mesodiagenesis and telodiagenesis. During eodiagenesis, the earliest iron mineral to be formed was berthierine. It was formed under suboxic conditions where iron-containing freshwater mixed with seawater at a temperature of about 25-45°C. Then, under anoxic or suboxic conditions, in the microbial methanogenesis zone, probably at a temperature of about 20°C, sideroplesite and siderite crystallized either from pore water of marine origin or from seawater that mixed with freshwater. Iron might have originated from clayey sediments supplied to the marine basin from land. At a later stage of diagenesis (mesodiagenesis), the following temporal sequence took place: sideroplesite containing a higher amount of magnesium, pistomesite, calcite and ankerite. The late generation of iron carbonates (sideroplesite and pistomesite) crystallized at a temperature of above 60°C from pore water enriched in the ^{18}O isotope, compared to the water from which early sideroplesite or siderite precipitated. Fe-calcite, Fe-dolomite and ankerite crystallized at temperatures of about 60°C

and about 70-160°C, respectively, either from pore water of marine origin or from water that reacted with the surrounding rocks. The isotopic composition of carbon in Fe-calcites is characteristic of the microbial methanogenesis zone. Ankerite, in contrast, probably formed in the thermal decarboxylation zone.

6. Among the diagenetic processes that affected the formation of carbonate minerals in sideritic rocks, cementation played the most important role. An important process was also the replacement by carbonate iron minerals, especially of the primary calcite in bioclasts and berthierine in ooids. Effects of the remaining processes are less pronounced. Mechanical compaction resulted in a denser packing of detrital material, especially in sandstones and coquinas, reducing the pore space for the crystallization of carbonate minerals. Dissolution effects are poorly visible in the carbonate minerals. Moreover, the process of fracture filling with carbonate minerals and, in places, by sulfates took place in the sideritic rocks

4.4.6. References cited

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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 institutions.

5.1. Foreign institutions.

5.1.1. Earth Science Institute, University of Jena, Germany

The beginnings of scientific collaboration with Prof. Dr Reinhard Gaupp in the field of diagenetic research date back to 1995 during the international conference XIII International Congress on the Carboniferous and Permian held in Kraków [E1]. This resulted in an invitation to participate in the European Workshop on Clay Mineralogy, University of Jena, Germany, Earth Science Institute, in 2000, which he organized. During my stay at the University of Jena, I had the opportunity to perform microscopic examinations and learn about the methodology of clay minerals research.

5.1.2. The Federal Institute for Geoscience and Natural Resources (BRG) in Berlin, Germany

In 1998, as part of collaboration with geologists from the BRG in Berlin, Dr N. Hoffmann and Dr W. Lindert, I participated in litho-genetic-facies studies of Permian and Carboniferous deposits on field profiles in north-eastern Germany. The research was also conducted on drilling materials in the Core Depositories Geological Survey of the Mecklenburg-Vorpommern Sternberg.

5.1.3. Instituto Geológico de Angola (IGEO)

In the period 2006-2010, I collaborated with a team of specialists reporting to the Director General Adao Neto from the Angolan Geological Survey, as part of an international project [R1] financed by the Ministry of Foreign Affairs. The project was entitled *Development support of the geological survey of Angola by the Polish Geological Institute*. The aim of my collaboration was to reactivate the Petrography Laboratory at the headquarters of the Angolan Geological Survey in Luanda. An important task was the purchase of equipment: a petrographic camera-supported microscope for transmitted and reflected light and a magnifying glass microscope. The devices were assembled and commissioned by me at the headquarters of the Angolan Geological Survey in Luanda. Petrographic (microscopic) research was carried out together with Maria de Fátima A. Luís da Cucha and Nuélvis Nuñez Delgado at the headquarters of the Angolan Geological Survey in Luanda during my four visits in 2006, 2007, 2008 and 2009, and at the Polish Geological Institute - NRI in Warsaw.

5.1.4. Institute of Geology and Geochemistry of Fossil Fuels of the National Academy of Sciences of Ukraine in Lviv

In 2007-2010, I collaborated with a team of Dr Andriy Poberezhski in Lviv as part of the international project [R2] (Agreement between the Government of Poland and the Government of Ukraine) of cooperation in the field of science and technology: *“Oil exploration prospects and hydrocarbon potential of the Miocene and the Mesozoic-Palaeozoic basement in the border area of the Carpathian Foredeep in Poland and Ukraine”*. Lithological and facies studies, supported by sampling for the research, were carried out on drilling materials in a drill core depository near Sryj, 70 km from Lviv. Working in a large research team allowed for the combination of petrographic, mineralogical, geochemical, petrophysical and sedimentological studies performed in terms of the hydrocarbon potential

of rocks. Results of these studies are presented in publications [J10], [J11], [J12], [J22] indexed in the Journal Citation Report.

5.2. National institutions

5.2.1. Oil and Gas Institute - National Research Institute in Kraków

My collaboration with employees of the Oil and Gas Institute - National Research Institute, mainly with Dr Hab. Piotr Such and Dr Eng. Grzegorz Leśniak, has continued since around 1992. It focuses mainly on combining petrophysical and diagenetic research. The result of this collaboration was a joint publication [B1] Kozłowska A., Such P., Kobyłecka A., 1998. *Ewolucja przestrzeni porowej utworów karbonu radomsko-lubelskiego*. Prace PIG, 165: 167-176. Other numerous research projects, include [F1], [F3], [G6], [G8], [N1], [N3], [S13], [S18], [S28], [S41].

My collaboration with INiG-NRI also concerned computer image analysis. In 2003, I had the opportunity to perform measurements with Dr Eng. G. Leśniak on my own preparations. The acquired knowledge and skills allowed for the commissioning of equipment for computer image analysis at the Polish Geological Institute-National Research Institute in Warsaw. The results of the research are the publication [J3] Kozłowska A., Kuberska M., 2006. *Zastosowanie metody komputerowego przetwarzania i analizy obrazu w mikroskopowej analizie skał*. Przegląd Geologiczny, 54/8: 671-673 and research projects [S3], [S9], [S32].

I also performed research and studies ordered by the Oil and Gas Institute-NRI - [X2], [X3].

5.2.2. Institute of Geological Sciences, Polish Academy of Sciences, Research Center in Kraków

Thanks to the collaboration with Prof. Dr Hab. Jan Środoń, I had the opportunity to visit the Institute of Geological Sciences PAS in Kraków in 1993. As part of my stay, I conducted laboratory work on the clay fraction separation procedure. Then, XRD analyses were performed from the obtained samples. This collaboration resulted in the launch of the Laboratory of Clay Minerals Separation at the Polish Geological Institute-NRI in Warsaw which I direct.

Since 2015, I have been collaborating with Dr Hab. Marek Szczerba in the field of X-ray examinations supported by petrographic studies within the research projects [S27], [S40], [S41].

5.2.3. Maria Curie-Skłodowska University, Lublin

In the years 2000–2015, I collaborated with Prof. Dr Hab. Stanisław Hałas, head of the Mass Spectrometry Department at the Institute of Physics, Maria Curie-Skłodowska University, in the field of isotope research. Determinations of $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ in carbonate minerals and K/Ar ages of authigenic illite were made. The combination of results of isotopic research petrographic and mineralogical research is presented in publications [H1], [J1], [J6], [J7], [J9], [J18], [J25].

5.2.4. Jagiellonian University, Faculty of Geology

Owing to the collaboration with Prof. Dr Hab. Eng. Marek Michalik, Institute of Geological Sciences, I carried out infrared studies of minerals from the kaolinite subgroup in 2005-2009 as part of the research projects [N1], [N3].

5.2.5. Silesian University, Department of Natural Science, Institute of Earth Sciences, Sosnowiec

My collaboration with Prof. Dr Hab. Leszek Marynowski in biomarker analysis started in 2020 as part of the research project [S41].

5.2.6. Polish Oil and Gas Company S.A.

Collaboration with specialists from the Polish Oil and Gas Company S.A. (PGNiG) started in 1992 (among others with Andrzej Rochewicz, Arkadiusz Buniak, Aleksander Protas). In the regional units in Wołomin, Piła and Chmielnik, I conducted lithological and facies studies of Carboniferous, Jurassic and Cretaceous deposits on drill cores to select samples for petrographic studies. Based on the collected material, I performed a petrographic analysis, the results of which are included in research projects, among others, [G4], [G5], [G8], [N1], [S16], [S19], [S20] and in publications [H1], [J1], [J6], [J8], including co-authorship with A. Buniak [J4].

In 2020, the collaboration with PGNiG concerned the implementation of the research project [W3], under which I carried out, in association with Dr M. Kuberska, a diagenetic study of Carboniferous deposits from the Orzesze 1 borehole.

5.2.7. Petrobaltic

Within the framework of a research project [U1] carried out in 1996-1997, I conducted research at the Petrobaltic headquarters in Gdańsk on the lithology of Carboniferous deposits

from drill cores of boreholes located in the Polish sector of the Baltic Sea. The selected core samples were subjected to petrographic analysis.

5.2.8. PGE Mining and Conventional Power S.A.

As part of the research project [W1], I conducted research in 2011 in the field of petrography of Lower Jurassic deposits from the Kaszewy 1 borehole.

5.2.9. Gora Energy Sp. Z o.o.

My collaboration with specialists from the Gora Energy Sp. Z o.o. in 2013 consisted in the performance, in association with Dr M. Kuberska, of a petrographic expert's study of Carboniferous deposits based on thin sections from the Sicina 1 and 2 boreholes [W2].

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

6.1. Didactic achievements.

Since 1993, I have trained technical employees several times in the field of laboratory work on the procedure of clay fraction separation from rocks at the Laboratory of Clay Minerals Separation, Polish Geological Institute-National Research Institute in Warsaw.

In 2003, as part of the Petrological Workshop - Diagenesis Research in Warsaw (Polish Geological Institute-NRI and Faculty of Geology of the University of Warsaw), I gave a lecture at the Faculty of Geology of the University of Warsaw, entitled *Diagenesis of silicoclastic rocks - cementation of clay minerals*, and participated in conducting petrographic classes.

In the period 2005-2010, I organized and conducted classes at the Polish Geological Institute-National Research Institute in Warsaw and at the AGS headquarters in Luanda for the employees of the Angolan Geological Survey, in the field of petrographic research.

6.2. Organizational achievements.

In the years 1993–1995, I organized the Laboratory of Clay Minerals Separation at the Polish Geological Institute-National Research Institute in Warsaw, which I direct to date. It involved preparing a laboratory room and equipping it with laboratory equipment and chemical reagents.

From 2001 to 2021, I was a co-organizer of the 1st to 10th National Conference on Petrological and Mineralogical Research in Geology, which was held at:

Polish Geological Institute - National Research Institute, Warsaw - I (2001), II (2005), III (2007), IV (2009), V (2011), IX (2019), X (2021), PGI-NRI, Leszcze near Kłodawa - VI (2013), Sandomierz - VII (2015), and PGI-NRI, Kraków - VIII (2017).

In 2003, I co-organized the Petrological Workshop - Diagenesis Research, in Warsaw at the Polish Geological Institute - NRI and at the Faculty of Geology at the University of Warsaw.

In the years 2005-2010 I organized the Petrographic Laboratory in the Angolan Geological Survey in Luanda, Angola. This involved the purchase of a polarizing microscope equipped with a reflected light and a camera, and a low magnification microscope (microscope magnifier) in Poland. The purchased equipment was sent to Angola and I assembled and commissioned it at the headquarters of the Angolan Geological Survey in Luanda.

In the period 2013-2017, I was the Secretary of the Scientific Council of the PGI-NRI. My duties included preparation of the Minutes from meetings of the Supervisory Board. From 2017 to date (term of office 2017-2021), I have been an elected member of the Scientific Council of PGI-NRI and a member of the Organizational and Economic Committee in this Council. The tasks of the Committee include giving opinions on candidates for managerial positions and on plans and financial reports of PGI-NRI.

Since 1992, I have been a leader of 14 projects in which the team of participating specialists consisted of 2 to 6 people. These were 12 research projects financed by the Ministry of Science and Higher Education [G5-G7; G9; G11; S3; S9; S12; S18; S19; S32; S33] and 2 research grants (2007-2013) financed by the National Science Centre [N3; N4]. The research projects were implemented by employees of PGI-NRI in collaboration with specialists from other research units, including Oil and Gas Institute-NRI, Institute of Geological Sciences PAS in Kraków, Jagiellonian University and Polish Oil and Gas Company in Wołomin and Piła.

6.3. Achievements in popularizing science.

I am the author and co-author of nine popular science articles in periodicals:

[T1] Maliszewska A., Kozłowska A., 2003. Diageneza piaskowców górnego karbonu. *Przegląd Eureka*, 3, 13: 14.

- [T2] Kozłowska A., Kuberska M., 2006. Zachodnia Anatolia – geotermalny rejon Turcji. *Przegląd Geologiczny*, 54, 4: 296-297.
- [T3] Kozłowska A., 2012. Kamień budowlany w zabytkach czeskiej Pragi. *Przegląd Geologiczny*, 60, 3:145-147.
- [T4] Kozłowska A., Jarmołowicz-Szulc K., 2015. Kamień w zabytkowych budowlach Brisbane (Australia). *Przegląd Geologiczny*, 63, 6: 345-347.
- [T5] Jarmołowicz-Szulc K., Kozłowska A., 2016. Wulkanizm rejonu Auckland, Nowa Zelandia. *Przegląd Geologiczny*, 64, 2: 101-105.
- [T6] Kozłowska A., Jarmołowicz-Szulc K., 2017. Jeden z siedmiu naturalnych cudów świata – Góra Stołowa w RPA. *Przegląd Geologiczny* 65, 10: 625-628.
- [T7] Jagielski G., Jankowski L., Kiersnowski H., Kijewska S., Kozłowska A., Krzyżak E. i inni (14 Autorów), 2019. Koncesje na poszukiwanie, rozpoznawanie oraz wydobywanie złóż ropy naftowej i gazu ziemnego w Polsce w 2019 i 2020 roku – postępowanie przetargowe i przetarg inwestorski. *Przegląd Geologiczny*, 67, 12: 938-960.
- [T8] Jagielski G., Kiersnowski H., Kijewska S., Kozłowska A., Krzyżak E., Kuberska M., Laskowicz R., Roszkowska-Remin J., Smajdor Ł., Wesołowski M., Wójcik K., Żuk T. i inni (12autorów), 2019. Ropa naftowa i gaz ziemny w Polsce: postępowanie przetargowe i przetarg inwestorski (open door) na koncesje węglowodorowe w 2019 i 2020 roku". *Zeszyty Naukowe Instytutu Gospodarki Surowcami Mineralnymi i Energią Polskiej Akademii Nauk*, 108: 127–140.
- [T9] Jarmołowicz-Szulc K., Kozłowska A., 2021. 155 lat od odkrycia diamentów w Afryce Południowej - złoża kimberlitowe i aluwialne w rejonie Kimberley. *Przegląd Geologiczny*, 69, 3: 174-178, 202.

In 2012-2013, I co-participated in the preparation of the scenario and organization of the Exhibition entitled *Islandia – wyspa czterech żywiołów*, at the Polish Geological Institute-National Research Institute in Warsaw

In 2014, I was a co-author of the information brochure entitled *Hydrocarbons from unconventional resources - shale gas and oil, tight gas, coal bed methane*. PGI-NRI Offer science & research.

In 2017, in co-authorship with Prof. Dr Hab. A. Maliszewska and Dr M. Kuberska, I gave a presentation entitled *O badaniach skał syderytowych jury środkowej Kujaw zainicjowanych przez profesora Jerzego Znoskę*, during a scientific session dedicated to the memory of Professor Jerzy Znosko at the PGI-NRI in Warsaw.

In 2019, on the 100th anniversary of the Institute, I participated in the organization of the Exhibition on the fence of the Polish Geological Institute-NRI in Warsaw, entitled *Surowce mineralne Polski pod mikroskopem*.

In 2019, I was a co-author of the advertising folder and the information brochure entitled *Oil and Gas in Poland: 5th Tender Blocks*.

In 2020, I participated in the production of a film from the series *Kopernik była kobietą*, episode 17 entitled *Sand*. My participation consisted in preparing various sand samples and presenting them in macro and micro scales (under the microscope).

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

7.1. Discussion of the remaining scientific-research achievements which are not basis for applying for the degree of habilitated doctor.

Scientific issues of my scientific and research achievements include petrographic, mineralogical and geochemical studies of rocks of various ages. The basic tool of my work is a polarizing microscope. Since the 1990s, I have widely used cathodoluminescence analysis (CL), fluid inclusion (FI) studies, scanning electron microscopy (SEM) studies, X-ray analysis (XRD), infrared (IR) analysis, and computer image analysis in my research. Among important studies are isotope determinations of carbon and oxygen in carbonate minerals, oxygen, sulfur and strontium in sulphate minerals, and K/Ar age in authigenic illite. Moreover, an important aspect of my research is the assessment of reservoir properties of clastic rocks based on petrophysical analysis.

Prior to obtaining the PhD degree

In 1986–1992, I was involved in research on petrography of Precambrian igneous and metamorphic rocks from north-eastern Poland, as a co-author in the research projects [G1] and [G2].

In the period 1989–1990, I participated in the research on the mineral composition of schlich from the Kudowa region as a co-author in the research project [G3]. The aim of the project was to prepare schlich picture of the Sudetes.

Since 1991, I have studied Carboniferous sedimentary rocks. The main research area was the north-western part of the Lublin Graben and the Warsaw Block. Later, the research also covered the central part of the Lublin Graben. The work was carried out within the

framework of PGS research projects [G4], [G8] and research grant projects (Leader: Prof. Dr Hab. M. Narkiewicz) [F1], in which I was among the authors, and within several scientific and research projects [G5], [G6], [G9], [G11], in which I was the leader and the main author. In the period 2000-2002, I was the main author in the thesis grant (Leader: Prof. Dr Hab. A. Maliszewska) [F3] that finally resulted in my doctoral dissertation. It concerned the diagenesis of Upper Carboniferous (Pennsylvanian) sandstones from 10 boreholes located on the boundary of the Warsaw Block and the Lublin Graben (north-western part). The main components of the cement in the studied sandstones are detrital clay minerals and authigenic minerals, such as: quartz, kaolinite and carbonates. Locally, there are abundant authigenic illite, authigenic chlorite, iron hydroxides and hematite. Sulfates and pyrite constitute a negligible percentage of the cement. Quartz cement forms two generations of syntaxial overgrowths on quartz grains. I have distinguished two morphological types of kaolinite: a worm-like type - early diagenetic, which occurs mainly in the upper parts of the Carboniferous succession, and a blocky type that formed at the later stages of diagenesis, dominant at greater depths. At depths greater than 3000 m, locally slightly shallower, there are intergrowths of kaolinite and dickite, in which the dickite content is about 20% on average. The K/Ar age determinations in fibrous illite indicate the beginning of its crystallization from 205.4 to 167.3 million years, i.e. in the Late Triassic and Middle Jurassic. Among carbonate cements, the following have been distinguished: siderite and ankerite, which are common, and less common Fe-calcite, Fe-dolomite and dolomite. The mineral referred to as siderite represents minerals of the FeCO_3 - MgCO_3 isomorphic series. I distinguished two generations of minerals from the siderite group: early and late. Early cement is composed of finely crystalline sideroplesite or siderite, often in the form of rhombohedrons and spherulites. Late cement is enriched in magnesium and represents sideroplesite, occasionally pistomesite, in some places represented by rhombohedrons. The most important diagenetic processes operating in the studied sandstones are compaction, which reduced an average of about 41% of the primary porosity, and cementation, which reduced it by an average of about 36%. Another important diagenetic process affecting porosity of the sandstones is dissolution that results in the formation of secondary porosity in the rock (up to about 7%). Two stages have been distinguished in the diagenetic history of Carboniferous sandstones: eo- and mesodiagenesis, as indicated by the burial curves. Based on the results of both isotope studies ($\delta^{18}\text{O}$ of kaolinite, siderite, Fe-dolomite, ankerite and anhydrite) and analysis of fluid inclusions (T_h homogenization temperature - late siderite, Fe-dolomite and ankerite), and taking into account the hypothetical sequence of authigenic

minerals, I tried to reconstruct the evolution of the oxygen isotope relationships in the pore water. Over time, the oxygen isotopic composition in the pore water gradually changed towards higher values of $\delta^{18}\text{O}$ and only in the final stage of diagenesis did it return to a lower value. On the basis of the research, I estimated that the Carboniferous deposits were subjected to a maximum temperature of about 120°C during diagenesis.

The research results obtained under the research projects in the years 1992-2002 were presented in papers and posters at conferences: 9 national [D2-D10] and 6 foreign [E1-E6]. The doctoral dissertation was published in 2004 [H1]. The assessment of reservoir properties of the studied sandstones is included in [J1], while the diagenesis of Carboniferous deposits against the background of burial-thermal history is presented in [J2]. I also presented the results of my PhD research in the publication from 2005 [I1].

In the years 1996–1997, I studied Carboniferous deposits in Western Pomerania (11 boreholes, including 3 in the Baltic Sea) as part of a commercial project commissioned by the Petrobaltic company [U1], being one of the project team members. My research focused especially on the analysis of rock cements in terms of their diagenetic alterations.

In the period 1996-1998, I was the leader of the project [G7] aimed at creating a digital petrographic bibliography of Poland for the years 1965-1995.

In the years 1998-2001, as part of the research grant (Leader: Prof. Dr Hab. T. Peryt) [F2] and a scientific-research project [G10], together with Prof. Dr Hab. A. Maliszewska and Dr M. Kuberska, I analyzed Miocene deposits from the Carpathian Foredeep (22 boreholes) in terms of their reservoir properties. The research results were presented in a poster at an international conference [E7] and in the publication [C4].

After conferring the PhD degree

After obtaining the doctoral degree, my scientific activity included not only the studies of Middle Jurassic deposits, described in the scientific achievement, but also rocks of various ages, which are described below.

7.1.1. Studies of Carboniferous rocks

After PhD, I continued research on Carboniferous deposits in the Lublin Basin (central and south-eastern part), Western Pomerania and south-western Poland.

In the years 2002-2005, I conducted studies of diagenesis and reservoir properties of rocks in the Lublin Basin within the framework of a large research project of the Polish Geological Survey (PSG) (Leader: Prof. Dr Hab. M. Narkiewicz) [S4]. In 2007-2009, I was

the leader and the main author in the research grant [N3] that involved studies of the south-western part of the Lublin Graben. Then, in 2008-2011, I was the leader and one of the main authors in the research project [S19]. An important element of this project was the connection of diagenetic studies with facies and sequence stratigraphy research conducted by Dr M.I. Waksmundzka. In total, I examined rock material from over 20 boreholes. The research results obtained under the projects in 2002-2011 were presented in papers and posters at 4 national [K2-K5; K7] and 10 foreign [L2; L3; L5; L8; L11; L13; L14; L20; L30; L32] conferences, and in 3 publications [J7], [J9] and [J28].

Since 2015, I have been dealing with petrography and mineralogy of the earliest Carboniferous deposits (Tournaisian, Visean) in the Lublin Basin, being among the participants of the research projects [S27] and [S40]. The research results are presented in the publication [J30] of 2021.

In the years 2002–2006, I also conducted research on Carboniferous deposits in Western Pomerania. As one of the main authors in the research projects [S1], [S2], [S5] and in the research grant led by Dr M. Kuberska [N1], I dealt with diagenesis and evolution of pore space sandstones from 14 boreholes. In 2017-2019, I was the leader and main author in the research project [S33], under which I extended the research area to the Baltic Sea (3 boreholes). The obtained research results were presented in papers and posters at 4 national [K8; K11; K26] and 5 foreign [L1; L7; L17; L21; L29] conferences, and in 3 publications [J4], [J6] and [J25].

In 2006, I started research on Carboniferous deposits from south-western Poland within the framework of the research project [S11]. In the years 2013-2019, as part of two large research projects of the Polish Geological Survey (PSG) (Leader: Dr Hab. T. Podhalańska) [S23; S34], I participated, in association with Dr Hab. M. Sikorska-Jaworowska and Dr M. Kuberska, in petrographic studies of Carboniferous deposits from 10 boreholes in the Fore-Sudetic Monocline in search for tight gas. The results of the research were presented in a paper presented at the national conference [K20] and in the publications [J21] and [J24].

Moreover, Carboniferous deposits were the subject of research conducted within the projects [S10] and [S14].

7.1.2. Studies of Miocene rocks

In the period 2007-2010, I took part in a large international research project [R2] on Miocene deposits in the Carpathian Foredeep in Poland and Ukraine. Together with Dr M. Kuberska and Prof. Dr Hab. A. Maliszewska, we performed petrographic, mineralogical and

geochemical studies of Miocene deposits in terms of their hydrocarbon potential. The study covered rock material from 8 boreholes from Poland and 13 from Ukraine. We estimated that the Miocene deposits were exposed to temperatures $<100^{\circ}\text{C}$ during diagenesis. The diagenetic history covered eo- and mesodiagenesis. Determinations of carbon and oxygen isotopes in carbonate cements indicate their formation in the microbial methanogenesis zone from pore water being a mixture of sea water and meteoric water. The $^{87}\text{Sr}/^{86}\text{Sr}$ values in calcite suggest that radiogenic strontium was supplied to the sediment by waters from land. Sandstones from the area of Poland are characterized by better reservoir properties compared to those from Ukraine. The research results of the project were presented in papers and posters at the following conferences: 4 national [K6; K9; K15; K23] and 5 foreign [L16; L18; L19; L23; L27], and presented in 4 publications [J10], [J11], [J12] and [J22].

7.1.3. Studies of Lower Jurassic rocks

In 2008, I started my research on Lower Jurassic deposits in terms of their reservoir properties, as one of the participants of a research project concerning Mesozoic deposits in the Łódź-Miechów Basin [S13]. In the years 2009-2011, I was the leader and the main author in the research project [S18] that covered the area of Polish Lowlands. In Jurassic sandstones, the following diagenetic carbonate minerals have been distinguished: Fe-dolomite/ankerite, two generations of siderite (a mineral of the siderite-magnesite series) and calcite. The results of carbon isotope determinations in carbonate minerals indicate their precipitation in the microbial methanogenesis zone. The $\delta^{18}\text{O}$ values of siderite, calcite and ankerite indicate their precipitation from pore water enriched in the ^{18}O isotope compared to the water from which the early siderite precipitated. The Jurassic sandstones are characterized by very good and good permeabilities. Primary porosity is dominant, which often exceeds 20%, while the permeability ranges from 0.001 to 1930.756 mD. The most important diagenetic processes in the sandstone are compaction, cementation and dissolution. The compaction reduced the primary porosity by an average of about 30%, and the cementation by about 21%. I presented the research results of this project in the publication [J18] and at the international [L22] and national [K18] conferences.

7.1.4. Studies of Permian rocks

In the years 2008-2010, in association with Dr M. Kuberska, I performed a petrographic analysis extended by additional studies (CL, SEM, XRD) of Rotliegend rocks from four boreholes in the western part of the Fore-Sudetic Monocline. The studies allowed

for the conclusion that the various colours of the rocks (red-brown and light grey-greenish, mottled) are related to the changes in Eh and pH within the deposits during diagenetic alterations. The research was conducted as part of the project [S17], and the research results were presented in the publication [J13].

In 2018-2019, together with Dr M. Kuberska, I performed a petrographic analysis of Zechstein rocks from the Mostno-1 borehole, as part of the project [S37]. The research results were presented in the publication [J29] and at the foreign conference [L33].

7.1.5. Studies of Ordovician and Silurian rocks

In the period 2013-2019, as part of two large projects of the Polish Geological Survey (PSG) (Leader: Dr Hab. T. Podhalańska) [S23; S34], I was a co-author, together with Dr M. Kuberska and Dr Hab. M. Sikorska-Jaworowska, of petrographic and mineralogical analyses of Ordovician and Silurian deposits in terms of the presence of oil and shale gas. The research covered three areas: the Baltic Depression (10 boreholes), the Podlasie Depression (7 boreholes) and the Lublin area (10 boreholes). The studies of Lower Paleozoic rocks prove their great similarity both in terms of mineralogical composition and susceptibility to hydraulic crushing processes. The research results were presented in the publications [J23] and [J24] and at the international conference [L31].

7.1.6. Studies of Ediacaran rocks

In 2016-2017, together with Dr Hab. M. Sikorska-Jaworowska and Dr M. Kuberska, I performed a petrographic analysis, extended by additional studies (CL, SEM, XRD), of Ediacaran rocks in a newly drilled Bibiela PIG 1 borehole - project [S29]. The research reveals that the Ediacaran rocks show a high degree of diagenesis; they are deformed and fractured. It was estimated that the alteration processes occurred under late diagenetic conditions, at a maximum temperature estimated at approx. 160°C. The results of the research will be presented in a paper prepared for the 10th National Conference (April 15-16, 2021, at the PGI-NRI in Warsaw) and in a publication in Vol. 69, No. 7 of *Przegląd Geologiczny*, which will contain articles related to the conference.

7.1.7. Studies of rocks of different ages

In 2008-2012, I participated in the study of Carboniferous, Permian, Jurassic and Cretaceous deposits as part of two large research projects [S16; S20] concerning the identification of geologic formations and structures for the safe storage of CO₂. The research

results are included in the publication [J8] and were presented at the national conferences [K16; K19] and at the foreign conference [L25].

Since 2015, I have been participating in the research project of the Polish Geological Survey titled *The protection of stratotype sections of drill cores...*, investigating Carboniferous deposits in the Łączna IG 9 borehole [S28] and Lower Cretaceous deposits (in association with Dr M. Kuberska) in the Strzelno IG 1 borehole [S41]. Since 2021, my research concerns Carboniferous deposits from the Lublin IG 2 borehole [S46].

7.1.8. Other research

In 2003, I started implementing the method of computer image processing and microscopic image analysis of rocks, as the leader of the research projects [S3; S9; S32].

Since 2006, as part of the Polish Geological Survey projects [S6; S7; S15; S22; S36; S43], titled *Profile Głębokich Otworów Wiertniczych Państwowego Instytutu Geologicznego*, I am the author and co-author of several contributions on the petrography of rocks of various ages. The characteristics of Carboniferous deposits are presented as chapters in the monographs [I2; I3; I4; I6; I7; I8; I9] and in the publications [J5; J14; J17; J19], of Rotliegend deposits as a the publication [J21; J27], of Lower Jurassic deposits in the publications [J15; J16], of Lower Cretaceous deposits as a chapter in the monograph [I5], and of Mesoproterozoic deposits as a chapter in the monograph [I10].

Since 2014, as part of the Polish Geological Survey projects [S24; S25; S30; S44], I have participated in the preparation of materials in the field of petrography and reservoir properties of Carboniferous deposits for the purposes of procedures for granting hydrocarbon concessions. I was the co-editor, with Dr M. Kuberska, a volume about of the Żabowo tender area.

In 2015-2017 I was a co-author in the Polish Geological Survey project [S31] that aimed at integrating geological data on the hydrocarbon systems in Poland (Leader: Dr. A. Becker). In the project, I dealt with the analysis of petrophysical data of Carboniferous and Permian deposits. The obtained data were used to compile a number of maps, including maps of porosity and permeability distribution, and hydrocarbon prospect maps.

In 2015–2019, as part of the Polish Geological Survey projects [S25; S35; S38], I participated in the receipt of drill cores and in the issuing of opinions on geological documentations of boreholes from concession areas in prospection for, and exploration and exploitation of hydrocarbon deposits.

In the years 2019-2020, I was one of the authors in the research project of the Polish Geological Survey [S39], which included the revaluation of the degree of country's geological exploration in terms of prospecting for and extraction of hydrocarbons and metal ores. As part of the project, I have summarized the petrographic characteristics of Carboniferous deposits from the Pomeranian Basin, Masovian Zone, Lublin Basin and south-western Poland in terms of exploration and extraction of hydrocarbons. Particular attention was paid to deposits seated at greater depths.

7.1.9. Commercial projects

In 2011, I participated in the project, commissioned by PGE Mining and Conventional Power S.A. [W1] (Leader: Dr E. Szykaruk), which aimed at carrying out research and work necessary to organize, perform and interpret geological surveys to select the best geologic structure for underground carbon dioxide storage. As part of the project, I performed a petrographic analysis of Lower Jurassic deposits from the Kaszewy 1 borehole.

In 2013, as part of a project commissioned by Gora Energy Sp. z o.o [W2], together with Dr M. Kuberska, I made a petrographic expert's report on 36 Carboniferous rock samples from the Sicina IG 1 and Sicina 2 boreholes, which included a petrographic description of thin sections and taking photomicrographs of the sections. They were presented on photo plates providing also relevant descriptions.

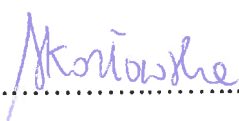
In 2020, I participated in a project commissioned by Polish Oil and Gas Company [W3] entitled: *Zapewnienie serwisu badań specjalistycznych podczas realizacji otworu wiertniczego Orzesze-1* (Leader: Dr J. Jureczka). As part of the project, I examine 100 rock samples in association with Dr M. Kuberska. Petrographic analysis, photographic documentation, analysis of the rock fracture in the scanning electron microscope (SEM), computer image analysis, and microfracture analysis were performed.

7.2. Summary of the scientific and research achievements (including the items included in point 4).

Table 2. List of scientific and research achievements before and after obtaining the Ph.D. degree; WoS – Web of Science; JCR – Journal Citation Report; * as of April 7, 2021

DOROBK NAUKOWO-BADAWCZY	Przed doktoratem	Po doktoracie	RAZEM
Total number of points MNiSW: Before 2019, for release year/for 2019 Years 2019-2021	no data/100 -	680/1785 340	680/1885 340
Total IF	-	5.640	5.640
Total 5-year IF	-	5.512	5.512
<i>h</i> -index according to the base WoS*	-	2	2
<i>h</i> -index according to the base Scopus*	-	6	6
<i>h</i> -index according to the base Google Scholar*	-	6	6
Total number of citations by WoS*/ Including no self citations	-	15/10	15/10
Total number of citations by Scopus*/ Including no self citations	-	112/65	112/65
Total number of citations by Google Scholar*	-	134	134
Total number of publications with chapters in monographs	5	41	46
Publications in the journals from the list JCR	-	7	7
Publications in the journals from the base WoS/Scopus/ Google Scholar	0/3/8	7/38/53	7/41/61
Popular science articles from the base Scopus	-	4	4
Conference materials posted in the base Scopus	-	2	2
Publications from the list A MNiSW	-	8	8
Publications from the list B MNiSW	3	47	50
Publications from 2019-2021 from the list MNiSW	-	7	7
Published monographs	-	1	1
Published chapters in monographs	1	10	11
Membership in the editorial boards of monographs	-	2	2
Published articles in scientific journals	4	30	34

Published articles in post-conference materials, foreign (Proceedings)	-	1	1
Published popular science articles	-	9	9
Speeches and co-authorship (paper/poster) at national conferences	2/8	10/16	12/24
Speeches and co-authorship (paper/poster) at international conferences	7/0	26/7	33/7
Article reviews	-	10	10
Project/grant supervision	5/0	7/2	12/2
Implementation/co-implementation of scientific and research projects, as well as PSG/grants	11/3	46/4	57/7
Commercial projects and expert opinions commissioned by companies	1	6	7
Participation in international programs	-	2	2
Co-organization of national conferences / workshops	1/0	9/1	10/1
Awards for scientific work and decorations	-	5	5


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(Applicant's signature)