Attachment 2b

RESUME
Summary of scientific career and achievements of the applicant

1. First name and surname: Katarzyna Narkiewicz

2. Diplomas, academic degrees, place and year of granting, and Ph.D. thesis title

Master of Science in geology (palaeozoology) – degree obtained at the Department of Geology of the Warsaw University in 1975. Thesis title: “Middle Devonian ostracods from the family Bufinidae in the Skały section (Holy Cross Mountains)”

Doctor of Natural Sciences in Geology (stratigraphy) – degree awarded due to the resolution of the Scientific Council of the Polish Geological Institute on 2007, October, 25^{th}. Thesis title: “Middle Devonian conodonts from the Radom-Lublin area: taxonomy, biostratigraphy and biofacies”

3. Information on previous employment in scientific institutions

1975 - now Polish Geological Institute-National Research Institute

1975-1976	Engineer
1977-2007	Scientific assistant
2007 - now	Senior scientific assistant (adiunkt)

4. Indication of achievement under Article 16 Paragraph 2 of the Act of March 14, 2003 “On Academic Degrees and Scientific Title and Degrees and Title in the Field of Arts” (Journal of Laws No. 65, item 595, with amendments)

a) Title of the scientific achievement:

Taxonomy and biostratigraphic significance of shallow marine conodonts of the Middle Devonian

b) Authors, titles of publications, year of issue, name of publisher

The scientific achievement includes the following four publications:

1. **Narkiewicz K**. and Bultynck P. 2010. The Upper Givetian (Middle Devonian) *subterminus* Conodont Zone in North America, Europe and north Africa. *Journal of Paleontology* 84(4): 588-625.

2. **Narkiewicz K**. and Narkiewicz M. 2010. Mid Devonian carbonate platform development in the Holy Cross Mts. (central Poland): new constraints from the conodont *Bipennatus* fauna. *Neues Jahrbuch Geologie und Paläontologie Abh*., 255(3): 287-300.

3. **Narkiewicz K**. 2011. Conodont biostratigraphy of the Middle Devonian in the Radom-Lublin area (south-eastern Poland). *In*: M. Narkiewicz (ed.) Devonian basins of south-eastern Poland. *Prace Państwowego Instytutu Geologicznego* 196: 147-192.

4. **Narkiewicz K**. 2013 (in press, published online: 27 December 2013). Taxonomic revision and phylogenetic affinities of the conodont *Bipennatus montensis* (Weddige, 1977) from the Eifelian (Middle Devonian) of Poland. *Paläontologische Zeitschrift*. DOI 10.007/S12542-013-0218-9.

c) Description of scientific aims of the above publications, results and their applications

Conodonts are principal tools of the Devonian stratigraphy, and the Middle Devonian is not an exception. In the Middle Devonian, shallow epicontinental seas extended over most areas of Europe (Poland included) and North America (Ziegler, 1988). During that time, similarly as in the Late Devonian, conodonts were most abundant in the deeper marine, particularly pelagic and hemipelagic facies. As these forms were also most widespread palaeogeographically, they became a basis for establishment of the so-called standard biozonation of a global importance (Ziegler and Sandberg, 1990; Clausen et al., 1993). Considerably less studied are those Middle Devonian conodonts that are associated with shallow-marine sediments. This impedes biostratigraphic dating of marginal basinal sediments where marine and continental facies interfinger. As a consequence, an age-correlation of sediments from various marine basinal zones becomes problematic, as are their comparisons with the co-eval continental basins.

Under such circumstances, the main aim of my studies was to establish better basis for an application of the shallow-water Middle Devonian conodonts for a supra-regional stratigraphy, through achieving better definition of taxonomic concepts and stratigraphic ranges, and correlation of the latter with the standard zonation.

The starting point for my studies, having been successively conducted since 1995, was the Radom-Lublin area. During the Middle Devonian it formed a part of a shallow-water epicontinental marine basin located at the southern margin of the Old Red Continent (Laurussia). A frequency of conodont elements is here generally low (<50 specimens per sample) nad therefore the Radom-Lublin Devonian has been long regarded as non-prospective as to the occurrence of conodont remains, and the previous studies were mostly localized and devoted to the Upper Devonian (Szulczewski, 1972a, b; Matyja and Żbikowska, 1974; 1985; Nehring, 1979). The results of my studies were initially of merely a regional significance, serving to date and correlate lithostratigraphic units in a basin scale. They were summarized in my Ph.D. thesis, defended in 2007. In the last years I have extended my studies over other regions of Poland and worldwide in order to apply the biostratigraphic results for supra-regional correlation, and for identification of global events, including eustatic, organic and other.

My studies had different scope and character with respect to both Middle Devonian stages – Eifelian and Givetian. Therefore, below I will present the result in two separate parts: (1) taxonomic, biostratigraphic and phylogenetic investigations of the Eifelian conodonts (K. Narkiewicz and M. Narkiewicz, 2010; Narkiewicz, 2013, and, partly, K. Narkiewicz, 2011), and (2) taxonomic and biostratigraphic investigations of the Givetian conodonts, and related problems of conodont zonations for shallow-marine facies (Narkiewicz and Bultynck, 2010 and K. Narkiewicz, 2011).

Eifelian conodont studies

The results of taxonomic and biostratigraphic investigations of the Eifelian of the Radom-Lublin area were summarized in the publication by K. Narkiewicz (2011). The collection comprises total number of 126 elements from 2 borehole sections, Świdno IG 1 and Szwejki IG 3. The taxonomic study allowed to identify 7 taxa of species and subspecies rank, including 1 taxon previously unknown from Poland, and one form described in an open nomenclature. The stratigraphic ranges of the taxa were referred to the conodont zonations presented by Narkiewicz and Bultynck (2010).

This allowed to identify two zones in the Eifelian. The conodont data were presented against modified lithostratigraphic divisions (M. Narkiewicz, 2011 a, b). This made possible to correlate sedimentary successions and to further constrain chronostratigraphy, as well as to analyze relationships with global eustatic events (M. Narkiewicz et al., 2011a).

Based on biostratigraphic analysis, the lower and upper Eifelian boundaries were established in a more or less detail. The Lower-Middle Devonian (=Emsian-Eifelian) boundary was approximately set in the Świdno IG 1 section between an uppermost part of the Przewodów Member and a lower part of the Giełczew Member of the Telatyń Formation, whereas in the Szwejki IG 3 borehole it runs in the lowermost part of the Marls and Calcareous Shales Unit. The Eifelian-Givetian boundary can be approximately placed in the middle part of the Marls and Calcareous Shales Unit in the Szwejki IG 3 borehole.

The results of an utmost supraregional significance were obtained during the studies of the shallow-marine dolomites of the Wojciechowice Formation in the Zachełmie Quarry located in the north-western part of the Holy Cross Mountains (K. Narkiewicz and M. Narkiewicz, 2010). I discovered here the assemblage of conodonts attributable to the genus *Bipennatus* Mawson 1993, in particular to its species *Bipennatus montensis* (Weddige 1977). The total stratigraphic range of *B. montensis* corresponds to the *costatus* Zone (Lower Eifelian). Earlier, the age of the strata in question was estimated as Eifelian to Givetian, based on indirect evidence.

Initially, the conodont material was obtained from a single sample (K. Narkiewicz and M. Narkiewicz, 2010), while later, six more samples appeared productive (Narkiewicz, 2013). The studied collection appeared to be the largest in the world with regard to the studied species, which allowed to amend its original diagnosis (Weddige, 1977), present its phylogeny, evolution, palaeoecology and a total stratigraphic range (K. Narkiewicz and M. Narkiewicz, 2010; Narkiewicz, 2013).

The oldest assemblage from the Zachełmie section contained the forms similar to *Bipennatus* as well as to the genus *Ozarkodina* Branson and Mehl 1933. Detailed analysis of these conodonts has shown that the genus *Bipennatus* evolved from ozarkodinid forms at the turn of Emsian and Eifelian and in the earliest Eifelian. During that process the height of denticles was differentiating, with the lowest denticles being formed in the middle part of a specimen. These middle denticles were longitudinally split and the initial trough formed (Narkiewicz, 2013).

Moreover, comparative studies have shown evolutionary continuity between the species *Bipennatus montensis* and *Bipennatus bipennatus* (Bischoff and Ziegler 1956). In order to prove the gradation between the species I applied for the first time a method of photographing thin, blade-like conodont elements in a transmitted light. The conodont elements are composed of a transparent hyaline matter, and white opaque so-called albid matter which is concentrated mostly in denticles (Sweet, 1988). Owing to transmitted-light images I was able to observe a distribution of both types of the matter and draw conclusions as to the mode and timing of denticles formation. Detailed analysis of denticles forming in a succession of stratigraphically younger specimens clearly demonstrated the phyletic continuity between *Bipennatus montensis* and *Bipennatus bipennatus*. This finding further led to the revision of *Bipennatus* (Mawson, 1993) and its phylogenetic lineage, as well as allowed to raise the earlier subspecies *montensis* and *bipennatus* (Weddige, 1977; Mawson, 1993) to the species level.

The forms found within the particular assemblages represented various ontogenetic stages of *B. montensis* – from juvenile to mature (K. Narkiewicz and M. Narkiewicz, 2010; Niedźwiedzki et al., 2010, Supplementary Information). This indicates presence of a primary biocenose suggesting lack of stronger redeposition, which reinforces stratigraphic conclusions. The palaeoecological studies have shown that *Bipennatus montensis* preferred areas of an inner shelf, nearshore and very shallow-water, but at the same time rather calm, where other conodont species appeared very rarely (K. Narkiewicz and M. Narkiewicz, 2010).

Application of the results. – The results of the conodont investigations of the Zachełmie section have important biostratigraphic implications on a regional and wider scale. The results were applied to date a characteristic developmental stage of the Devonian carbonate sedimentation in the Holy Cross Mountains, namely uniform dolomitic facies of a very shallow shelf (K. Narkiewicz and M. Narkiewicz, 2010; cf. Szulczewski, 1995). They also offered new clues to the question of identification of global eustatic cycles (Johnson et al., 1985) in the Eifelian depositional development (K. Narkiewicz and M. Narkiewicz, 2010).

Considered on a global scale, the described results attained an exceptional significance in view of the discovery of the trackways of early tetrapod animals in Zachełmie (Niedźwiedzki et al., 2010). The key conodont sample was localized above the trackway-bearing interval, which indicated that it is not younger than the *costatus* Zone. Owing to this conclusion it appeared that the trackways are the oldest tetrapod fossils known so far. This led to a total revision of evolutionary concepts regarding emergence of tetrapods from a specialized group of fishes (Janvier at Clément, 2010). Thus, the conodonts contributed to a large degree to a recognition of the tetrapod trackways discovery as a groundbreaking event, distinguished by the “Nature” front-cover (Niedźwiedzki et al., 2010).

Givetian conodont studies

Due to a very rare occurrence of the index deeper-water conodonts in the areas of shallow-marine basins, defining successive standard zones of the Upper Givetian and lowermost Frasnian (*hermanni*, *disparilis* and Lower *falsiovalis* – cf. Fig. 1) has been hardly possible in such settings. Therefore, during my studies I attempted to correlate zonation schemes for both above facies realms. The turning point was documenting the shallow-water *subterminus* and *Pandorinellina insita* faunas for the first time in south-eastern Poland and also in Europe of (Narkiewicz, 2006; Narkiewicz and Bultynck, 2007). They have been known earlier only from North America (Klapper et al., 1971; Bunker and Klapper, 1984; Witzke et al., 1988; Rogers, 1998).

According to the American authors the *subterminus* Fauna corresponded more or less to the standard *disparilis* Zone. Its lower boundary was defined as the first appearance of *Icriodus subterminus* Youngquist 1947, whereas the upper one – as the first appearance of *Pandorinellina insita* (Stauffer 1940). The *subterminus* Fauna was divided into the lower and upper parts with a boundary defined as the first appearance of *Polygnathus angustidiscus* Youngquist 1945 and *Mehlina gradata* Youngquist 1945. Unfortunately, lack of adequate data on first occurrences of the diagnostic species precluded correlation of the above mentioned boundaries with the standard subdivision.

Based on a conodont material from the Radom-Lublin area and Holy Cross Mountains, north-eastern France (Boulonnais), Belgian-French Ardennes, Canada (Manitoba and north-eastern Alberta), USA (Iowa), Morocco (Eastern Anti-Atlas) and published data, Narkiewicz and Bultynck (2010) established an alternative zonation for the Upper Givetian in shallow-marine facies. This zonation, based on taxa composing the *subterminus* Fauna, including index species *Icriodus subterminus* in particular, was correlated with the zonation for deeper-marine environments (i.e., standard zonation). In addition, detailed taxonomic and biostratigraphic investigations of the species *Icriodus expansus* Branson and Mehl 1938 allowed to supplement the icriodid zonation for slightly deeper shelf facies (Bultynck and Gouwy, 2008) by introducing the *expansus* Zone in the Upper Givetian.

The study focused first of all on correct diagnoses of both key *Icriodus* species, and on constraining their first stratigraphic appearances in order to date lower boundaries of both zones. Afterwards, the upper boundaries of the zones have been identified, both boundaries have been correlated with the standard zonation and a worldwide stratigraphic significance of the new zones for a correlation of late Givetian deposits has been discussed.

Correct taxonomic definition of both species was particularly important because *I. subterminus* was regarded as a long-ranging taxon, occurring from the *ensensis* Zone (Upper Eifelian) (Belka et al., 1997) up to the Lower *rhenana* Zone of the Upper Frasnian (Upper Devonian) (Ziegler and Sandberg, 1990). On the other hand, *I. expansus* was commonly erronously identified in the literature. First of the above species was revised based on the material supplied by Gilbert Klapper from the area of the classical occurrence of the *subterminus* Fauna in Iowa State. The revision of *I. expansus* was based on own material and on published data. Among the forms previously attributed to *I. subterminus*, besides the latter species also the new species *Icriodus cedarensis* have been distinguished. In both species two morphotypes α and β have been described.

In order to define stratigraphic ranges of *I. subterminus* and *I. expansus* 45 accompanying taxa have been analysed. As a result of this study 2 new species were described, diagnoses of 4 taxa were amended and stratigraphic ranges of further 9 taxa were revised. It was found that the stratigraphic range of *I. subterminus* is narrower than previously assumed, comprising the uppermost part of the *hermanni* Zone up to the MN 3 Zone (for morphotype α) and MN 4 (for morphotype β) (cf. Fig. 1). On the other hand, *I. expansus* appears near the base of the *hermanni* Zone, and disappears in the MN 5 (*punctata*) Zone, and thus similarly as earlier presented. The analysis of the stratigraphic ranges allowed to define lower and upper boundary of both the zones and a further subdivision of the *subterminus* Zone (see Fig. 1).

The lower *subterminus* Zone boundary was correlated with the uppermost part of the standard *hermanni* Zone, while the upper one with the first occurrence of *Ancyrodella* representatives. The upper boundary was thus moved considerably above the original upper boundary of the *subterminus* Fauna, and at the same time the concept of a separate *insita* Zone has been abandoned. Such an approach was adopted because it appeared that *I. subterminus* is still frequent in the *insita* Fauna, and moreover the occurrence of the index species *Pandorinellina insita* strongly depends on facies and, additionally, on local conditions, and commonly this species does not occur at all.

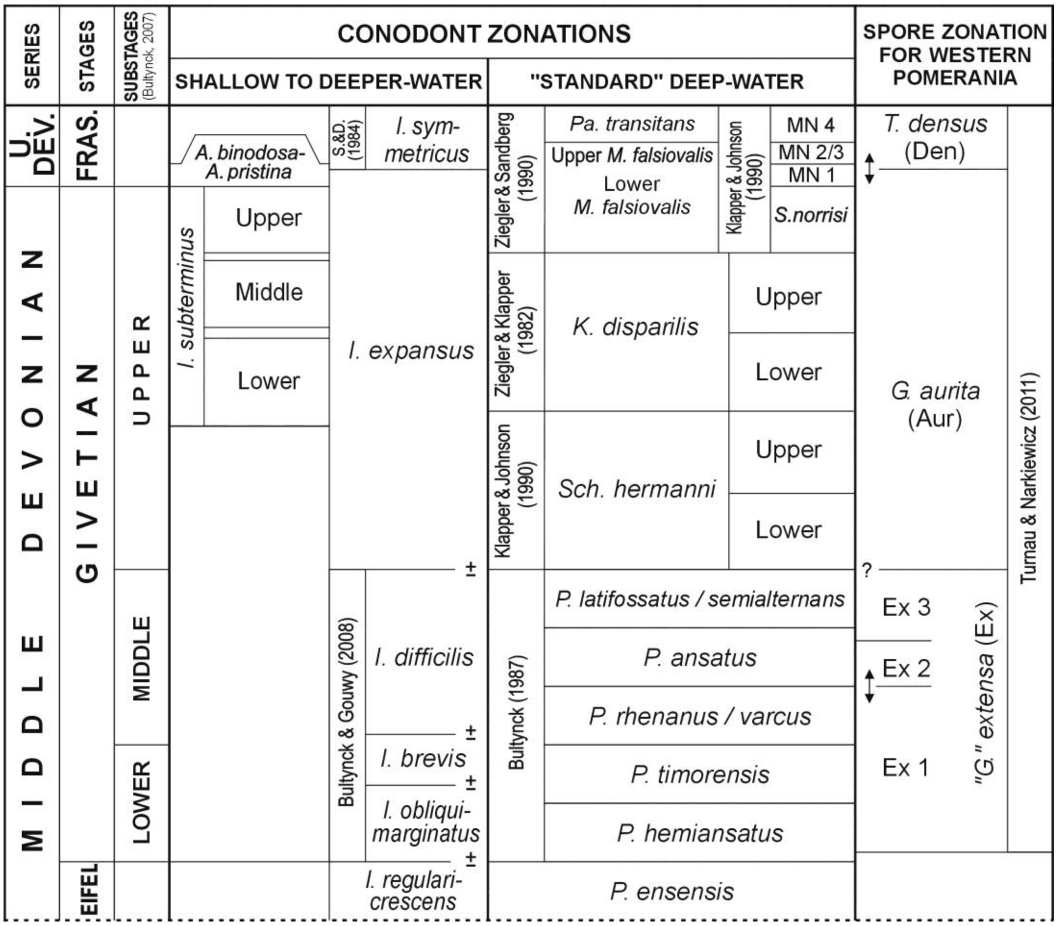

Fig. 1. Correlation of the conodont subdivisions of the Givetian and Lower Frasnian for shallow-water nearshore facies and middle-outer shelf, with the standard zonation (outer shelf and continental slope facies) (Narkiewicz and Bultynck, 2010). Additionally, a correlation with the spore zonation is presented (Turnau and Narkiewicz, 2011).

The lower boundary of the Middle *subterminus* Zone was defined at the interval of the first occurences of *P. angustidiscus* and *Mehlina gradata*, and the lower boundary of the Upper *subterminus* Zone was referred to the interval of the first occurrences of *Pa. insita* and *Skeletognathus norrisi* (Uyeno 1967). To facilitate a recognition of respective subzones, characteristic taxa were indicated, which co-occur with the index species *I. subterminus* and with other species defining the zonal boundaries. For the Lower *subterminus* Zone these are *Icriodus cedarensis* n. sp. (erected in the discussed paper), *Schmidtognathus latifossatus* (Wirth 1967) and *Polygnathus linguiformis linguiformis* Hinde 1879, for the middle one - *Polygnathus pollocki* Druce 1976, and for the upper - *Polygnathus webbi* Stauffer 1938. As a result of the analysis of the author's own collection and published data it was demonstrated that the entire *subterminus* Zone or some of its subdivisions occur in the Old Red (Laurussia) continent, including USA, Canada, areas of France, Belgium and Poland, as well as in the north-western part of the Gondwana Continent in Morocco.

The lower boundary of the icriodid *expansus* Zone was correlated with the base of the standard *hermanni* Zone and at the same time with top of the *difficilis* Zone (Fig. 1) based on the first stratigraphic appearance of the index species *Icriodus expansus*. Upper boundary of the zone coincides with the base of the *Icriodus symmetricus* Zone (Sandberg and Dreesen, 1984). It was not attempted to correlate this boundary with the top of the *subterminus* Zone because *I. expansus* and *I. subterminus* preferred different facies and their co-occurrence is rare. *Icriodus tafilaltensis* n. sp. (erected in the discussed publication) is a characteristic species facilitating identification of the *expansus* Zone, and its stratigraphic range nearly coincides with the range of *I. expansus*.

The conodont zonations and taxonomic conclusions presented in the publication by Narkiewicz and Bultynck (2010) provided a basis for a verification of the data from the Radom-Lublin area published by Narkiewicz and Bultynck (2007). In this earlier paper 38 taxa were identified, and in the case of 11 taxa the total stratigraphic ranges were revised. The ranges were defined according to the standard zonation (Ziegler and Sandberg, 1990; Marshall and House, 2000; Klapper and Johnson, 1990), alternative zonation by Bultynck (1987) as well as ”endemic” North American zonation based on *subterminus* and *insita* faunas (Rogers, 1998; Klapper et al., 1971). The result of the study was identification of 5 Givetian conodont zones and their correlation in the entire study area.

In the publication by K.Narkiewicz (2011) not only the earlier conodont data have been verified but also new, so far unpublished material was analysed and presented, based on borehole sections Strzelce IG 2, Świdno IG 1, Szwejki IG 3 and Krowie Bagno IG 1. In total, 51 taxa were identified, mostly belonging to *Polygnathus* and *Icriodus* genera. Thirteen taxa were described in the systematic part, including 10 found for the first time in Poland. Description of the new taxa has required a compilation of a consistent descriptive terminology for both genera for the first time in Poland. Moreover, 12 taxa from the papers by Malec et al. (1996), K. Narkiewicz and M. Narkiewicz (1998) and Narkiewicz and Bultynck (2007) were revised. The taxonomic ranges of the taxa were referred to the conodont zonations from the paper by Narkiewicz and Bultynck (2010). This allowed to identify 6 Givetian zones. The novelty, when compared to the earlier paper by Narkiewicz and Bultynck (2007), was documentation in the study area of the presence of the *subterminus* Zone and its three subzones, as well as the Lower *falsiovalis* Zone. The conodont data were discussed against the new lithostratigraphic framework (M. Narkiewicz 2011 a, b) which allowed better chronostratigraphic correlation of the sections and dating lithofacies boundaries. Application of the revised conodont biostratigraphy made it possible to re-affirm significance of eustatic and tectonic events in shaping depositional architecture (M. Narkiewicz et al., 2011a).

Based on biostratigraphic study (K. Narkiewicz, 2011) the Middle-Upper Devonian boundary and Givetian substages boundaries have been established in a more or less detailed way. The Middle-Upper Devonian (=Givetian-Frasnian) boundary was precisely determined in the Giełczew PIG 5 borehole section in the uppermost part of the Giełczew Member of the Telatyń Formation at the depth 1967.1 m. Less precise data were obtained from the boreholes Krowie Bagno IG 1, Szwejki IG 3 and Bąkowa IG 1. In the first one the discussed boundary runs in the 30 meters-thick interval between an upper part of the Giełczew Member of the Telatyń Formation, and the lowermost part of the Modryń Formation. In the Szwejki IG 3 section the boundary is traced either in the Iłżanka Formation or above, in the lowermost part of the Dolomites and Limestones Unit. On the other hand, in the Bąkowa IG 1 section the base of the Frasnian runs within the 50 meters-thick interval in the middle part of the Iłżanka Formation.

Application of the results. – The results of conodont investigations described in the papers by Narkiewicz and Bultynck (2010) and K. Narkiewicz (2011) were applied for the purposes of regional correlation and interpretation of the depositional architecture of the Łysogóry-Radom and Lublin basins (M. Narkiewicz et al., 2011a). Conodonts allowed to attribute the transgressive members of the depositional cycles T-4 i T-5 to the *ansatus* and *norrisi* zones, respectively. The former cycle represents the eustatic cycle IIa (Taghanic Onlap - Johnson et al., 1985; House, 1985). The T-5 cycle is interpreted as equivalent of the cycle IIb (Johnson et al., 1985) corresponding to the *Mesotaxis* Event (Racki, 1993).

The above outlined results were also applied for establishing a correlation between the conodont and spore zonations of the Givetian and Lower Frasnian. In the paper by Turnau and Narkiewicz (2011) the biostratigraphic evaluation of the spore material has been carried out with reference to the conodont zonations of the Givetian for shallow-marine facies, presented by Narkiewicz and Bultynck (2010; see also Fig. 1). Such comparison allowed to constrain dating of the first and last occurrences of stratigraphically important spore taxa. Obtained results were discussed against the literature data, which led in some cases to revision of earlier published conodont taxonomical and biostratigraphic results. The dating of some Middle Devonian stratigraphic units from Boulonnais, Eifel Mountains and Holy Cross Mountains have been verified.

The most important result of the Givetian conodonts studies was the introduction of the conodont zonation for shallow-marine deposits and its correlation with the standard zonation for deeper marine facies (Narkiewicz and Bultynck, 2010). This allowed to achieve a more precise correlation with the Givetian spore zonation (Turnau and Narkiewicz, 2011) which further resulted in better correlation tools for marine and terrestrial strata. Significance of these results is confirmed by the citation of both above named papers in the fundamental volumes of ”The Geologic Time Scale 2012” (Becker et al., 2012).

5. Description of other scientific achievements

All results of my investigations are related to different aspects of the organic group Conodonta, which have been studied by myself since 1990. Apart from the main subject of my interest, i.e. the taxonomy and biostratigraphy of the Middle Devonian conodonts, my scientific activity was devoted also to selected questions of systematics and biostratigraphy of the Upper Devonian and Triassic forms. I was also involved in palaeothermal analysis of Palaeozoic and Triassic sedimentary basins based on the conodont colour alteration index (CAI).

Investigations of Upper Devonian conodonts

1. Narkiewicz M. and **Narkiewicz K**. 1992. Transgressive pulse in the Upper Frasnian of the Janczyce I section (Holy Cross Mts): sedimentology and conodont biofacies. *Geological Quarterly* 36(3): 281-304.

2. **Narkiewicz K**. and Narkiewicz M. 2008. The mid-Frasnian subsidence pulse in the Lublin Basin (SE Poland): sedimentary record, conodont biostratigraphy and regional significance. *Acta Geologica Polonica* 58(3): 287-301.

3. **Narkiewicz K**. and Bultynck P. 2011. Conodont biostratigraphy of the Upper Devonian in the Lublin area (south-eastern Poland). *In*: (M. Narkiewicz, ed.) Devonian basins of south-eastern Poland. *Prace Państwowego Instytutu Geologicznego* 196: 193-254.

The subject of the paper by M. Narkiewicz and K. Narkiewicz (1992) is a distinct transgressive pulse observed in the key borehole section Janczyce I in the eastern part of the Holy Cross Mountains. This event has been dated based on conodonts as an upper part of the Upper *rhenana* Zone (Upper Frasnian). Rapid transition from shallow marine sediments to deeper shelf has been documented using sedimentological observations and data on quantitative composition of conodont assemblages (biofacies). It has been found that shallow-water icriodid biofacies is rapidly replaced by deeper-water palmatolepid-polygnathid biofacies.

Successive Upper Devonian conodont studies conducted in the Lublin area since 2005 resulted in dating lithostratigraphic units and their boundaries (K. Narkiewicz and M. Narkiewicz 2008; Narkiewicz and Bultynck, 2011). This in turn made possible to correlate the investigated strata, determine age of major transgressive-regressive cycles and depositional events on both regional and global scales.

In the Upper Devonian of the Lublin Basin the conodonts have been found in the Frasnian Modryń Formation and in the Famennian Bychawa and Firlej formations. The sediments of the Modryń Formation are predominantly shallow-marine and commonly represent environments that were unfavourable for the presence of conodont remains. Occurrence of these remains is restricted to certain horizons or intervals where we observe their larger accumulations. For that reason a few earlier findings and related occassional biostratigraphic investigations of the Upper Devonian were concerned with single boreholes and cored intervals, mainly in the Famennian and the Frasnian-Famennian boundary (Szulczewski, 1972a, b; Matyja and Żbikowska, 1974; 1985; Nehring, 1979).

The investigations by the author, the results of which were summarized in the paper by Narkiewicz and Bultynck (2011), are based on materials from 15 borehole sections and 114 conodont samples that furnished an exceptionally rich collection. The collected material of the Frasnian conodonts amounts to 2139 specimens found in 100 samples from 13 boreholes. The specimens were ascribed to 9 genera including 44 species and subspecies and 35 taxa described in an open nomenclature. The collection is dominated by polygnathids. With regard to number of specimens and taxonomic diversity it equals the Canadian collection (Klapper and Lane, 1985) and that from the central parts of the East European Platform (Ovnatanova and Kononova, 2001; 2008). For the first time in Poland it was possible to identify representatives of 14 taxa known from other regions of the Rhenohercynian Basin and areas of the East European Platform. Diagnoses and descriptions of these taxa were presented in the systematic part (Narkiewicz and Bultynck, 2011). The Frasnian material, particularly the stratigraphically important forms were illustrated in 11 photographic plates (K. Narkiewicz and M. Narkiewicz, 2008, Pls 1-2; Narkiewicz and Bultynck, 2011, Pls I-IX).

Polygnathids that dominate among the Frasnian conodonts are forms associated with shallow-water environments. They are not useful when applying the Frasnian conodont zonations according to Ziegler and Sandberg (1990) and Klapper (1989) based mainly on palmatolepids, i.e. forms characteristic for open marine and/or deeper-water environments. Also, it was not possible to refer to the polygnathid-based zonations by Klapper (1997) and Ovnatanova and Kononova (2001, 2008), mainly because of lack of index *Polygnathus* taxa and difficulties to define their first stratigraphic appearance. Therefore, in most cases the age of the strata was determined basing on a comparison of total stratigraphic ranges of possibly all taxa encountered in particular assemblages (samples). To this end, first and last occurrences of 44 taxa were analysed of which 8 were verified in terms of their stratigraphic ranges, based on own material and on literature data. It was possible to identify 6 conodont zones in the Frasnian, comprising all substages, i.e. lower, middle and upper ones. The acquired data allowed to better constrain the age of lithostratigraphic units. The Givetian-Frasnian boundary was determined in the uppermost part of the Telatyń Formation, and not at the boundary between the Telatyń and Modryń formations, as previously assumed.

The Famennian has been analysed in 4 boreholes, and the collected material amounts to more than thousand specimens. In the case of the Famennian conodonts, the investigations were focused on determination of most characteristic, stratigraphically important taxa that were illustrated in 2 plates (Narkiewicz and Bultynck, 2011; Pl. X and XI). For the purposes of the biostratigraphic analysis the determinations of some taxa from the papers by Szulczewski (1972b) and Nehring (1979) have been verified. The top of the Modryń Formation appeared to be diachronous as it runs within the Lower Famennian or at the Frasnian-Famennian boundary. It was also found that the boundary between the Bychawa and Firlej formations is traced in an upper part of the Lower Famennian or in a lower part of the Middle Famennian.

M. Narkiewicz (2011b) divided the Frasnian sediments into five transgressive-regressive cycles (M-1 do M-5). The thickest and the most widespread cycle M-3 was earlier described as VIa cycle by K. Narkiewicz and M. Narkiewicz (2008). The age of the lower and upper boundaries of the cycle has been established based on conodont data. It was also found that rapid deepening of the basin centre in the Middle Frasnian (Upper *hassi* Zone) was not associated with an eustatic transgression but was controlled tectonically. The comparison of the results from the Lublin Basin and published data from the Pripyat Graben (Belarus) led to the conclusion stressing the common tectonic mechanism of subsidence in both areas. Remaining T-R cycles could have been attributed, mainly based on the results of the conodont investigations, to pulses of eustatic transgressions.

Investigations of Triassic conodonts

1. **Narkiewicz K**. 1999. Conodont biostratigraphy of the Muschelkalk (Middle Triassic) in the central part of the Polish Lowlands. *Kwartalnik Geologiczny* 43(3): 313-328.

2. **Narkiewicz K**., Szulc J. 2004. Controls on migration of conodont fauna in peripheral oceanic areas. An example from the Middle Triassic of the Northern Peri-Tethys. *Geobios* 37(4): 425-436.

In the Triassic epicontinental facies in Poland the conodont elements have been found only in the Middle Triassic, i.e. in the Muschelkalk. During that time most of the Polish territory formed an eastern part of the Germanic Basin that was located north of the Tethys Ocean with which it was connected by three intermittently active straits (gates).

In the seventies and eighties of the last century vigorous investigations of Middle Triassic conodonts were carried out succesfully in the Holy Cross Mountains and Upper Silesia areas (Trammer, 1971; 1972; 1975; Zawidzka, 1975). Nearly a quarter century later I documented the presence of conodont elements in the Polish Lowlands, in 7 boreholes, in 14 samples from the Lower and Upper Muschelkalk (subdivision according to Gajewska, 1997). Collected material amounts to a total number of 80 specimens ascribed to 8 genera, out of which three (*Neogondolella*, *Paragondolella* and *Nicoraella*) are stratigraphically important. Among the 17 identified species two have been described for the first time from the Polish area. The stratigraphic ranges of particular taxa have been referred to the subdivion proposed by Kozur (1968;1980) oraz Budurov and Trifonova (1995). This allowed to define the conodont zones *germanica* and *kockeli* (Lower and Middle Anisian) in the Lower Muschelkalk, and the zones *1,2* and *4* (Upper Anisian and Ladinian) in the Upper Muschelkalk.

Recovery and age determination of the exceptionally fragile and brittle Middle Triassic conodont elements in the shallow marine sediments of the Polish Lowlands have a great significance for stratigraphy of these strata. It was also possible to correlate them with the lithostratigraphic units of southern Poland. Determination of the occurrence of the conodont Zone 2, characteristic for the Upper Muschelkalk of the Germanic Basin (Kozur, 1968, 1980) in the Krośniewice IG 1 borehole (depth 4656.5 m) unambigously resolved a controversy between the investigators (Liszkowski and Topulos, 1996 versus Dadlez et al., 1997), excluding a possibility of the Lower Triassic occuring at the depth 4717-3105 m.

The palaeobiogeographic analysis of conodonts decribed in my paper from 1999 revealed that, besides cosmopolitan forms known from the Tethys, also endemic forms known only from the Germanic Basins are present. Confirmed were also earlier observations (Trammer, 1973; Głazek et al., 1973) that the fauna from the Lower Muschelkalk of the Polish part of the Germanic Basin differs from the German conodont assemblages in which the platform taxa belonging to genera *Neogondolella* and *Paragondolella* are lacking. These preliminary palaeobiogeographic conclusions were followed by studies of conodont migrations (Narkiewicz and Szulc, 2004) based on the data from the Polish and German parts of the Germanic Basin as well as from the Tethys. The data corresponded to the time interval from the Early Anisian when conodonts first appeared in the Germanic Basin, until the Ladinian (earliest Longobardian) when they disappeared from the Polish part of the basin due to unfavourable facies conditions.

Forms described by Zawidzka (1975) and Trammer (1971,1975) were partly revised while the stratigraphic ranges of investigated taxa were carefully analyzed. The ranges where juxtaposed against the lithostratigraphy, facies succession and sealevel changes for the Muschelkalk of the Polish part of the Germanic Basin. This comparison has shown that migration of cosmopolitan forms from the Tethys was taking place through three gates in different time intervals related to successive transgression stages and sealevel highstands in the basin. In the Early and Middle Anisian the conodonts reached the eastern part of the basin through the East-Carpathian and Silesian-Moravian gates. The genus *Nicoraella* whose apparatus comprised ramiform P_1 elements expanded over the entire Germanic Basin while the genera *Neogondolella* and *Paragondolella* with platform P_1 elements did not reach the German part, probably due to unfavourable conditions (low salinity). In the Late Anisian and Early Ladinian the migration pathway led mainly through the Western Gate, and, during a limited interval at the Illyrian-Fassanian boundary (=Anisian-Ladinian boundary), through the East Carpathian Gate.

Studies of thermal maturity based on conodonts

1. **Narkiewicz K**. and Nehring-Lefeld M. 1993. Application of CAI indicators in the analysis of sedimentary basins. *Przegląd Geologiczny* 41(11): 757-763.

2. **Narkiewicz K**., Grotek I., Matyja H. 1998. Thermal maturity of organic matter in the Upper Devonian deposits of the Radom-Lublin and Pomerania area. *In*: (M. Narkiewicz, ed.) Sedimentary basin analysis of the Polish Lowlands. *Prace Państwowego Instytutu Geologicznego* 165: 235-244.

3. Grabowski J., **Narkiewicz K**., Poprawa P. 1999. First resulta of paleomagnetic and paleothermal (CAI) investigations of the highest Sub-Tatric units in the Polish Tatra Mts. *Przegląd Geologiczny* 47(2): 1532-158.

4. Poprawa P., **Narkiewicz K**., Swadowska E., Bruszewska B. 2001. Maturity analysis and 1-d modelling of thermal history of potential source rock for hydrocarbons in the area of Liplas-Tarnawa. *In*: (H. Matyja, ed.) Paleozoic basement of the central segment of the Polish Outer Carpathians (Liplas-Tarnawa region). *Prace Państwowego Instytutu Geologicznego* 174: 173-201.

5. **Narkiewicz K**. and Malec J. 2005. New conodont CAI database. *Przegląd Geologiczny* 53(1): 33-37.

Conodont elements are composed of apatite lamellae encapsulating organic matter which undergoes a gradual coalification while heated, leading to a permanent change of colour. The colour scale determined for such changes served to define the conodont CAI (colour alteration index) (Epstein et al., 1970; Rejebian et al., 1987). It allows to estimate maximum temperatures experienced by sediments in a broad range of diagenetic conditions. CAI is applied for basic palaeothermal investigations in analysing tectono-thermal history of sediments, as well as by petroleum companies to estimate petroleum potential of hydrocarbon source rocks. In Poland the CAI studies were pioneered by Bełka (1982,1990,1993).

The present author was the first in Poland to apply CAI in investigations carried out in the framework of an integrated sedimentary basin analysis, the key element of which is a study of a tectono-thermal history of a basin. The first step to these investigations was the methodological study explaining analytical procedures, applicability limits of the method, possibility of its application, and the case study for the Ordovician to Triassic interval in the Zawiercie-Olkusz area in the Cracow-Silesian region (Narkiewicz and Nehring-Lefeld, 1993). As a result of the CAI study it was estimated that the Devonian and Carboniferous sediments are prospective for petroleum exploration while the Ordovician-Silurian and Triassic are non-prospective, being thermally overmature and immature, respectively.

The CAI method has been subsequently applied for the analysis of the Lublin and Pomeranian basins (Narkiewicz et al., 1998). Investigations of the Upper Devonian strata indicated that almost entire area of both basins, except for small zones of thermal anomalies, is prospective for hydrocarbon generation and preservation. Distribution of the CAI values made it possible to reconstruct burial history of the studied basins.

In the Carpathians a thermal maturity has been studied in the studies of the Sub-Tatric Nappes of the Western Tatra Mountains (Grabowski et al., 1999), and in the Upper Devonian-Lower Carboniferous rocks of the Carpathian Flysch basement east of Cracow (Poprawa et al., 2001). In the first case low CAI values (1.5-2) suggest surprisingly weak thermal alteration of the investigated sediments which contributed to proper assesment of remagnetization characteristics. On the other hand, CAI for the Carpathian basement displays an overall high degree of thermal alteration which in turn suggests a lack of potential for a hydrocarbon preservation. The lowest CAI values of 1-1.5, typical for thermally immature sediments, were observed in the Tournaisian clasts occuring in Permian conglomerates. Palaeotemperatures calculated based i.a. on the CAI results served to reconstruct a thermal basin history and a history of hydrocarbon generation and accumulation.

As the most important achievement of my CAI studies, apart from their application in sedimentary basins analysis, I regard the construction of the first Polish data base of the conodont CAI, which contains all available values determined by myself and acquired from literature (Narkiewicz and Malec, 2005). The data base contains results from 298 boreholes and surface exposures, and has been compiled in the Microsoft Access 2000 system. In order to present its practical applicability in regional studies the digital CAI distribution map has been produced for the Devonian of the Holy Cross Mountains. The map has been later used i.a. in the thermal history studies of the Holy Cross region (M.Narkiewicz et al., 2010).

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