Annex 2b. Scientific curriculum vitae in English

1. Name and surname: Jan Malec

2. Scientific degrees – with their names, places and year of obtaining, and title of Ph.D. thesis

1977 M.Sc. in Palaeozoology obtained at the Faculty of Geology, University of Warsaw
Title of M.Sc. thesis: "The genus *Cytherella* (Ostracoda) from the uppermost Cretaceous and lowermost Tertiary from Bochotnica upon Vistula" [in Polish]
Supervisor: Prof. dr hab. Janina Szczechura

2002 Ph.D. in Earth Sciences, domain: geology, conferred by the resolution of the Scientific Board of the Polish Geological Institute in Warsaw on 14.11.2002
Title of Ph.D. thesis: "Stratigraphy of rocks from the Lower/Middle Devonian transition in the Łysogóry Region of the Holy Cross Mountains" [in Polish]
Supervisor: Prof. dr hab. Marek Narkiewicz

3. History of employment in scientific institutions

1978 – present day
Polish Geological Institute – National Research Institute, as:
1978 – trainee
1980-1982 – assistant
1982-1991 – senior assistant
1991-2003 – assistant
2003-2015 – assistant professor

4. Indication of scientific achievement following article 16 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.):

a) title of scientific achievement:

Conodont-based biostratigraphy of the Devonian and Carboniferous in the Holy Cross Mountains and the central part of the Małopolska Massif

b) List of papers presenting the scientific achievement: (author/authors, title, year, journal)

1. Fijałkowska-Mader A., **Malec J.** 2011. Biostratigraphy of the Emsian to Eifelian in the Holy Cross Mountains (Poland). *Geological Quarterly*, 55(2): 109-138.
I am the co-author of the concept of the paper, figures and tables. My percentage contribution is estimated at 50%.
2. Malec J. 2014. The Devonian-Carboniferous boundary in the Holy Cross Mountains (Poland). *Geological Quarterly*, 58(2): 217-234.
I am the sole author of the concept of the paper, text, illustrations and figures with photographs of the conodonts. My percentage contribution is 100%.
3. Malec J. 2015. Biostratygrafia utworów dewonu i karbonu z centralnej części masywu małopolskiego na podstawie konodontów. *Biuletyn Państwowego Instytutu Geologicznego*, 462: 41-82.

I am the sole author of the concept of the paper, text, illustrations and figures with photographs of the conodonts. My percentage contribution is 100%.

c) scientific aim of the papers mentioned above and the achieved results:

The main focus of the studies was determining the biostratigraphic position of the poorly known Palaeozoic successions from the Holy Cross Mountains and the Małopolska Massif. They included deposits from the Lower/Middle Devonian and the Devonian/Carboniferous transitions in the Holy Cross Mountains, and the succession of the Devonian and Lower Carboniferous carbonate rocks from the Małopolska Massif. The research was based mainly on conodont analysis.

Justification of the research

My inspiration to undertake conodont research of the Lower/Middle Devonian transition in the Holy Cross Mountains was the poorly known biostratigraphy in this part of the succession. The study focused on rock series from the Kielce Region, both in field exposures and in drilling logs. The biostratigraphy of deposits devoid of conodonts or with a low frequency of these microfossils was supported by analysis of biostratigraphically significant ostracod and foraminifer assemblages.

The research in the Upper Devonian and Lower Carboniferous was justified by the need to determine, based on conodonts and ostracods, the biostratigraphy of continuous sedimentary successions across the transition between the two systems, to document the chronostratigraphic position of the Devonian/Carboniferous boundary, to trace changes in conodont assemblages caused by the Hangenberg event, and to determine the duration of sedimentation of the siliceous claystones of the Zaręby Beds – the deepest facies in the Carboniferous of the Holy Cross Mountains. These studies were conducted in the eastern part of the Gałęzice-Bolechowice Syncline in the Kowala section and in the Ruda Strawczyńska 1 drilling log, located in the nearby, western Mesozoic margin of the Holy Cross Mountains.

Biostratigraphic analysis of Devonian and Carboniferous deposits in the central part of the Małopolska Massif was undertaken to supplement data in the knowledge of the Devonian and Lower Carboniferous stratigraphy in the key area of the Devonian-Carboniferous basin in southern Poland. Based on conodonts, I have determined the biostratigraphic position of the Devonian and Carboniferous deposits in the Węgrzynów IG 1 and Pągów IG 1 drillings. In the first core, conodont studies were earlier conducted in a narrow interval encompassing the uppermost Famennian and Lower Carboniferous (Chorowska, 1972), whereas in the second drilling log such analyses were never made.

Biostratigraphy of deposits across the Lower/Middle Devonian transition

Fijałkowska-Mader A., **Malec J.** 2011. Biostratigraphy of the Emsian to Eifelian in the Holy Cross Mountains (Poland). *Geological Quarterly*, 55(2): 109-138.

Comprehensive results of the biostratigraphic analysis of deposits from the Lower/Middle Devonian transition in the Łysogóry Region of the Holy Cross Mountains have been presented in my Ph.D. thesis (Malec, 2002), and their summary is offered by Fijałkowska-Mader and Malec (2011). The latter paper generalizes the results of my biostratigraphic analysis from the Lower/Middle Devonian transition from the Kielce Region, which I discuss below.

Kielce Region

Based on conodonts, I have determined the biostratigraphic position of deposits from the Lower/Middle Devonian transition in the western and south-western part of the Kielce Region, in exposures in the vicinity of Zbrza, in the northern part of Kielce (Szydłówek, Skrzele), and in the Porzecze IG 5A, Zaręby IG 2, Kolejówka IG 1, Kostomłoty IG 1, Dąbrowa D-5, Dyminy IG 2, and Strawczynek IG 1 drilling logs (Malec, Studencki, 1988; Malec, 1988, 1989, 1992, 1993c). The generalized results of this research, supplemented by the analysis of unpublished documentary data, have been summarized in Fijałkowska-Mader and Malec (2011). The conodont material, encompassing over 200 specimens, was collected from a wide lithological spectrum, such as claystones, dolomites, marls and limestones, included into a number of lithostratigraphic units distinguished in the Lower/Middle Devonian boundary interval (Fijałkowska-Mader, Malec, 2011): mudstone member, corresponding to the upper part of the Winna Beds (after Tarnowska, 1976, 1981, 1999), pyrite-bearing and siderite claystone member (Porzecze Member of Wójcik, 2015), dolomite member (Dębska Wola Member of Wójcik, 2015), Dąbrowa limestone member and the overlying bioturbated dolomite member (dolomites and dolosparites with bioturbation and skeletal fauna of Narkiewicz and Olkowicz-Paprocka, 1983; Brzeziny Member of Wójcik, 2015). The conodont assemblage is dominated by representatives of the genus *Icriodus*, at a subordinate contribution of the genus *Polygnathus*. A total of 6 conodont species was distinguished in the deposits from the Lower/Middle Devonian transition: *Polygnathus linguiformis linguiformis* Hinde, *Icriodus corniger rectirostratus* Bultynck, *I. corniger retrodepressus* Bultynck, *I. corniger corniger* Wittekindt, *I. corniger leptus* Weddige and *I. werneri* Weddige, characteristic of two conodont zones: the *patulus* Zone from the Upper Emsian with the index taxon *I. corniger rectirostratus*, and the *partitus* Zone from the Lower Eifelian, encompassing the remaining conodont taxa (Malec 1988, 1993c; Fijałkowska-Mader, Malec, 2011). The analyzed conodont assemblages indicate the diachronous character of the lithostratigraphic boundaries across the Lower/Middle Devonian transition. The oldest conodonts (*I. corniger rectirostratus*) found in the dolomite member (Dębska Wola Member of Wójcik, 2015) in the Stara Góra IG 1 log, define the Late Emsian age of these deposits. The most abundant conodont assemblage occurs in the Dąbrowa limestone member (Tarnowska, Malec, 1987; Malec, 1989, 1992; Fijałkowska-Mader, Malec, 2011), in which the presence of *I. corniger retrodepressus* indicates the lowermost Eifelian *partitus* Zone (Weddige, 1977, 1982). The same conodont species, accompanied by *I. corniger corniger* was found in the upper complex of the pyrite-bearing and siderite claystone member (Porzecze Member of Wójcik, 2015) (Malec, 1993c). I have documented the Lower Eifelian conodonts *I. corniger retrodepressus* also in the marly dolomites of the Zaręby IG 2 log in the depth interval 1097.7-1098.7 m, within the mudstone member from the upper part of the Winna Beds (Malec, 1984; unpublished personal data). The youngest conodonts from the Lower/Middle Devonian transition were noted in dolomites with bioturbations (dolomites and dolosparites with bioturbation and skeletal fauna of Narkiewicz, Olkowicz-Paprocka, 1983; Brzeziny Member of Wójcik, 2015). They are represented by an assemblage composed of *I. corniger corniger* and *I. werneri* (Malec, 1992, 1993c, unpublished personal data), indicating a Lower Eifelian age of the deposits from the *partitus* Zone (compare Weddige, 1982). Conodonts analyzed across the Lower/Middle Devonian transition in the Kielce Region indicate that the chronostratigraphic boundary between the Emsian and Eifelian can be distinguished within several lithostratigraphic units: Dąbrowa limestone member, dolomite member (Dębska Wola Member of Wójcik, 2015), pyrite-bearing and siderite claystone

member (Porzecze Member of Wójcik, 2015) and mudstone member (Fijałkowska-Mader, Malec, 2011).

Beside conodonts, ostracod assemblages have turned out to be good tools for the biostratigraphic analysis of strata from the Lower/Middle Devonian transition in the Kielce Region. The older assemblage occurring in the dolomite member (Dębska Wola Member of Wójcik, 2015), comprises the same species as deposits of the *patulus* Zone in the upper Emsian of the Łysogóry Region, whereas the younger assemblage, present in the Dąbrowa limestone member, is typical of the lowermost Eifelian *partitus* Zone (Malec, 1979, 1989; Nehring-Lefeld et al., 2003b; Fijałkowska-Mader, Malec, 2011). The biostratigraphic position of the older complexes of the pyrite-bearing and siderite claystone member (Porzecze Member of Wójcik, 2015) was determined based on foraminifers – practically the only fossils occurring in these deposits (Malec, 1983, 1986, 1992; Malec, Studencki, 1988; Fijałkowska, Malec, 2011). The stratigraphic significance of the foraminifers studied by me from the Emsian/Eifelian transition in the Kielce Region was presented in the "Atlas skamieniałości przewodnich i charakterystycznych" [Atlas of index and characteristic fossils] for the Devonian (Soboń-Podgórska, Tomaś, 2003).

The biostratigraphic position (*patulus* Zone) of the basal part of the dolomite member (Dębska Wola Member of Wójcik, 2015) and the pyrite-bearing and siderite claystone member (Porzecze Member of Wójcik, 2015), lying directly on the sandstone deposits of the Winna Beds indicates that these deposits originated during an eustatic sea-level rise related to the later phase of the transgressive-regressive cycle Ic (Johnson et al., 1985), which took place during the sedimentation of the Wydryszów limestones member in the Łysogóry Region (Malec, 2001a, 2005). The subsequent eustatic event related to sea-level rise in the *partitus* Zone took place at the beginning of sedimentation of the Dąbrowa limestones member. It corresponds to a global transgression from the Emsian/Eifelian transition, known as the Jugleri, Chotec or Em/Ei Event (Walliser 1985, 1996; Clausen et al., 1993; Racki, 1995, 1997). Beside the Dąbrowa limestones, with abundant and taxonomically rich open marine fauna, with the brachiopods *Chimaerothyris dombrowiensis* (Gürich) (Studencka, 1993) and nautiloids (Malec, 1989; Malec, Romanek, 1994), the transgressive pulse in the *partitus* Zone was recorded in the Kielce Region as sedimentation of the youngest complex of the pyrite-bearing and siderite claystone member (Porzecze Member after Wójcik, 2015), with foraminifers, crinoids, bryozoans and conodonts (Malec, 1988, 1993c), and the carbonate complex with marine fauna noted in the Zaręby IG 2 drilling (Malec, 1984) within mudstones related to a terrestrial environment (Tarnowska, 1976, 1981). The Early Eifelian transgression did not cover the entire Kielce Region. The area between Chęciny and Dyminy was land, on which marine sedimentation encroached later, most probably in the upper part of the *costatus* Zone (Malec, 1991).

To the south of the Kielce Region, in the central part of the Małopolska Massif, the Emsian/Eifelian transgression is recorded by the presence of a carbonate complex with the brachiopods *Chimaerothyris dombrowiensis* (Jaworowski et al., 1967; Tarnowska, 1990). Conodont dating of the sediments from the Lower/Middle Devonian transition in the Holy Cross Mountains indicates that these brachiopods appeared in the upper part of the *partitus* Zone, over ten metres above the first occurrence of the conodont *Icriodus corniger retrodepressus* (Fijałkowska-Mader, Malec, 2011).

Application of the results. – Determination of the conodont-based biostratigraphy of sediments from the Lower/Middle Devonian transition has contributed to increased stratigraphic significance of other groups of micro- and macrofauna, co-occurring with these fossils. These data have particularly high value in determining the biostratigraphic position of deposits from drillings, containing fossils ascribed to particular conodont zones (e.g. Żakowa et al., 1986; Malec, 1992). Another application of the achieved results can be the use in

regional biostratigraphic correlation of the brachiopod *Chimaerothyris dombrowiensis* (Gürich), common in the Devonian of the Holy Cross Mountains, which appeared in the Early Eifelian in the *partitus* Zone. The obtained results may also be used in the precise determination of the biostratigraphic position of deposits based on miospore analysis. Such analysis, conducted across the Lower/Middle Devonian boundary in the Holy Cross Mountains, has indicated a relatively good correlation between standard conodont and miospore zones (Fijałkowska-Mader, Malec, 2011; Filipiak, 2011).

Biostratigraphy of deposits across the Devonian/Carboniferous boundary

Malec J. 2014. The Devonian-Carboniferous boundary in the Holy Cross Mountains (Poland). *Geological Quarterly*, 58(2): 217-234.

In the Holy Cross Mountains, deposits across the Devonian/Carboniferous boundary occur in localized areas. The exposed artificial sections are situated within two active quarries: Ostrówka near Gałęzice and Kowala. In the latter area occur deposits recording a complete succession of the Devonian/Carboniferous boundary interval (Czarnocki, 1933; Malec, Migaszewski, 1992; Malec, 1993a, b, 1995, 2014; De Vleeschouwer et al., 2013), whereas stratigraphic gaps and condensation have been noted in the Gałęzice area (Szulczewski, 1981; Szulczewski et al., 1996). Beside these localities, deposits from the Devonian/Carboniferous transition have been recognized by excavations in the Miedziana Góra Syncline (Żakowa, Pawłowska, 1966; Żakowa, 1981) and in the Bolechowice 1, Jabłonna IG 1, Zaręby IG 2 and Kowala 1 drillings (Żakowa, 1967; Jurkiewicz, 1971; Żakowa et al., 1983, 1985). In the Bolechowice and Zaręby successions, conodont- and miospore-based biostratigraphic analysis has indicated a continuous succession of Famennian to Tournaisian strata (Freyer, Żakowa, 1967; Filipiak, 2004). Deposits from the Devonian/Carboniferous transition have also been recognized in the Ruda Strawczyńska 1 drilling, situated about 10 km to the west of the Palaeozoic exposure in the Holy Cross Mountains (Pawłowska, Pawłowski, 1978; Malec, 2009, 2014).

The Kowala area is a key locality in the Kielce Region with deposits from the Devonian/Carboniferous transition (Czarnocki, 1933). I have recognized these strata using excavation works, and distinguished several characteristic lithostratigraphic units across the Devonian/Carboniferous transition: uppermost Famennian limestones and marls of the *Wocklumeria* Zone, claystones with sandstone interbeds and beds of pyroclastic rocks, limestones with *Acutimitoceras* cephalopods, marly clays with interbeds of limestones, and siliceous claystones, whose stratigraphic position I have determined based on conodonts (Malec, 1993a, 1995, 2014).

In the Kowala section, exposed by an excavation ditch, I have distinguished 33 conodont species across the Devonian/Carboniferous transition; based on them I evidenced the presence of 6 conodont zones: *expansa* and *praesulcata* in the Upper Famennian and *sulcata*, *duplicata*, *sandbergi* and *crenulata* in the Lower Tournaisian. Analysis of the stratigraphic ranges of the conodonts indicates that the chronostratigraphic boundary between the Devonian and Carboniferous in Kowala occurs in the basal part of the marly clays with interbeds of limestones of the Radlin Beds. Similar positions of the Devonian/Carboniferous boundary have been suggested based on conodonts (Dzik, 1997), ostracods (Olempska, 1997) and miospores (Filipiak, 2004).

Biofacies

In the analyzed Kowala section, in the lower to upper *expansa* zones, the conodont assemblages are dominated by the bispathodid biofacies, with a subordinate contribution of the representatives of the palmatolepid and polygnathid biofacies. These biofacies are considered typical of basinal settings and the lower part of the basinal slope (compare

Sandberg, Dreesen, 1984; Dreesen et al., 1986; Dreesen, 1992). In the analyzed succession, in the uppermost part of the *Wocklumeria* limestone, most conodonts of the genus *Palmatolepis* become extinct and most species of the genus *Bispathodus* disappear in the lower *praesulcata* Zone. In limestones with *Autimitoceras* fauna, belonging to the upper *praesulcata* Zone, I have documented the presence of conodonts of the genus *Prothognathodus*. Their presence in successions with the Devonian/Carboniferous transition is related to the Late Famennian transgression, during which their adaptive radiation took place (compare Becker, 1996; Kaiser et al., 2008). The protognathid biofacies is considered characteristic of the outer shelf and basinal slope (Kalvoda et al., 1999) or more shallow marine settings (Dreesen, 1992). In the Lower Carboniferous of Kowala, the conodont assemblages are represented by the siphonodellid-polygnathid biofacies, which points to an outer shelf setting (Kalvoda et al., 1999). In the Lower Carboniferous of Kowala, the contribution of conodonts from the siphonodellid biofacies rises significantly from the *duplicata* Zone (Malec, 1995, 2014; Dzik, 1997), which points to a sea-level rise in the Early Carboniferous (Kalvoda et al. 2013).

Event stratigraphy

Conodont-based biostratigraphy in the Kowala succession has allowed me to state that changes in the lithologies and fossil assemblages across the Devonian/Carboniferous transition occur in similar biostratigraphic intervals as in other areas, indicating the influence of global factors (Malec, 1993a, 1995, 2014). The sedimentation of the lithologies between the limestones with *Wocklumeria* and the clay marls of the Radlin Beds took place during global climate and biotic perturbations across the Devonian/Carboniferous boundary, known as the Hangenberg Event (Walliser, 1985, 1996; House, 2002; Kaiser et al., 2011; De Vleeschouwer et al., 2013). They are related to glaciations in the Southern Hemisphere, climate coolings and warmings, which were accompanied by relatively rapid sea-level changes. Sea-level fall and its subsequent rise in the middle *praesulcata* Zone, in the Kowala section related to the beginning of claystone sedimentation, including black claystones rich in organic matter, well exposed in Kowala Quarry (Filipiak, Racki, 2005; De Vleeschouwer et al., 2013), had led to a drastic, global extinction, one of the largest Phanerozoic extinctions (Walliser, 1996; Streel et al., 2000; Sandberg et al., 2002; Kaiser et al., 2011). In the Kowala succession, the biotic crisis related to the Hangenberg Event is distinct also in the succession of conodont faunas. The beginning of the event is marked by the extinction of almost all species of the genera *Palmatolepis* and *Bispathodus*. The Late Famennian transgressive pulse is expressed in the Kowala section by sedimentation of limestones with *Acitimitoceras* and appearance of a new group of conodonts from the genus *Prothognathodus*. Sedimentation of siliceous claystones of the Zaręby Beds corresponds to the subsequent transgressive pulse in the Early Carboniferous of Kowala, documented in the lower part of the *crenulata* Zone (Malec, 1993a, 1995, 2014; Dzik, 1997). In the beginning of this zone took place sedimentation of lithologically similar deposits in other parts of Europe and the world (Kaiser et al., 2011; Kumpan et al., 2014).

In the succession of the Ruda Strawczyńska 1 drilling, I have determined the biostratigraphy of deposits across the Devonian/Carboniferous transition based on conodonts and ostracods. In limestones and marly dolomites from the depth 852.5-863.0 m, lying directly below the siliceous claystones of the Zaręby Beds, I have not found conodonts; instead, I have recognized here a rich assemblage of benthic ostracods (Malec, 2009) characteristic of the deep-marine Thuringian ecotype (Gründel, 1961; Blumenstengel, 1993; Olempska, 1997), with a biostratigraphic position within the Early Carboniferous *sulcata-sandbergi* conodont zones (Malec, 2014). These deposits were assigned earlier to the Upper Famennian (Pawłowska, Pawłowski, 1978; Żakowa, Migaszewski, 1995). My analyses have shown that in this succession, the chronostratigraphic position of the Devonian/Carboniferous boundary lies in the depth interval of 863.0-870.0 m within the carbonate complex. Based on

conodonts, I determined the approximate biostratigraphic position (*trachytera*-lower *postera*) of the bioclastic Famennian limestones from the depth interval 893.6-915.5 m, with the brachiopods *Dzieduszyckia kielcensis* Roemer (Biernat, 1967), representing the only locality with these fossils in Poland (Biernat, 1967). In the Kadzielnia succession in Kielce, where this species was described by Pusch in 1833, the limestones with brachiopods were already completely exploited in the XIX century. Conodont analyses have evidenced that in the Ruda Strawczyńska succession, the boundary between the Frasnian and Famennian is located within 940.0-950.0 m of depth (Malec, 2009).

My biostratigraphic investigations across the Devonian/Carboniferous transition indicate that in the Holy Cross Mountains and their close western Mesozoic margin, the boundary between the Devonian and Carboniferous is located within carbonate deposits representing the basal part of the Radlin Beds. In the Kielce Region, with the exception of the Gałęzice-Bolechowice Syncline and the Radlin area, carbonate rocks lying below the siliceous claystones of the Zaręby Beds were so far assigned to the Upper Famennian, and the Devonian/Carboniferous boundary was located in the base of the Zaręby Beds (Żakowa, 1981; Żakowa, Migaszewski, 1995; Filipiak, 2004).

Application of the results. – Determination of the biostratigraphic position of the lithological complexes across the Devonian/Carboniferous transition in the Holy Cross Mountains, based on conodonts (and ostracods), will enable conducting regional and interregional comparative studies of the development of sedimentation and the influence of global climate changes on the development of organisms at the transition of both periods. The results of the studies in the Kowala succession indicate a large analogy in the lithologies and their biostratigraphic position with contemporaneous rock series in the Rhenish Slate Mountains. Deposits with the same lithological and faunal characteristics occur in both areas in the same biostratigraphic intervals.

Biostratigraphy of the Devonian and Carboniferous in the central part of the Małopolska Massif

Malec J. 2015. Biostratygrafia utworów dewonu i karbonu z centralnej części masywu małopolskiego na podstawie konodontów. *Biuletyn Państwowego Instytutu Geologicznego*, 462: 41-82.

In the central part of the Małopolska Massif, in the Boża Wola IG 1, Jaronowice IG 1, Pągów IG 1, Potok Mały IG 1, Włoszczowa IG 1, and Węgrzynów IG 1 drilling logs, I have conducted conodont-based biostratigraphic analysis of the Devonian and Carboniferous deposits (Malec 2001b, 2013, 2015). A total of 124 samples was analyzed. The presence of conodonts was determined only in two drillings – Węgrzynów IG 1 and Pągów IG 1, from which I obtained over 800 specimens. The collection is dominated by representatives of the genera *Palmatolepis* and *Polygnathus*, at a subordinate contribution of representatives of *Ancyrodella*, *Icriodus*, *Bispathodus*, *Pseudopolygnathus*, *Scaliognathus* and *Gnathodus*.

I have recognized 15 conodont zones in the Węgrzynów drilling. Twelve of them: lower *falsiovalis*, lower *hassi*, lower *rhenana*, upper *rhenana*, upper *rhenana*?/*linguiformis*, ?*triangularis*/?*crepida*, upper *rhomboidea*, lower *marginifera*, upper *marginifera*, ?uppermost *marginifera*-?lower *trachytera*, upper *trachytera* and middle-upper *postera*, document the presence of deposits from the Givetian/Frasnian boundary to the Upper Famennian, and the remaining three – the Lower Carboniferous: *delicatus* and *anchoralis* – Lower Tournaisian and *texanus* – Lower Visean. I determined the boundaries between the conodont zones based on the stratigraphic ranges of particular species or the presence of index taxa. The succession of conodont zones indicates that the Węgrzynów succession encompasses a complete

succession from the Upper Givetian to the Upper Famennian, excluding its uppermost part with the *expansa* and *praesulcata* zones.

The succession in the Węgrzynów drilling, encompassing deposits from the Givetian to the Upper Famennian has been sub-divided by me into eight informal lithostratigraphic units. The Givetian includes two units: calcareous dolomites and dolomites with stromatoporoids, the Givetian/Frasnian boundary interval – dolomitic limestones, the Frasnian – limestones with styliolines and bioclastic limestones, and the Famennian – bituminous marls and limestones, nodular limestones, limestones and marls. These units have been presented in the frames of a conodont biostratigraphic zonation. In the succession, the chronostratigraphic boundary between the Middle and Upper Devonian occurs within the dolomitic limestones at the depth of 2447.2-2529.0 m. The Frasnian/Famennian boundary has been located in the topmost part of the bioclastic limestones, below 1952.8 m. Conodont analyses have indicated that the Devonian/Carboniferous boundary occurs in the interval between 1448.8 and 1478.5 m. Lithological and sedimentological data indicate that the Devonian and Carboniferous deposits lie on each other with a sedimentary discontinuity at the depth of 1477.0 m, where the Upper Famennian limestones contact with Tournaisian limestones and sandstones (Jurkiewicz, 1973). In the Węgrzynów section there is a stratigraphic gap between the Devonian and Carboniferous, which encompasses two uppermost conodont zones of the Famennian (*expansa* and *praesulcata*) and most probably the lowermost conodont zones of the Tournaisian. The gap has a similar stratigraphic range (*expansa-crenulata*) as in the western part of the Holy Cross Mountains (compare Szulczewski, 1981; Szulczewski et al., 1996).

In the Węgrzynów log, the beginning of sedimentation of some lithological complexes coincides with eustatic fluctuations related to global transgressive-regressive pulses (Johnson et al., 1985). The sedimentation of dolomitic limestones from the Givetian/Frasnian transition in the *falsiovalis* Zone took place in the beginning of eustatic cycle IIb, distinguished as the Mesotaxis Event (Racki, 1993). Deposition of limestones with styliolines in the Lower Frasnian *punctata* Zone corresponds to eustatic cycle IIc, whereas the commencement of bituminous marls and limestones sedimentation of the *triangularis* Zone should be correlated with eustatic cycle IIe. Beside conodonts, the latter lithological complex contains fossils of pelagic organisms represented by styliolines, tentaculites, nautiloids and pseudoplanktonic bivalves of the genus *Guerichia*.

In the Pągów IG 1 drilling, based on conodonts I have determined the biostratigraphic position of Devonian carbonate deposits from the lowermost part of the section at the depth of 2961.2-3200.5 m. In the top, these strata contact with siliciclastic deposits of the Upper Visean (Jurkiewicz, 1976). Conodonts occurring in limestones in the depth interval of 2994.5-3094.5 m have allowed to document the presence of three conodont zones: *jamieae*-lower *rhenana*, upper *rhenana* and lower *expansa*. The first two zones indicate the presence of the Middle and Upper Frasnian, whereas the third points to the Upper Famennian. The Frasnian/Famennian boundary is located in the succession within carbonate deposits drilled without coring in the depth interval of 3000.0-3046.2 m, approximately encompassing seven conodont zones: from the upper *rhenana* Zone to the upper *postera* Zone, that is the Upper Frasnian and the Lower and Middle Famennian. In the Węgrzynów succession, deposits covering the same interval of the Devonian are represented by a 500-600 m sequence of strata. Data on the biostratigraphic position of deposits from the Frasnian/Famennian transition in Pągów indicate the presence of a stratigraphic gap between the two stages of the Upper Devonian, with an unknown biostratigraphic range and an unclear origin. The youngest Devonian strata (lower *expansa* Zone) documented in the Pągów succession evidence a stratigraphic gap between the Devonian and Carboniferous, which encompasses the uppermost Famennian, Tournaisian and Lower Visean.

Determination of the biostratigraphic position of the main lithological complexes in the Węgrzynów and Pągów successions and synchronization of the start of sedimentation of some of them with the global eustatic cycles has allowed to correlate the Middle Devonian, Upper Devonian and Lower Carboniferous deposits in the Devonian-Carboniferous basin of southern Poland. Conodont-based biostratigraphy of contemporaneous Devonian deposits in the central part of the Małopolska Massif indicate that the Devonian basin in the Węgrzynów area was characterized by a much larger subsidence rate than in the Pągów area to the north. I have compared the complete succession of Devonian strata, from the Eifelian to the Upper Famennian, and the Lower Carboniferous in the Węgrzynów succession with contemporaneous series recognized in the southern part of the Małopolska Massif (Dobiesławie 1 and Niwki 3 logs), the eastern part of the Upper Silesian Massif (Dębnik and Olkusz-Zawiercie areas), and the southern part of the Holy Cross Mountains. In the Węgrzynów succession, the lithostratigraphic horizon with high correlation values includes limestones with styliolines, which as the same lithofacies were recognized in the Olkusz-Zawiercie area (Narkiewicz, 1978), the Niwki 3 log (Zając, 1984, 1987), and in the southern part of the Holy Cross Mountains. In the latter area, styliolines are accompanied by the brachiopods *Phlogoiderhynchus polonicus* (Racki, 1993). The beginning of sedimentation of these deposits is correlated with transgressive pulse IIc from the *punctata* Zone (Racki, Turnau, 2000). Another characteristic lithofacies from the Devonian succession in Węgrzynów includes bituminous marls and limestones, which in the Holy Cross Mountains are represented by marly limestones linked with eustatic cycle IIe in the *triangularis* Zone (Racki, Turnau, 2000). Based on conodont studies I have determined that the sedimentation of the Lower Carboniferous redeposited bioclastic limestones began in the Węgrzynów area in the Tournaisian *delicatus* Zone, whereas in southern part of the Holy Cross Mountains analogous sediments appeared later – in the Lower Visean *bilineatus* Zone (Szulczewski et al., 1996).

Application of the results. – The central part of the Małopolska Massif was so far poorly recognized in relation to the biostratigraphy of the Devonian and Lower Carboniferous sedimentary succession. My research has for the first time allowed to correlate the Devonian strata from the central part of the Małopolska Massif with contemporaneous rocks from adjacent areas, that were formed during the same transgressive-regressive cycles. Determination of the biostratigraphic position of the Devonian and Carboniferous deposits in Węgrzynów and Pągów will gain particular significance in interregional correlation and analysis of development of sedimentation in the Devonian-Carboniferous basin of southern Poland. Determination of the biostratigraphy of the bituminous marls and limestones, rich in organic matter and traces of crude oil, may be used in the recognition of analogous horizons with regard to hydrocarbon prospecting in other areas.

Summary

1. In the western part of the Kielce Region in the Holy Cross Mountains, the oldest rocks from the Lower/Middle Devonian transition documented by conodonts belong to the Upper Emsian *patulus* Zone, and the youngest record the Lower Eifelian *partitus* Zone. The chronostratigraphic boundary between the Lower and Middle Devonian is located within lithologically varied deposits representing shallow-marine to continental settings. In this area the Upper Emsian and Lower Eifelian lithostratigraphic units are characterized by large diachroneity of their boundaries.

2. Conodonts analyzed in the continuous succession across the Devonian/Carboniferous boundary of Kowala document the biostratigraphic position of the sedimentological and biotic record of the Hangenberg Event. In most of the Kielce Region in the Holy Cross Mountains,

sedimentation of carbonate rocks from the Devonian/Carboniferous boundary interval continued till the Lower Tournaisian *sandbergi* Zone. As late as from the Lower Tournaisian *crenulata* Zone (lowermost Visean *texanus* Zone in the Gałęzice area) took place sedimentation of deep-marine siliceous claystones of the Zaręby Beds.

3. In the Pągów IG1 and Węgrzynów IG 1 drilling logs from the central part of the aMalopolska Massif, based on conodonts was documented Devonian strata from the Givertian/Frasnian boundary to the Upper Famennian, and in the latter section – also Lower Carboniferous strata of the Middle and Upper Tournaisian and Lower Visean. The Devonian and Carboniferous rocks from the central part of the Małopolska Massif show a distinct lithological similarity in fairly accurate stratigraphic intervals to successions from adjacent areas.

References cited:

Becker G., 1996. New faunal records and holostratigraphic correlation of the Hasselbachtal D/C boundary auxillary stratotype (Germany). *Annales Societe Geologique Belgique*, 117: 19-45.

Biernat G., 1967. New data on the genus *Dzieduszyckia* Siemiradzki, 1909 (Brachiopoda). *Acta Palaeontologica Polonica*, 12(2): 133-155.

Blumenstengel H., 1993. Ostracodes from the Devonian-Carboniferous boundary beds in Thuringia (Germany). *Annales Societe Geologique Belgique*, 115: 483-489.

Chorowska M., 1972. Konodonty dewonu górnego i karbonu dolnego z profilu Węgrzynów IG 1 (niecka miechowska). *Biuletyn Instytutu Geologicznego*, 233: 161-208.

Clausen C. D., Weddige K., Ziegler W., 1993. Devonian of the Rhenish Massif. *SDS Newsletter*, 10: 18-19.

Czarnocki J. 1933. Stratygrafia warstw granicznych między dewonem i karbonem w okol. Kowali. *Posiedzenia Naukowe Państwowego Instytutu Geologicznego*, 34: 31-34.

De Vleeschouwer D., Rakociński M., Racki G., Bond D. P. G., Sobień K., Claeys P., 2013. The astronomical rhythm of Late Devonian climate change (Kowala section, Holy Cross Mountains, Poland). *Earth and Planetary Science Letters*, 365: 25-37.

Dreesen R., 1992. Conodont biofacies analysis of the Devonian/Carboniferous Boundary Beds in the Carnic Alps. *Jahrbuch der Geologischen Bundesanstalt*, 135: 49-56.

Dreesen R., Sandberg C. A., Ziegler W. 1986. Review of Late Devonian and Early Carboniferous conodont biostratigraphy and biofacies models as applied to the Ardenne Shelf. *Annales Societe Geologique Belgique*, 109: 27-42.

Dzik J., 1997. Emergence and succession of Carboniferous conodont and ammonoid communities in the Polish part of the Variscan sea. *Acta Palaeontologica Polonica*, 42: 57-170.

Fijałkowska-Mader A., **Malec J.** 2011. Biostratigraphy of the Emsian to Eifelian in the Holy Cross Mountains (Poland). *Geological Quarterly*, 55(2): 109-138.

Filipiak P., 2004. Miospore stratigraphy of Upper Famennian and Lower Carboniferous deposits of the Holy Cross Mountains (central Poland). *Review of Palaeobotany and Palynology*, 128: 291-322.

Filipiak P., 2011. Palynology of the Lower and Middle Devonian deposits in southern and central Poland. *Review of Palaeobotany and Palynology*, 166: 213-252.

Filipiak P., Racki G. 2005. Unikatowy zapis dewońskich zdarzeń beztlenowych w profilu kamieniołomu Kowala k. Kielc. *Przegląd Geologiczny*, 53(10): 846-847.

Freyer G., Żakowa H., 1967. Famennian conodonts from borehole Bolechowice 1 (in the Holy Cross Mts). *Acta Geologica Polonica*, 17: 105-136.

Gründel J., 1961. Zur Biostratigraphie und Fazies der Gattendorfia-Stufe in Mitteldeutschland unter besonderer Berücksichigung der Ostracoden. *Freiberger Forschungshefte*, C 151: 54-144.

House M. R. 2002. Strength, timing, setting and cause of mid-Palaeozoic extinctions. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 181: 5-25.

Jaworowski K., Jurkiewicz H., Kowalczewski Z. 1967. Sinian i paleozoik z otworu wiertniczego Jaronowice IG 1. *Kwartalnik Geologiczny*, 11(1): 21-38.

Johnson J. G., Klapper G., Sandberg C. A., 1985. Devonian eustatic fluctuations in Euramerica. *Geological Society of America Bulletin*, 96: 567-587.

Jurkiewicz H., 1971. Wgłębna budowa geologiczna okolic Łagowa. *Biuletyn Instytutu Geologicznego*, 242: 5-27.

Jurkiewicz H., 1973. Węgrzynów IG 1. *Profile Głębokich. Otworów Wiertniczych Instytutu. Geol*ogicznego, 7.

Jurkiewicz H., 1976. Pągów IG 1. *Profile Głębokich Otworów Wiertniczych Instytutu Geol*ogicznego*,* 33.

Kaiser S. I., Steuber T., Becker R. T., 2008. Environmental change during the Late Famennian and Early Tournaisian (Late Devonian-Early Carboniferous): implications from stable isotopes and conodont biofacies in southern Europe. *Geological Journal*, 43: 241-260.

Kaiser S. I., Becker R. T., Steuber T., Aboussalam S. Z., 2011. Climate-controlled mass extinctions, facies, and sea-level change around the Devonian-Carboniferous boundary in the eastern Anti-Atlas (SE Marocco). *Palaeogeography, Palaeoclimatology, Palaeoecology*, 310: 340-364.

Kalvoda J., Babek O., Malovana A., 1999. Sedimentary and biofacies records in calciturbidites at the Devonian-Carboniferous Boundary in Moravia (Moravian-Silesian Zone, Middle Europe). *Facies*, 41: 141-158.

Kalvoda J., Kumpan T., Babek O. 2013. Upper Famennian and Lower Tournaisian sections of the Moravian Karst (Moravo-Silesian Zone, Czech Republic): a proposed key area for correlation of the conodont and foraminiferal zonations. *Geological Journal*. DOI: 10.1002/gj.2523. 2013.

Kumpan T., Babek O., Kalvoda J., Matys T., Fryda J. 2014. Sea-level and environmental changes around the Devonian-Carboniferous boundary in the Namur-Dinant Basin (S Belgium, NE France): A multi-proxy stratigraphic analysis of carbonate ramp archives and its use in regional and interregional correlations. *Sedimentary Geology*, 311: 43-59.

Malec J., 1979. Małżoraczki i otwornice dewonu środkowego z otworu Porzecze 5A. *Kwartalnik Geologiczny*, 23(4): 939-940.

Malec J., 1983. Stratygrafia iłów rudonośnych z rejonu Miedzianej Góry i Ławeczna. *Kwartalnik Geologiczny*, 27(4): 895-896.

Malec J. 1984. *Webbinelloidea similis* Stewart et Lampe (Foraminiferida) z eiflu synkliny łagowskiej (Góry Świętokrzyskie). *Kwartalnik Geologiczny*, 28(3/4): 555-568.

Malec J., 1986. Biostratygrafia dewońskich „iłów rudonośnych" z obszaru południowego Gór Świętokrzyskich. *Kwartalnik Geologiczny*, 30(2): 419-420.

Malec J. 1988. Wstępne informacje o sylurze i dewonie w antyklinie i synklinie niewachlowskiej. *Kwartalnik Geologiczny*, 32(2): 508-509.

Malec J. 1989. Lower Eifelian ostracods from the West Świętokrzyskie Mountains (Poland). *Acta Palaeontologica Polonica*, 34(3): 233-270.

Malec J. 1991. Uwagi o stratygrafii utworów z pogranicza dewonu dolnego i środkowego w zachodniej części Gór Świętokrzyskich. *Kwartalnik Geologiczny*, 35(4): 525-526.

Malec J. 1992. Arenaceous foraminifera from Lower-Middle Devonian boundary beds of western part of the Świętokrzyskie Mts. *Annals Societatis Geologorum Poloniae*, 62: 269-287.

Malec J. 1993a. Devonian-Carboniferous boundary at Kowala. In: Narkiewicz M. (Ed.). *Excursion Guidebook. Global Boundary Events. An Interdisciplinary Conference, Kielce-Poland, September 27-29*: 10-11.

Malec J. 1993b. Profil z pogranicza dewonu i karbonu w Kowali (informacje wstępne). *Posiedzenia Naukowe Państwowego Instytutu Geologicznego*, 49: 71-72.

Malec J. 1993c. Upper Silurian and Lower Devonian in the western Holy Cross Mts. *Geological Quarterly*, 37(4): 501-536.

Malec J., 1995. Devonian/Carboniferous boundary. In: *Guide to Excursion B4. XII International Congress on Carboniferous-Permian (XIII ICCP). August 28-September 2, 1995 Kraków, Poland*: 15-16.

Malec J. 2001a. Stratygrafia zdarzeniowa w profilu późnego emsu i wczesnego eiflu w regionie łysogórskim. *Posiedzenia Naukowe Państwowego Instytutu Geologicznego*, 57: 120-122.

Malec J., 2001b. Wyniki badań konodontowych utworów dewonu i karbonu w profilach otworów wiertniczych Pagów IG 1 i Węgrzynów IG 1 (niecka Nidy). *Posiedzenia Naukowe Państwowego Instytutu Geologicznego*, 57: 132-134.

Malec J., 2002. Stratygrafia utworów z pogranicza dewonu dolnego i środkowego w regionie łysogórskim Gór Świętokrzyskich. Rozprawa doktorska, s. 1-201. Archiwum PIG-PIB Warszawa.

Malec J. 2005. Litostratygrafia pogranicza dewonu dolnego i środkowego w regionie łysogórskim. *Biuletyn Państwowego Instytutu Geologicznego*, 415: 5-58.

Malec J., 2009. Uwagi o stratygrafii dewonu i karbonu w profilu otworu Ruda Strawczyńska 1. *Posiedzenia Naukowe Państwowego Instytutu Geologicznego*, 65: 31-32.

Malec J. 2013. Stratygrafia osadów dewonu i karbonu w profilach otworów wiertniczych Pągów IG 1 i Węgrzynów IG 1 (Niecka Nidziańska) na podstawie konodontów. W: *VII Świętokrzyskie Spotkania Geologiczno-Geomorfologiczne*. Busko-Zdrój 22-24 maja 2013. Georóżnorodność Ponidzia na tle innych obszarów północnej części zapadliska przedkarpackiego. Materiały konferencyjne: 51-52.

Malec J., 2014. The Devonian-Carboniferous boundary in the Holy Cross Mountains (Poland). *Geological Quarterly*, 58(2): 217-234.

Malec J., 2015. Biostratygrafia utworów dewonu i karbonu z centralnej części masywu małopolskiego na podstawie konodontów. *Biuletyn Państwowego Instytutu Geologicznego,* 452: 41-82.

Malec J., Studencki M. 1988. Dolny eifel na Szydłówku w Kielcach. *Biuletyn Instytutu Geologicznego*, 358: 73-92.

Malec J., Migaszewski Z., 1992. Wstępne dane o profilu pogranicza dewonu i karbonu w Kowali. *Przegląd Geologiczny*, 40(10): 607.

Malec J., Romanek A. 1994. Stratygrafia osadów z pogranicza dewonu dolnego i środkowego w Zbrzy. *Posiedzenia Naukowe Państwowego Instytutu Geologicznego*, 50: 113-115.

Narkiewicz M., 1978. Stratygrafia i rozwój facjalny dewonu i dolnego karbonu między Olkuszem a Zawierciem. *Acta Geologia Polonica*, 28(4): 415-470.

Narkiewicz M., Olkowicz-Paprocka I., 1983. Stratygrafia dewońskich utworów węglanowych wschodniej części Gór Świętokrzyskich. *Kwartalnik Geologiczny*, 27(2): 225-256.

Nehring-Lefeld M., Olempska E., **Malec J.,** Żbikowska B. 2003b. Gromada Ostracoda Laterielle, 1802. In: Budowa geologiczna Polski. Tom III. Atlas skamieniałości przewodnich i charakterystycznych. Część 1b-z. 1. Dewon: 367-458.

Olempska E., 1997. Changes in benthic ostracod assemblages across the Devonian-Carboniferous boundary in the Holy Cross Mountains, Poland. *Acta Palaeontologica Polonica*, 42: 291-332.

Pawłowska K., Pawłowski S., 1978. Charakterystyka utworów paleozoicznych (karbon, dewon) na podstawie otworu wiertniczego w Rudzie Strawczyńskiej. *Kwartalnik Geologiczny*, 22(4): 679-691

Racki G., 1993. Evolution of the bank to reef complex in the Devonian of the Holy Cross Mountains. *Acta Palaeontologica Polonica*, 37(2-4): 87-182.

Racki G., 1995. Co dalej z dewońska krzywą eustatyczną? *Przegląd Geologiczny*, 43(8): 632-636.

Racki G., 1997. Devonian eustatic fluctuations in Poland. *Courier Forschungsinstitut Senckenberg*, 199: 1-12.

Racki G., Turnau E., 2000. Devonian series and stage boundaries in Poland. *Courier Forschungsinstitut Senckenberg*, 225: 145-158.

Sandberg C. A., Dreesen R., 1984. Late Devonian icriodontid biofacies models and alternate shallow-water conodont zonation. *GSA Special Paper*, 196: 143-178.

Sandberg C. A., Morrow J. R., Ziegler W., 2002. Late Devonian sea-level changes, catastrophic events, and mass extinction. *GSA Special Paper*, 356: 473-487.

Soboń-Podgórska J., Tomaś A. 2003. Typ Protista, gromada Reticularea Lankester, 1885, rzad Foraminiferida Eichwald, 1830. In: Atlas skamieniałości przewodnich i charakterystycznych. Część 1b - z. 1, 2. Dewon. Budowa Geologiczna Polski, tom III: 27-39, Tab. I.

Streel M., Caputo M. V., Loboziak S., Melo J. H. G., 2000. Late Frasnian-Famennian climates based on palynomorph analyses and the question of the Late Devonian glaciation. *Earth-Science Reviews*, 52: 121-173.

Studencka J. 1983. *Chimaerothyris dombrowiensis* (Gürich) z dolnego eiflu Gór Świętokrzyskich. *Kwartalnik Geologiczny*, 27(3): 471-490.

Szulczewski M. 1981. Stratygrafia utworów dewonu i dolnego karbonu w kamieniołomie Ostrówka. In: *Przewodnik 53 Zjazdu Polskiego Towarzystwa Geologicznego, Kielce 6-8 września 1981*: 193-197.

Szulczewski M., Belka Z., Skompski S. 1996. The drowning of a carbonate platform: an example from the Devonian-Carboniferous of the southern Holy Cross Mountains, Poland. *Sedimentary Geology*, 106: 21-49.

Tarnowska M., 1976. Korelacja litologiczna dewonu dolnego w południowej części Gór Świętokrzyskich. *Biuletyn Instytutu Geologicznego*, 296: 75-128.

Tarnowska M., 1981. Dewon dolny w centralnej części Gór Świętokrzyskich. In: *Przewodnik 53 Zjazdu Polskiego Towarzystwa Geologicznego, Kielce 6-8 września 1981*: 57-68.

Tarnowska M., 1990. Sekwencja osadów dewonu dolnego w otworze wiertniczym Jaronowice IG 1. *Kwartalnik Geologiczny*, 34(3): 563-564.

Tarnowska M., 1999. Schemat dewońskiego wulkanizmu piroklastycznego w Górach Świętokrzyskich. In: *X Konferencja sozologiczna. Geologia i sozologia w regionie świętokrzyskim u schyłku XX wieku*: 43-54. Państwowy Instytut Geologiczny Oddział Świętokrzyski. Kielce 1999.

Tarnowska M., **Malec J**., 1987. Osady pogranicza emsu i eiflu w otworze wiertniczym Dąbrowa D-5. *Kwartalnik Geologiczny*, 31(2/3): 510-511.

Walliser O. H., 1985. Natural boundaries and ommission boundaries in the Devonian. *Courier Forschungsinstitut Senckenberg,* 75: 401-408.

Walliser O. H., 1996. Global Events in the Devonian and Carboniferous. In: *Global events and event stratigraphy in the Phanerozoic*. Springer.: 225-250.

Weddige K., 1977. Die Conodonten der Eifel-Stufe im Typusgebiet und in benachbarten Faziesgebieten. *Senckenbergiana Lethaea*, 58, 4/5: 271-419.
Weddige K., 1982. The Wetteldorf Richtschnitt as boundary stratotype from the view point of conodont stratigraphy. In: Proposal of a boundary stratotype for the Lower/Middle Devonian Boundary (partitus-Boundary). (eds. R. Werner and W. Ziegler). *Cour. Forsch. -Institut Senckenberg*, 55: 26-37.
Wójcik K., 2015. The uppermost Emsian and lower Eifelian in the Kielce Region of the Holy Cross Mts. Part I: Lithostratigraphy. *Acta Geologica Polonica*, 65(2): 141-179.
Zając R., 1984. Stratygrafia i rozwój facjalny dewonu i dolnego karbonu południowej części podłoża zapadliska przedkarpackiego. *Kwartalnik Geologiczny*, 28(2): 291-316.
Zając R., 1987. Stratygrafia i rozwój facjalny dewonu i dolnego karbonu południowej części podłoża zapadliska przedkarpackiego. Odpowiedź. *Kwartalnik Geologiczny*, 31(4): 599-608.
Żakowa H., 1967. Dolny karbon w okolicy Bolechowic (Góry Świętokrzyskie). *Acta Geologia Polonica*, 17(1): 51-103.
Żakowa H., 1981. Rozwój i stratygrafia karbonu Gór Świętokrzyskich. In: *Przewodnik 53 Zjazdu Polskiego Towarzystwa Geologicznego, Kielce 6-8 września 1981*: 89-100.
Żakowa H., Pawłowska J. 1966. Karbon synkliny miedzianogórskiej. *Biuletyn Instytutu Geologicznego*, 195: 5-64.
Żakowa H., Szulczewski M., Chlebowski R. 1983. Górny dewon i karbon w synklinie borkowskiej. *Biuletyn Instytutu Geologicznego*, 345: 5-134.
Żakowa H., Nehring-Lefeld M., **Malec J.** 1985. Devonian-Carboniferous boundary in the borehole Kowala 1 (southern Holy Cross Mts, Poland). Macro- and microfauna. *Bulletin of the Polish Academy of Sciences, Earth Sciences*, 33: 87-95.
Żakowa H., Radlicz K., **Malec J.** 1986. Podłoże permu w okolicy Szydłowca. *Kwartalnik Geologiczny*, 30(1): 23-48.
Żakowa H., Migaszewski Z., 1995. Góry Świętokrzyskie Mts. *Prace Państwowego Instytutu Geologicznego*, 148: 109-119.

5. Report on other scientific achievements

Beside conodont biostratigraphy of the Devonian and Carboniferous, my scientific interests have focused on the lithostratigraphy of the Lower and Middle Devonian transition, and the studies of foraminifers and ostracods in this part of the Devonian succession. Moreover, I have studied the sedimentology of Cambrian, Silurian, Lower and Middle Devonian strata, determined the thermal maturity of Silurian, Devonian, Carboniferous and Triassic rocks, and the reservoir host rock character of Palaeozoic and Mesozoic rocks. I have also popularized geological knowledge. The full list of my papers with my personal contribution, cited in the "scientific-research achievements" is given in Annex 3.

Studies of Cambrian deposits

In the Cambrian of the Holy Cross Mountains I have studied the sedimentology of the Pepper Mts Shale Formation and the Wiśniówka Sandstone Formation.

The sedimentary setting of the Pepper Mts Shales, assigned to the middle Cambrian (Series 3) and upper Cambrian (Furongian) (Kowalczewski et al., 2006), was considered as a shallow marine, shelf environment, in which sedimentation took place below the normal wave base (Orłowski, 1968; Przewłocki, 2000). I have studied the exposures of the Pepper Mts Formation between the Kamecznica Podmąchocicka to the west to the Pepper Mts to the east (Malec, 2007e, f, 2010a, b, 2011a, 2012b; Malec, Salwa, 2014). I have separated the deposits

of the formation into two formal lithostratigraphic units: the Pepper Mts Claystones Formation and the Kamień Łukawski Mudstones Formation (Malec, in press). Deposits of the first unit, extending from the vicinity of Kielce to the vicinity of Sandomierz were formed on the basin plain, whereas the second unit, restricted to the Pepper Mts, developed on the basin slope.

The sedimentary setting of the upper Cambrian (Furongian) Wiśniówka Sandstones was determined as very shallow-marine, and the thick-bedded sandstones were interpreted to be formed due to storm events (Dżułyński, Żak, 1960; Radwański, Roniewicz, 1960, 1962; Orłowski, 1968). Results of my sedimentological investigations carried out in the entire area of occurrence of this unit, from Wiśniówka to the west to the Karwów area to the east indicate that the sedimentation the sedimentation of these deposits took place within submarine fans, in channel and interchannel zones. The thick-bedded sandstones of the formation were formed on the basin slope in effect of gravitational, high-density sand debris flows (Malec 2003d, 2005b, 2007a, b, d, g, h, 2008b, 2009a, 2010c, 2012a).

Lithologically variable Cambrian deposits, drilled below the Miocene in the SE margin of the Holy Cross Mountains, were studied by me with regard to their sedimentology in 26 drillcores. They can be assigned to several lithostratigraphic units from the Cambrian succession of the Kielce Region in the Holy Cross Mountains (Malec, Kuleta, 2009a).

I have also studied the original collection of W. Sedlak comprising several thousand "fossils" from deposits of the upper Cambrian (Furongian) Wiśniówka Sandstone Formation collected in the Święty Krzyż area. The specimens present in this collection, belonging to the *Corallicyathida*, and occurring *in situ* in the field, have been questioned as real fossils by Bodzioch (2000). I have shown that the specimens from the collection in reality represent mineralization structures within tectonic breccia or on tectonic surfaces perpendicular to the bedding (Malec, 2007i, j, 2008e).

Studies of Silurian deposits

I have conducted studies of Silurian deposits in the Holy Cross Mountains and in the western margin of the Małopolska Massif.

In the Niestachów section, located in the Kielce Region, based on existing exposures and research excavations, I have recognized a 500 m thick succession encompassing the Prągowiec Beds and the Ludlow greywackes of the Niewachlów Beds. In the latter I distinguished 11 lithostratigraphic complexes (Malec, 2005a). In the next stage of research, the deposits were studied with regard to petrography and the source areas of detrital material (Malec, Kuleta, 2008a; Malec et al., 2015).

In the Bardo Syncline I conducted sedimentological studies of the greywackes belonging to the Niewachlów Beds in the Zalesie area (Trela, Malec, 2006). In the western part of this structural unit, near Widełki, research excavations have allowed for studying the succession from the transition between the Prągowiec Beds and greywackes of the Niewachlów Beds (Malec, 2004c, 2014), and correcting the inappropriate interpretation of the stratigraphic succession of these units presented by Stupnicka et al. (1991).

Near Zbrza in the NW part of the Holy Cross Mountains, I have made research excavations to expose the succession of the Ordovician/Silurian transition, which was studied with regard to petrology and biostratigraphy (Malec, 2005c; Trela et al., 2006a).

In the Łysogóry Region, I studied the sedimentology of the Silurian claystones and greywackes in the cores of the Daromin IG 1, Kichary IG 1 and Wilków 1 boreholes (Trela et al., 2006b; Malec et al., 2007b; Trela, Malec, in press).

Based on comparative analysis of the Silurian and Lower Devonian macro- and microfauna from the Holy Cross Mountains and other parts of Europe I have presented the palaeogeography of this area in the Silurian and Early Devonian (Malec, 2004a, b).

During the Conference of the Polish Geological Society in 2006 I have presented a synthetic characteristics of the litho- and biostratigraphy of the Silurian deposits in the Holy Cross Mountains (Malec, 2006).

Moreover, I conducted sedimentological studies of Silurian greywackes of the Mrzygłód Beds and Łapczyca Formation in 4 drillcores from the Zawiercie area and in the Łapczyca 2 drillcore, which were also studied with regard to petrography; the studied successions were correlated with the Ludlow of the Holy Cross Mountains (Malec et al., 2005, 2008; Malec, Kuleta, 2009b).

Studies of Devonian deposits

Lower Devonian

I have studied the sedimentology of the Lower Devonian Barcza Beds in the vicinity of the abandoned quarries near Barcza; my investigations have indicated an alluvial sedimentary setting. The complex results of sedimentological, miospore, vertebrate remains and trace fossil analyses of the Barcza Beds are now being prepared for publishing (Malec et al., in preparation).

Middle and Upper Devonian

In the succession of the Middle Givetian silicoclastic deposits of the Świętomarz Beds, in the Łysogóry region, I have distinguished 7 lithofacies and determined their sedimentary setting. It was related with a distal part of a prodelta, to which terrigenous material was supplied from the south-east, from the orogenic zone and the craton zone of a continental block (Malec, Kuleta, 2008b; Malec, 2011b, 2012, 2012b; Kuleta, Malec, in press).

In research excavations near Pokrzywianka, I have described the lithology and the fossils from the Middle Givetian Świętomarz, Pokrzywianka and Nieczulice Beds (Malec, 2008a).

In the Bostów 7 drillcore I sub-divided the 400 m sequence of Givetian strata into lothostratigraphic units, and distinguished deposits of the Skały, Świętomarz, Pokrzywianka and Nieczulice Beds (Malec, 2007c).

Near Nieczulice, in an artificial exposure I recognized a succession of deposits at the transition between the Nieczulice and Kostomłoty Beds, within which, based on abundant conodont assemblages, I located the Givetian/Frasnian boundary (Malec, 2007l).

In the Bąkowa IG 1 drillcore I studied the ostracod assemblage from the depth interval 1434.7-2418.0 m, which documented deposits from the Givetian and the Givetian/Frasnian transition. Most of these deposits correspond to the Nieczulice Beds, and the underlying sandstones – to the Świętomarz Beds from the Łysogóry Region of the Holy Cross Mountains (Malec, 2009b).

Interpretation of 13 seismic logs from the western Mesozoic margin of the Holy Cross Mountains (Malec et al., 2007a) has led to drill the Odrowążek 1 borehole for hydrocarbon prospecting. I have conducted a stratigraphic analysis of the deposits drilled below the Permian strata, and distinguished the Lower and Middle Devonian deposits representing the Zagórze, Grzegorzowice, Wojciechowice formations and the basal part of the Skały Formation from the Łysogóry Region (Malec et al., 2007d).

Upper Devonian – Lower Carboniferous

I have investigated the $\delta^{13}C$ record in the limestones from the Devonian/Carboniferous transition in the Kowala succession. They indicate that oscillations in the isotope record of rhe studied deposits are related to the Hangenberg Event (Trela, Malec, 2007, 2008a, b).

Studies of thermal maturity based on conodonts

Beside using conodonts for biostratigraphy, I have used my collection of these microfossils to determine the thermal maturity of Devonian, Carboniferous and Triassic rocks. My studies have confirmed the earlier opinion of Belka (1990) that the Devonian strata of the Kielce-Łagów Synclinorium have been strongly heated, whereas they are much less mature to the south of that area; and a strong heating of the Lower and Middle Devonian in the Łysogóry region and a light heating of the Upper Devonian in this area (Narkiewicz, Malec, 2005).

Studies conducted in the central part of the Małopolska Massif, in the Węgrzynów IG 1 and Pągów IG 1 drillcores, indicate increase of the CAI from 2 in the Lower Carboniferous to 3 in the Givetian in the first drillcore. Intense heating of the Upper Devonian in the Pągów IG 1 (CAI 4.5) points to an additional contribution of an increased heat stream near a tectonic zone. The rather low palaeotemperature value in the organic matter from the Triassic deposits of the Małopolska Massif indicates that the Devonian and Carboniferous strata gained thermal maturity in the Late Carboniferous, prior to their uplift in the Variscan orogeny (Malec, 2015a).

Studies of reservoir host rocks

In selected lithostratigraphic successions of the Palaeozoic in the Holy Cross Mountains, encompassing Cambrian, Ordovician, Silurian, Carboniferous and Permian deposits, I conducted investigations focused on determining their hydrocarbon potential based on the pyrolytic Rock-Eval analysis. The Llandovery Bardo Beds, Lower Carboniferous Zaręby beds and Upper Permian Zechstein limestones have been determined to be rich in organic matter (Malec, 2006a; Malec et al., 2007c, 2010). I also conducted studies of selected Middle and Upper Devonian horizons of the Holy Cross Mountains with regard to search for host and reservoir rocks (Malec et al., 2005a – archival data), and of Palaeozoic and Mesozoic rocks in the north-western Mesozoic margin of the Holy Cross Mountains with regard to their hydrocarbon potential (Malec et al., 2008b – archival data).

Geoeducation

In the area of the planned Łysogóry Geopark I have taken part in the selection and characteristics of the geotourist values of 21 geosites (Fijałkowska-Mader, Malec, 2013).

The unique in terms of geotourism and geoeducation Devonian succession and caves of Kadzielnia have been presented in a book and a tourist guide (Urban et al., 2011, 2013), in which I was responsible for the characteristics of the Devonian rocks.

In 2010-2014 I elaborated documentary cards for 65 geosites in the Świętokrzyskie Province, including 35 individually.

I am also the co-author of a book – syllabus for classes and exercises for geography teachers (Pieńkowski et al., 2013).

Popularization and promotion of PGI-NRI

For the exhibition commemorating the 75 anniversary of the Holy Cross Branch of PGI-NRI, I have prepared a poster entitled "Palaeontology".

I prepared three chapters in the promotion folder of the Holy Cross Branch of PGI-NRI entitled "Microfossils from the Holy Cross Mountains".

During the Kielce Science Festivals I have popularized geology among school children (Malec, 2004d, 2005e, 2006b, 2007j, 2012d).

References cited:

Belka Z., 1990. Thermal maturation and burial history from conodont colour alteration data, Holy Cross Mountains, Poland. *Courier Forsch.-Inst. Senckenberg*, 118: 241-251.

Bodzioch A., 2000. Pseudoskamieniałości *Corallicyathida* z kambru Łysogór. *Streszczenia referatów PTG*, 9: 39-46. Poznań.

Czarnocki J. 1951. Złoże rud żelaza w Dąbrowie pod Kielcami w związku z zagadnieniem rud dewońskich w Świętokrzyskim. *Prace Państwowego Instytutu Geologicznego*. 7: 95-114.

Dżułyński S., Żak C., 1960. Środowisko sedymentacyjne piaskowców kambryjskich z Wiśniówki i ich stosunek do facji fliszowej. *Rocznik Polskiego Towarzystwa Geologicznego*, 30(2): 213-241.

Kowalczewski Z., Żylińska A., Szczepanik Z., 2006. Kambr w Górach Świętokrzyskich. W: *77 Zjazd Naukowy Polskiego Towarzystwa Geologicznego. Procesy i zdarzenia w historii geologicznej Gór Świętokrzyskich*. Ameliowka k. Kielc, 28-30 czerwca 2006 r.: 14-27.

Orłowski S., 1968. Kambr antykliny łysogórskiej Gór Świętokrzyskich. *Biuletyn Geologiczny Uniwersytetu Warszawskiego*, 10: 153-218.

Przewłocki Z., 2000. Środowisko depozycji kambryjskiej formacji łupków z Gór Pieprzowych, Góry Świętokrzyskie. Rozprawa doktorska. *Archiwum Wydziału Geologii Uniwersytetu Warszawskiego.* 1-155.

Radwański A., Roniewicz P., 1960. Struktury na powierzchniach warstw w górnym kambrze Wielkiej Wiśniówki pod Kielcami. *Acta Geologia Polonica*, 10(3)371-399.

Radwański A., Roniewicz P., 1962. Środowisko sedymentacji górnego kambru okolic Opatowa. *Acta Geologia Polonica*, 12(3): 431-446.

Stupnicka E., Przybyłowicz T., Żbikowska B., 1991. Wiek szarogłazów niewachlowskich i łupków z Widełek k. Barda (Góry Świętokrzyskie). *Przegląd Geologiczny*, 39: 389-393.

Tarnowska M., 1990. Sekwencja osadów dewonu dolnego i eiflu w otworze wiertniczym Jaronowice IG 1. *Kwartalnik Geologiczny*, 34(3): 563-564.

Wójcik K., 2015. The uppermost Emsian and lower Eifelian in the Kielce Region of the Holy Cross Mts. Part I: Lithostratigraphy. *Acta Geologica Polonica*, 65(2): 141-179.