Annex 2b

Scientific curriculum vitae

Patrycja WÓJCIK-TABOL

Institute of Geological Sciences, Jagiellonian University

Kraków 2017

1. Name:

Patrycja Wójcik-Tabol

1.2. Scientific degrees:

- 19.10.2004 - Ph. D. in Earth Sciences

Ph. D. thesis: *Palaeoenvironment of deposition and early diagenesis of the Cretaceous oxygen deficiency deposits in the Polish part of the Pieniny Klippen Belt in the light of mineralogical and geochemical studies* [in Polish]

Supervisor: Prof. M. Adam Gasiński

Institute of Geological Sciences, Jagiellonian University; domain: geology

- 21.06.1999 - Master of Science in Geology

Master's thesis: *Authomorphic and collomorphic precipitates of zinc sulphides in the Olkusz mine* [in Polish]

Supervisor: Prof. Witold Żabiński

Institute of Geological Sciences, Jagiellonian University

1.3. Academic positions:

- 1999–present

Jagiellonian University

Faculty of Biology and Earth Sciences

Institute of Geological Sciences, Kraków, Poland

- 2009–present: assistant professor
- 2003–2008: assistant
- 1999– 2004: Ph.D. Studies

2. Indication of scientific achievement

following article16 par.2 of act from 14 March 2003 on scientific degrees and scientific title and on degrees and title in arts (Journal of Laws no. 65, pos. 595 with changes.):

2.1. Title of the scientific achievement

The scientific achievement includes six peer-reviewed papers. The title is:
The studies of provenance, conditions of deposition and diagenesis of fine-grained sediments enriched in organic matter based on mineralogical and geochemical indicators

2.2. List of papers presenting the scientific achievement

Publications copies are in Annex 6

[1] Oszczypko-Clowes, M., <u>Wójcik-Tabol, P.,</u> Płoszaj, M., 2015. The source areas of the Grybów sub-basin in the light of micropaleontological, mineralogical i geochemical provenance analysis (Outer Carpathians, Poland). Geologica Carpathica, 66, 6: 515–534. doi: 10.1515/geoca-2015-0042 (MNiSW[1] – 20, 2015[2]: 1.523, 5 year IF[3]: 1.406).

I am the author of the paper's concept. I co-authored the text of the paper and I am the sole author of the petrological and geochemical studies, the statistical calculations, the figures no. 5 to no. 12 and Table 4. My percentage contribution in the paper is 50 %.

[2] <u>Wójcik-Tabol, P.</u>, 2015. Depositional redox conditions of the Grybów Succession (Oligocene, Polish Carpathians) in the light of petrological i geochemical indices. Geological Quarterly, 59 (4): 603–614. doi: 10.7306/gq.1240 (MNiSW – 20, IF 2015: 0.858, 5-year IF: 0.918)

I am the author of the paper's concept, the petrological and geochemical studies, text of the paper and all the figures. My percentage contribution in the paper is 100%.

[3] <u>Wójcik-Tabol, P.,</u> Ślączka, A., 2015. Are Early Cretaceous environmental changes recorded in deposits of the western part of the Silesian Nappe - A geochemical approach. Palaeogeography Palaeoclimatology Palaeoecology, 417: 293–308. http://dx.doi.org/10.1016/j.palaeo.2014.10.040 (MNiSW – 35, IF 2015: 2.525, 5-year IF: 3.02)

I am the author of the paper's concept. Field work was carried out together with Professor Andrzej Ślączka. I was responsible for the analytical procedures, the interpretation, preparing all the figures. I have co-authored manuscript of the paper. My percentage contribution in the paper is 80%.

[1] MNiSW – points according to the Ministry of Science and Higher Education, from the 5th of December 2016
[2] IF – index factor of journal in the year of the paper published
[3] 5-year IF – 5-yaer index factor of journal calculated in 2015, Journal Citation Reports®

[4] Wójcik-Tabol, P., Ślączka, A., 2013. Provenance of Lower Cretaceous deposits of the western part of the Silesian Nappe in Poland (Outer Carpathians): evidence from geochemistry. Annales Societatis Geologorum Poloniae, 83: 113–132. (MNiSW – 20, IF 2013: 0.727, 5-year IF: 0.815)

I am the author of the paper's concept. The field works were done by us together with Professor Andrzej Ślączka. My tasks included the analytical procedures description, interpretation, preparing all the figures and part of the text. My percentage contribution in the paper is 80%.

[5] Wójcik-Tabol, P., Oszczypko, N., 2012. Trace element geochemistry of the Early to Late Cretaceous deposits of the Grajcarek thrust sheets - a paleoenvironmental approach (Małe Pieniny Mts., Pieniny Klippen Belt, Poland). Geological Quarterly, 56 (1): 169–186. (MNiSW – 20, IF 2012: 0.761, 5-year IF: 0.918)

I am the co-author of the paper's concept. Field works were carried out with Professor Nestor Oszczypko. I am the sole author of the description of mineralogical and geochemical data, and their interpretation. I prepared the figures (except Fig. 2) and major part of the manuscript. My percentage contribution in the paper is 70%.

[6] Wójcik-Tabol, P., Ślączka, A., 2009. Provenance of siliciclastic i organic material based on geochemical indices in the Albian-Turonian sediments – preliminary studies from Lanckorona Area in the Silesian Nappe, Polish Outer Carpathians. Annales Societatis Geologorum Poloniae, 79: 53–66. (MNiSW – 20, IF 2009: 0.619, 5-year IF: 0.815)

I am the author of the paper's concept. Field works were carried out with Professor Andrzej Ślączka. I was responsible for analytical procedures, interpretation, preparing all the figures and major part of the manuscript. My percentage contribution in the paper is 75%.

2.3.1. Scientific aim of the papers mentioned above and the achieved results

– methodological assumptions in mineralogical and geochemical studies of black shales

The black shales are related to enhanced accumulation of organic matter resulted from: (I) intensive flux of organic remains; (II) anaerobic conditions. Organic petrology associated with pyrolysis data, biomarkers studies and stable isotopes of organic carbon ($\delta^{13}C_{org.}$) are used in examination of derivation and maturity of organic matter (Hofmann *et al.*, 2000; Peters *et al.*, 2005) [1][2][3][6]. Presence of marine organic matter is usually correlative with higher concentrations of P_2O_5, SiO_2, Ba, Cd, Ag (Brumsack, 2006) [2][3].

The geochemistry of fine-grained sediments can provide information regarding provenance, as well as the tectonic setting and the palaeoenvironmental evolution of sedimentary basins. The chemical composition of the sediments is a function of several variables, including the nature of the parent rocks, the weathering processes active in the source area, sorting during transportation, reworking of older sediments (e.g., Nesbitt and Young, 1982; McLennan *et al.*, 1993; Fedo *et al.*, 1995), as well as sedimentary and post-sedimentary conditions (Elderfield and Sholkovitz, 1987; Wignall and Newton, 1998; Jones and Manning, 1994; Brumsack, 2006). It is necessary to consider the diagenetic processes that involved the alteration of unstable minerals and the precipitation of new phases, usually associated with chemical changes (Lev et al., 1988, 1999; Rasmussen et al., 1998; González-Álvarez and Kerrich, 2010) [1][4][5][6].

Profound studies of chemical and mineral composition of fine-grained rocks allow an interpretation of the sedimentation and diagenesis conditions in the wider context, including influence of many global and local factors (climate, paleogeography, palaeotectonic, volcanism etc.) [1–6].

Black shales are of world-wide occurrence in Lower Cretaceous rock sequences. They are interpreted as being the record of global periods of so-called “Oceanic Anoxic Event” (OAEs, e.g. Schlanger and Jenkyns, 1976; Jenkyns, 2010; Föllmi, 2012). OAEs are recognised as one among many possible consequences of environmental changes (Föllmi, 2012). These Early Cretaceous episodes of environmental changes (EEC) are defined by the presence of organic carbon-rich (OC-rich) facies and a diagnostic carbon isotope signature (Föllmi, 2012).

The monotonous succession of Lower Cretaceous dark sediments, occurring in the western part of the Silesian Nappe and in the Grajcarek thrust-sheets, were studied in detail to document horizons, reflecting environmental changes that was recorded by geochemical indicators [3][5][6]. There is necessary to compare geochemical indicators with studies of organic material, e.g. organic petrology, Rock-Eval pyrolysis, the stable organic C isotope ratio and the molecular composition of bitumen [3].

Formation of black shales associated with oceanic anoxic events (Schlanger and Jenkyns, 1976) was commonly succeeded by deposition of a hemipelagic, iron-rich succession, known as the Cretaceous Oceanic Red Beds (CORBs; Hu *et al.*, 2005). The transition from black shales to red/variegated deposits within the Cretaceous succession known from the Tethyan and Atlantic oceans (Schlanger and Cita, 1982; Bralower *et al.*, 1993; Hu *et al.*, 2005; Wójcik-Tabol, 2006) is believed as a record changing depositional conditions from anoxic/dysoxic to oxic due to cooling of climate and/or intensification of bottom circulation (Hu et al., 2005) [5][6]

Near the Eocene-Oligocene boundary (EOB), the Earth ’s climate shifted toward more cool condition (Zachos *et al.*, 1993). Depositional environment, including redox condition, salinity and organic matter input was studied in the Oligocene formations using organic geochemistry (kerogen description and hydrocarbon generation processes, biomarkers), stable isotopes composition in carbonates ($\delta^{13}C_{carb.}$, $\delta^{18}O$) and in kerogen and hydrocarbons ($\delta^{13}C_{org.}$), sedimentological and microfacial analyses (e.g., Kotarba and Koltun, 2006; Sachsenhofer *et al.*, 2009; Soták, 2010; Bechtel *et al.*, 2012). It is worthwhile to ask if any such chemical records would be found in the Oligocene succession of the Grybów Unit. A comprehensive geochemical investigations (stable carbon isotope ratio and major, and trace-elements variation, kerogen examination) of Oligocene sediments are conducted in the sections of the

Ropa and Grybów Tectonic Windows (Grybów Unit). The obtained results are discussed in terms of their implications to oxygenation changes and their potential reasons [1][2].

Climate changes have influenced on weathering of continental rocks and biosphere growth, thus they were important factors, controlling type and quantity of siliciclastics, in respect of biogenic material. Palaoegeography and palaeotectonic also influenced on sedimentation regime and redox conditions. The factors mentioned above were discussed for the Cretaceous and Oligocene Carpathian successions [1][4][5][6].

The provenance examinations include: (I) Lithology of parent rocks (II) importance of subaerial weathering using the A–CN–K triangular plot, CIA, PIA and CPA, and REE distribution and Th/U ratio; (III) geotectonic setting, basing on interaction between High Fields Strenght (HFS) elements i Large Ion Lithophile (LIL) elements; (IV) sorting and recycling, and diagenetic alterations [1][4–6].

– criteria for selecting the material studied

During opening of the Carpathians basin and post-rift subsidence (Early Cretaceous), the Silesian Basin was filled with siliciclastic turbidites and hemipelagic shales enriched in organic carbon of the Veřovice Formation (Oszczypko 2004; Golonka et al., 2008b; 2011). The black shales of the Veřovice Formation are accepted as anoxic facies (Golonka et al., 2008a) [3][6].

During the Albian–Cenomanian (Gedl, 2001; Bąk et al., 2005, Golonka et al., 2008b) turbidite complexes of the Lhoty Formation were deposited in the axial part of the basin. The Barnasiówka Radiolarian Shale Formation (BRSF) is developed as the green radiolarian shales and radiolarites, intercalated with black shales containing bentonites and ferro-manganiferous concretions and layers (Książkiewicz 1951; Bąk et al., 2001). These black shales correspond to the Bonarelli Level that is equivalent to the Cenomanian-Turonian event of oceanic anoxia (OAE 2; Bąk, 2007). The BRSF is overlain by the Turonian Variegated Shales that represent a product of deep-sea hemipelagic sedimentation under oxic conditions (Hu et al, 2005) [6].

The Cretaceous deposits of the Grajcarek Succession display similarity to the Cretaceous sequences that are known from the Polish Outer Carpathians i.e. the Spas Shales and Veřovice Formation (Książkiewicz, 1977; Golonka and Raczkowski, 1984a, b; Oszczypko et al., 2004). The Hulina Formation resembles the Cenomanian-Turonian Barnasiówka Radiolarian Shale Formation (Bak, 2007; Wójcik-Tabol and Slaczka, 2009) and the Malinowa Formation is similar to the variegated shales (Birkenmajer, 1977; Birkenmajer and Oszczypko, 1989) [5].

The sections of Lower Cretaceous sediments of the western part of the Silesian Nappe studied are exposed in the upper level of Lipnik Creek, W of Bielsko-Biała, and in Wieprzówka Creek near the village Rzyki, located SE of Andrychów. The sediments exposed in the Lipnik section belong to the Hradište, Veřovice and Lhoty formations (Geroch and Nowak, 1963). The chronostratigraphic subdivision of the sediments was based on foraminifera (Geroch and Nowak, 1963), and dinocysts (Gedl, 2003; Golonka et al., 2011). In the Rzyki section, the upper part of the Veřovice Formation and the Lhoty Formation are exposed (Uchman and Cieszkowski, 2008; Golonka et al., 2011). The age of the Veřovice and Lhoty formations was established in the Rzyki section on the basis of dinocyst assemblages. This section is known as informal equivalent of stratotype section of the Veřovice Formation (Golonka et al., 2008a) [3][4].

The exposures studied in the Grajcarek thrust-sheets are located in the upper course of the Sztolnia Stream along a 250 m section (Oszczypko *et al*., 2004). The "Black Flysch" of the Szlachtowa and Opaleniec formations is overlain by the radiolarian shales of the Hulina Formation (Birkenmajer, 1977). The Hulina Formation have been also sampled from exposures on the S slope of Hulina Mt. In the Sztolnia Stream the siliceous shales of the Hulina Formation are followed by cherry-red and green, argillaceous shales of the Malinowa Formation (Birkenmajer, 1977; Birkenmajer and Oszczypko, 1989). The sections are tectonically involved, yet the Cretaceous succession is complete and dated by foraminifera biostratigraphy (Oszczypko *et al*., 2004) [5].

The sections studied in western part of the Silesian Nappe, within the Lanckorona Foothills, are situated on the N slope of the Zamkowa Hill. The studied succession appears in reverse order and contains numerous tectonic hiatuses. Nevertheless, variation of the BRSF lithology and transition to the variegated shales are displayed here. This section is accepted as hipostratotype of the BRSF (Bąk et al., 2001) [6].

During the Late Eocene–Oligocene, as results of regional compression in the Alpine area, prominent paleogeographic changes took place in the Outer Carpathian sedimentary area, which was transformed from remnant oceanic basin into a flexural foreland basin (Oszczypko 1999). It was manifested by shallowing of all sub-basins and isolation from oceanic areas (Van Couvering et al. 1981; Oszczypko-Clowes, 2001). During the Rupelian this resulted in decline of the circulation of currents, followed by the reduced oxygen environment, with eutrophic population of microfossils, and deposition, under anoxic bottom water conditions, of dark organic-rich shales of the Menilite formation (Oszczypko-Clowes and Żydek 2012).The Oligocene, anoxic facies in the Tethys/Paratethys region spread from the Alpine Molasse Basin throughout the Carpathians to the Caspian Basin (Vetö, 1987; Popov *et al*., 2004; Sachsenhofer et al., 2009) [1][2].

The Oligocene Podgrybowskie Beds and the Grybów Marl Formation (also known as the Grybów Beds) of the Grybów Unit are recognized as a counterpart of the Menilite Formation (Książkiewicz, 1977). The Menilite Formation is commonly accepted as representing anoxic environment (Kotarba and Koltun, 2006; Soták, 2010; Kotlarczyk and Uchman, 2012) [1][2].

The aim of the study was to unveil the redox conditions and organic matter sources during the deposition of the Oligocene succession of the Grybów Nappe in respect of its petrology and chemical composition. If anoxia had occupied the basin, the sediment deposited therein would have showed appropriate features. Several commonly accepted inorganic indices (U/Th, V/V+Ni, Ni/Co, TOC – total organic carbon, TOC/S) were used in an attempt to interpret the redox conditions during the formation of the dark-coloured strata in the Grybów Nappe. The degree of illitisation of smectite, the thermal maturity of kerogen, and the stable isotopic compositions of carbonates were studied in order to investigate the alteration of sediments owing to high-temperature and diagenetic processes. The samples were collected from stratotype-locality in the Grybów tectonic window [2] and from two sections in the Ropa tectonic window [1]. The sections from both tectonic windows exposed the Oligocene succession of the Grybów Unit consisting of Podgrybowskie Beds, Grybów Marl Formation and Krosno Beds. Their biostratigraphy was established based on calcareous nannofossils (Oszczypko-Clowes and Ślączka, 2006; Oszczypko-Clowes 2008).

2.3.2. Achieved results and their application

- provenance of fine-grained sediments of turbiditic and hemipelgic facies

The provenance and diagenesis influence were examined in the fine-grained rocks from the following units:

1. Lower Cretaceous

1.1. formations: Hradište, Veřovice and Lhoty (western part of the Silesian Nappe, Bielsko-Biała and Andrychów vicinities) [4]; formations: Lhoty, Barnasiówka Radiolarian Shale and Variegated Shales (western part of the Silesian Nappe, Lanckorona Foothills) [6];

1.2. formations: Szlachtowa, Opaleniec, Hulina and Malinowa of the Grajcarek thrust-sheets [5];

2. Oligocene succession of the Grybów Unit, including Podgrybowskie Beds, Grybów Marl Formation, Krosno Beds from the Ropa Tectonic Windows [1].

The rocks studied were sourced by terrigenous and biogenic material [1][4][5][6]. SiO_2 and CaO primarily represent silica and calcite, respectively. Concentration of Al_2O_3 reflects phyllosilicate content. The ratios between these major mineralogical components are shown in the triangular diagram SiO_2–Al_2O_3x5–CaOx2 (Taylor and McLennan, 1985) [5], in the bivariate diagram SiO_2 *vs.* Al_2O_3 [5][6] or using the spider diagrams displaying the normalized concentrations of major and minor elements [4]. Taking to account the major elements contents, most formations studied are similar to PAAS and UCC [4][5][6]. The Hulina and Barnasiówka formations contain biogenic silica [5] [6] whereas the Grybów succession is calcareous [1].

The material studied contains lower amounts of HFSE and LILE than PAAS and UCC [1][4][5][6]. La, Th and Hf tend to be concentrated in silicic rocks more readily than in basic rocks that accommodate Sc, Cr and other compatible elements (Cullers, 2000). The felsic or basic nature of source rocks are presented in the plot of La/Th versus Hf, proposed by Floyd and Leveridge (1987), which corresponds to the diagram of Th against Sc (McLennan et al., 1993) to the diagram of Cr/V *vs*. Y/Ni (Bhatia i Crook, 1986). The diagram A–CN–K (Nesbitt and Young, 1984; Fedo et al., 1997) allow to assess the lithology of parent rocks [1][4][5].

The samples studied from all formations fall into the fields of felsic and felsic-intermediate sources [1][4][5]. However, basic contribution cannot be excluded for the Hulina Fm. rich in Cr and Sc [5]. The BRSF contains volcaniclastics as is shown in the diagram of (V+Ni+Cr/Al_2O_3) vs. (Zr/TiO_2) (Andreozzi et al., 1997) [6].

Above conclusions agree with general paradigm that the external Carpathians basins were supplied generally from the European Platform, Bohemian Massif and the submarine ridges, which were built of continental crust (Ślączka, 1976; Bąk, 2007; Golonka et al., 2011)

[4][5][6]. Detrital material accumulated in the Oligocene sediments of the Grybów Unit originated from the Marmarosh Massif, which is the eastern prolongation of the Fore-Magura Ridge (Oszczypko et al., 2005) [1].

The mafic rocks were produced during evolution of the Czorsztyn (Oravic) Ridge (Birkenmajer and Lorenc 2008; Krobicki et al., 2008; Spišiak et al., 2011) [5] and/or during the opening of the Outer Carpathian basin (Lucińska-Anczkiewicz et al., 2002; Oszczypko et al., 2012) [4][6].

Importance of subaerial weathering. Hydrolytic weathering of unstable minerals, such as feldspar, led to the loss of Na and Ca ions. As weathering continued, K-feldspars should also have been weathered, releasing K (Fedo *et al.*, 1995, 1997). The expected pathways of increasing degrees of weathering for igneous rocks can be traced on the A–CN–K triangular plot (Nesbitt and Young, 1984). Progressive weathering shifts the residual composition towards the Al_2O_3 apex. In the A–CN–K diagram, the results are located in upper part of triangle, closer to the A–K join [1][4][5].

The most widely used chemical index to determine the degree of source-area weathering is the Chemical Index of Alteration (CIA, Nesbitt and Young, 1982). The degree of chemical weathering can be also estimated using the Plagioclase Index of Alteration (PIA; Fedo et al., 1995). The chemical proxy of alteration (CPA; Cullers 2000) was used as a complement to the CIA when it is affected by CaO from minerals other than silicates.

CIA values corrected for potassium-addition vary from 85 to 93.5 for the Lhoty and Veřovice formations, respectively. [4]. The Szlachtowa Fm. and the Hulina Fm. show the highest values of CIA (average 80), whereas the Malinowa and Opaleniec formations reveal the lowest (average 77). The samples show very high PIA values, averaging from 92.9 in the Opaleniec and Malinowa formations to 96.8 in the Hulina formations [4]. The CIA values for the Grybów Unit varying from 72.4 to 80.6 correlate with CPA that are between 90.5 and 96.5 [1].

The ratio of Th/U can be used as a weathering indicator, because of the low solubility of Th and the oxidation of U^{4+} to the soluble U^{6+} (Taylor and McLennan, 1985; McLennan et al., 1993). The Th/U ratio for the Lhoty Formation [4] and for the Hulina and Malinowa formations [5] are higher than that for UCC (Taylor and McLennan, 1985; Rudnick and Gao, 2003). The black shales of the Hradište and Veřovice, and Szlachtowa, Opaleniec and Hulina formations have Th/U ratios additionally diminished, owing to the accumulation of U in organic matter under reducing conditions [4][5].

Intense weathering produces fractionation of the LREE/HREE. Preferential retention of HREE in solution may cause an increase in (La/Yb) normalized relative to PAAS and UCC. Values of $(La/Yb)_{PAAS}$ show positive correlation with PIA and CIA for the Grajcarek Unit samples [5] .

The studied formations contains strongly weathered material. The highest degree of weathering was established for the Veřovice, Szlachtowa (Aptian – Albian) and Hulina (Cenomanian – Turonian) formations. The smaller ones were for the Lhoty, Opaleniec (Upper Albian – Cenomanian) and Malinowa (Turonian – Campanian) formations [4, 5]. The source rocks of the Oligocene Grybów Unit are less weathered than these of the Cretaceous formations [1].

Tectonic settings. Ternary La–Th–Sc diagram (Bhatia and Crook, 1986) has been used to constrain the tectonic settings for the deposition of the Cretaceous succession studied. The deposits plot within the continental islands arc [4][5], which is partly in agreement with the major element tectonic discrimination shown in the K_2O/Na_2O vs. SiO_2 diagram [5].

An evidence for continental crust as the chief alimentary area was the geochemical signatures and the position of the Carpathian basin as a back-arc basin (Golonka et al, 2011), bonded to the CIA tectonic province [4].

The mosaic structure of the European Plate and the contribution of metamorphic rocks of granulite and partly eclogite facies is reflected in the association of heavy minerals (including kyanite) found in the Hradište Fm [4]. Granulite and eclogite facies typify the conditions of regional metamorphism that act during orogenesis. They can be connected to the old Variscan orogenic belt of the Bohemian Massif [4].

Sorting and recycling. Sorting during transportation exerts a major influence on the composition of clastic sediments. Gravitational fractionation can result in the separation of quartz and heavy minerals from phyllosilicates.

The influence of detrital heavy minerals on geochemistry was tested, using an inverse correlation with Al_2O_3. The most plausible and consistent carrier of Zr and Hf is zircon. Ternary diagram plotting $10\times Al_2O_3$–Zr–$200\times TiO_2$ illustrates the presence of sorting-related fractionations (Garcia et al. 1991). The Cretaceous samples are near to PAAS. However, the Veřovice and Szlachtowa formations and the Podgrybowskie Beds go towards Zr apex [1][4][5].

The Zr/Sc ratio is a useful index of sediment recycling. When Zr/Sc is plotted against Th/Sc (McLennan et al. 1993), Zr enrichment during sorting can be evaluated. In the Zr/Sc vs. Th/Sc diagram samples of the Grajcarek Unit are clustered along the primary compositional trend, near the andesite point, but the Szlachtowa Fm. falls along a trend involving minor zircon addition [5]. In the Zr/Sc vs. Th/Sc diagram samples of the Grybów Unit fall along a trend involving zircon addition suggestive of a recycling effect [1]. The addition of zircon in the Veřovice Fm. is illustrated on the La/Th *vs*. Hf diagram (Floyd and Leveridge, 1987) [4].

Positive correlation between TiO_2, Zr and SiO_2 in the Opaleniec, Malinowa, Veřovice formations and Podgrybowskie Beds suggest presence of rutile and zircon sorted together with quartz [1][4][5]. The contribution of recycled material is inferred from occurrences of inertinite and rounded grains of glauconite and heavy minerals (zircon, rutile and tourmaline). The co-occurrence of rounded and fresh, unabraded grains of heavy minerals suggests a mixed provenance of the clastic material, both from crystalline and older sedimentary rocks. [1][4][5].

Visible lithology differences between sections can be clearly associated with different distance from the source area. The Górnikowski sections are characterized by higher content of clastic material. The samples from the Chełmski sections contain more clay fraction than the Górnikowski section samples, as is shown in the diagram of $\log(SiO_2/Al_2O_3)$ vs. $\log(Fe_2O_3/K_2O)$ after Herron (1988) and by higher CIA and CPA values. The Chełmski sections display more distal and more fractionated facies of turbidites [1].

Diagenetic changes. Diagenetic processes could have exerted an influence on the Lower Cretaceous sequences of the Silesian Unit. Concentrations of Fe and trace metals (e.g., Mo, Au, Cu) in the Verovice Formation and silica and potassium additions in the Verovice and Lhoty formations, as well as fractionation of REE and Nb, Ta, Zr, Hf, and Y, can be explained as resulting from the action of basinal brines. The fluids were of hydrothermal origin and/or were released, owing to the dewatering of clay minerals [4].

During diagenesis of the BRSF, the bituminite material becomes thin banded or fine grained and increasingly vitrinite-like. The metabituminite might be more accurate for the characterization of the coalification residues of bituminite. REE were redistributed in sediments during diagenesis (Rasmussen *et al.*, 1998; Lev *et al.*, 1998, 1999; González-Álvarez i Kerrich, 2010) and this overprint is related with the presence of secondary minerals, such as phosphates and sulphur minerals. Diagenetic origin of the ferromanganese nodules was presented by Bąk (2007). Massive, irregular aggregates of pyrite and large octahedral crystals (average 20 μm in diameter) precipitated diagenetically in sediments underlying oxic water column (Wignall and Newton, 1998) [6].

The Malinowa Fm. exhibits high accumulation of HFSE correlative with the clay fraction and TiO_2 as well as with apatite and Fe-oxides that probably are secondary phases [5]. Similar post-depositional processes recorded by Fe-Mn-Mg mineralization, phosphate precipitation, REE fractionation and U enrichment were recognized in the Grybów succession [1]. Moreover, diagenetic hot fluids influenced on the Grybów Unit caused the illitisation of smectite and the enrichment in light $\delta^{18}O$ [2].

The Cretaceous episodes of environmental changes

An initial stage of sedimentation in the Proto-Silesian Basin was connected with a post-rifting thermal stage under extensional conditions. The samples studied represent the detrital deposits of low-density currents and normal turbidites, accumulated since the latest Barremian to Albian. The late Barremian in the Tethys was a time of cooling and aridity. Concurrently, the preservation of organic matter was lowered and the burial rate of phosphorus diminished. Under these conditions dark grey, calcareous shales interbedded with mottled marls of the upper part of the Hradište Formation were deposited. The dark grey shales of the Hradište Formation can be interpreted as reflecting the onset of detritus and nutrient flux, preceding bioproductivity and anoxia development in the Proto-Silesian Basin.

The renewed rise of organic matter accumulation occurred around the Barremian–Aptian boundary and is recognized as the Taxy EEC towards more humid conditions (Föllmi, 2012). At that time in the Proto-Silesian Basin, deposition of the Veřovice Formation began. The organic matter was mainly interpreted as terrestrial with a subordinate contribution of phytoplankton [3][6]. The deposition took place under anoxic conditions [3].

The Aptian was a time of fall in global sea-level that might have caused partial isolation of the Proto-Silesian Basin and then stagnation of the water column. The black shales of the Veřovice Formation probably were deposited under those regimes. The negative excursion in $\delta^{13}C_{org}$ and the positive excursion immediately afterwards in the lower part of the Veřovice Formation can be related to the Selli EEC (Bralower et al., 1994; Föllmi, 2012). The Selli Episode is commonly linked with the accumulation of marine organic matter (Arthur et al., 1990; Bralower et al., 1994; Hochuli et al., 1999).

The ancestors of organic matter were algae and microorganisms and land plants. The depositional conditions were disoxic. The absence of anoxia during the Aptian Selli Episode was proposed by Hochuli et al. (1999) for the western Tethys. The absence of carbonates and the high iron content in the Veřovice Formation might be linked with volcanic activity.

The interval above the Selli Episode often is attributed to the late Aptian eustatic rise in sea-level and the succeeding fall. The negative spike of $\delta^{13}C_{org}$ could be related to the Fallot EEC (Föllmi, 2012). The Fallot Episode is associated with increasing bio-productivity and anoxia development [3].

The upper Aptian–lowest Albian black shales are recognised as an OAE 1b record (Bralower et al., 1994). The Aptian–Albian Paquier Episode is equated with the return of conditions of oxygen deficiency, associated with a humid climate and the flow of freshwater, stimulating marine bio-productivity (Erbacher et al., 1996; Föllmi, 2012). The upper part of the Veřovice Formation in the Rzyki section and the lower part of the Lhoty Formation in the Lipnik section are interpreted as a record of the Paquier EEC. The presence of medium- to thick-bedded sandstones and conglomerates, and mottled shales at the top is typical of this part of the section. A considerable excursion towards heavy values in $\delta^{13}C_{org}$ is obvious. The currents transported oxygenated waters and disturbed the anoxia of the bottom waters.

In the lower Albian, green, mottled shales appear as signal of aerobic conditions in the sedimentary basin. The renewed rise in accumulation of organicmatter occurs in the middle part of the Lhoty Formation (late Albian). This interval can be linked with OAE 1c (Toolebuc Episode) associated with the accumulation of continental organic matter (Erbacher et al., 1996; Hofmann et al., 2000). This interval records the accumulation of terrigenous organic matter, which would not have influenced oxidation. The reducing conditions within the sediments probably were induced by hydrothermal solutions during diagenesis.

Generally, the OC-rich sediments studied from the Hradište, Veřovice and Lhoty formations reflect anoxic deposition according to the Detrital-OAE model with occasionally increased marine bioproductivity. In narrow back-arc basin, being the northern branch of the Tethys, the Early Cretaceous EEC are not clearly visible in the lithologies, but become apparent in light of the geochemical indicators [3].

Similarly monotonous rocks succession of “Black Flysch” represent the Lower Cretaceous of the Grajcarek Unit. Accumulations of U, Th, Mo, As correlative to S for the Szlachtowa and Opaleniec formations suggest that the deposition environment was anoxic in relation to OAE 1 [5].

The Szlachtowa and Opaleniec formations contain clay mineral assemblages including kaolinite, similar to the Lhota Formations of the Silesian Nappe [5][6]. Kaolinite enrichment probably reflects widespread accumulation of material weathered under warm and humid conditions (Chamley, 1989). The influence of weathering is confirmed by high values of the weathering proxies [4][5].

Towards the top, the amount of smectite increases gradually. The shales of the BRSF consist mainly of smectite-rich phases. The increase in smectite indicates influence of the Cenomanian transgression (Chamley, 1989). Smectite might evidence climatic condition or volcanic activity suitable for neoformation of clay minerals (Chamley, 1989).

Clay minerals assemblage of the Hulina Fm (counterpart of the BRSF in the Grajcarek Unit) includes illite/smectite and chlorite (Wójcik-Tabol and Oszczypko, 2010). Increasing amounts of illite and chlorite is typial for the Cenomanian-Turonian Interval (the Bonarelli level from the Umbria-Marche Basin) due to cooling of climate and accelerated physical weathering (Chamley, 1989).

The Hulina and Barnasiówka formations are characterized by diminishing input of terrigenous material and biogenic silica appearance (Wójcik-Tabol i Oszczypko, 2010) due to eustatic sea level rise and proceeding transgression [5][6].

The abundance of radiolarians is linked to the marine organic matter enrichment - bituminite (International Committee for Coal Petrology, ICCP, 1993) and concentration of trace metals that can be accumulated in the sediment primarily bound to organic carbon or sulphides [5][6].

The litho- and biostratigraphical position of the BRSF and Hulina Fm, and their similarity to other Cenomanian-Turonian Boundary Intervals in terms of mineralogy and geochemistry allow to interpret the BRSF and Hulina Fm as the counterparts of the Bonarelli Level and record of OAE 2 [5][6].

Red marls and shales of the Malinowa Fm. of the Grajcarek Unit and Variegated Shales of the Silesian Unit that represent the CORB follow the black shales of the Cenomanian–Turonian Interval. Deposition of the CORB might have been resulted from global cooling, and/or intensification of bottom circulation (Wójcik-Tabol and Oszczypko, 2010). Cold climate is inferred from kaolinite disappearance and drop in weathering indices [4][5]. An aerobic condition is suggested by high concentration of Fe^{3+}, Mn and low accumulation of sulphide forming elements [5][6].

The Oligocene episode of environmental changes

During the Late Eocene – Oligocene, as results of regional compression in the Alpine area, prominent paleogeographic changes took place in the Outer Carpathian sedimentary area, which was transformed from remnant oceanic basin into a flexural foreland basin (Oszczypko 1999). It was manifested by shallowing of all sub-basins and isolation from oceanic areas (Van Couvering et al. 1981; Oszczypko-Clowes 2001) [1][2].

The stable carbon isotope composition of carbonates ($\delta^{13}C_{carb}$) is a useful indicator of the salinity degree in the deposition environment. According to Anderson and Arthur (1983) a decrease in $\delta^{13}C_{carb}$ suggests decreasing salinity. In this context, it is most likely that the Grybów Fm. represents a marine environment influenced by fresh water inflow [2].

The terrestrial nature of organic matter was obtained in the materials studied. The contribution of marine organic matter cannot be excluded for the more pelagic samples of the Grybów Fm. Similarly mixed contribution of terrestrial and marine organic matter was obtained from the Menilite Formation of the Outer Carpathians (Kotarba and Koltun, 2006) and other Oligocene units (Schulz et al., 2002; Sachsenhofer et al., 2009; Bechtel et al. 2012) [2].

The marine seaways closure in the Rupelian resulted in expansion of dysaerobic bottom conditions in the Paratethys and the sedimentation of organic matter (OM)-rich sediments. The Grybów Fm. was formed under dysoxic to anoxic conditions [1][2].

The oxygen concentration/depletion was controlled by the turbiditic currents that might have ventilated the bottom waters. The upper part of the Grybów Marl Formation is developed as more pelagic sediments instead of turbiditic facies. Additionally, the Chełmski section displays more distal turbiditic facies, which contain less detritus. Contrary to that, the Górnikowski section represents more proximal turbiditic facies enriched in detrital material. Consequently, the upper part of the Grybów Formation of the Chełmski section records more anoxic-sulphidic conditions [1][2].

Conclusions

The formations of the Lower Cretaceous of the Silesian and Grajcarek units, and the Oligocene Grybów Succession were sourced from abrasion of the felsic-intermediate igneous and metamorphic rocks. The contribution of some mafic compounds was considered for the Hulina, Hradište and Veřovice formations.

Tectonic setting of the alimentary area was define as continental islands arc. Basic volcanism of oceanic islands or interplate volcanism was generated in result of continental crust thinning of the Czorsztyn Ridge. The teschenite mafic volcanism was active in the Late Jurassic – Early Cretaceous in relation to rifting and the Carpathian Basin opening. The volcaniclastics in the Branasiówka Formation can be linked to felsic volcanism in the adjacent areas.

The source rocks of the Lower Cretaceous formations of the Silesian and Grajcarek units were intensely weathered. The higher values of the alteration proxy were obtained for the Veřovice, Szlachtowa fms (Aptian – Albian) and Hulina Fm (Upper Cenomanian – Lower Turonian), whereas the Lhoty, Opaleniec fms (Upper Albian – Cenomanian) and Malinowa (Turonian – campanian) reveal lower weathering degree. The Grybów Succession seems to be the least weathered. The Th/U ratio is not reliable weathering proxy for the sediments enriched in organic matter.

Abundant zircon in the Veřovice, Szlachtowa fms and Podgrybowskie Beds is recognized as an indicator of detritus recycling. The heavy minerals were delivered from the igneous, methamorhic and sedimentary rocks. The mineral fractions of the Opaleniec, Malinowa, Veřovice fms and Podgrybowskie Beds are better sorted. The facies of the distal turbidite are the best sorted, as is shown by two section of the Grybów Unit from the Ropa Tectonic Window.

The diagenesis fingerprints are common. There are rhomboedric carbonates, secondary apatites and Fe-oxides, Mn nodules, different morphotypes of pyrite, illitization and bituminite transformation in metabituminite. The chemical composition is modified due to K-metasomatism, HFSE redistribution and low values of $\delta^{18}O$.

Generally, the black shales from the Hradište, Veřovice and Lhoty formations of the Silesian Unit and from the Szlachtowa and Opaleniec formations of the Grajcarek Unit record anoxic deposition according to the Detrital-OAE model with occasional blooms of plankton. The Early Cretaceous EEC are not clearly visible in the lithologies, but become apparent in light of the geochemical indicators.

Kaolinite is common in the Lower Cretaceous formations, indicating intensive chemical weathering under warm and humid climate. Cooling of climate is signed by illite and chlorite in the Hulina Fm. The eustatic sea level rise limited detrital input and favored biogenic silica accumulation accompanied by marine organic matter. Radiolarites and black shales of the Barnasiówka and Hulina formations are the Cenomanian-Turonian boundary interval, equivalent of the Bonarelli level, recording the OAE 2. Then deposition of the CORB might have been resulted from climate cooling, and/or aeration of bottom waters.

The Grybów Succession was deposited in shallow marine with episodic inflow of fresh waters. Supply of terrestrial and marine organic matter triggered oxygen deficiency conditions development. The oxygen availability was controlled by the turbiditic currents that might have ventilated the bottom waters.

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3. The other achievements of the research

3.1. Research provided before the doctoral degree

After graduation of high school (1st LO in Olkusz) in 1994, I started study of geology in the Institute of Geological Sciences of the Jagiellonian University. I specialized in mineralogy-petrology-geochemistry and I chose zinc sulphides from the Olkusz mine as a research object of my master thesis. I consider this task as the beginning of my scientific work. At first, Professor Czesław Harańczyk was my tutor. I collected the samples from the mine by my own. Three morphotypes of ZnS were distinguished: granular, banded and colloform sphalerite. The Cd content was main factor controlling the color of ZnS. Granular sphalerite and some dark-brown bands contained Ag, whereas the pale bands held Cu and Ge.

Different texture and chemical additions of sphalerite reflect changing composition and saturation of the ore-forming fluids, and precipitation conditions (Wójcik, 2000).

The master thesis entitled *Authomorphic and collomorphic precipitates of zinc sulphides in the Olkusz mine* I defended in 1999 under supervision of Professor Witold Żabiński (Institute of Geological Sciences of the Jagiellonian University).

After that, I continued my geological education during the Ph.D. studies in the Faculty of Biology and Earth Sciences of the Jagiellonian University. My examinations focused on the intercalations of black shales occurring within the Albian–Cenoamanian rock formation of the Pieniny Klippen Belt. They are similar to other Tethyan counterparts in terms of lithofacies and foraminiferal assemblages. From that reason the question about the petrological and geochemical fingerprints of the Oceanic Anoxic Events (OAE) in the Pieniny basin was asked. The theme of my PhD was suggested by prof. M. Adam Gasiński (Jagiellonian University), who also was my mentor. My doctoral dissertation was entitled: *Palaeoenvironment of deposition and early diagenesis of the Cretaceous oxygen deficiency sediments from the Pieniny Klippen Belt (Poland) in light of mineralogical and geochemical studies.*

The reviewers of my dissertation were Prof. Zbigniew Sawłowicz (Institute of Geological Sciences, Jagiellonian University) and Prof. Mariusz Orion Jędrysek (Institute of Geological Sciences, Wrocław University).

The total organic carbon was established using Rock-Eval pyrolysis. Origin of the organic matter was defined by macerals examinations and kerogen type evaluation. Redox conditions were inferred from concentration of redox-sensitive trace elements (Ag, Cd, Cu, Ni, Pb, Zn, V, As, Ba, Co, U, Mn) and ratios of V/V+Ni, V/Cr and U/Th. Beside the mentioned above, the pyrite morphotypes and mineral composition were investigated. The aim of these studies was to bound the Pieniny black shales with global events. The studies were financially supported by State Committee for Scientific Research and AAPG (annex 3).

New petrological and geochemical data lead to a consistent depositional model of the C_{org}.-rich sedimentation within the Pieniny Basin during the mid-Cretaceous. Considerable terrestrial runoff into the Pieniny Basin occurred during the late Albian OAE 1c. Detrital macerals accumulated under aerobic conditions on the shelf and continental slope. Fertilization of surface water induced primary productivity; aerobic degradation of organic matter led to the development of an oxygen-minimum zone within mid-water. The lower part of Pomiedznik Fm (Czorsztyn Unit), Trawne Mb and the lower part of Kapuśnica Fm (Branisko Unit) contain black shales of OAE 1c.

The oxygen-minimum zone spread over almost all of the Pieniny Basin during the Albian-Cenomanian OAE 1 d. It is recorded in the upper part of Pomiedznik Fm (Czorsztyn Unit) and Kapuśnica Fm (Branisko Unit). At the same time, the Grajcarek Basin resembled a stagnant pool. During the mid-Cenomanian the oxygen minimum zone retracted and covered only the shelf and upper/middle slope. Stagnant pools might have formed in the depressions. Turbidity currents flowed down the slope and deposited calciturbiditic sequences with organic detritus in the Branisko and Pieniny basins. At the end of the Cenomanian, isolated anoxic or even H_2S-bearing basins existed on the shelf. The slope was still occupied by the oxygen-minimum zone. stagnant waters occupied the deepest part of the basin. OAE 2 is recorded in the Magierowa Mb (Wójcik-Tabol, 2006; Wójcik-Tabol, 2008a, b).

The results of investigations of the black shales from the Cretaceous rock formations of the Pieniny Klippen Belt were presented during many geological conferences (Wójcik and Gasinski, 2000; Wójcik-Tabol, 2001; 2002 a, b; 2003 a–c; 2004; 2005; Pióro and Wójcik–Tabol, 2003; Niesiołowska and Wójcik-Tabol, 2006 a, b). The paper presenting summary of Ph.D. thesis was awarded by the Świdziński Scientific Award 2007 (annex 3).

3.2. Research provided after my Ph.D.

Mineralogical and geochemical studies in the Carpathians and adjacent areas.

Lower Cretaceous. In the Polish Outer Carpathians, the contact zone of the Magura Nappe and the Pieniny Klippen Belt is known as the Grajcarek Succession (Unit). This succession contains the "black flysch" deposits, with controversial age, overlain by the Cenomanian radiolarian shales, followed by the Turonian through Campanian variegated shales (CORB). The major and trace elements were analyzed, as well as relation of trace metals (Mo, Cu, Ni Mo, Cu, Pb, Zn, Ni, Co, As, V/V+Ni, U/Th) with organic matter content (TOC) was recognized. The Szlachtowa and Opaleniec Fms were formed under disoxic/anoxic environment of the stagnant basin. Trace metals were trapped into reactive organic matter and sulphides during sedimentation, and/or later due to diagenetic pyritization. The radiolarian shales are interpreted as settled through the mid-water oxygen minimum zone. The periods of anoxia were interrupted by intervals of disoxic conditions at the sea bottom, related to changes in surface productivity and fluctuations in bottom water circulation. The trace-element distribution characterizes the hemipelagic regime of sedimentation of both the upper portion of the "black flysch" (spotty shales) as well as the radiolatian shales, which were deposited during increasing sea-level. During the Late Cretaceous, crucial change in oceanic sedimentation occurred in the Tethys (Oszczypko & Wójcik-Tabol, 2008; Wójcik-Tabol & Oszczypko, 2010).

The Lower Cretaceous black shales are known overall from Carpatho-Alpine domain. Therefore, my next step was researching the black shale facies from the Proto-silesian Basin (Kosakowski and Wójcik-Tabol, 2010; Wójcik-Tabol and Ślączka, 2009, 2013, 2015) and from the Renodanubian Basin (Wójcik-Tabol and Ślączka, 2013). The sedimentation of black shales in the Renodanubian Basin lasted from Hauterivian / Barremian to Albian. The calcareous sedimentation lasted until Albian in the northern zone of the Renodanubian Basin (Ślączka i in., 2016). Deposition of the Lower Cretaceous black shales in the Renodanubian Basin occurred under oxygen deficiency conditions. The bottom water may have been aerated by turbidity currents (Wójcik-Tabol and Ślączka, 2013). The Wolfpassing and Gault formations resemble the counterparts from the Proto-silesian Basin in respect of mineral and chemical composition, TOC contents and type of organic matter (Kosakowski i Wójcik-Tabol, 2010; Wójcik-Tabol i Ślączka, 2013, 2015).

In the Polish Outer Carpathians the most complete sequence of the Lower Cretaceous sediments with higher OC concentration are know from the Silesian Nappe. The upper Barremian–Albian OC-rich flysch deposits of the Hradište, Veřovice and Lhoty formations, exposed in the upper flow of the Lipnik creek, westwards from Bielsko Biała town. Detailed biostratigraphical data available from the Lipnik section allow to make an attempt to analyse the relation between geochemical and microfaunal episodes. The most significant change from assemblage with *P. hauteriviana* to *V. neocomiensis* correlates with the Taxy Episode at the Barremian/Aptian boundary. The early Aptian Selli Episode seems to coincide with the disappearance of abundant verneuilinids between the lower and upper part of Veřovice Fm. The appearance of assemblage with *P. alternans* can be linked to the Paquier Episode and OAE 1b (Wójcik-Tabol and Malata, 2014).

In the same time, the cover-beds in a flysch catena located in Mt. Gora Zamkowa at Lanckorona (the Wieliczka Foothills) were studied. Lithological discontinuities in the profiles are manifested. Texture and mineral composition of these deposits are fairly controlled by the properties of sandstones even though they only found in the uppermost parts of the investigated slopes (Kacprzak et al., 2010; 2011 a, b; 2012). Results obtained from Mt. Gora Zamkowa were compared to that from Mt. Mała Rawka in the Bieszczady Mts. However, the areas are located in different parts of the Carpathians, they display a similar pattern of slope geology, with sandstones dominating the upper slope sections and shales underlying the lower parts were taken into consideration. Cover deposits (cover beds) – transported and transformed by geomorphic processes, with apparent aeolian admixture – constitute the solum parent material of soils occupying most of the investigated slopes (Kacprzak et al., 2010, 2015).

Upper Cretaceous in the Outer Carpathians. I was still interested in an evolution of the Carpathian Basin and reconstruction of alimentary area, thus I started studying petrological features of the Godula Beds. The Ostravice Sandstone Member as the lowermost part of the Godula Formation was identified and described as a lithostratigraphic unit in the Polish part of the Outer Carpathians. My task were thin-section investigations. Gravel-sized grains appear separately, dispersed by finer material. There are quartz mono- and polycrystalline and pieces of rocks (grains of altered granite and basalts, schists and gneisses). Sedimentary rock clasts are represented by sandstones, shales, cherts and Štramberk type limestones (Cieszkowski et al., 2016).

The climate changes and subsequent mass extinction are often explained by asteroid impact. There is no doubts that the K/Pg mass extinction was coincident with asteroid impact. One of convenient evidence is shocked quartz. I attempted to find shocked quartz in K/Pg boundary interval from the Polish Outer Carpathians (Skole Unit, Husów Thrust Sheet, Bąkowiec section). The difficulties in identifying shock features in quartz grains collected from turbiditic material was presented in short note (Wójcik-Tabol, 2012). Changes of the mineral and chemical composition in the K–Pg section were discussed in respect of dynamic of turbidity sedimentation and possibly influence of acidification effect (Gasiński et al, 2012; 2013).

The Paleogene in the northern zone of the Magura Nappe, called Siary Subunit is represented by the variegated shales of the Łabowa Shale Formation. It was studied in details in the area of Sucha Beskidzka (Beskid Makowski Mts.). Traces of manganese, ferric and copper mineralization were noticed. Enrichment with takes place under higher oxidation potential than Fe accumulation. Cu mineralization suggests that Cu was leached from sediments by diagenetic solution and precipitated at the CO_2 presence. Rare earth elements

(REE) distribution patterns do not prove hydrothermal origin of the mineralizing solutions (Cieszkowski et al., 2014).

Oligocene of the Grybów Unit. Results of studies of the Grybów Unit from the Grybów and Ropa tectonic windows, concerning origin of allochtonous material, depositional conditions and hydrocarbon potential are presented in Wójcik-Tabol and Oszczypko-Clowes, 2012 a, b; Oszczypko-Clowes et al., 2015; Wójcik-Tabol, 2015; Wójcik-Tabol, in press).

The Grybów Unit in the Szczawa tectonic Window may record a drop of the salinity in the sedimentary basin. Freshening the basin could have been resulted from intensified fluvial input. Drop of CaO contents and increasing of Al_2O_3 and incompatible elements (Ti, Hf, Th, U, Ta, Nb) as well as concentration of plant remains support incorporation of terrestrial compounds into sediments. The fresh water influx supplied nutrient elements (e.g. phosphorous) that induced bio-productivity. Subsequently, degraded organic matter caused the oxygen minimum zone development as is suggested by high ratios of V/V+Ni Ni/Co and accumulation of As, Zn, Mo, Se, Ag co-occurring with S (Oszczypko-Clowes and Wójcik-Tabol, 2014; 2015).

Dolomitization, K-addition (associated with illitization) and fractionation of trace elements (Nb/Ta, Zr/Hf, Y/Ho, Th/U and LREE sloping down to HREE) are mainly explicit in the Szczawa tectonic window and suggest that rocks were infiltrated by brines, possibly being the "shchava" type (Oszczypko et al., 2016).

Other researches. Geochemistry was useful tool in examination of the climatic changes recorded at the Triassic–Jurassic boundary in the Križna Unit (Belianske Tatry Mts, Slovakia) and the Upper Berriasian in the Western Balkan tectonic unit (Bulgaria).

The Triassic–Jurassic boundary interval was studied in the continuous section of the Carpathian Keuper followed by the Rhaetian Fatra Formation in the Kardolína section situated on a steep western slope of the Mt Pálenica (NNE of the Tatranská Kotlina village) in the Belianske Tatry Mts. Total rock analyses of 12 samples were performed in order to obtain a more precise idea of the origin of the source material and to determine chemical changes potentially forced by hydrological, climatic and other factors. Detritus originated from felsic parent rocks is more abundant in the Carpathian Keuper as is suggested from more frequent lithogenic elements and flat REE distribution. Contents of P_2O_5, MnO, and S_{tot} are higher in the Fatra Formation limestone than in the Carpathian Keuper dolostone: they document a shift in sedimentary conditions associated with marine transgression. Rhythmicity within the Fatra Formation may record monsoon like climatic fluctuations. Black shale deposition recorded input of terrigenous organic matter and eolian dust. Pyrite framboids and redox-sensitive elements indicate anoxic condition (Wójcik-Tabol and Michalik, 2011; Michalík et al., 2013)

The Barlya section is located at the northern end of the village of Barlya (Sofia District). The section occupies part of WNW-ESE trending monocline of thick Mesozoic rocks that composes the southwest end of the Western Balkan tectonic unit. The Berriasian interval of the Barlya section includes the Glozhene and the Salash formations developed as an alternation by micritic limestones and marly limestones. Increase of lithogenic element (e.g., Al, Ti, Zr, Th and others) contents is regarded as a reliable proxy of detrital input. Influx of fine grained terrigenous material increases in the Upper Berriasian up to the Berriasian/Valanginian boundary. It is coeval with an important climatic turnover in Western

Tethys; however, it might have been strengthened by a general regression and regional tectonic events in the Carpatho–Balkan area. Two oxygen deficient intervals were documented by Ni/Co, U/Th, Mo, Cd, Zn: the first in the Lower Berriasian; the second one in the uppermost Upper Berriasian up to the boundary with Valanginian. Both intervals correlate with an elevated sea-level in the Western Tethys. Enhanced bioproductivity is suggested in the Lower Berriasian. Chemical indices of parent rocks alteration (CIA, CPA, Rb/Sr) increase in lower part of the succession and stay high in upper part. It suggests abrupt climate change, that promoted intense chemical weathering (Grabowski et al., 2015 a–c; 2016).

Black shales of the Aalenian, Bajocian, Kimmeridgian and Tithonian from the central part of the Polish Basin were studied to establish their hydrocarbon potential. The results of Rock-Eval indicate the presence of mixed organic matter (type III/II kerogen) occurring in the Upper Jurassic strata, whereas gas-prone type III kerogen prevails in the Middle Jurassic strata. High relative concentrations of biomarkers typical for terrestrial material confirm a distinct dominance of organic matter derived from land plants. Deposition took place under oxic – suboxic, locally anoxic conditions. The maturity of organic matter ranges from immature phase to mid-phase of “oil window”. The growth of organic matter maturity took place after deposition of the Upper Jurassic and after deposition of Upper Cretaceous. The generation was terminated as a result of post-Cretaceous inversion of area. The source rocks do not show expulsion (Kosakowski et al., 2015).

Bibliometric indicators and scientific plans

The results of my researches were published in 18 original papers, 13 in journals of Journal Citation Reports and 5 in peer reviewed journals (List B of Ministry of Science and Higher Education). In addition, the results were published in 35 conference reports. I personally presented them during 21 national and international conferences. The total impact factor of my publications according to the Web of Science (in the publication year) is 15.156; The citation index (without autocitations) is 18; the Hirsch index is 3 (data from 20.04.2017) (Annex 3).

I was a manager of two projects of the State Committee for Scientific Research, of two projects financed by the Ministry of Science and Higher Education. I was the contractor in one project of the Ministry of Science and Higher Education. Currently I am a contractor in one project of the National Science Centre (Opus) (Annex 3).

My didactic duties at the Jagiellonian University include 210 hours a year (lectures, field works and tutorials) (Annex 4). I was a tutor of 17 masters and BA theses. I improved my qualifications by taking part in the Ars Docendi courses (Annex 4).

I am happy to be involved in activities popularizing science, e.g. during the Science Festival and the Malopolska Night of Scientists. I gave lectures and run workshops for children, youth and students of The University of the Third Age (Annex 4).

I received the Jagiellonian University Rector’s Award for team achievements in 2006 and 2007, and the AAPG grant. I was honored with the special award of the Director of the Institute of Geological Sciences for didactic achievements.

I would like to focus on further examinations of fine-grained rocks in terms of their provenance, and conditions of deposition and diagenesis. I am looking forward to finalizing the projects started.

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