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# The uppermost Emsian and lower Eifelian in the Kielce Region of the Holy Cross Mts. Part I: Lithostratigraphy.

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ABSTRACT:

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The paper provides a description of primary geological logs, characteristics and formal lithostratigraphy of the uppermost Emsian and lower Eifelian of the Kielce Region of the Holy Cross Mts., central Poland. Nine sections of this interval, representing the whole area of the Kielce Region, and ranging between the Lower Devonian clastics of the Winna Formation and the Middle Devonian carbonates of the Kowala Formation were studied.

The succession is divided into the Barania Góra Dolomite and Limestone Formation and the Wojciechowice Dolomite Formation. Six members are distinguished within the former. In the western part of the region these are (in stratigraphical order): Porzecze Claystone Member, Dębska Wola Dolomite Member, Dąbrowa Limestone Member, and Brzeziny Dolomite Member. In the eastern part, the formation is divided into the Janczyce Dolomite Member and the Jurkowice Dolomite Member. Additionally, the Wszachów Dolomite Member and Nowy Staw Dolomite Member are distinguished within the overlying Wojciechowice Formation. The thickness of the uppermost Emsian–Eifelian succession ranges from ca. 200 m in the eastern part to ca. 130 m in the western part of the Kielce Region.

**Key words:** Lithostratigraphy; Devonian; Eifelian; Holy Cross Mountains; Dolomites.

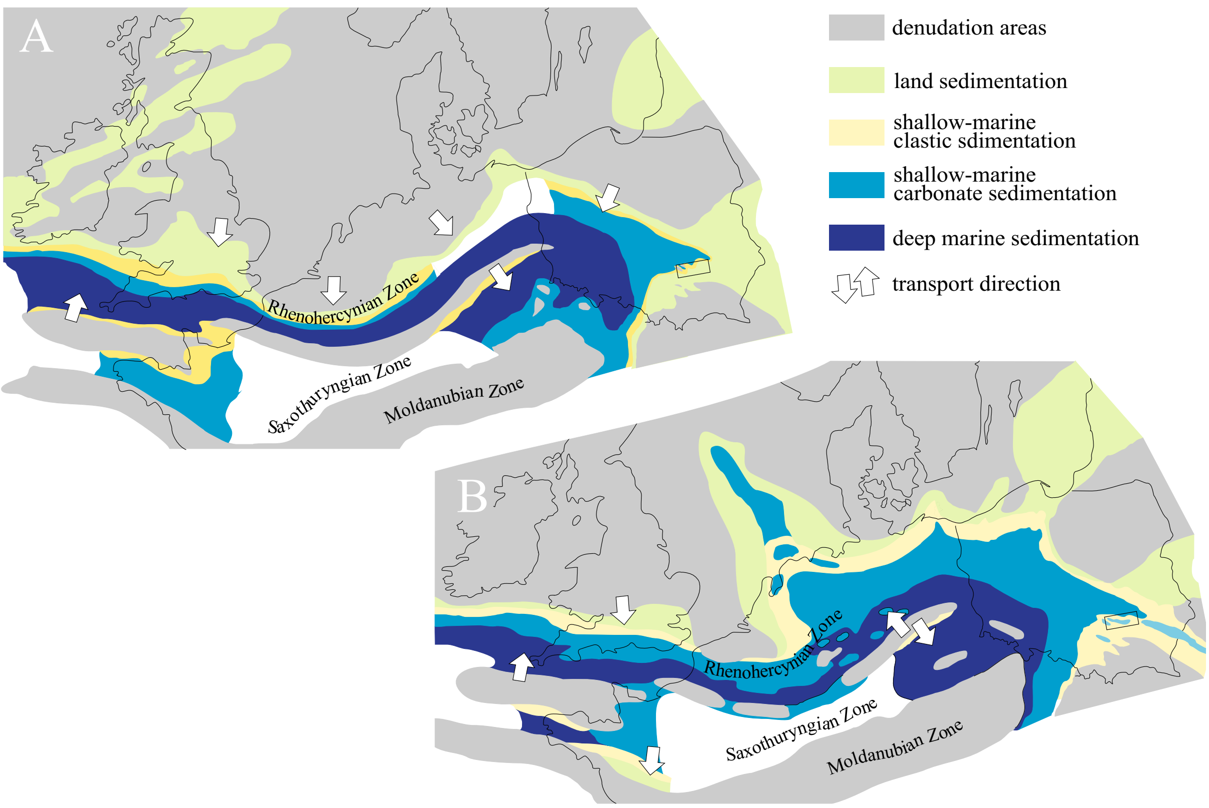
## INTRODUCTION

At the turn of the Early and Middle Devonian, a first-order transgression-regression cycle began, with a generally transgressive regime prevailing during the Middle and early Late Devonian (Johnson *et al*. 1985; Sandberg *et al*. 2002). Great changes occurred in facies arrangement and palaeogeography on the southern edge of Laurussia. Post-Caledonian palaeotopography, regional extension due to Rhenohercynian Ocean spreading, local tectonic activity and pulsatory sea-level rise were the main factors that controlled the sedimentary processes during the early stage of the transgression (Bełka and Narkiewicz 2008). As a result, a broad Laurussian shelf appeared, and a huge system of shallow-marine carbonate ramps and platforms started to develop (Text-fig. 1).

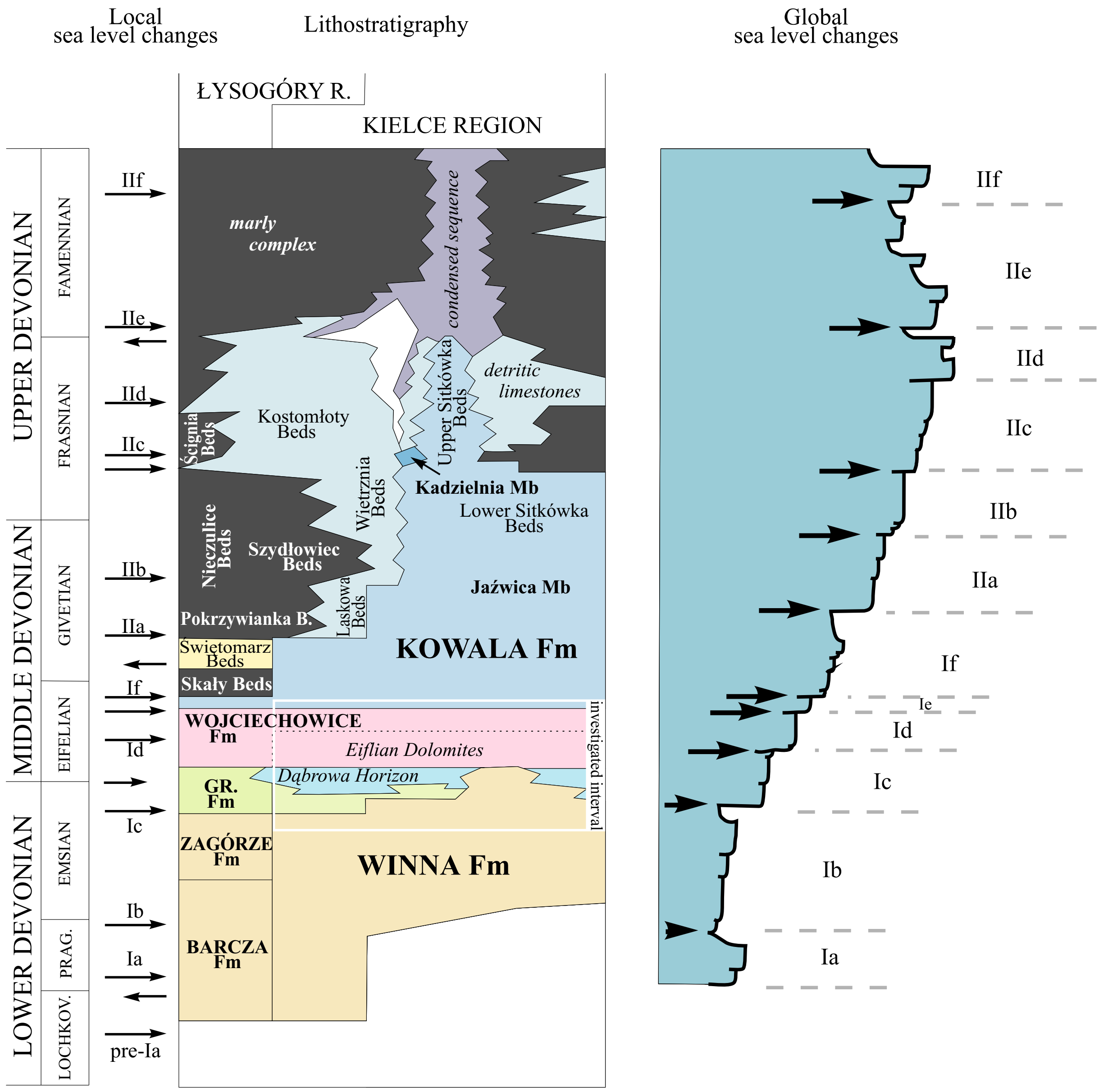
In the latest Emsian, the transgression reached the area of the present Holy Cross Mts. (HCM). The palaeogeographical and facies development of the area was related to first-order global sea-level fluctuations with minor contribution of local tectonic events (Racki and Narkiewicz 2000; Szulczewski 1978, 1995a, 2006; Text-fig. 2). This consecutively resulted in: (i) late Emsian termination of continental sedimentation and development of marginal and marine clastic deposition (Łobanowski

1971, 1981, 1991; Szulczewski and Porębski 2008); (ii) latest Emsian–early Eifelian retrogradation of clastic lithotypes beyond the Holy Cross area and development of carbonate lagoonal environments (Wójcik 2013); (iii) early Eifelian short-term constitution of open-marine environments (Malec 2005; Wójcik 2013); (iv) late Eifelian unification of shallow carbonate shelf environments (Skompski and Szulczewski 1994; Narkiewicz and Narkiewicz 2010; Niedźwiedzki *et al*. 2010; Narkiewicz and Ratellack 2014; Wójcik 2013; Narkiewicz *et al*. 2015); (v) Givetian to Frasnian transformation of a carbonate shelf into an isolated reef-rimmed shallow-marine "Dyminy" carbonate platform surrounded by deeper Łysogóry and Chęciny-Zbrza intrashelf basins (Szulczewski 1971; Racki 1993; Racki *et al*. 2002; Wójcik 2012); (vi) late Frasnian to early Famennian drowning of a carbonate platform and its transformation into a pelagic platform (Szulczewski 1978; Szulczewski *et al*. 1996; Wójcik 2009, 2012); and (vii) late Famennian–Early Carboniferous unification of deep marine marly sedimentation (Szulczewski 1971, 1973, 1995, 2006).

The upper Emsian and the Eifelian, being the oldest parts of the transgressive succession, are a subject of intensive investigations in the Kielce (southern) Region of the HCM, including stratigraphical analyses and reconstruction of facies development. The part of the succession under study spans between the Winna and the Kowala formations and includes a number of informal and poorly recognized lithostratigraphical units (see Narkiewicz and Olkowicz-Paprocka 1983; Narkiewicz *et al*. 2006; Fijałkowska-Mader and Malec 2011). The poor definition of these units, as well as poor understanding of facies patterns, geographical and stratigraphical distribution, and mutual relations between the units, has led to markedly different interpretations of the area's history at the turn of the Early Devonian transgression (compare: Racki and Turnau 2000; Narkiewicz *et al*. 2006; Bełka and Narkiewicz 2008; Fijałkowska-Mader and Malec 2011; see also Text-fig. 4). Therefore, before crucial issues referring to the studied interval can be addressed (such as the time, directions and causes of the transgression, architecture of facies tracks, or eustatic *vs* tectonic control of the changes observed in the sedimentary environment), a reliable time-space facies architecture must be worked out. As the available data do not allow the introduction of a refined sequence stratigraphical framework, the pattern presented herein is a formal lithostratigraphical scheme, which is the subject of the present paper. All other issues will be addressed elsewhere.




Text-fig. 1. Main sedimentary zones along the southern Laurussian shelf during the early stage of the Devonian transgression: **A** – in the Late Emsian, **B** – in the Eifelian (modified after Miłaczewski 1980 and Mabille and Boulvain 2007). Black square - Holy Cross Mts.




Text-fig. 2. Devonian lithostratigraphy of the Holy Cross Mts. compared with local and global sea level changes (after Sandberg *et al.* 2002; Narkiewicz *et al.* 2006, Bełka and Narkiewicz 2008). White square – investigated interval

## GEOLOGICAL BACKGROUND

The Palaeozoic of the Holy Cross Mountains (HCM) is subdivided by the Holy Cross Dislocation into the northern (Łysogóry) and southern (Kielce) units. These units are parts of the Łysogóry and Małopolska terranes respectively, and both belong to the Trans-European Suture Zone (TESZ) – an amalgamation of terranes consolidated at the turn of the Silurian and Devonian (Nawrocki 2000, 2003; Nawrocki and Poprawa 2006; Nawrocki *et al.* 2007; Narkiewicz 2007; Bełka and Narkiewicz 2008). Although small relocations of particular structural units of the TESZ took place during the Variscan orogeny (Konon 2006, 2007), large-scale post-Silurian displacements are questionable. Palaeomagnetic data from the Nawodzice Sandstones (Nawrocki *et al.* 2007), Mójcza Limestone (Schätz *et al.* 2006), as well as from the Bardo Diabase (Nawrocki 2000; Nawrocki *et al.* 2013) indicate a similar position of the Małopolska Block in relation to Baltica since the Cambrian. This seems to be confirmed also by the presence of similar endemic faunas (e.g. *Chimaerothyris dombrowiensis*, Studencka 1983), as well as of unique facies (Spirifer sandstones:

Studencki and Studencka 1986) in the Devonian in both HCM regions. However, the HCM cannot be treated as a united and facially homogeneous area during the Devonian. In spite of a common transgressive regime prevailing throughout the area, significant differences occur in facies development between the northern and southern HCM regions, which are expressed in succession thickness, lithological variety and by diachroneity of lithostratigraphical boundaries of corresponding units (Szulczewski 1995, 2006; Text-fig. 2). The facies autonomy and tectonic separateness of the Łysogóry and Małopolska units are especially well expressed in the Lower Devonian: regressive facies and a more or less continuous succession in the northern region correspond to a great stratigraphical gap and the Silurian/Devonian unconformity in the southern unit (Szulczewski 1995, 2006; Kozłowski 2008; compare with Kowalczewski *et al*. 1998 and Malec 1993, 2001).

## EXISITING LITHOSTRATIGRAPHY IN THE HOLY CROSS MOUNTAINS

### Łysogóry Region

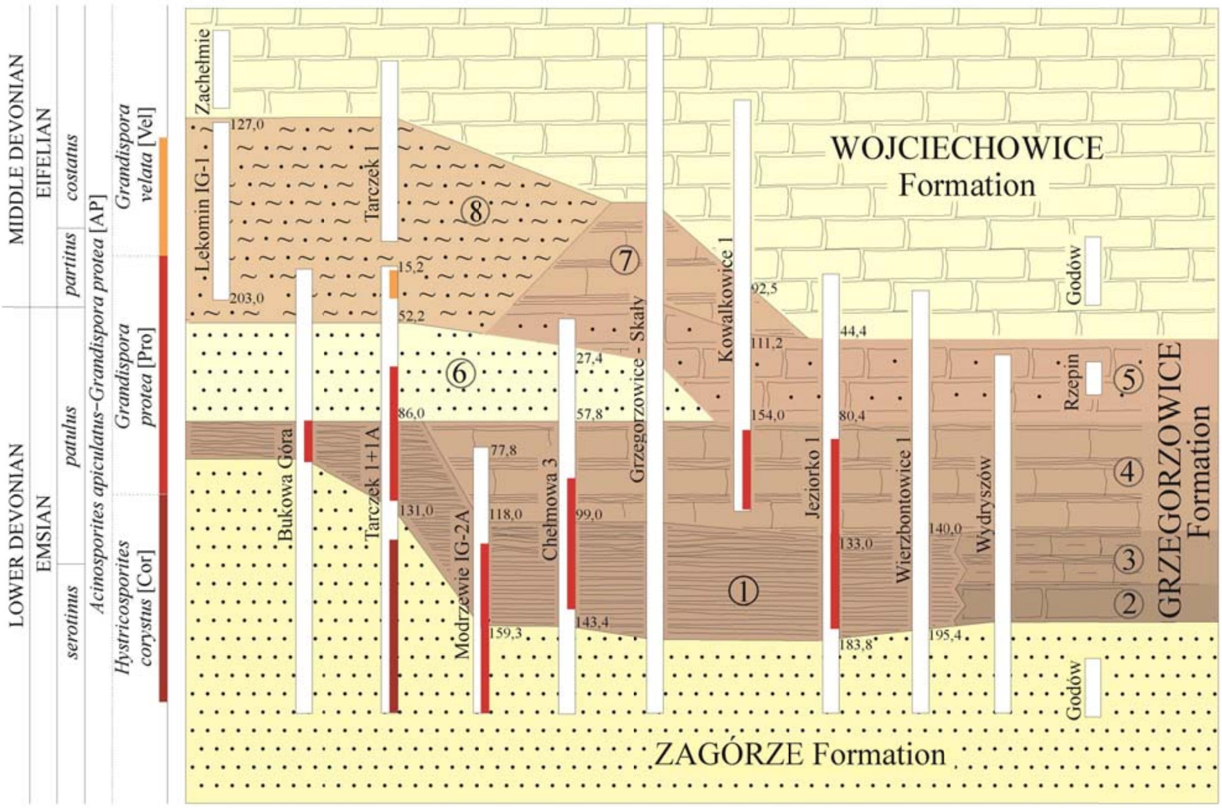
In the Łysogóry region, the upper Emsian to Eifelian succession is well recognized (Czarnocki 1919, 1950, 1957; Pajchlowa 1957; Łobanowski 1971, 1981, 1990; Kowalczewski 1971; Adamczak 1976; Kłossowski 1985; Malec 2001, 2002, 2005; Szulczewski and Porębski 2008; Narkiewicz and Narkiewicz 2010, 2014; Niedźwiedzki *et al*. 2010; Fijałkowska-Mader and Malec 2011; Filipiak 2011; Narkiewicz and Ratellack 2014; Grabowski *et al*. 2015; Narkiewicz *et al*. 2015). The Lower Devonian is ca. 550 m thick and is divided into the Bostów, Klonów, Barcza, and Zagórze formations (see Narkiewicz *et al*. 2006; Text-fig. 2). The 110 m thick Zagórze Formation is the oldest Devonian transgressive unit (Szulczewski and Porębski 2008), clearly Emsian in age (Malec 2001, 2005; Filipiak 2011). The uppermost Emsian and lower Eifelian beds, 95 to 160 m thick, are distinguished as the Grzegorzowice Formation (Text-fig. 2), and are subdivided into eight members: (1) Bukowa Góra Claystone; (2) Warszówek Dolomite; (3) Godów Marl; (4) Wydryszów Limestone; (5) Kapkazy Sandstone; (6) Rzepin Dolomite; (7) Zachełmie Siltstone and Sandstone; and (8) Dąbrowa Limestone (Malec 2005; Text-fig. 3). Such a broad definition of the Grzegorzowice Formation was rejected by Szulczewski (2006) and by Szulczewski and Porębski (2008), albeit followed by Fijałkowska-Mader and Malec (2011) and by Filipiak (2011). The original subdivision of Malec (2005) is preserved herein (Text-figs 2 and 3). The upper part of the Eifelian is referred to the Wojciechowice Formation defined by Kłossowski (1985), who subdivided it into the Chmielowiec Member in the lower part, and the Crystalline Dolomites Member in the upper part (see detailed description in Skompski and Szulczewski 1994). Narkiewicz and Narkiewicz (2010; see also Narkiewicz and Ratellack 2014; Narkiewicz and Narkiewicz 2014; Grabowski *et al*. 2015; Narkiewicz *et al*. 2015) revised the Wojciechowice Formation and referred the upper member to the Kowala Formation.

### Kielce Region

In the Kielce Region, the Emsian/Eifelian boundary succession was the subject of only a few investigations, limited to general lithological descriptions (see Text-figs 2, 4). Czarnocki (1957) distinguished the *Placoderm Sandstone*, which he referred to the Lower Devonian (Emsian). More recently, Tarnowska (1976, 1981 and 1987) subdivided this succession into the following units: *Lower Mudstone*, *Middle Sandstone*, *Upper Mudstone* and *Upper Sandstone*. The lowermost unit was later redefined as the Haliszka Formation (Fijałkowska-Mader and Malec 2011; after Tarnowska 1995). The remaining three units, in the rank of members, have been included to the Winna Formation (see Tarnowska 1988; Bełka and Narkiewicz 2008, p. 395; Fijałkowska-Mader and Malec 2011).

In the western part of the region, Czarnocki (1957) distinguished the *Dąbrowa Horizon* and the *Eifelian Dolomites*, which overlie the *Placoderm Sandstone*. Studencka (1983) interpreted the *Dąbrowa Horizon* as a biostratigraphical unit – the taxon range zone of *Chimaerothyris* (*Spirifer*) *dombrowiensis*. Two additional lithological units: the *Pyrite-bearing and Sideritic Claystone Member* and the *Dolomite Member*, still below the *Dąbrowa Horizon*, have been revealed in a series of boreholes: Dąbrowa-D5 (Tarnowska and Malec 1987), Porzecze IG-5A (Kowalczewski 1979; Malec 1979, 1980, 1984a; Fijałkowska-Mader and Malec 2011), Zaręby 2 (Malec 1984b), and Dyminy-2 (Tarnowska 1987; Filipiak 2011). These units have also been documented in the north-western part of the region: in the Szydłówek trench (Malec and Studencki 1988) and in the Skrzetle trench (Malec 1993, 2001a, see also the discussions in Kowalczewski *et al*. 1998; Narkiewicz 2002; Szulczewski 2006; Kozłowski 2008).

In the eastern part of the Kielce Region, Narkiewicz *et al*. (1981) and Narkiewicz and Olkowicz-Paprocka (1983) reported the existence of two lithological units



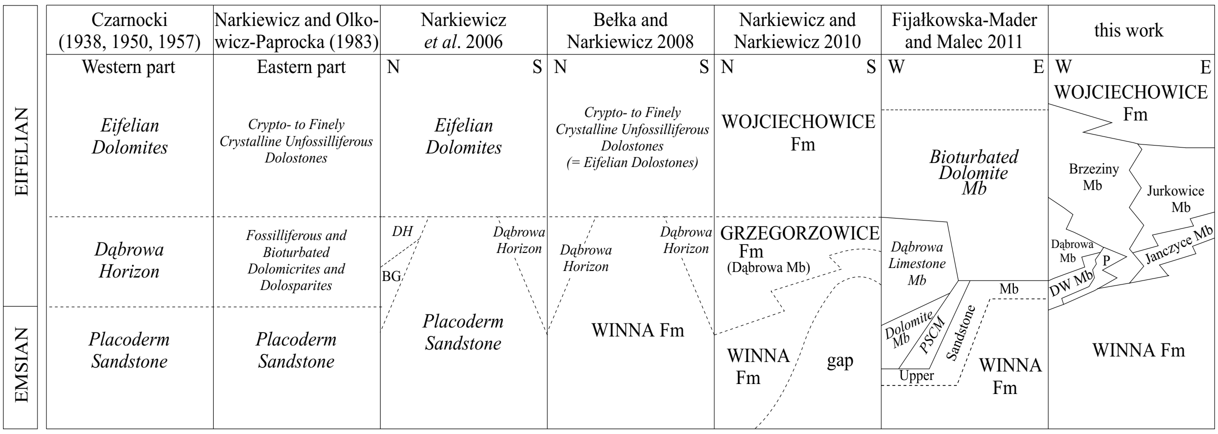

Text-fig. 3. Lithostratigraphical schemes around the upper Emsian and Eifelian in the Łysogóry Region of the Holy Cross Mts. according to Malec (2005), supplemented by palynostratigraphical data of Filipiak (2011). 1-8 – Grzegorzowice Formation: 1 – Bukowa Góra Member, 2 – Warszówek Member, 3 – Godów Member, 4 – Wydryszów Member, 5 – Rzepin Member, 6 – Kapkazy Member, 7 – Dąbrowa Member, 8 – Zachełmie Member

of postulated Eifelian age (Janczyce-1 borehole core and Jurkowice quarry). In stratigraphical order these are the *Fossiliferous and Bioturbated Dolomicrites and Dolosparites Unit*, and the *Unfossiliferous Crypto- and Fine-crystalline Dolomites Unit*. The authors treated the units as facies-equivalents of the *Dąbrowa Horizon* and the *Eifelian Dolomites* respectively. Romanek and Rup (1990) recognized similar units in in the Kowala 1 borehole core.

Summarizing, the Emsian/Eifelian boundary succession of the Kielce Region is composed of a number of lithologically variable, poorly recognized and inadequately defined units, spanning an interval between the Lower Devonian siliciclastics of the Winna Formation and the Middle Devonian–Frasnian carbonates of the Kowala Formation (Text-figs 2, 4). However, a simple and straightforward formalization of these units is difficult. This is because of the equivocal definition of the *Dąbrowa Horizon* – the crucial lithostratigraphical unit of the analyzed succession. So far, the unit was variously defined as:

(1) lithological unit of limestones and marls with abundant fossils (= *Dąbrowa Horizon* according to Gürich 1896; = complex VIII in Pajchlowa 1957; = Grzegorzowice Limestone Member in Malec 2001b, 2002; = Kielce Limestone in Tarnowska 1987; = Dąbrowa Limestone Member in Malec 2005);
(2) limestones, dolomites and shales with fossils and/or bioturbations that overlie the Lower Devonian siliciclastics and underlie the *Unfossiliferous Crypto- and Fine-crystalline Dolomites* (= Couvinian in Czarnocki 1950, 1957; = complexes III-VIII in Pajchlowa 1957; = *Dąbrowa Horizon* in Filonowicz 1973, = complexes D and E in Głazek *et al*. 1981, = *Fossiliferous and Bioturbated Dolomicrites and Dolosparites* unit in Narkiewicz *et al*. 1981 and Narkiewicz and Olkowicz-Paprocka 1983); and finally,
(3) taxon range zone of *Chimaerothyris* (*Spirifer*) *dombrowiensis* (Studencka 1983).

Also the lithology and stratigraphical/geographical ranges of the units, which underlie the *Dąbrowa Horizon* – the *Pyrite-bearing and Sideritic Claystone Member* and the *Dolomite Member*, are poorly recognized. Finally, distinguishing between the *Eifelian Dolomites* in the western part of the region and the *Unfossiliferous Crypto- and Fine-crystalline Dolomites* in the eastern part of the region is unreliable.

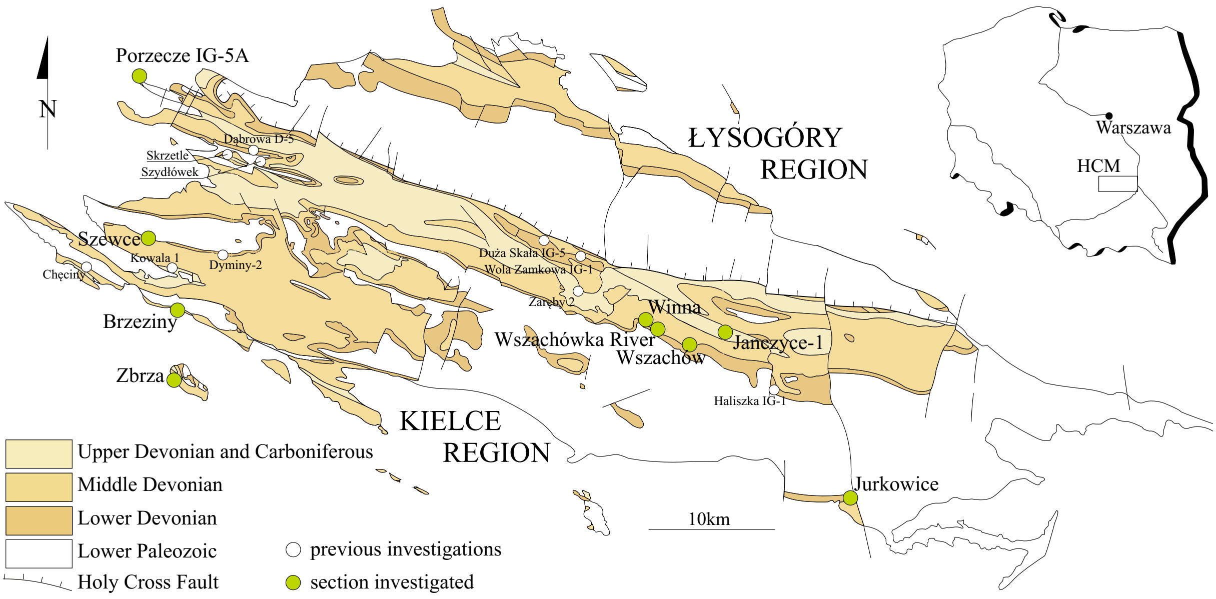



Text-fig. 4. Lithostratigraphical schemes around the upper Emsian and Eifelian in the Kielce Region of the Holy Cross Mts. according to various authors. BG – Bukowa Góra shales, *DH – Dąbrowa Horizon*, PSCM – Pyrite-bearing and Sideritic Claystone Member, DW Mb – Dębska Wola Member, P – Porzecze Member

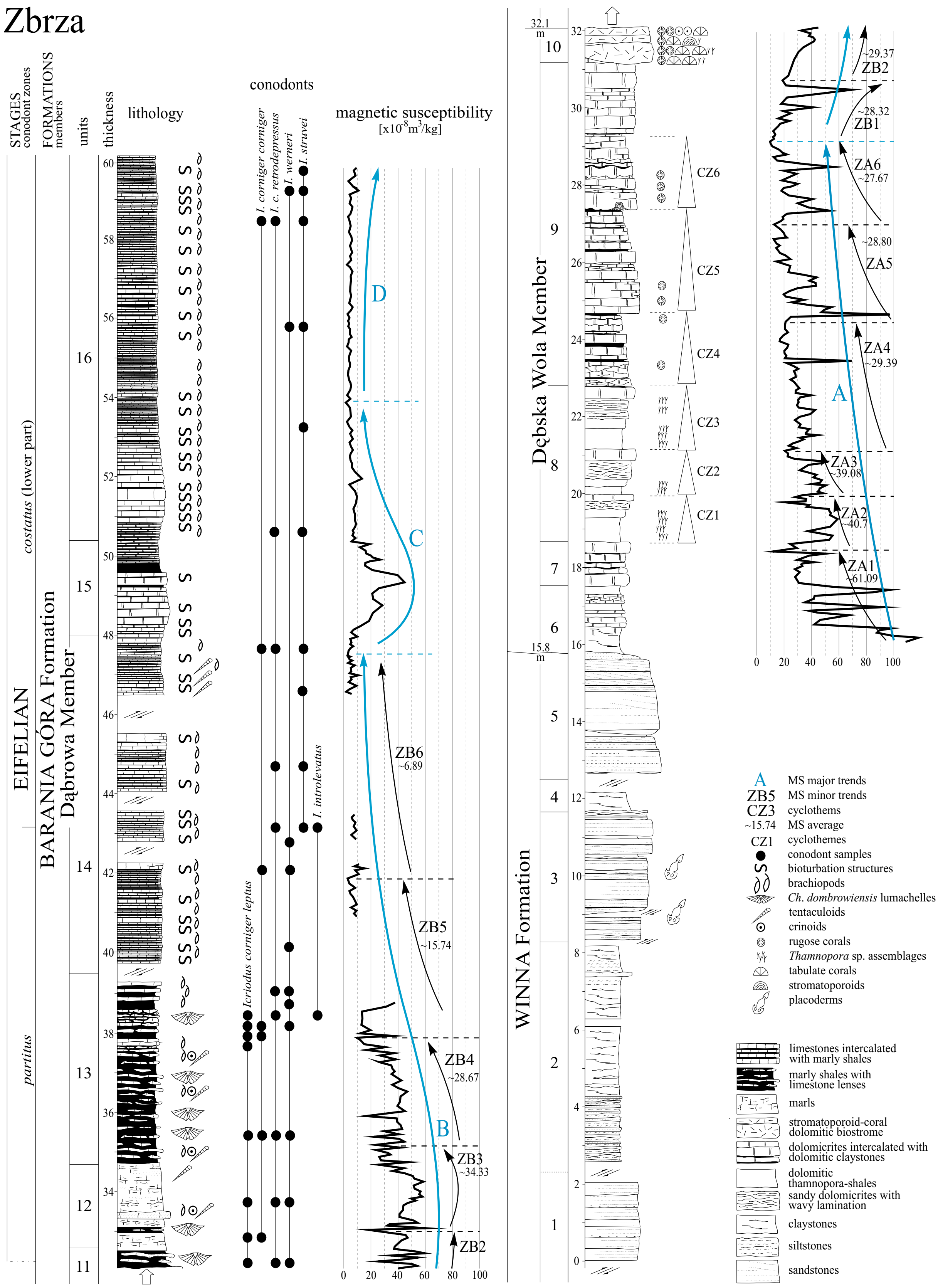
## METHODS

The Upper Emsian and Eifelian deposits have been recognized in nine sections in the Kielce Region (Text-fig. 5). In the eastern part, five sections have been investigated: Jurkowice, Winna and Wszachów quarries, Wszachówka River valley and the Janczyce-1 borehole core. In addition, comments are made on the published data from the Zaręby 2 borehole core (Malec 1984b). In the western part, four sections have been recognized: the Zbrza, Brzeziny and Szewce trenches, and the Porzecze IG-5A borehole core. These investigations are supplemented by published data from the Dyminy-2 (Tarnowska 1987) and Kowala 1 (Romanek and Rup 1990) borehole cores. Some of the investigated sections (trenches) were only temporary exposures excavated during work on public water conduits, and thus any renewed research would need new excavations.

The studied sections represent from 33 to 203 m long continuous successions of the uppermost Emsian and Eifelian. About 2000 lithological samples, including 420 polished slabs, 250 thin sections, 108 conodont samples and 4970 magnetic susceptibility measurements have been analyzed. Biostratigraphical analyses and magnetic susceptibility measurements have been performed in the laboratories of the Faculty of Geology, University of Warsaw and in the Palaeomagnetic Laboratory in the Polish Geological Institute – National Research Institute.




Text-fig. 5. Location of the investigated sections. Geological map of the Palaeozoic core of the Holy Cross Mts. after Konon (2006 and citations therein), simplified




Text-fig. 6. Lithological succession, conodonts and magnetic susceptibility in the Zbrza section

DESCRIPTION OF SECTIONS

## Zbrza

The section is located in the vicinity of the village of Zbrza, in the south-western part of the Kielce Region: 50°43′27.0″N, 20°33′49.0″E (Pl. 6). The Palaeozoic rocks in this locality are exposed in the Zbrza Antycline as a part of the Wolica-Zbrza Fold, the largest tectonic structure of the southern Mesozoic surrounding of the HCM. The Cambrian to Upper Devonian strata of the area were the subject of detailed investigations (Deczkowski and Tomczyk 1969; Filonowicz 1968, 1973; Kucia 1987; Wójcik 2009, 2012; see also Czarnocki 1919; Studencka 1983; Hajłasz 1967; Racki 1993, p. 95). The Zbrza Anticline is also one of the most important outcrops of the *Dąbrowa Horizon* (Gürich 1896; Zbroja *et al*. 2007). So far, however, the Emsian to Eifelian succession of the area has been described only in general (Filonowicz 1973; Malec and Romanek 1994; Filipiak 2011).

The Lower–Middle Devonian boundary succession in the village of Zbrza was exposed during the construction of public water conduits in spring 2011. The exposure ran from the southern end of the village (house no. 1) and continued 175 m to the north. At present, it can be traced along the drains. The exposed succession was 61 m thick and has been divided into 16 lithological units (Text-fig. 6 and Pl. 1). 345 lithological samples, 125 polished slabs, 50 thin sections and 911 magnetic susceptibility measurements were analyzed.

*Lithology*

**Unit 1** (2 m thick) is composed of 25–35 cm thick beds of light grey, medium-grained flat-bedded quartz sandstones with intercalations of green siltstone laminae.

**Unit 2** (5.4 m thick) is composed of red and red-violet siltstones alternating with thin layers of violet fine-grained quartz-muscovite sandstones predominating in the lowermost (1.6 m thick) and uppermost (1.1 m thick) parts of the unit. A 2.7 m thick package of green claystones occurs in the middle part.

**Unit 3** (3.2 m thick) is composed of 5–40 cm thick beds of light grey quartz sandstones with flat or low-angle cross-bedding, intercalated by thin packages of green claystones. Thin lenses of placoderm breccias occur on the upper surfaces of two sandstone beds.

**Unit 4** (0.5 m thick) is composed of green claystones, reduced tectonically at the top.

**Unit 5** (3.2 m thick) is composed of two thick beds of light grey medium-grained cross-bedded quartz sandstones (55 and 100 cm thick) and few thinner sandstone beds intercalated by thin and discontinuous laminae of green claystones.

**Unit 6** (1.7 m thick) is composed of brown to yellow dolomitic claystones, which constitute the base of the Devonian carbonate succession. A few lenses of yellow-weathering dolomitic sandy marls occur in the upper part.

**Unit 7** (1.15 m thick) is composed of several 10–30 cm thick beds of reddish marly/sandy dolomicrites separated by thin packages of brown dolomitic claystones.

**Unit 8** (3.7 m thick) is composed of a cyclic succession of the following packages:

Package A: greenish dolomitic claystones (20–40 cm thick) with abundant *Thamnopora* sp.;
Package B: yellowish marly dolomicrites with abundant *Thamnopora* sp. (15–40 cm thick);
Package C: yellowish sandy dolomicrites with wavy lamination and single thamnoporoid remains;
Package D: yellowish sandy dolomicrites in single massive beds (30 cm thick).

The packages are arranged into 3 cyclothems (ABCD, ABCD, ABCACAD), the thickness of which ranges between 1.2 and 1.3 m.

**Unit 9** (12.4 m thick) is characterized by a subtle cyclicity of the following packages:

Package E: grey-violet dolomicrites and dolomitic limestones (20–40 cm thick) with flat surfaces, intercalated by brown dolomitic claystones; single rugose corals and tabulates occur within the dolomites;
Package F: reddish marly dolomicrites with wavy surfaces, intercalated by brown dolomitic claystones;
Package G: thin beds of yellow sandy dolomitic claystones.

The packages are arranged into 3 cyclothems (EFG, EFG, EFG), the thickness of which ranges between 2.0 and 2.7 m. The cyclicity vanishes in the upper part represented by reddish dolomicrites with single corals.

**Unit 10** (30–95 cm thick) is composed of three beds of reddish stromatoporoid-coral dolomites with predominant *Thamnopora* sp. and rugose corals overgrown by tabular stromatoporoids. There are also lenses of crinoid detritus. In the Zbrza Anticline, the deposits of this unit build several bioherms, up to a dozen or so metres high.

**Unit 11** (65 cm thick) is composed of greenish marly shales with lenses of monospecific (*Chimaerothyris dombrowiensis*) brachiopod lumachelles and crinoidal limestones. The brachiopods are well preserved, complete and oriented vertically. Adult forms predominate, with no signs of redeposition. The lenses cut the underlying shale laminae, but are smoothly covered by the overlying beds.

**Unit 12** (2.2–3 m thick) is composed of yellow- to greenish marls. Single brachiopods, crinoids and tentaculoids occur within the marls.

**Unit 13** (4.6 m thick) is composed of greenish marly shales with lenses of monospecific (*Chimaerothyris dombrowiensis*) brachiopod lumachelles and crinoidal limestones, similar to those in unit 11. The abundance of organodetritic limestone horizons increases towards the top of the unit. The coarse-grained beds are dominated by detritus of brachiopods (*Chonetes angustestriata*, *Athyris concentrica* and rare *Chimaerothyris dombrowiensis*). Less common are tentaculoids (*Tentaculites schlotheimi*, *T. subconicus*), gastropods (*Murchisonia* sp.), crinoids, bryozoans, tabulate corals (*Thamnopora* sp.), rugose corals, molluscs, microconchids, trilobites (*Dechenella dombrowiensis*) and rare cephalopods.

**Unit 14** (8.8 m thick) is composed of several tens of grey thin-bedded limestones intercalated by green marly shales. Three main lithological types of limestones can be distinguished:

- grained limestones with fossil detritus throughout: brachiopods and tentaculoids with minor contribution of gastropods, bryozoans, tabulate and rugose corals, molluscs, trilobites and cephalopods occur. The lower surfaces have a clearly erosional character, while the upper surfaces are indistinct and show a gradual transition into micrite. Some grained limestones show graded bedding, with brachiopod coquinas at the top. *Skolithos* isp. filled up with green marls appears at the tops of some of the surfaces;
- flaser limestones: detritus of fossils build 1–2 cm thick laminae/strips within a micritic matrix;
- micritic limestones: grey, grey-greenish and grey-reddish thin-bedded marly limestones with bioturbation structures and occasional flat lamination. *Chonetes angustestriata* in monospecific lumachelles appear rarely on top surfaces. This is a second type of autochthonous brachiopod lumachelles in the section.

The three types of limestones within the unit show approximately equal proportions.

**Unit 15** (2.5 m thick) is composed of light grey and reddish sandy dolomicrites and dolomitic marls intercalated by brown dolomitic claystones. 11 thin beds of dolomitic sandy marls (ca. 12–15 cm thick), with a nodular texture to wavy lamination, occur in the lower part of the unit, Very thin layers of reddish marls occur above.

**Unit 16** (9.5 m thick) is composed of grey, thin-bedded grained limestones, flaser limestones (micritic limestones, in which smudges and/or irregular laminae of grains occur) and micritic limestones intercalated by green marly shales, similar as in unit 14. The micritic limestones predominate in the upper part of the unit.

*Biostratigraphy*

A collection of 75 conodont specimens from 34 dissolved samples (21 positive) has been obtained, and the following taxa were identified: *Icriodus corniger corniger*, *I. corniger leptus*, *I. curvirostratus*, *I. introlevatus*, *I. corniger retrodepressus*, *I. werneri*, and *I. struvei*. The assemblage documents the *Polygnathus costatus partitus* and *P. c. costatus* zones, with the boundary between them recognized in unit 14 (see Text-fig. 6). The conodont results and correlation are broadly discussed in Wójcik (2013 and in preparation).

*Magnetic susceptibility*

A collection of 718 samples derived from 7-cm intervals in the carbonate part of the succession (Dębska Wola and Zbrza members) has been measured. Average MS is $27.2\times10^{-8}m^3/kg$. The MS curve is divided into 4 major asymmetrical fluctuations/trends (Text-fig. 6):

**Trend A** is 13.3 m thick and ranges from unit 6 to the upper part of unit 9. The trend is divided into 6 minor fluctuations:

ZA1: 2.6 m thick with average MS $61.09\times10^{-8}m^3/kg$;
ZA2: 1.4 m thick with average MS $40.7\times10^{-8}m^3/kg$,
ZA3: 1.2 m thick with average MS $39.08\times10^{-8}m^3/kg$,
ZA4: 3.4 m thick with average MS $29.39\times10^{-8}m^3/kg$,
ZA5: 2.6 m thick with average MS $28.8\times10^{-8}m^3/kg$,
ZA6: 2.1 m thick with average MS $27.67\times10^{-8}m^3/kg$;

**Trend B** is 16.3 m thick and ranges from the upper part of unit 9 to the upper part of unit 14. The trend is divided into 6 minor fluctuations:

ZB1: 1.6 m thick with average MS $28.32\times10^{-8}m^3/kg$,
ZB2: 2.8 m thick with average MS $29.37\times10^{-8}m^3/kg$,
ZB3: 1.6 m thick with average MS $34.33\times10^{-8}m^3/kg$,

ZB4: 2.8 m thick with average MS 28.67×$10^{-8}$$m^3$/kg,
ZB5: 3.5 m thick with average MS 15.74×$10^{-8}$$m^3$/kg,
ZB6: 4 m thick with average MS 6.89×$10^{-8}$$m^3$/kg;

**Trend C** is 6.5 m thick and ranges from unit 15 to the lower part of unit 16. The average MS in trend C is 6.89×$10^{-8}$$m^3$/kg;

**Trend D** includes the uppermost part of the succession, with the thickness of at least 6 m, and the average MS of 4,86×$10^{-8}$$m^3$/kg.

The MS results and correlation are broadly discussed in Wójcik (2013 and in preparation).

**Brzeziny**

The section is located in the south-western part of the Kielce Region, in the eastern part of the Chęciny Anticline: 50°46′14.6″N, 20°34′48.2″E (Pl. 6). The Emsian–Eifelian transition was recognized in the western part of the antycline by Głazek *et al*. (1981) in the vicinity of the town of Chęciny. The Lower Devonian siliciclastics cropping out in that area are very thin (only a few metres thick), a typical *Dąbrowa Horizon* is lacking (dolomites with bioturbation structures and grained intercalations occur in the lower part of the succession), and only the dolomites are commonly present in small outcrops along the Castle Hill. The topmost part of the Eifelian succession – the *Eifelian Dolomites,* is partly exposed in the nearby Radkowice and Jaźwica quarries. In the vicinity of the village of Brzeziny, the thickness of the clastic succession increases and the *Dąbrowa Horizon* appears. So far, the succession has not been described. Only very general remarks can be found in Filonowicz (1973) and Studencka (1983).

A 56 m thick succession of Emsian and Eifelian deposits in the village of Brzeziny was recognized by the author in 2010. A 65 m long trench was made, longitudinally cutting the southern slope of the Siedliskowa Hill, running along the northern side of road no. 763, ca. 100 m east of the cemetery and 150 m north of house no. 271 on Chęcińska Street. The exposed succession was 56 m thick and has been divided into 8 lithological units (Text-fig. 7 and Pl. 2). 220 lithological samples, 80 polished slabs, 27 thin sections, 21 conodont samples and 380 magnetic susceptibility measurements were analyzed.

*Lithology*

**Unit 1** (1.6 m thick) is composed of 7–12 cm thick beds of yellow medium-grained quartz sandstones with placoderm remains. A 25 cm thick breccia occurs at the top.

**Unit 2** (5.6 m thick) is composed of grey siltstones, which predominate in the lower and upper parts of the unit. Thin layers of red-violet fine-grained quartz-muscovite sandstones occur in the middle part.

**Unit 3** (90 cm thick) is composed of brown dolomitic claystones overlain by four beds of yellow and violet dolomitic sandy marls with intercalations of claystones

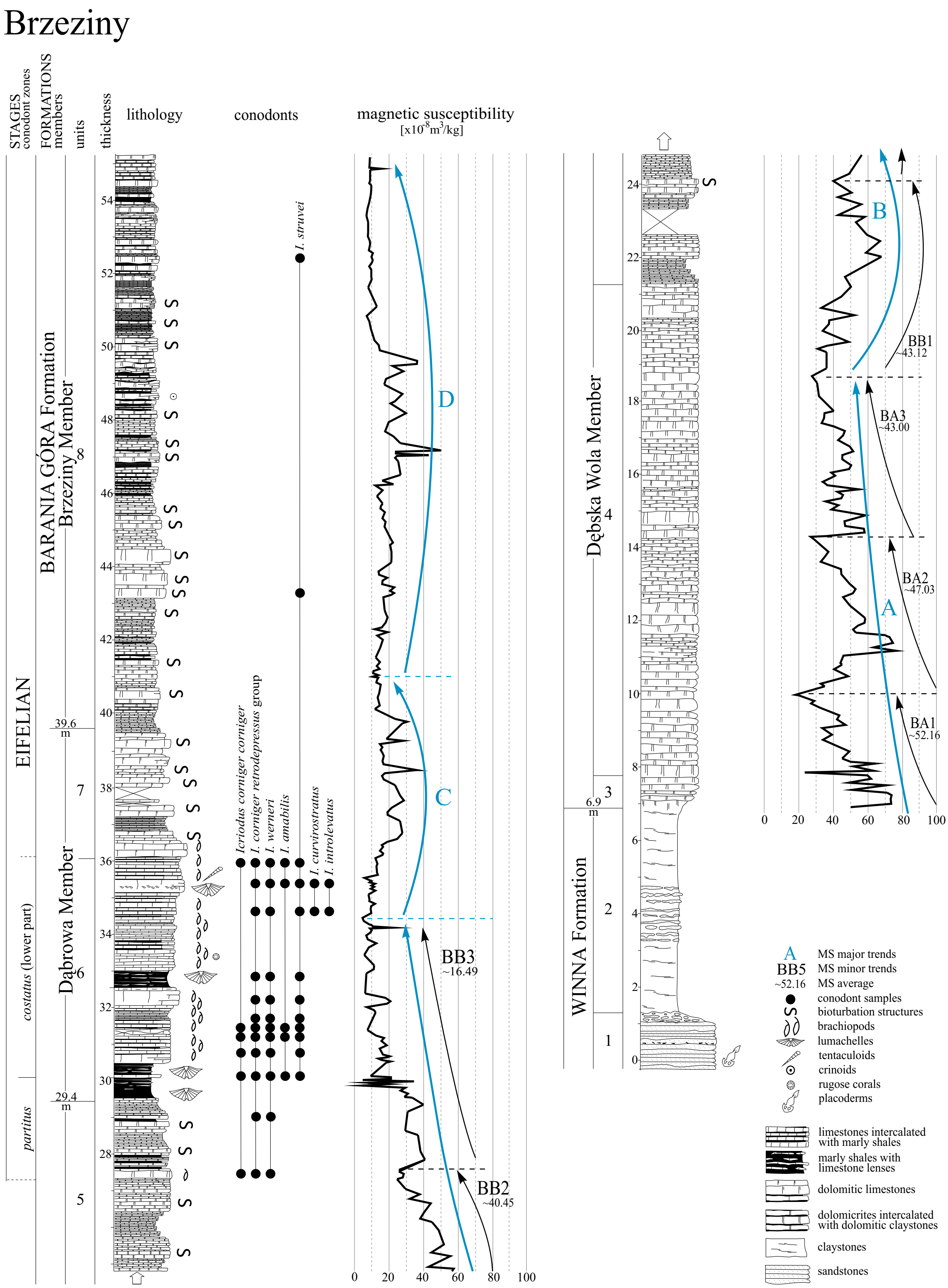
**Unit 4** (13.5 m thick) is composed of 5–35 cm thick beds of marly dolomites intercalated by very thin laminae of brown claystones.

**Unit 5** (8.2 m thick) is composed of 1–10 cm thick beds of grey-violet marly dolomicrites with intercalations of brown claystones. *Chondrites* isp. horizons and dolosparite laminae/strips occur in the thickest dolomite beds, albeit not forming indivi dual beds.

**Unit 6** (6.9 m thick) is composed of two, 95 and 35 cm thick packages of green marly shales with monospecific (*Chimaerothyris dombrowiensis*) brachiopod lumachelle lenses (compare with units 11 and 13 in the Zbrza section). Packages of 10–25 cm thick beds of grey limestones occur in the middle and upper parts of the unit. Similarly as in the Zbrza section, three types of limestones can be distinguished: micritic, flaser and grained limestones. *Chimaerothyris dombrowiensis* and *Chonetes angustestriata* are the most frequent brachiopods. In some beds, crinoids are also present. Gastropods (*Murchisonia* sp.), tentaculoids, microconchids, as well as single trilobites (*Dechenella* sp.), corals and cephalopods are less common. Bioturbation structures (*Chondrites* isp.) occur in almost all beds, and are especially abundant around the grained laminae/strips.

**Unit 7** (3.05 m thick) is composed of 5–25 cm thick beds of green micritic dolomitic limestones. Intercalations of brown dolomitic claystones occur in the lower part. Single brachiopods (*Chonetes* sp.) and crinoids are also present.

**Unit 8** (15.9 m thick) is composed of 5–40 cm thick beds of red to violet marly dolomicrites with intercalations of brown dolomitic claystones. Several thicker, greenish beds occur in the middle part of the unit and as single tabular beds in its upper part. Fossils are very rare and limited to thin sparry laminae/strips. Bioturbation horizons, dominated by *Chondrites* isp., occur more frequently.




Text-fig. 7. Lithological succession, conodonts and magnetic susceptibility in the Brzeziny section

*Biostratigraphy*

A collection of 87 conodonts from 21 dissolved (14 positive) samples has been obtained, and the following taxa were distinguished: *Icriodus corniger corniger*, *Icriodus corniger retrodepressus* group (including. *I. c. retrodepressus* Bultynck 1970 and *I.* n. sp. Narkiewicz 2013), *Icriodus curvirostratus*, *Icriodus introlevatus*, *Icriodus werneri*, *Icriodus struvei*, *Icriodus amabilis*. The assemblage documents two conodont zones – *Polygnathus costatus partitus* and *P. c. costatus*, with the boundary between them established in the lower part of unit 6 (Text-fig. 7). The conodont results and correlation are broadly discussed in Wójcik (2013 and in preparation).

*Magnetic susceptibility*

A collection of 380 samples from 15-cm intervals has been measured. Average MS is 26,9×$10^{-8}m^3$/kg. The MS curve is divided into 4 major asymmetric fluctuations/trends (Text-fig. 7):

**Trend A** is 11 m thick and ranges from the base of unit 3 to the upper part of unit 4. The trend is divided into 3 minor fluctuations:

BA1: 2.9 m thick with average MS 52.16×$10^{-8}m^3$/kg,
BA2: 4.3 m thick with average MS 47.03×$10^{-8}m^3$/kg,
BA3: 3.8 m thick with average MS 43.87×$10^{-8}m^3$/kg,

**Trend B** is 15.8 m thick and ranges from the upper part of unit 4 to the middle part of unit 6. The trend is divided into 3 minor fluctuations:

BB1: 5.4 m thick with average MS 43.12×$10^{-8}m^3$/kg,
BB2: 3.6 m thick with average MS 40.45×$10^{-8}m^3$/kg,
BB3: 6.8 m thick with average MS 16.49×$10^{-8}m^3$/kg,

**Trend C** is 6.6 m thick and it ranges from the upper part of the unit 6 to the lower part of the unit 8. The average MS is 26.9×$10^{-8}m^3$/kg.

**Trend D** is 10 m thick and includes the upper part of the succession (unit 8). The average MS is 22.27×$10^{-8}m^3$/kg.

The MS results and correlation are broadly discussed in Wójcik (2013 and in preparation).

**Szewce**

The section is located in the central-western part of the Kielce Region: 50°50′27.1″N, 20°28′57.8″E (Pl. 6). A 33 m thick succession of Emsian and Eifelian deposits of the Dyminy Anticline was temporarily exposed in the village of Szewce in 2011. A 75 m long trench, excavated during public water conduit construction, was located along the eastern side of road S8, starting from the overpass to the north. The succession has been divided into 4 lithological units (Text-fig. 8). 76 lithological samples, 25 polished slabs, 16 thin sections, 15 conodont samples and 429 magnetic susceptibility measurements were analyzed in the section (Text-fig. 8).

*Lithology*

**Unit 1** (9 m thick) is composed of grey to green claystone and siltstone packages interbedded with thin-bedded yellow sandstones. Single placoderm impressions occur.

**Unit 2** (2.3 m thick) is composed of thin-bedded yellow fine-grained quartz sandstones with placoderm impressions and charred remains, and with thin intercalations of siltstone packages.

**Unit 3** (3.7 m thick) is composed of a 65 cm thick package of red-brown dolomitic claystones in the lower part and a 1.5 m thick package of brown dolomitic marls in the middle part. 20 – 30 cm thick brown-green and grey-green marly limestones with fenestral structures occur in the uppermost part of the unit. Two beds of nodular limestones with single cystoids and gastropods, topped by intraformational breccias, are present in the uppermost part of the unit. The unit can be clearly distinguished from the overlying deposits due to the presence of limestone beds and fossils. An important feature is the absence of *Chimaerothyris dombrowiensis* and other fossils typical of the *Dąbrowa Horizon*.

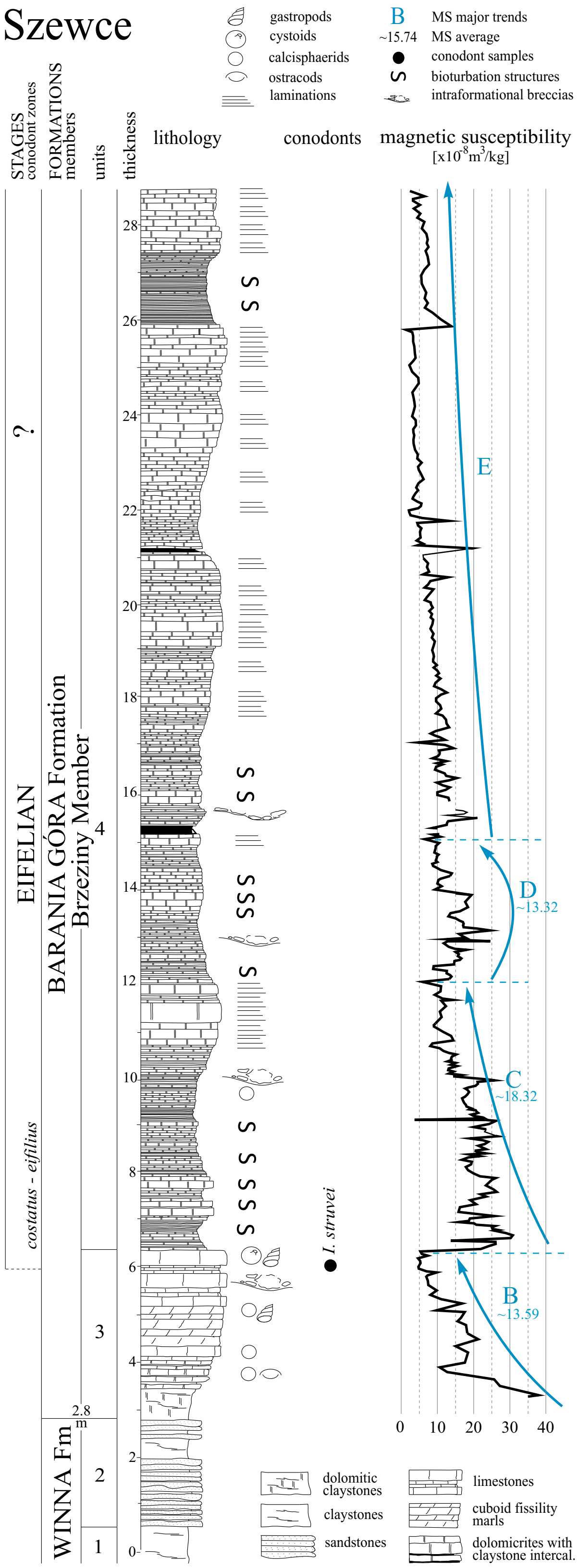
**Unit 4** (27 m thick) is composed of a cyclic succession of the following packages:

Package A (5–17 cm thick): brown dolomitic claystones;
Package B (0.6–4.2 m thick): thin-bedded greenish to violet dolomitic marls with rare horizons of bioturbation structures;
Package C (1.2–2.8 m thick): thin- to medium-bedded reddish to violet laminated marly dolomicrites with rare stromatolites.

The unit is divided into 5 ABC cyclothems, the thickness of which ranges between 2.25 and 6.45 m.

*Biostratigraphy*

Of the 15 dissolved samples only one was positive, yielding two specimens of the conodont *Icriodus struvei*. This taxon indicates an age not older than the upper part of the *Polygnathus costatus costatus* Zone of the Eifelian stage (Text-fig. 8). The conodont results and correlation are broadly discussed in Wójcik (2013 and in preparation).




Text-fig. 8. Lithological succession, conodonts and magnetic susceptibility in the Szewce section

*Magnetic susceptibility*

A collection of 429 samples derived from 7-cm intervals has been measured. Average MS is 13×$10^{-8}m^3/kg$. The MS curve is divided into 4 major asymmetric fluctuations/trends (Text-fig. 8):

**Trend B** is 3.5 m thick and embraces unit 3. Average MS is 13.59×$10^{-8}m^3/kg$,

**Trend C** is 5.7 m thick and embraces the lower part of unit 4. Average MS is 18.32×$10^{-8}m^3/kg$,

**Trend D** is 3.1 m thick and it ranges through the middle part of the unit 4. Average MS is 13.32×$10^{-8}m^3/kg$,

**Trend E** is 13.5 m thick and embraces the upper part of unit 4. Average MS is 8.02×$10^{-8}m^3/kg$.

The MS results and correlation are broadly discussed in Wójcik (2013 and in preparation).

**Kowala 1 borehole (Romanek and Rup 1990, Narkiewicz 1991)**

The location of the Kowala 1 borehole is 50°48′04.52″N, 20°33′35.96″E (central-western part of the Kielce Region; central part of the Gałęzice-Bolechowice Syncline). The core is deposited in the National Geological Archive in the Holy Cross Branch of the Polish Geological Institute – National Research Institute in Kielce. The core went through a complete, 993.6 m thick Devonian succession, reaching the Cambrian below (Racki 1985, Romanek and Rup 1990, Narkiewicz *et al*. 1990, Żakowa and Radlicz 1990, Nehring-Lefeld 1990, Turnau 1990, Narkiewicz 1991). The siliciclastics at the base of the Devonian succession are only 2 m thick and are followed by ca. 140 m thick Eifelian carbonates. Romanek and Rup 1990 (see also Narkiewicz 1991) subdivided the latter into a 97 m thick *Bioturbated Dolomites with Macrofossils Unit* (882.7–989.7 m depth), and a circa 30 m thick *Detritic and Laminated Dolomite Unit* (846.8–882.7 m depth). The first unit is composed mostly of bioturbated dolomicrites and dolomicrosparites with *Chondrites* isp. assemblages. Single brachiopods, corals, stromatoporoids and crinoids are present and are especially abundant in the upper part of the unit (884.0–889.9 m depth). The second unit is composed of flat-laminated dolomicrites and detritic dolomites with horizons of intraformational breccias and oolites.

**Dyminy-2 borehole (Tarnowska 1987, Filipiak 2011)**

The location of the Dyminy-2 borehole is 50°48′50.88″N, 20°38′33.61″E (central-western part of the Kielce Region; southern limb of the Dyminy Antycline). The core is deposited in the National Geological Archive in the Holy Cross Branch of the Polish Geological Institute – National Research Institute in Kielce. The 222 m deep Dyminy-2 borehole went through the Lower Devonian to Eifelian succession. Tarnowska (1987) divided the succession into 4 units: Lower Devonian siliciclastics, *Lower Dolomite Unit*, *Dąbrowa Horizon* (*Kielce Limestone*), and *Upper Dolomite Unit*. The *Lower Dolomite Unit* (137.7–109.0 m depth) is composed of sandy dolomites and dolosparites with crinoids, corals, stromatoporoids, brachiopods, ostracods and fishes. Above, unfossiliferous laminated dolomicrites with fenestral structures occur. The *Dąbrowa Horizon* (109.0–96.0 m depth) is composed of bioclastic limestones with ostracods, crinoids, brachiopods, gastropods, conodonts, tentaculoids, trilobites, foraminifers and fish remains. The *Upper Dolomite Unit* is built of dolomicrosparites and bioturbated dolomites in the lower part (96.0–45.0 m depth) and unfossiliferous dolomicrites with microbial lamination in the upper part (45.0–15.0 m depth). Filipiak (2011) identified the Eifelian *velatalangii* palynostratigraphic Zone within the *Dąbrowa Horizon*. He also indicates the position of the Emsian/Eifelian boundary interval at depths between 143.0 and 110.0 m.

### Szydłówek, Skrzetle, Dąbrowa D5 (Malec and Studencki 1988, Malec 1993, 2001, Tarnowska and Malec 1987)

The Emsian and Eifelian deposits in the north-western part of the Kielce Region were recognized in the Szydłówek road-cutting (Malec and Studencki 1988) and Skrzetle trench sections (Malec 1993, 2001), as well as in the Dąbrowa D5 (Tarnowska and Malec 1987) and Porzecze IG-5A (Kowalczewski 1979; Fijałkowska-Mader and Malec 2011) borehole cores. The sections exposed the *Pyrite-bearing and Sideritic Claystone Member*, which overlies the Winna Formation. The deposits are black to yellow in colour in the lower part, and red and brown-red at the top of the unit. Siderite nodules, limonite breccias, and siltstone and sandstones intercalations occur frequently, but the carbonate content is also significant. Rare brachiopods, including *Chimaerothyris dombrowiensis*, as well as crinoids and tentaculoids occur. Foraminifers (*Amphitremoida*, *Lagenammina*, *Saccammina*, *Hyperammina* and different morphotypes of *Webbinelloidea*), ostracods, and conodonts (*Icriodus corniger retrodepressus* group, *I. corniger corniger* and *I. corniger* cf. *leptus*) are also present. In the Dąbrowa D5 borehole core, the *Pyrite-bearing and Sideritic Claystone Member* is overlain by the *Dąbrowa Horizon*, composed of few metres of predominantly micritic and grained limestones. It yielded abundant *Chimaerothyris dombrowiensis*, algae, ostracods, foraminifers, and rare conodonts (*Icriodus werneri*). The *Dąbrowa Horizon* is not present in the Szydłówek and Skrzetle sections, in which the pyrite-bearing and sideritic claystones are overlain by dolomites. Single brachiopods, tentaculoids, corals and conodonts, as well as horizons of bioturbation structures occur within the lower part of the dolomitic succession.

### Porzecze IG-5A borehole

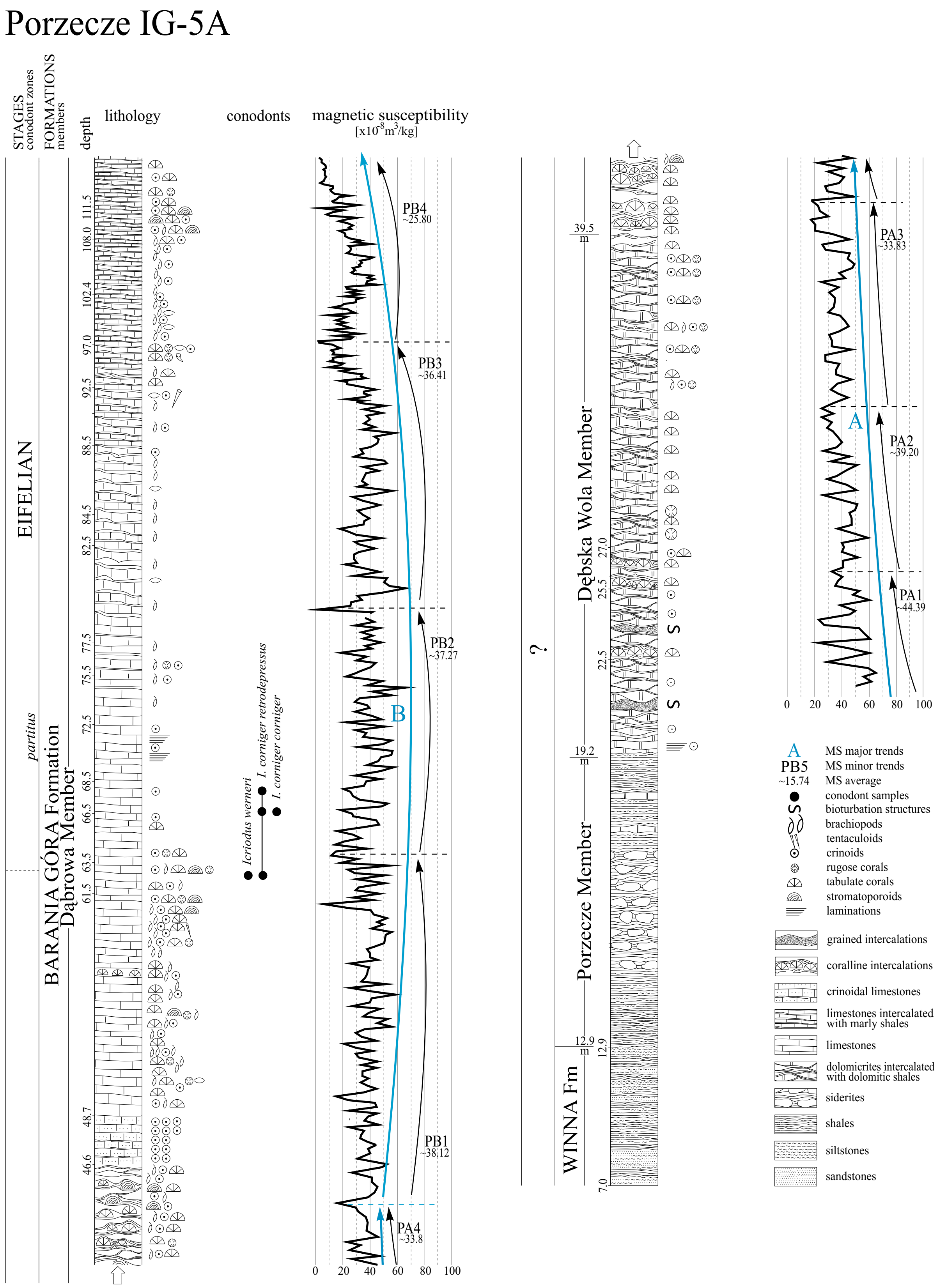
The location of the Porzecze IG-5A borehole is 50°56′56.96″N, 20°30′34.64″E (north-western part of the Kielce Region; northern limb of the Miedziana Góra Anticline). The core is deposited in the National Geological Archive in the Holy Cross Branch of the Polish Geological Institute – National Research Institute in Kielce. The borehole cored the most complete Emsian–Eifelian succession in the north-western part of the Kielce Region. A detailed lithological description can be found in Kowalczewski (1979; see also Fijałkowska-Mader and Malec 2011). In the present paper this description is supplemented by magnetic susceptibility measurements (Text-fig. 9).

*Lithology*

The succession of the Porzecze IG-5A borehole is 66 m thick (Text-fig. 9). Fijałkowska-Mader and Malec (2011) divided it into 4 lithological units: Upper Sandstone Member of the Winna Formation (7.0–12.9 m, 5.1 m thick); *Pyrite-bearing and Sideritic Claystone Member* (12.9–19.2 m, 5.4 m thick); *Dolomite Member* (19.2–39.5 m, 15.6 m thick); and *Dąbrowa Limestone Member* (39.5–116.5 m, 33.8 m thick).

*Biostratigraphy*

The stratigraphy of the Porzecze IG-5A section was presented by Malec (1979, 1980, 1984, 1990, 1992 and 1993) and summarized in Fijałkowska-Mader and Malec (2011). Accordingly, the boundary between the Lower and Middle Devonian was located within the Dąbrowa Member, at 62.7 m depth, based on the first appearance of the conodont *Icriodus corniger retrodepressus*. However, it should be noted that no conodonts were recorded below this depth. This long barren interval may therefore easily represent Eifelian age as well.




Text-fig. 9. Lithological succession (after Kowalczewski 1979), conodonts (after Fijałkowska-Mader and Malec 2011) and magnetic susceptibility (this work) in the Porzecze IG-5A borehole core

*Magnetic susceptibility*

A collection of 553 samples derived from 20-cm intervals has been measured. Average MS is 36.08× $10^{-8}m^3/kg$. Two major MS fluctuations/trends (A–B), divided into minor fluctuations, are identified (Text-fig. 9):
**Trend A** ranges from 21.3 m to 45.1 m depth and is divided into 4 minor fluctuations:

PA1: 21.3–26.6 m depth, average MS 44.39 ×$10^{-8}m^3/kg$,
PA2: 26.6–32.8 m depth, average MS 39.20×$10^{-8}m^3/kg$,
PA3: 32.8–40.5 m depth, average MS 33.83×$10^{-8}m^3/kg$,
PA4: 40.5–45.1 m depth, average MS 33.80×$10^{-8}m^3/kg$;

**Trend B** ranges from 45.1 m to 116.5 m depth and is divided into 4 minor fluctuations:

PB1: 45.1–64.0 m depth, average MS 38.12×$10^{-8}m^3/kg$,
PB2: 64.0–79.5 m depth, average MS 37.27×$10^{-8}m^3/kg$,
PB3: (79.5–97.1 m depth, average MS 36.41×$10^{-8}m^3/kg$,
PB4: 97.1–116.5 m depth, average MS 25.80×$10^{-8}m^3/kg$.

The MS results and correlation are broadly discussed in Wójcik (2013 and in preparation).

**Jurkowice Quarry**

The section is located in the south-eastern part of the Kielce Region: 50°37′39″N, 21°21′26″E (Pl. 6). Eifelian and Givetian carbonates are exposed in the Jurkowice and Budy quarries. The Devonian of the area was intensively studied (Czermiński and Ryka 1962; Pajchlowa and Stasińska 1965; Kaźmierczak 1971; Baliński 1973; Olempska 1979; Narkiewicz *et al*. 1981; Narkiewicz 1991; Racki 1993; Racki and Soboń-Podgórska 1993; Preat and Racki 1993; Hajłasz 1993; Zdanowski 1997), however, most of the studies were dedicated to the Givetian. The Eifelian was reported by Narkiewicz *et al*. (1981) and Zdanowski (1997). According to them, a ca. 100 m thick Eifelian succession, exposed in the Jurkowice quarry, may be subdivided into a *Fossiliferous and Bioturbated Dolomicrites and Dolosparites Unit* at the base (43 m thick) and a *Unfossiliferous Crypto- and Finecrystalline Dolomites Unit* at the top (>58 m thick). Zdanowski (1997) documented the early Eifelian age of the lower unit (*Polygnathus costatus costatus* conodont Zone).

The Eifelian carbonates currently exposed in the Jurkowice quarry represent approximately the same stratigraphical interval as documented in the papers referred to above. The section available at present is located ca. 150 m north of the quarrying front as it was in 1997. A new lithological log, magnetic susceptibility measurements and sedimentological investigations were provided in 2011 and 2012. The succession has been divided into six lithological units (Text-fig. 10). 120 lithological samples, including 45 polished slabs and 27 thin sections, as well as 766 magnetic susceptibility measurements were analyzed in the section.

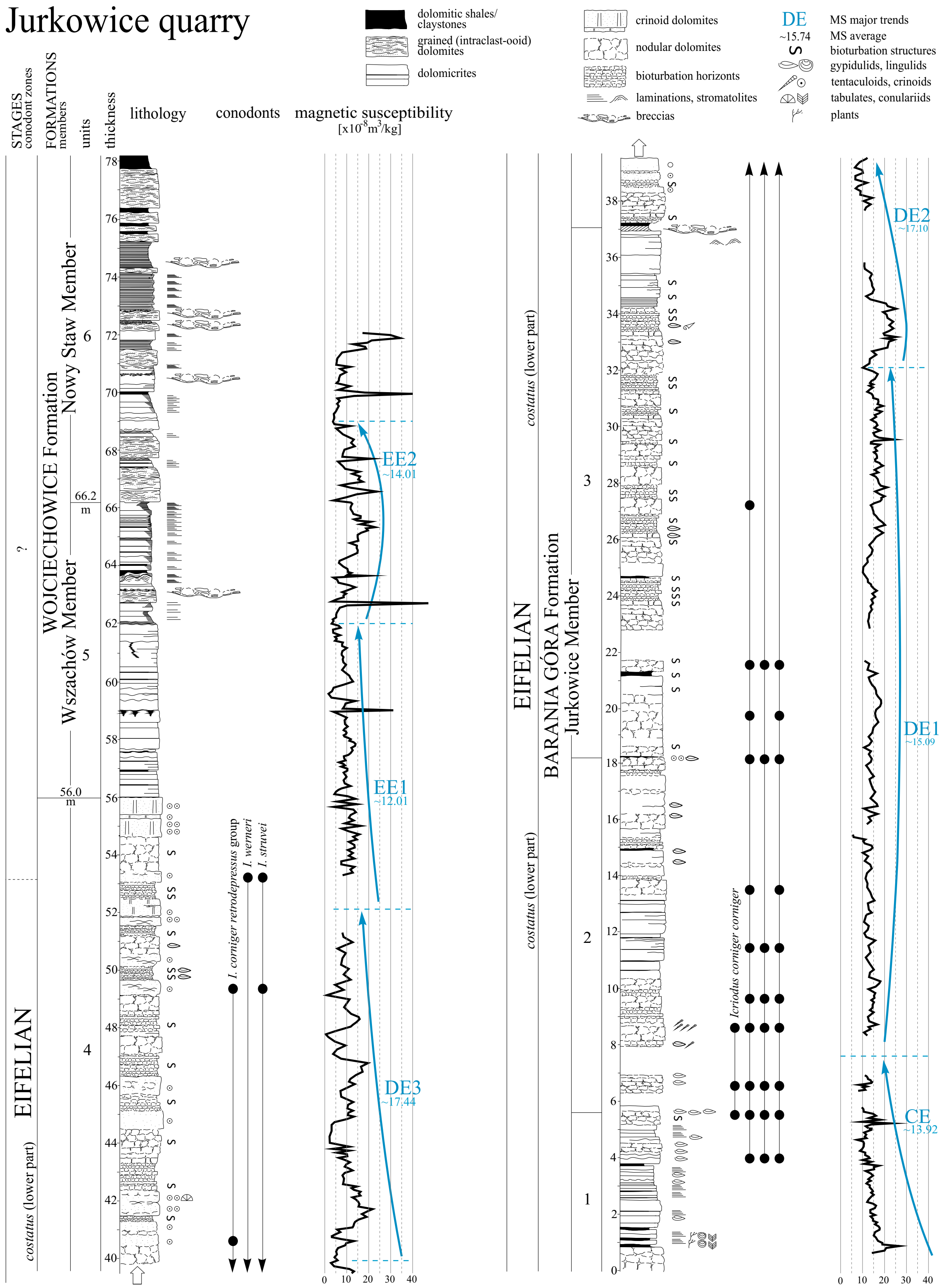
*Lithology*

**Unit 1** (5.6 m thick) is exposed in the oldest part of the quarry. Thin- and medium-bedded grey laminated dolomicrites occur in the lowermost part of the succession, just several metres above the sandstones of the Winna Formation. They are intercalated by thin packages of dolomitic shales. Horizons of bioturbation structures (*Chondrites* isp.) appear on the surfaces, as well as within the beds. Numerous conulariids, plants remains and molluscs occur within the grained laminae/strips. Brachiopods (*Gypidula* sp.) are locally abundant, building monospecific lumachelles.

**Unit 2** (12 m thick) is composed of 20–50 cm thick beds of brown-grey dolomicrites and fine-crystalline dolomites with wavy interbedding. Thin laminae of black dolomitic shales occur on some surfaces. Thin tentaculoid lumachelles with detritus of bryozoans, crinoids and gastropods appear at the top of some beds, while numerous brachiopods (*Gypidula*) occur at the tops of others. *Chondrites* isp. concentrations with single *Planolites* isp. are common and constitute characteristic, blue-weathering 15 cm thick bioturbation horizons in the upper part of the unit. Detritus of shelly fossils occurs throughout.

**Unit 3** (18.8 m thick) is composed of up to 2.5 m thick beds of grey-blue weathering nodular dolomicrites intercalated by strongly bioturbated horizons. The nodules are more or less isolated, up to 5 cm in diameter, and surrounded by residual laminae/strips of clay minerals. In some parts, the nodular texture changes into wavy/irregular bedding. Single *Gypidula* sp. appear on the upper surfaces. The bioturbation horizons reach a thickness of up to 40 cm and contain a dense and compact network of *Chondrites* isp. burrows and rare *Planolites* isp. Rare laminae of detritic material with crushed crinoids and brachiopods also appear. The burrows penetrate the rock completely, resulting in the bed being subdivided into minor irregular more or less isolated sub-beds. The nodular structure disappears in the upper part of the unit and the dolomite beds become more regular and homogeneous. A 30 cm thick regolith horizon covered by a distinctive (clearly visible in the quarry) 20 cm thick package of orange clays occurs in the topmost part of the unit.

**Unit 4** (18.5 m thick) is composed of up to 2 m thick beds of yellow-weathering nodular dolomites with bioturbation horizons. There are irregular lenses of homo-




Text-fig. 10. Lithological succession, conodonts (after Zdanowski 1997, revised) and magnetic susceptibility in the Jurkowice quarry section geneous crinoid dolomites with *Thamnopora* sp. detritus. Three (up to 2 m) thick homogeneous beds of crinoid dolomites occur at the top of the unit.

**Unit 5** (10.3 m thick) is composed of dark, micritic and bituminous dolomicrites. The absence of bioturbation structures and shelly fossils, and the presence of a distinct horizon of stromatolitic domes, are characteristic features. Medium-bedded dark micritic dolomites with flat to wavy surfaces coated with iron crusts, intercalated by black dolomitic shales predominate in the lower part of the unit. Flat laminations are common in this part. A continuous bed of stromatolites, with 40 cm domes, and with irregular internal laminations, occur in the upper part. A package of dolomitic shales compensates the dome-relief, and a 2.5 m thick package of dark dolomicrites with flat laminations occur at the top.

**Unit 6** is composed of a cyclic succession of the following lithological packages:

Package A: thick-bedded yellowish grained dolomites with flaser laminations and erosional lower surfaces. The flaser lamination is expressed as several cm long micritic, more or less continuous laminae/strips within a grained, intraclast-ooid matrix. The micritic laminae/strips build small stromatolitic domes at the tops of the grained beds;

Package B: green micritic dolomites with flat laminations and intraformational breccia horizons (10–30 cm thick);

Package C: green to yellowish dolomitic shales (up to 10 cm thick);

Package D: variegated siltstones (up to 5 cm thick).

The packages are arranged into 8 ABCD cyclothems, the thickness of which ranges between 1.0 and 1.8 m. The uppermost part of the Jurkowice succession is composed of similar deposits, with a domination of variegated (greenish) dolomitic shales with breccia horizons. The deposits are strongly folded and thrust into particular blocks, interpreted as collapse breccias (see Narkiewicz 1991).

*Biostratigraphy*

Zdanowski (1997) collected 508 conodonts from 14 samples derived from the lower part of the succession (herein units 1 to 4). The material has been revised by the author (Wójcik 2013 and in preparation), who identified the following taxa: *Icriodus corniger corniger, I. c. retrodepressus* group (including. *I. c. retrodepressus* Bultynck 1970 and *I*. n. sp. Narkiewicz 2013)*, I. werneri* and *I. struvei*. The assemblage indicates the lower part of the *Polygnathus costatus costatus* Zone (Text-fig. 10). No conodonts have been obtained from units 5 and 6.

*Magnetic susceptibility*

A collection of 766 samples from 10-cm intervals has been measured. Average MS is $14.99\times10^{-8}m^3/kg$. Six mjor MS trends (CE – EE2), subdivided into minor fluctuations, are identified (Text-fig. 10):

**Trend CE** is 7 m thick and ranges from unit 1 to the lower part of unit 2. Average MS is $13.92\times10^{-8}m^3/kg$;

**Trend DE1** is 25 m thick and ranges from the upper part of unit 2 to the lower part of unit 3. Average MS is $15.09\times10^{-8}m^3/kg$;

**Trend DE2** is 9 m thick and ranges from the upper part of unit 3 to the lower part of unit 4. Average MS is $17.1\times10^{-8}m^3/kg$;

**Trend DE3** is 12 m thick and embraces the middle part of unit 4. Average MS is $17.44\times10^{-8}m^3/kg$;

**Trend EE1** is 9 m thick and ranges from the upper part of unit 4 to the lower part of unit 5. Average MS is $12.01\times10^{-8}m^3/kg$;

**Trend EE2** is 7 m thick and ranges from the upper part of unit 5 to the lower part of unit 6. Average MS is $14.01\times10^{-8}m^3/kg$.

The MS results and correlation are broadly discussed in Wójcik (2013 and in preparation).

**Wszachówka River valley**

The section is located in the eastern-central part of the Kielce Region: 50°46′9.1″N, 21°7′29″E (Pl. 6). The lowermost part of the Devonian carbonate succession crops out south of the Winna quarry, along the Wszachówka River valley. An only partially exposed, ca. 50 m thick succession, was studied in 2012. The succession has been divided into 3 lithological units (Text-fig. 11). 60 lithological samples, 45 polished slabs and 22 thin sections were analyzed.

*Lithology*

**Unit 1** (7.5 m thick) is composed of 10–30 cm thick beds of dark sandy dolomicrites with corals, algae, crinoid remains and bioturbation structures. Fossils are scattered within a marly matrix. Rare thin beds of dolomicrites with fenestral structures appear in the upper part of the unit.

**Unit 2** (30 m thick) is composed of thin- to medium-bedded dark dolomicrites with abundant *Chondrites*-like bioturbation structures.

**Unit 3** (10 m thick) is composed of thin beds of dolomicrites. *Chondrites* isp. and single *Planolites* isp. appear on the upper surfaces together with single tentaculoids and gypidulids. Rare thin laminae of *Gypidula* lumachelles also occur.

*Biostratigraphy*

Two specimens from the *Icriodus corniger retrodepressus* group and 5 specimens of *Icriodus struvei* have been obtained from 8 studied conodont samples. They belong to two conodont zones: *Polygnathus costatus partitus* Zone and *P. c. costatus* Zone, with the boundary located probably within unit 2 (Text-fig. 11). The conodont results and correlation are broadly discussed in Wójcik (2013 and in preparation).

**Wszachów quarry**

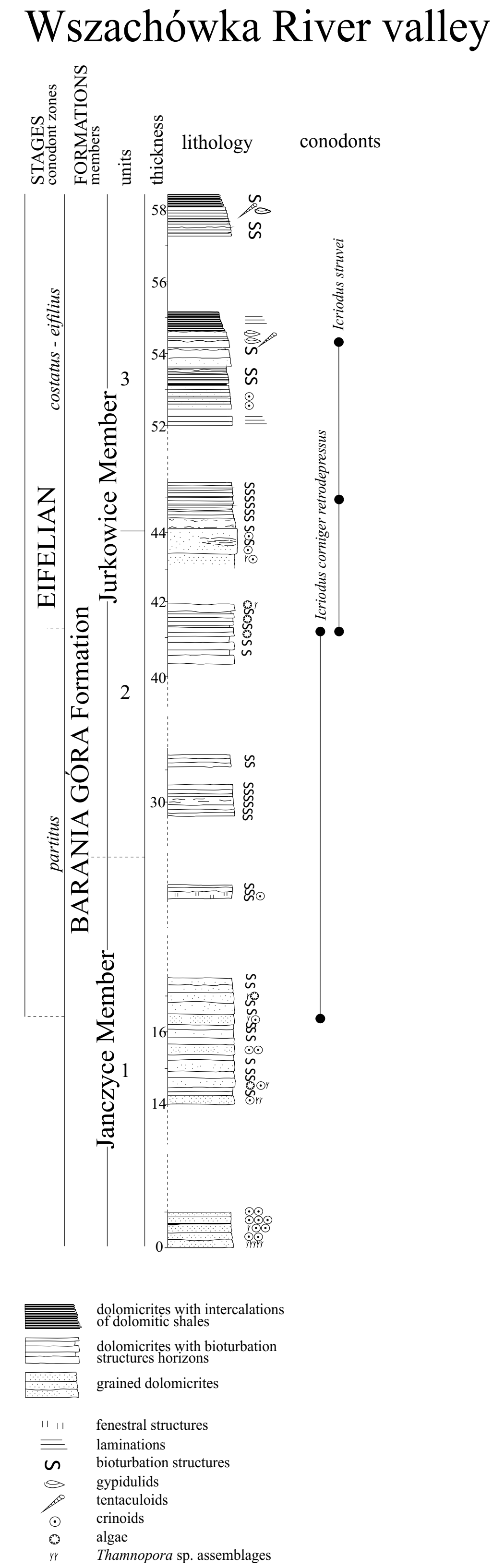
The section is located in the eastern-central part of the Kielce Region: 50°45′47.40″N, 21°8′39.90″E (Pl. 6). The Wszachów quarry is situated near the village of Krowianka, east of the town of Łagów and south of the Wszachówka River. The quarry exposes the lower part of Devonian dolomites (below the Kowala Formation). A complete succession is exposed along the western wall of the quarry, on the 2nd and 3rd quarrying levels. A 78-m thick succession was recognized in 2012. The succession has been divided into four units (Text-fig. 12 and Pl. 4). 120 lithological samples, 30 polished slabs, 16 thin sections, 25 conodont samples and 481 magnetic susceptibility measurements were investigated.

*Lithology*

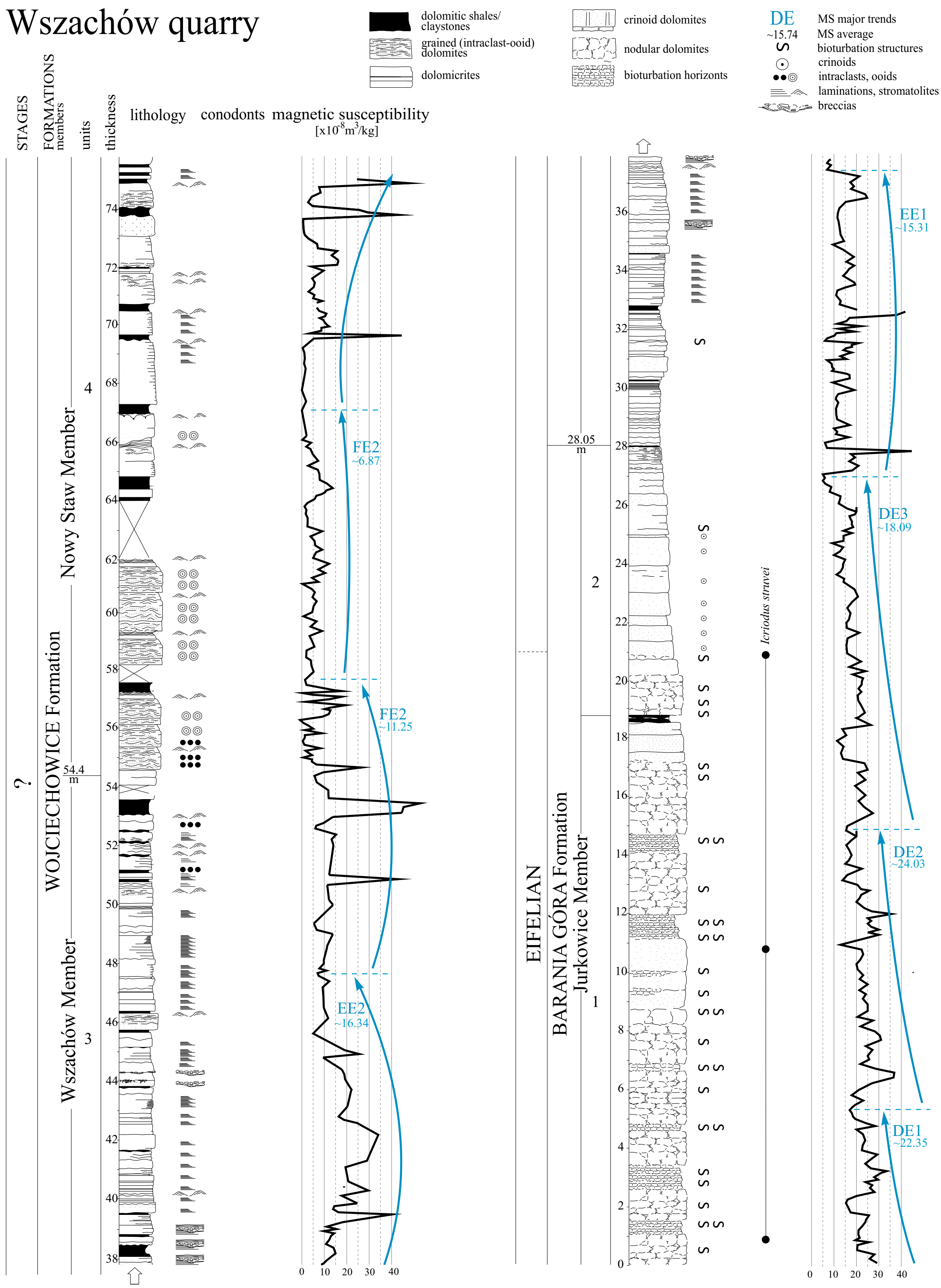
**Unit 1** (18.5 m thick) is composed of thick beds of dolomicrites and fine-crystalline dolomites with a nodular texture. Nodules, up to a dozen or so cm in diameter, are more or less isolated and surrounded by thin black clay smudges. The 1.0–2.2 m thick beds are separated by 20 cm thick horizons of *Chondrites*-dominated bioturbation structures. A distinctive, 15 cm thick package of black shales occurs at the top.

**Unit 2** (9.3 m thick) is composed of thick beds of fine-crystalline homogeneous dolomites with single crinoids.

**Unit 3** (22.5 m thick) is composed of deposits characterized by a black colour and the absence of fossils and bioturbation structures. Four lithological packages in a cyclic succession can be distinguished:




Text-fig. 11. Lithological succession and conodonts in the Wszachówka River valley near Łagów



Text-fig. 12. Lithological succession, conodonts and magnetic susceptibility in the Wszachów quarry section

Package A: medium-bedded dolomicrites with flat lamination intercalated by black dolomitic shales (up to 3 m thick). Laminations are regular, flat and continuous;
Package B: thick-bedded grained (intraclast) dolomites with erosional lower surfaces. They are characterized by a flaser texture expressed by alternating micritic matrix and 2–5 cm thick grained (intraclast) laminae/strips;
Package C: medium-bedded laminated dolomicrites with stromatolitic domes at the tops of the beds. Irregular, wavy lamination and thin intraformational breccia horizons occur within;
Package D: yellowish to greenish variegated sandy siltstones and claystones a dozen or so cm thick.

The described packages are arranged into 8 ABCD cyclothems, the thickness of which ranges between 2 and 4.5 m.

**Unit 4** (22 m thick) is composed of a cyclic succession of the following lithological packages:
Package A: black dolomicrites with (occasional) flat lamination (dozen or so cm thick);
Package B: light-grey grained (ooid-intraclast) dolomites with flaser lamination and erosional lower surfaces. 2–5 cm thick laminae/strips of ooid and intraclast dolosparites cut the dolomicritic matrix;
Package C: grey-green dolomicrites with wavy laminations, stromatolites and intraformational breccias;
Package D: greenish to yellowish dolomitic siltstones and claystones with sparry laminae/lenses.

The described deposits are arranged into 5 ABCD cyclothems, the thickness of which ranges between 2.4 and 3.4 m. This cyclicity disappears in the middle part of the unit, in which a thick package of laminated dolomicrites appear. Grained dolomites reappear in the upper part. Distinctive beds of white dolomitic oosparites occur at the top of the section.

*Biostratigraphy*

Only 3 specimens of *Icriodus struvei* have been obtained from 3 samples (25 dissolved). They indicate the *Polygnathus costatus costatus* Zone or younger (Text-fig. 17). The conodont results and correlation are broadly discussed in Wójcik (2013 and in preparation).

*Magnetic susceptibility*

A collection of 481 samples derived from 15-cm intervals has been measured. Average MS is 14.77×$10^{-8}m^3/kg$. Seven major MS fluctuations (DE1 – FE2) are identified (Text-fig. 14):

**Trend DE1** is 5.2 m thick and embraces the lower part of unit 1. Average MS is 22.35×$10^{-8}m^3/kg$;
**Trend DE2** is 9.6 m thick and embraces the middle part of unit 1. Average MS is 24.03×$10^{-8}m^3/kg$;
**Trend DE3** is 12.1 m thick and ranges from the upper part of unit 1 to the upper part of unit 2. Average MS is 18.09×$10^{-8}m^3/kg$;
**Trend EE1** is 10 m thick and ranges from the uppermost part of unit 2 to the lower part of unit 3. Average MS is 15.31×$10^{-8}m^3/kg$;
**Trend EE2** is 10.2 m thick and embraces the middle part of unit 3. Average MS is 16.34×$10^{-8}m^3/kg$;
**Trend FE1** is 10 m thick and ranges from the upper part of unit 3 to the lower part of unit 4. Average MS is 11.25×$10^{-8}m^3/kg$;
T**rend FE2** is 9.15 m thick and embraces the middle part of unit 4. Average MS is 6.87×$10^{-8}m^3/kg$.

The MS results and correlation are broadly discussed in Wójcik (2013 and in preparation).

**Winna quarry**

The location of the Winna section is 50°46′22.55″N, 21°7′40.75″E (Pl. 6). The Winna quarry is located between the villages of Nowy Staw, Winna and Wszachów, on the northern side of the Wszachówka River. Devonian dolomites belonging to the upper part of the *Unfossiliferous Crypto and Fine-crystalline Dolomites Unit* of Narkiewicz and Olkowicz-Paprocka (1981) and to the lower part of the Kowala Formation (Narkiewicz 1991) are exposed in the quarry. A complete succession crops out along the western wall on the 2nd quarrying level. A 42 m thick lower part of the succession was studied in 2011. The succession has been subdivided into 5 lithological units (Text-fig. 13 and Pl. 5). 70 lithological samples, 30 polished slabs, 21 thin sections, 12 conodont samples and 335 magnetic susceptibility measurements were investigated.

*Lithology*

**Unit 1** (15 m thick) is composed of a cyclic succession of the following lithological packages:
Package A: thick-bedded light grey grained (oolite and intraclast) dolomites with flaser textures. All lower surfaces have an erosional character. In the lower part of the unit grained dolomites constitute separate beds; in the upper part, they occur as lenses within the dolomicrites. Flaser textures are expressed as grained (ooid-intraclast) intercalations within the dolomicritic matrix.
Package B: green-grey dolomicrites with wavy lamination and stromatolites. The wavy lamination occurs

within internal structures of the stromatolitic domes, and only in the external part are their shapes parallel to the domes. Numerous horizons and lenses of intraformational breccias occur within the laminites.

Package C: grey and grey-green dolomicrites with flat lamination;

Package D: yellow to green-yellow sandy-muscovite dolomitic siltstones and sparry laminae/strips (evaporation pseudomorphs).

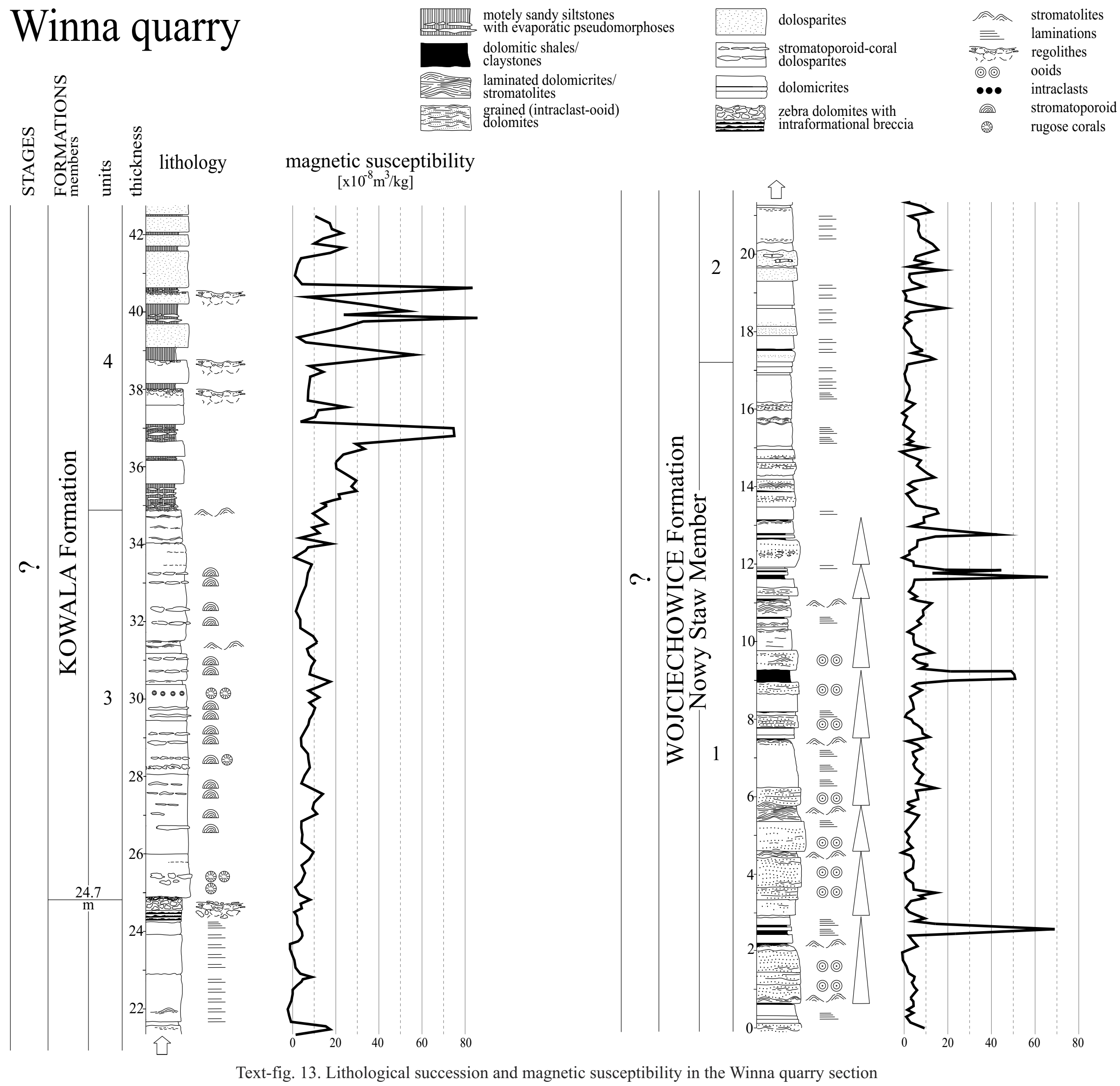
The described deposits are arranged into 11 ABCD cyclothems with an average thickness of ca. 1 m.

**Unit 2** (7.8 m thick) is composed of 50–100 cm thick beds of green-grey dolomicrites with subtle flat lamination. A 50 cm thick bed of rhythmically laminated dolomite, a 40 cm thick nodular dolomicrite (bioturbation structures) and a 30 cm thick intraformational breccia/regolith with an iron coat occur at the top of the unit.

**Unit 3** (11.3 m thick) is composed of 70 to 250 cm thick beds of fine- to medium-crystalline dolosparites. Numerous remnants of stromatoporoids and corals occur, concentrating in flat horizons within the beds.

**Unit 4** (9.6 m thick) is composed of blue-green weathering, 10–60 cm thick packages of sandy dolomitic siltstones with sparry laminae/strips intercalated by thick beds of dolosparites.

**Unit 5** is composed of a thick succession of thick-bedded dolosparites with stromatoporoid and coral remnants.




Text-fig. 13. Lithological succession and magnetic susceptibility in the Winna quarry section

*Biostratigraphy*

No conodonts were found in the 12 dissolved samples.

*Magnetic susceptibility*

A collection of 355 samples derived from 12.5 cm intervals has been used for MS measurements. No evident MS fluctuations are found (Text-fig. 13). The MS results and correlation are broadly discussed in Wójcik (2013 and in preparation).

**Janczyce-1 borehole**

The location of the Janczyce-1 borehole is 50°45′38.27″N, 21°13′28.96″E (central-eastern part of the Kielce Region). The core is deposited in the National Geological Archive in Halinów. The 1251.6 m deep Janczyce-1 borehole was situated in the Piotrów Syncline, east of the town of Łagów. A report on the complete Devonian succession was published by Narkiewicz and Olkowicz-Paprocka (1983) and Narkiewicz (1991). The lithologies of the interval between 1033.0 and 1251.6 m have been described and magnetic susceptibility measurements have been made (Text-fig. 14).

*Lithology*

**Unit 1** (depth: 1246.0–1251.6 m) is composed of light grey fine-grained quartz sandstones with flat bedding intercalated by bioturbated horizons of wavy-laminated dolomitic siltstones/heterolits. The upper boundary has been defined arbitrarily at the level where the grain-supported framework disappears, and quartz grains become suspended within the dolomitic matrix.

**Unit 2** (depth: 1246.0–1203.0 m; 37 m thick) is composed of a cyclic succession of the following packages:

Package A: 20 to 150-cm thick beds of thamnoporoid dolomites with 30–60 cm thick intercalations of intraclast dolomites with minor contributions of coral and crinoid detritus;

Package B: up to a few metres thick dolomicrites. Wavy laminations and/or nodular structures occur in the two lowermost cyclothems. Very thin intercalations of intraclast grained dolomites appear.

Package C: 2 to 4 m thick grey-green dolomicrites with fenestral fabrics. The fabric is probably connected with a primary laminated texture. Small stromatolitic domes appear in the topmost part of some of the packages.

The packages are arranged into 5 ABC cyclothems with thicknesses of 6 m, 9 m, 13.5 m, 3.5 m and 5 m respectively.

**Unit 3** (depth: 1203.0–1182.2 m; ca. 20 m thick). It is represented by interbedded packages of nodular dolomicrites and bioturbated horizons with grained laminae. The proportions of these deposits varies along the succession. In the lower part (depth: 1203.0–1194.8 m), structureless or subtly laminated dolomicrites predominate. Wavy-laminated dolomicrites occur above. Single laminae of intraclast grained dolomites with single brachiopod and crinoid remains also occur. The degree of bioturbation increases in the upper part of the unit (depth: 1194.8–1182.2 m), in which a fine nodular texture is common. *Chondrites*-dominated structures concentrate in individual horizons. Single grained laminae, dominated by crinoid and brachiopod detritus occur in this part of the unit.

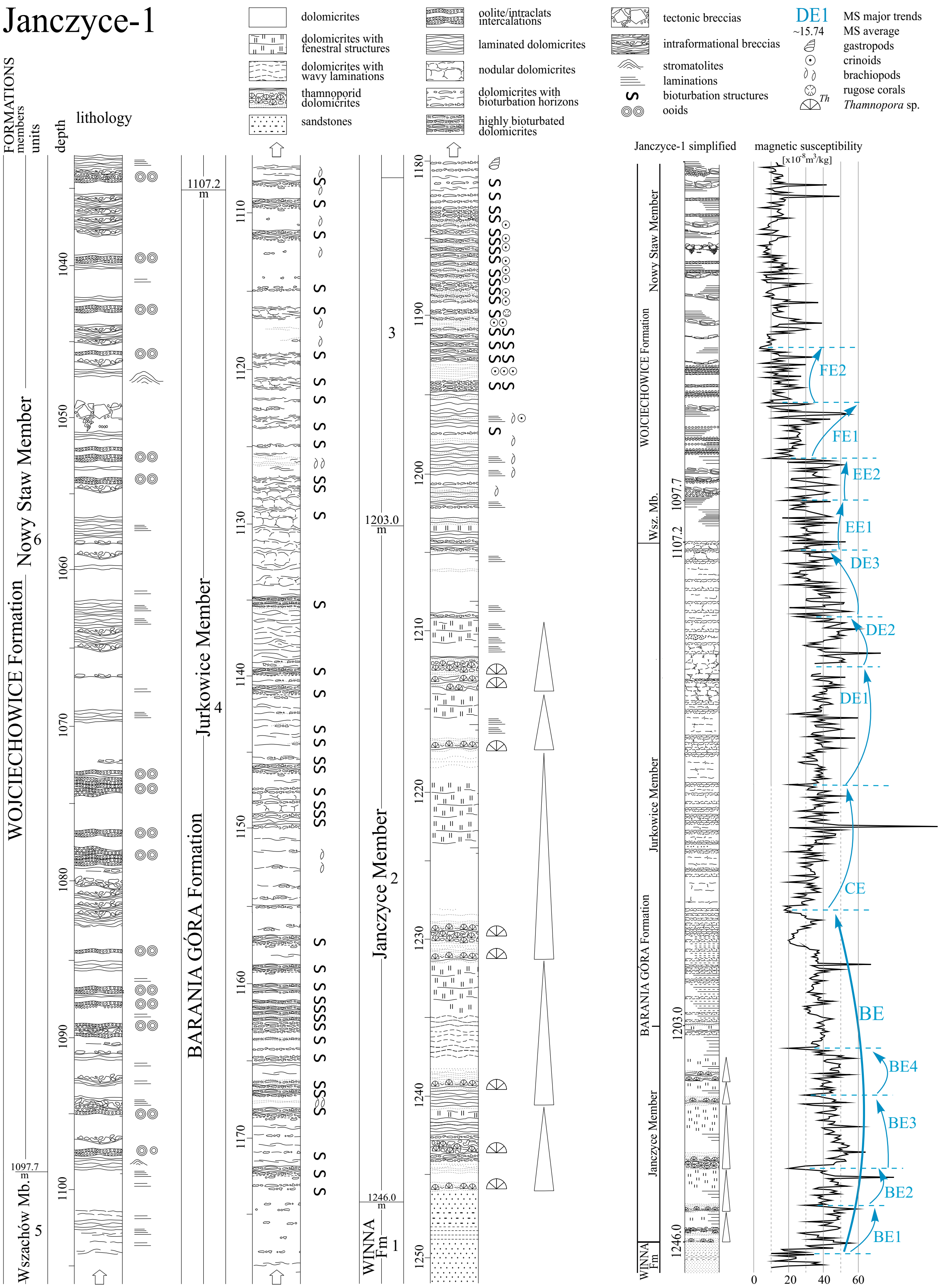
**Unit 4** (depth: 1182.2–1097.7 m; ca. 70 m thick). The lower part of the unit (depth: 1182.2–1155.0 m) is dominated by up to a few metres thick packages of dolomicrites with wavy lamination interbedded with up to 1 m thick bioturbation horizons (*Chondrites*-dominated). Rare laminae of brachiopod-crinoid remains occur, as well as monospecific brachiopod lumachelles (depth 1167.8 m). Blue-weathering nodular dolomicrites occur in the upper part of the unit (depth: 1155.0–1107.2 m). The more or less isolated nodules are emphasized by black clay laminae/strips. In some places, especially in the upper part, the nodular structure disappears or becomes more regular to form a flat lamination. The last fossils, including shelly fossils and ichnofossils, occur there.

**Unit 5** (depth 1107.2–1097.7 m; 10.5 m thick) is composed of dark grey dolomicrites devoid of fossils and bioturbation structures. Subtle flat lamination appears in the upper part of the unit. It is more evident at the top, where a 15 cm thick stromatolitic dome occurs.

**Unit 6** (depth: 1097.7–1023.0 m; 74 m thick) is composed of dolomicrites with subtle lamination and thick beds of intraformational breccias and grained dolomites. The grained dolomites occur in up to 1.5 m thick beds. Flaser wavy lamination, expressed as alternating micritic and intraclast-ooid grained laminae, occur within the unit. In the middle part of the succession (depth: 1097.7–1079.7 m), several packages of 1–1.5 m thick oolitic dolomites are clearly visible.

*Magnetic susceptibility*

A collection of 937 samples derived from 25-cm intervals has been measured. Average MS is 33.34× $10^{-8}m^3/kg$. Nine major MS fluctuations/trends (BE – FE2) are identified (Text-fig. 14):




Text-fig. 14. Lithological succession and magnetic susceptibility in the Janczyce-1 borehole core

**Trend BE** ranges from 1246.0 to 1180.0 m depth, average MS is $42.48\times10^{-8}m^3/kg$. The trend is subdivided into 4 minor MS fluctuations: BE1 – BE4;
**Trend CE** ranges from 1180.0 to 1155.25 m depth, average MS is $36.37\times10^{-8}m^3/kg$;
**Trend DE1** ranges from 1155.25 to 1132.5 m depth, average MS is $48.6\times10^{-8}m^3/kg$;
**Trend DE2** ranges from 1132.5 to 1123.0 m depth, average MS is $24.03\times10^{-8}m^3/kg$;
**Trend DE3** ranges from 1123.0 to 1109.5 m depth, average MS is $38.3\times10^{-8}m^3/kg$;
**Trend EE1** ranges from 1109.5 to 1099.5 m depth, average MS is $33.68\times10^{-8}m^3/kg$;
**Trend EE2** ranges from 1099.5 to 1091.0 m depth, average MS is $33.39\times10^{-8}m^3/kg$;
**Trend FE1** ranges from 1091.0 to 1080.0 m depth, average MS is $27.06\times10^{-8}m^3/kg$;
**Trend FE2** ranges from 1080.0 to 1069.5 m depth, average MS is $15.69\times10^{-8}m^3/kg$;

The MS results and correlation are broadly discussed in Wójcik (2013 and in preparation).

**Zaręby 2 borehole (Tarnowska 1976, Malec 1984b, Fijałkowska-Mader and Malec 2011)**

The location of the Zaręby 2 borehole is 50°47′02.79″N, 21°02′47.23″E (central part of the Kielce Region; Łagów Syncline). The core is deposited in the National Geological Archive in Leszcze. The 1375 m deep Zaręby 2 borehole cored the Lower Devonian – Eifelian succession. Tarnowska (1976) divided the clastic part of the succession into 4 lithological units: *Lower Siltstone Member with Volcanites* (1146.4–1218.2 m depth); *Middle Sandstone Member* (1131.4–1146.4 m depth), *Upper Siltstone Member with Volcanites* (1089.7–1131.4 m depth), and *Upper Sandstone Member* (1080.1–1089.7 m depth). The first unit is defined as the Haliszka Formation, the remaining three belong to the Winna Formation (Fijałkowska-Mader and Malec 2011). The siliciclastics are overlain by sandy dolomites with remnants of corals and stromatoporoids (1075.6–1080.1 m depth), followed by the *Eifelian Dolomites*. Malec (1984b) and Fijałkowska-Mader and Malec (2011) noticed the presence of carbonate beds with Eifelian conodonts within the upper part of the *Upper Siltstone Member*.

## LITHOSTRATIGRAPHY

Based on the geological documentation presented, a formal lithostratigraphical scheme for the upper Emsian and lower Eifelian of the Kielce Region of the HCM is proposed herein. The lithostratigraphical units are defined (Text-figs 15 and 16) according to "Polskie Zasady Stratygrafii" (*Polish Stratigraphical Code*) defined by Racki and Narkiewicz (2006).

### BARANIA GÓRA DOLOMITE AND LIMESTONE FORMATION

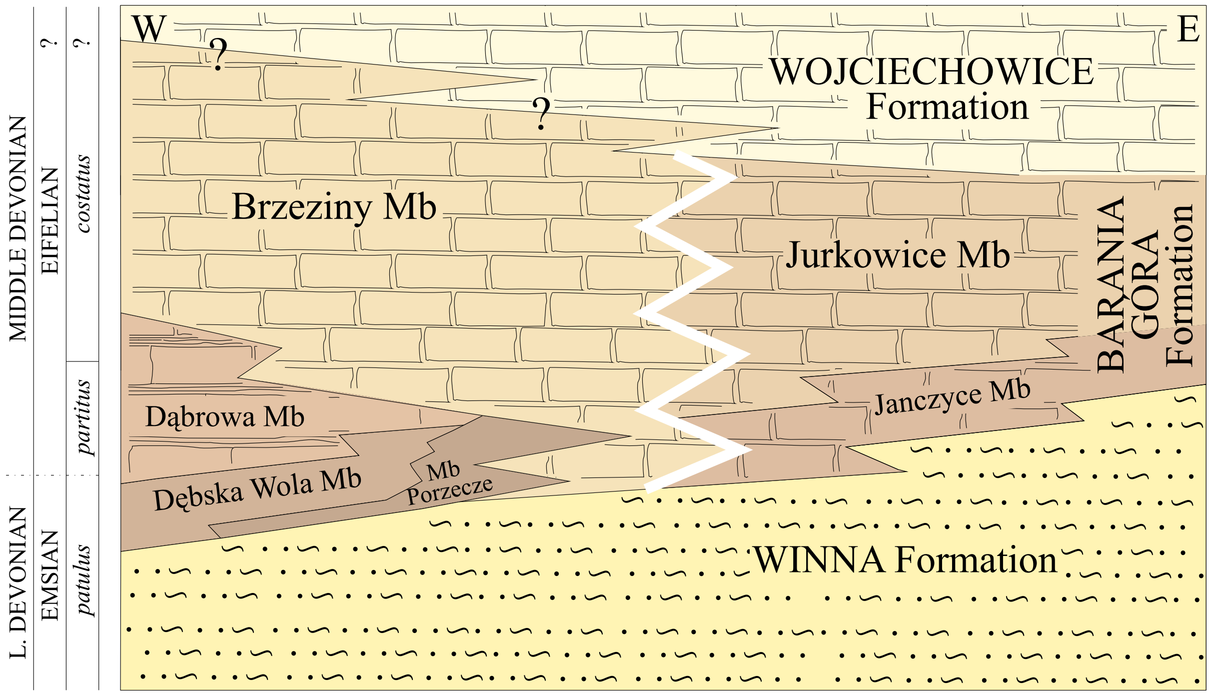
**(Polish name: formacja dolomitów i wapieni z Baraniej Góry)**

**Derivation of name**. From Barania Hill in the Zbrza Anticline, from where the most complete succession has been described.

**Definition**. The Barania Góra Formation is composed of various types of fossiliferous or bioturbated dolomites and limestones (belonging to separate members), which overlie the clastic deposits of the Winna Formation and underlie the unfossiliferous dolomites of the Wojciechowice Formation.

**Stratotype and hypostratotypes**. The type area of the Barania Góra Formation is located in the south-western part of the Kielce Region – in the Zbrza Anticline, on the western slope of Barania Hill, along the road scarp at the southern end of the village of Zbrza (Text-figs 5 and 6 and Pl. 6). The section in Zbrza is the stratotype section of the lower part of the formation. The Dyminy-2 borehole core (at 45.0 – 96.0 m depth) is the stratotype of the upper part of the formation (the core is deposited in the National Geological Archive in the Holy Cross Branch of the Polish Geological Institute – National Research Institute in Kielce). The hypostratotypes for the eastern part of the Kielce Region are defined in the Jurkowice section and in the Janczyce-1 borehole core.

**Boundaries**. The Barania Góra Formation is underlain by the Winna Formation and overlain by the Wojciechowice Formation. The lower boundary is defined at the base of a carbonate succession. In the western part of the Kielce Region this is the base of the Porzecze, Dębska Wola or Dyminy members. It can be traced in the Zbrza (base of unit 6, Text-fig. 6), Brzeziny (base of unit 3, Text-fig. 7), Szewce (base of unit 3, Text-fig. 8) and Skrzetle (see description in Malec 1993) sections, and in the Dyminy-2 (137.7 m depth, see Tarnowska 1987), Dąbrowa D5 (71.5 m depth, see Tarnowska and Malec 1987) and Porzecze IG-5A (19.2 m depth, see Kowalczewski 1979 and Fijałkowska-Mader and Malec 2011) borehole cores. In the eastern part, it can be traced in the Jurkowice section (base of unit 1, Text-fig. 10) and




Text-fig. 15. Lithostratigraphical scheme around the upper Emsian and Eifelian in the Kielce Region of the Holy Cross Mts. (longitudinal organization)

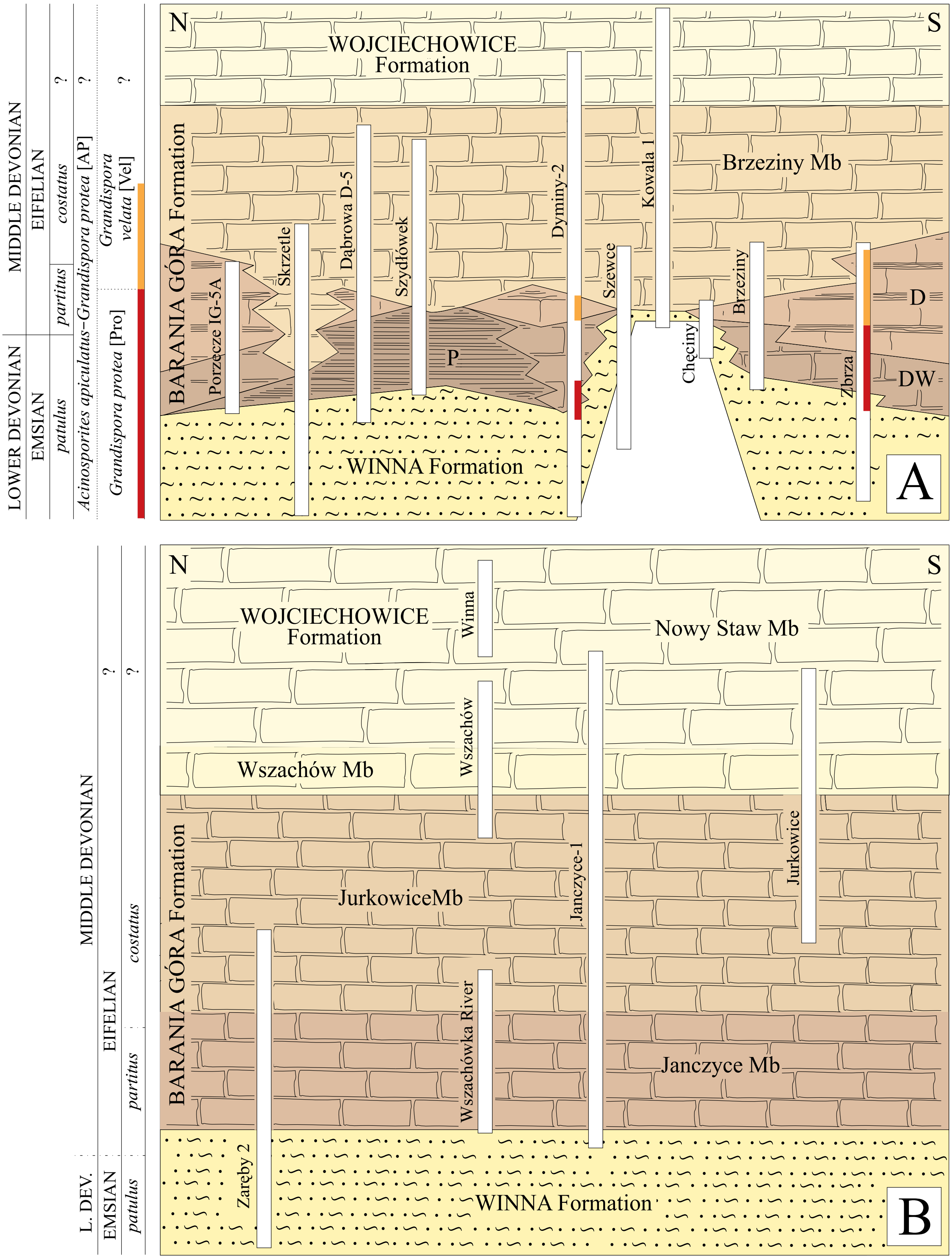
in the Janczyce-1 borehole core (1246.0 m depth, Text-fig. 14). The upper boundary is defined as the last occurrence of bioturbated or fossiliferous dolomite. In the western part of the region it can be traced in the Dyminy-2 borehole core (45.0 m depth, see Tarnowska 1987). In the eastern part, it is exposed in the Jurkowice (base of the unit 5, Text-fig. 10) and Wszachów (base of the unit 3, Text-fig. 3) sections, and in the Janczyce-1 borehole core (1107.2 m depth).

**Occurrence and thickness**. The Barania Góra Formation is limited to the Kielce Region of the Holy Cross Mountains. The formation is divided into six members, but a considerable lithological variety occurs between the eastern and western parts of the region. Two units – the Janczyce and Jurkowice members, with a combined thickness of ca. 130 m, are limited to the eastern part. Four units – the Porzecze, Dębska Wola, Dąbrowa and Brzeziny members, with a combined thickness of up to ca. 70 m, are limited to the western part. Additionally, in the western part of the Kielce Region, a lateral lithological variability occurs: the Dąbrowa Member is limited to the north-western and south-western part of the region and is absent in the central-western part.

**Lithology**. The Barania Góra Formation includes pyrite-bearing and sideritic claystones (Porzecze Member); coral-bearing dolomites, micritic dolomites, wavy-laminated dolomites and sandy dolomites arranged (occasionally) into cyclic successions (Dębska Wola Member); fossiliferous limestones, marls, marly shales with brachiopod lumachelle intercalations (Dąbrowa Member); thin-bedded dolomites with horizons of bioturbation structures (Brzeziny Member); coral-bearing dolomicrites, laminated dolomicrites and fenestral dolomicrites arranged into cyclic successions (Janczyce Member); and thick-bedded nodular dolomites and crinoidal dolomites with horizons of bioturbation structures (Jurkowice Member).

**Origin**. The formation represents a shallow-marine carbonate-clastic sedimentation during the earliest stage of the Devonian transgression, before constitution of a carbonate platform. The deposits belonging to particular members originated in different sedimentary environments; from lagoonal, through stromatoporoid-coral shallows to open-marine areas (occasionally below storm wave base) on a distally-steepening ramp (Wójcik 2013 and in preparation).

**Age**. The formation is early Eifelian in age. The conodont material collected indicates the interval between the *Polygnathus costatus partitus* Zone and the lower part of the *P. c. costatus* Zone (Wójcik 2013 and in preparation), albeit a latest Emsian age is postulated by Fijałkowska-Mader and Malec (2011) for the lowermost part of the formation (Porzecze Member). The age is confirmed by the




Text-fig. 16. Lithostratigraphical schemes around the upper Emsian and Eifelian in the Kielce Region of the Holy Cross Mts. (latitudinal organization) supplemented by palynostratrigraphical data of Filipiak (2011). **A** – western part of the region, **B** – eastern part of the region. P – Porzecze Member, DW – Dębska Wola Member, D – Dąbrowa Member palynostratigraphical data of Fijałkowska-Mader and Malec (2011) and Filipiak (2011).

**Porzecze Claystone Member**
**(Polish name: ogniwo iłowców z Porzecza)**

**Derivation of name**. From the Porzecze IG-5A borehole core, in which a complete succession was available.

**Earlier names**. The member was earlier distinguished as: the *Ore-bearing Claystones and Siltstones Member* (Tarnowska and Malec 1987, Fijałkowska-Mader and Malec 2011), the *Ore-bearing Claystones* (Malec 1986, 1993), the *Pyrite-bearing Claystones from Szydłówek* (Malec and Studencki 1988) and the *Pyrite-bearing and Sideritic Claystone Member* (Fijałkowska-Mader and Malec 2011).

**Definition**. The Porzecze Member overlies the clastics of the Winna Formation and underlies the succession of dolomites or limestones in the northern and north-western parts of the Kielce Region. The member is defined as a package of brown, black and yellowish pyrite-bearing claystones and siltstones with siderite concretions.

**Stratotype and hypostratotypes**. The town of Kielce is the type area of the Porzecze Member. The stratotypes of the lower and upper parts of the member are located in the Skrzetle and Szydłówek sections respectively.

**Boundaries**. The Porzecze Member is underlain by the Winna Formation and overlain by the Dębska Wola Member or the Brzeziny Member (if the Dąbrowa Member is absent). The lower boundary is defined as the base of the pyrite-bearing or limonite-bearing claystone package that underlies the carbonate succession. It can be traced in the Skrzetle section and in the Porzecze IG-5A borehole core at 12.9 m depth. The upper boundary is defined as the base of the first continuous bed of dolomite or limestone. It is exposed in the Szydłówek section and in the Porzecze IG-5A (19.2 m depth) and Dąbrowa D5 (at 71.5 m depth) borehole cores.

**Occurrence and thickness**. The Porzecze Member occurs in several sections in the northern and north-western part of the Kielce Region (Text-fig. 5). The member occurs in the Szydłówek (30 m thick; see description in Malec and Studencki 1988) and Skrzetle (5.7 m thick; see description in Malec 1993 and 2001) sections, as well as in the Porzecze IG-5A (5.4 m thick; see description in Kowalczewski 1979, Fijałkowska-Mader and Malec 2011; Text-fig. 9) and Dąbrowa D5 (71.5 – 103.5 m depth; see description in Tarnowska and Malec 1987) borehole cores. The presence of similar deposits was also noticed in the Stara Góra IG-1 and Wola Zamkowa 2 borehole cores (Studencka 1983), as well as in old shafts near the villages of Daleszyce, Górno, Baćkowice and Piotrów. The member disappears in the central and southern parts of the Kielce Region.

**Lithology**. The Porzecze Member is composed of brown to black structureless or wavy-laminated claystones with fromboidal pyrite, yellowish structureless claystones with siderite concretions, and dolomitic claystones and siltstones (Tarnowska and Malec 1987, Malec and Studencki 1988, Malec 1993).

**Fossils**. The numerous benthic agglutinated foraminifers represent an autochthonous assemblage. Rare crinoids, remnants of bryozoans, brachiopods (including *Chimaerothyris dombrowiensis*), tentaculoids and conodonts occur in the upper part of the unit, probably of allochthonous origin (Tarnowska and Malec 1987, Malec 1987, Malec and Studencki 1988, Malec 1993).

**Magnetic susceptibility**. Not measured.

**Origin**. The Porzecze Member represents shallow-marine lagoonal sedimentation, with open marine influences in the upper part of the unit (Wójcik 2013 and in preparation).

**Age**. The assemblage of conodonts collected by Malec (1993) and discussed in Fijałkowska-Mader and Malec (2011) indicates the interval between the uppermost Emsian (*Polygnathus costatus patulus* conodont Zone) and lower Eifelian (*Polygnathus costatus partitus* conodont Zone). Wójcik (2013 and in preparation) suggested an early Eifelian age only.

**Dębska Wola Dolomite Member**
**(Polish name: ogniwo dolomitów z Dębskiej Woli)**

**Derivation of name**. From the village of Dębska Wola, where the deposits were identified for the first time (Filonowicz 1973).

**Earlier names**. The member was earlier distinguished as: the *Dolomite Member* in Fijałkowska-Mader and Malec (2011) and the *Dolomitic Unit* below the *Dąbrowa Horizon* in the Dyminy-2 borehole core in Tarnowska (1987).

**Definition**. The Dębska Wola Member is composed of dolomites (dolomicrites and fine-crystalline dolosparites with occasional abundant corals), which underlie the Dąbrowa Member.

**Stratotype and hypostratotypes**. The type area is located in the Zbrza Anticline, on the western slope of the Barania Hill, along the road scarp at the southern end of the village of Zbrza. The Zbrza section is the stratotype section of the member (Text-figs 5, 6 and Pls 1, 6). The hypostratotype is established in the Dyminy-2 borehole core between 137.7 and 110.0 m depth.

**Boundaries**. The Dębska Wola Member is underlain by the Winna Formation or the Porzecze Member and overlain by the Dąbrowa Member. The lower boundary is defined as the base of a dolomitic succession – the base of brown dolomitic claystones or dolomicrites. It was established in the Porzecze IG-5A core at the base of the first dolomite bed (19.2 m depth), in the Brzeziny section at the base of unit 3 and in the Zbrza section at the base of unit 6. The upper boundary is defined as the base of limestones, marls or marly shales of the Dąbrowa Member. It was established at the top of unit 10 in the Zbrza section, at the top of unit 5 in the Brzeziny section and at the top of the last dolomite bed in the Porzecze IG-5A core (39.5 m depth).

**Occurrence and thickness**. The Dębska Wola Member occurs in the south-western part of the Kielce Region (Text-fig. 5, Pl. 6). It can be traced along the Chęciny and Dyminy Anticlines. The member occurs in the Zbrza (units from 6 to 10, 16 m thick; Text-fig. 6 and Pls 1, 6) and Brzeziny (units from 3 to 5, 22.5 m thick; Text-fig. 7 and Pls 2, 6) sections, as well as in the Dyminy-2 (between 137.7 and 110.0 m depth, 28 m thick; see description in Tarnowska 1987) and Porzecze IG-5A (between 19.2 and 39.5 m depth, 15.6 m thick; see description in Kowalczewski 1979 and Fijałkowska-Mader and Malec 2011; Text-fig. 9) borehole cores. The presence of dolomites underlying the Dąbrowa Member has also been noted near the villages of Szczecno and Osiny.

**Lithology**. The lowermost part of the unit is composed of brown dolomitic claystones and dolomicrites. In the middle part, the unit is composed of *Thamnopora* dolomicrites, fine-crystalline dolosparites with corals, marly dolomicrites with wavy lamination and dolomicrites, arranged in 5 to 6 cyclothems. The upper part of the member is composed of stromatoporoid-coral biostromal dolomites. In the Brzeziny section, corals are absent and the cyclothems are not recognized, albeit cyclicity is visible on the MS curve.

**Magnetic susceptibility**. The member is generally characterized by high MS values, over $40\times10^{-8}$ $m^3$/kg in the lower part, decreasing towards the top. The main asymmetric decreasing trend A corresponds to the member. Minor asymmetric (decreasing) MS fluctuations correspond well to particular lithological cyclothems. The lower part of trend B begins in the upper part of the member.

**Origin**. The Dębska Wola Member represents shallow-marine, temporary cyclic carbonate sedimentation within lagoonal environments with isolated stromatoporoid-coral shallows and swells (Wójcik 2013 and in preparation).

**Age**. Filipiak (2011) proved the latest Emsian–early Eifelian age of the member (*protea* palynostratigraphic Zone) in the Dyminy-2 borehole core and in the Zbrza section.

**Dąbrowa Limestone Member**
**(Polish name: ogniwo wapieni z Dąbrowy)**

**Derivation of name**. From the village of Dąbrowa (northern part of Kielce), in which the deposits were recognized for the first time (Pusch 1833, Gürich 1896).

**Earlier names**. The member was earlier distinguished as: the *Dąbrowa Horizon* in Gürich (1896) and Filonowicz (1973), the *complex VIII* in Pajchlowa (1957), the *Kielce Limestone Unit* in Tarnowska (1987), the *Grzegorzowice Limestone Member* in Malec (2002) and the *Dąbrowa Limestone Member* in Tarnowska and Malec (1987), Malec (2005), Fijałkowska-Mader and Malec (2011), and Filipiak (2011).

**Definition**. The Dąbrowa Member was defined by Malec (2005) in the Grzegorzowice-Skały section in the Łysogóry Region of the Holy Cross Mountains. A refined definition of the member is proposed herein. The unit is composed of grey to greenish micritic limestones and fossiliferous grained and flaser limestones, marls and marly shales with a subordinate contribution of dolomites in separate internal packages. The presence of *Chimaerothyris dombrowiensis* is an auxiliary criterion for distinguishing the member.

**Stratotype and hypostratotypes**. Malec (2005) established the Grzegorzowice-Skały section in the Łysogóry Region as the stratotype section of the Dąbrowa Member. The Zbrza section is proposed herein as the hypostratotype section for the Kielce Region (Text-figs 5, 6 and Pls 1, 6).

**Boundaries**. The Dąbrowa Member is underlain by the Dębska Wola or the Porzecze members and overlain by the Brzeziny Member. The boundaries of the unit surround the lithosome of limestones, marls or marly shales within a dolomitic background. The lower boundary is defined as the base of the first limestone or marl bed or at the base of the first marly shales package. It can be traced in the Porzecze IG-5A borehole core at the base of the first limestone layer (39.5 m depth), in the Brzeziny section at the base of unit 6 and in the Zbrza section at the base of unit 11. The upper boundary is defined as the top of the last limestone bed. It can be traced at the top of unit 7 in the Brzeziny section.

**Occurrence and thickness**. The Dąbrowa Member occurs in both the Łysogóry and Kielce regions of the Holy Cross Mountains, albeit belonging to two different formations. In the Kielce Region, the member is limited to the western part of the area (Text-fig. 5). The thickness of the unit increases to the north-west and to the south-west. The unit is absent along the Dyminy Anticline in the western-central part of the area. The Dąbrowa Member occurs in the Zbrza (units 11 to 16, 28 m thick at least; Text-fig. 6 and Pls 1, 6) and Brzeziny (units 6 and , ca. 10 m thick; Text-fig. 7 and Pls 2, 6) sections, as well as in the Porzecze IG-5A (from 39.5 m depth to the end of the core, 30 m thick at least; Text-fig. 9), Dyminy-2 (96.0–109.0 m depth, 13 m thick; see description in Tarnowska 1987) and Dąbrowa D5 (66.0–71.5 m depth; see description in Tarnowska and Malec 1987) borehole cores. The occurrence of limestones with *Chimaerothyris dombrowiensis* was also noticed near the villages of Szczecno and Osiny. In the Łysogóry Region, the unit occurs in the Grzegorzowice-Skały section (35 m thick; see description in Malec 2005) and in the Kowalkowice 1 borehole core (111.2–92.5 m depth, ca. 10 m thick; see description in Malec 2005).

**Lithology**. The Dąbrowa Member is composed of micritic, grained and flaser limestones alternating with marls and marly shales. Marly intervals concentrate in the lower part of the unit in the Brzeziny and Zbrza sections. Numerous brachiopod lumachelles occur in these intervals. Grained and flaser limestones dominate in the lower and middle parts of the unit and recede in the upper part, in which micritic limestones predominate. Thin packages of dolomites occur within the unit in the Grzegorzowice-Skały and Zbrza sections.

**Fossils**. Shelly-fossils concentrate within grained beds and laminae/strips. *Chimaerothyris dombrowiensis*, *Athyris concentrica* and *Chonetes angustestriata* are the most abundant brachiopods. Numerous tentaculoids, crinoids, gastropods, corals, and rare trilobites, holothurids, conodonts, microconchids, scolecodonts, bryozoans, hedereloids, algae, ostracods and molluscs are present. *Chondrites* isp. and *Skolithos* isp. are the most numerous ichnofossils.

**Magnetic susceptibility**. The Dąbrowa Member has generally high MS values in the lower part of the unit (from 35 to 40 $\times 10^{-8}$ $m^3$/kg), decreasing towards its top. Higher MS values at the base of the unit result from the greater content of marls and marly shales. The major asymmetric trend B generally corresponds to the member and can be traced in all sections. Minor 3 to 6 MS fluctuations within trend B are also distinguishable. The major symmetric C and D trends are distinguished in the upper part of the unit in the Zbrza section.

**Origin**. The Dąbrowa Member represents open-marine carbonate-clastic sediments deposited on the middle and outer ramp, occasionally below the storm wave base (Wójcik 2013 and in preparation).

**Age**. The stratigraphical range of the Dąbrowa Member spans from the upper part of the *Polygnathus costatus partitus* conodont Zone to the lower part of the *Polygnathus costatus costatus* conodont Zone, within the lower Eifelian. The age is proved by numerous conodonts, collected and described by Wójcik (2013 and in preparation).

**Brzeziny Dolomite Member**
**(Polish name: ogniwo dolomitów z Brzezin)**

**Derivation of name**. From the Brzeziny section, in which a complete succession is available.

**Definition**. The Brzeziny Member is a dolomitic unit underlying the Wojciechowice Formation in the western part of the Kielce Region. As opposed to the Wojciechowice Formation, the member contains horizons of bioturbation structures and thin grained intercalations. Dolomitic limestones occur subordinately at its base.

**Stratotype and hypostratotypes**. The Brzeziny section is the stratotype section of the lower part of the unit (Text-figs 5, 7 and Pls 2, 6). The Dyminy-2 borehole core (45.0 and 96.0 m depth) is the stratotype section of the upper part of the unit (the core is deposited in the National Geological Archive in the Holy Cross Branch of the Polish Geological Institute – National Research Institute in Kielce.

**Boundaries**. The Brzeziny Member is underlain by the Winna Formation or by the Porzecze and Dąbrowa members, and is overlain by the Wojciechowice Formation.

The lower boundary is defined as the base of the first dolomite bed above the Dąbrowa Member or above the Winna Formation or the Porzecze Member, if the Dąbrowa Member is absent. The boundary can be traced in the Brzeziny section at the base of unit 8, in the Szewce section at the base of unit 3, in the Skrzetle and Szydłówek sections above the Porzecze Member, as well as in the Dyminy-2 (at 96.0 m depth) and Dąbrowa D5 (at 66.0 m depth) borehole cores. The upper boundary is defined at the top of the last bed with bioturbation structures. It can be traced in the Brzeziny and Zbrza sections, as well as in the Dyminy-2 borehole core (at 45.0 m depth).

**Occurrence and thickness**. The member occurs in the western part of the Kielce Region in the Brzeziny (unit 8, 15 m thick at least; Text-fig. 7 and Pls 2, 6) and Szewce (units 3 and 4, 26 m thick at least; Text-fig. 8 and Pl. 6) sections, as well as in the Dyminy-2 (45.0–96.0 m depth, ca. 50 m thick; see description in Tarnowska 1987) and Dąbrowa D5 (5.2–66.0 m depth; see description in Tarnowska and Malec 1987) borehole cores. Deposits included in the member were also described from the Skrzetle (Malec 1993, 2001), Szydłówek (Malec and Studencki 1988) and Chęciny (Głazek *et al*. 1981) sections. The Brzeziny Member also occurs near the villages of Zbrza, Szczecno and Osiny.

**Lithology**. The Brzeziny Member is composed of thin-bedded reddish structureless dolomicrites with horizons of bioturbation structures and grained laminae/strips, intercalated with brown dolomitic claystones. Small stromatolites and fenestral fabrics appear sporadically. A package of dolomitic limestones occur at the base of the unit in the Szewce section.

**Fossils**. Allochthonous shelly fossils occur within the grained intercalations. Single crinoids, tentaculoid remains, ostracods and conodonts are present. Paraautochthonous gypidulid assemblages appear on some of the surfaces. *Chondrites* isp. predominate among the ichnofossils.

**Magnetic susceptibility**. The member has generally low MS values; ca. $22\times10^{-8}$ $m^3$/kg in Brzeziny section and $18\times10^{-8}$ $m^3$/kg in the lower part to $8\times10^{-8}$ $m^3$/kg in the upper part of the Szewce section. The major trends D correspond to the member in the Brzeziny section, the major trends C, D and E occur in the Szewce section.

**Origin**. The Brzeziny Member represents shallow-marine carbonates deposited on the outer side of a distally steepened ramp (Wójcik 2013 and in preparation).

**Age**. The member is Eifelian in age, not older than the *Polygnathus costatus partitus* conodont Zone in the Skrzetle and Szydłówek sections (Fijałkowska-Mader and Malec 2011) or than the *Polygnathus costatus costatus* conodont Zone in the Zbrza, Brzeziny and Szewce sections. The upper boundary is not dated, and probably runs within the *Polygnathus costatus costatus* conodont Zone. The age is postulated basing on conodonts collected and described by Wójcik (2013 and in preparation).

**Janczyce dolomite Member**
**(Polish name: ogniwo dolomitów z Janczyc)**

**Derivation of name**. From the Janczyce-1 borehole core, in which a complete succession is available.

**Definition**. The Janczyce Member occurs at the base of the Devonian carbonate succession in the central-eastern part of the Kielce Region and is composed of a cyclic succession of as follows (from base to top): grained dolomicrites intercalated with thamnopora-boundstones, structureless dolomicrites, dolomicrites with wavy lamination and dark dolomicrites with fenestral structures.

**Stratotype**. The interval of the Janczyce-1 borehole core between 1203 m and 1246 m depth is the stratotype section of the member (Text-figs 5, 14). The core is deposited in the National Geological Archive in Halinów.

**Boundaries**. The Janczyce Member is underlain by the Winna Formation and overlain by the Jurkowice Member. The lower boundary is defined as the first layer of dolomites above the clastic succession and can be traced in the Janczyce-1 core at 1246.0 m depth. The upper boundary is defined as the top of the cyclic succession and can be traced in the same core at 1203.0 m depth.

**Occurrence and thickness**. The Janczyce Member occurs in the eastern part of the Kielce Region, in the Janczyce-1 (unit 2, 37 m thick; Text-fig. 14) borehole core, as well as in the valley of the River Wszachówka (unit 1; Text-fig. 11 and Pl. 6). The presence of similar deposits is also postulated in the Zaręby 2 borehole core, at the base of the carbonate succession (see description in Tarnowska 1976).

**Lithology**. The member is composed of grained (crinoid-intraclast) dolomicrites intercalated with *Thamnopora*-boundstones (a little sandy at the base of the unit), structureless dolomicrites, dolomicrites with wavy lamination and dark dolomicrites with fenestral structures. In the Janczyce-1 core, the strata are arranged into 5 cyclothems. Similar deposits are partially exposed in the valley of the River Wszachówka, in which sandy dolomicrites, dolomites with wavy laminations and bioturbated dolomicrites with algae and coral remains occur.

**Magnetic susceptibility**. The member has medium MS values, with average around $42\times10^{-8}$ $m^3/kg$. The major BE trend has been distinguished within the unit. It is divided into BE1, BE2, BE3 and BE4 subtrends, which correlate well with the lithological cyclothems.

**Origin**. The Janczyce Member represents shallow-marine cyclic carbonates deposited in lagoonal environments (Wójcik 2013 and in preparation).

**Age**. The member is Eifelian in age, and ranges from the *Polygnathus costatus partitus* conodont Zone to the lower part of the *Polygnathus costatus costatus* conodont Zone according to conodont material collected and described by Wójcik (2013and in preparation).

**Jurkowice dolomite Member**
**(Polish name: ogniwo dolomitów z Jurkowic)**

**Derivation of name**. After the village of Jurkowice, in which a quarry is located.

**Earlier names**. The *Fossiliferous and Bioturbated Dolomicrites and Dolosparites Unit* in Narkiewicz *et al*. (1981), Narkiewicz and Olkowicz-Paprocka (1983) and Zdanowski (1997).

**Definition**. The Jurkowice Member is a dolomitic unit underlying the Wojciechowice Formation in the eastern part of the Kielce Region. As opposed to the Wojciechowice Formation, nodular texture, thin-grained fossiliferous intercalations and horizons of intense *Chondrites*-like bioturbations occur in the Jurkowice Member. The unit can be easily distinguished from the Brzeziny Member by the presence of nodular texture, greater thickness of particular beds, and, occasionally also by blueish weathering.

**Stratotype and hypostratotypes**. The Jurkowice quarry section is proposed as the stratotype section of the Jurkowice Member (Text-figs 5, 10 and Pls 3, 6). The Janczyce-1 borehole core between 1203.0 and 1104.0 m depth is proposed as the hypostratotype (Text-figs 5 and 14).

**Boundaries**. The Jurkowice Member is underlain by the Janczyce Member of the Winna Formation and overlain by the Wojciechowice Formation. The lower boundary is defined in the Janczyce-1 borehole core at the depth of 1203.0 m, at the top of the last cyclothem, as well as in the Jurkowice quarry at the base of unit 1, above the sandstones belonging to the Winna Formation. The upper boundary is defined as the top of the last layer of crinoid dolomite or nodular dolomite in the succession. It is detected in the Janczyce-1 core at 1104.0 m depth, at the level where nodular texture and shelly fossils disappear, in the Jurkowice section at the top of unit 4 above the last crinoid dolomite layer, and in the Wszachów section at the top of unit 2 above the last nodular dolomite layer. Above the upper boundary, the horizons of bioturbation structures and shelly fossils disappear completely in the succession.

**Occurrence and thickness**. The Jurkowice Member occurs in the eastern part of the Kielce Region, in the Jurkowice (units 1 to 4, 55 m thick; Text-fig. 10 and Pls 3, 6) and Wszachów (units 1 and 2, 28 m thick at least; Text-fig. 12 and Pls 4, 6) sections, in the Wszachówka River valley (units 2 and 3; Text-fig. 11 and Pl. 6), as well as in the Janczyce-1 borehole core (1203.0–1104.0 m depth, ca. 90 thick; Text-fig. 14).

**Lithology**. The member is composed of medium-bedded dolomicrites with thin-grained fossiliferous intercalations, thick-bedded nodular dolomicrites and fine-crystalline dolosparites, thick-bedded dolomicrites with crinoids, and thick-bedded crinoidal dolomites. The strata are intercalated by horizons of *Chondrites*-dominated bioturbation structures.

**Fossils**. Numerous lingulids, molluscs, conulariids and plant remains occur within the grained intercalations/laminae in the lowermost part of the member. Assemblages of gypidulids, tentaculoids, crinoids, scolecodonts, conodonts and bryozoans remains occur in other separate laminae/strips. Gypidulids and tentaculoids build the single and very thin lumachelle horizons. *Chondrites* isp. with subordinate contribution of *Planolites* isp. predominate among the ichnofossils.

**Magnetic susceptibility**. The member has medium MS values, with an average from $15\times10^{-8}$ $m^3/kg$ in Jurkowice section, through $20\times10^{-8}$ $m^3/kg$ in the Wszachów section, up to $38\times10^{-8}$ $m^3/kg$ in the Janczyce-1 borehole core. The major MS trends BE, CE, DE1, DE2 and DE3 are distinguished within the unit.

**Origin**. The Jurkowice Member represents shallowing carbonate sedimentation on the middle part of the ramp and around crinoidal meadows (Wójcik 2013 and in preparation).

**Age**. The Member is Eifelian in age and belongs to the lower part of the *Polygnathus costatus costatus* conodont Zone according to the conodont material collected by Zdanowski (1997) and revised and described by Wójcik (2013 and in preparation).

**WOJCIECHOWICE DOLOMITE FORMATION (Narkiewicz and Narkiewicz 2010)**

**Wszachów Dolomite Member (Polish name: ogniwo dolomitów z Wszachowa)**

**Derivation of name**. From the village of Wszachów, in which a quarry is located.

**Definition**. The Wszachów Member is a characteristic unit of dark unfossiliferous dolomites with a horizon of stromatolitic domes.

**Stratotype and hypostratotypes**. The Wszachów section along the western wall of the quarry is the stratotype section of the Wszachów Member (Text-figs 5, 12 and Pls 4, 6). The hypostratotype is established in the Jurkowice section along the eastern wall of the quarry (Text-figs. 5 and 10 and Pls 3, 6).

**Boundaries**. The Wszachów Member is underlain by the Barania Góra Formation and overlain by the Nowy Staw Member. The lower boundary is defined at the top of the last bed of nodular, bioturbated or crinoidal dolomites of the underlying Barania Góra Formation. The boundary can be traced in the Jurkowice section at the base of unit 5, in the Wszachów section at the base of unit 3, and in the Janczyce-1 borehole core at 1104.0 m depth. The upper boundary is defined as the base of the first thick layer of intraclast-oolite dolomites, ca. 1 m above a characteristic horizon with stromatolitic domes. The boundary can be traced in the Jurkowice section at the base of unit 6, in the Wszachów section at the base of unit 4, and in the Janczyce-1 borehole core at 1097.0 m depth.

**Occurrence and thickness**. The member is recognized in the eastern part of the Kielce Region, in the Wszachów (unit 3, 10 m thick; Text-fig. 12 and Pls 4, 5) and Jurkowice (unit 5, 10 m thick; Text-fig. 10 and Pls 3, 4) sections, as well as in the Janczyce-1 borehole core (1104–1097 m depth, ca. 7 m thick; Text-fig. 14). Similar deposits were described also by Tarnowska in the Dyminy-2 borehole core (15.0–45.0 m depth).

**Lithology**. The member is composed of dark dolomicrites, dolomicrites with flat lamination, dolomicrites with wavy lamination, stromatolite horizons and variegated siltstones, organized in cyclothems.

**Fossils**. Absence of any shelly fossils and ichnofossils.

**Magnetic susceptibility**. The member has generally low MS values, with an average from $13\times10^{-8}$ $m^3/kg$ in the Jurkowice section, through $15.5\times10^{-8}$ $m^3/kg$ in the Wszachów section, up to $33\times10^{-8}$ $m^3/kg$ in the Janczyce-1 borehole core. The major MS trends EE1 and EE2 are distinguished within the unit.

**Origin**. The Wszachów Member represents shallow-marine carbonate sedimentation within lagoonal environments with a predominance of subtidal conditions (Wójcik 2013 and in preparation).

**Age**. The member is Eifelian or younger in age, however, not older than the lower part of the *Polygnathus costatus costatus* conodont Zone, as can be deducted from conodonts derived from the underlying Jurkowice Member (Wójcik 2013 and in preparation).

**Nowy Staw Dolomite Member (Polish name: ogniwo dolomitów z Nowego Stawu)**

**Derivation of name**. From the village of Nowy Staw, in which the Winna quarry is located.

**Definition**. The Nowy Staw Member is a distinctive unit comprising fine- to medium grained oolitic-intraclast dolomites intercalated by various kinds of dolomites and arranged into a cyclic succession.

**Stratotype and hypostratotypes**. The vicinity of the town of Łagów is the type area of the member. The Wszachów section is proposed as the stratotype of the lower part of the member (Text-figs 5, 12 and Pls 4, 6). The Winna section is proposed as the stratotype of the upper part of the member (Text-figs 5, 13 and Pls 5, 6). The Janczyce-1 borehole core interval between 1097.0 m and 1023.0 m depth is proposed as the hypostratotype section (Text-figs 5, 14).

**Boundaries**. The Nowy Staw Member is underlain by the Wszachów Member and overlain by the Kowala

Formation. The lower boundary is defined as the base of the first thick bed of grained oolite-intraclast dolomites, ca. 1 m above a distinctive horizon of stromatolitic domes. The boundary can be traced in the Wszachów and Jurkowice sections at the base of units 4 and 6 respectively, as well as in the Janczyce-1 borehole core at 1097.0 m depth. The upper boundary is defined as the base of the first stromatoporoid-coral dolomite bed. It is established in the Winna section, at the base of unit 3, where it is emphasized by a breccia/conglomerate layer, as well as in the Janczyce-1 borehole core at 1023.0 m depth.

**Occurrence and thickness**. The Member is recognized in the eastern part of the Kielce Region, in the Janczyce-1 borehole core (depth interval between 1097 m and 1023 m, ca. 70 m thick; Text-fig. 14), as well as in the Jurkowice (unit 6; Text-fig. 10 and Pls 3, 6), Wszachów (unit 4; Text-fig. 12 and Pls 4, 6) and Winna (units 1 and 2; Text-fig. 13 and Pls 5, 6) sections. Similar deposits have been described in the Kowala 1 borehole core by Romanek and Rup (1990, see also Narkiewicz 1991) between 882.7 and 846.8 m depth.

**Lithology**. The Nowy Staw Member comprises: dark grey dolomicrites with flat lamination, grained intraclast-oolitic dolomites, dolomicrites with wavy lamination, horizons of stromatolitic domes, greenish flat laminated dolomicrites, intraformational breccia horizons, and variegated siltstones and claystones with anhydrite pseudomorphs, arranged in several ca. 1.5-m thick cyclothemes. The number of cyclothems differs between the sections.

**Magnetic susceptibility**. The member has generally low MS values, up to $10\times10^{-8}$ $m^3$/kg in the Winna and Wszachów sections, and somewhat higher, with an average of ca. $20\times10^{-8}$ $m^3$/kg, in the Janczyce-1 borehole core. The major MS trends EE2, FE1 and FE2 are distinguished in the lower part of the unit. There is a lack of any relation between the MS trends and the lithological cyclothems.

**Origin**. The member represents shallow-marine carbonate cyclic sedimentation within lagoonal environments with a predominance of inter- and supratidal conditions (Wójcik 2013 and in preparation).

**Age**. The Nowy Staw Member is Eifelian or younger in age, and not older than the lower part of the *Polygnathus costatus costatus* Zone (Wójcik 2013 and in preparation).

## DISCUSSION

A detailed lithological description of the succession and recognition of actual geographical and stratigraphical organization and the extent of particular lithological units constitute basic requirements in reconstructing the three-dimensional architecture of any stratigraphical interval, and form the basis of subsequent regional palaeogeographical reconstructions. Such studies were missing for the uppermost Emsian and Eifelian in the Kielce Region, an interval critical for understanding the onset and early stages of the Devonian transgression over the area of the present day Holy Cross Mountains. This paper fulfils the gap.

The investigations reported herein, carried out in nine sections and supplemented by published data, representing both the eastern and western parts of the Kielce Region, have revealed great lateral and vertical lithological variability around the Emsian–Eifelian boundary interval in the area. One new formation – the Barania Góra Formation – has been defined and divided into six members. Additionally, two new members have been distinguished within the overlying Wojciechowice Formation (Text-figs 15, 16). Although a strong lithological variability of the studied interval was reflected in the reports of former researches (Text-fig. 4), the geographical/stratigraphical distribution and characteristics of particular lithostratigraphical unit was not, so far, fully understood. Moreover, their position within a transgressive Devonian succession was uncertain.

One of the main issues, which needed serious consideration before constructing a complete lithostratigraphical scheme, concerned the geographical continuity of particular units distinguished in the Kielce Region; to what extent the apparently similar lithosomes are really the same in the eastern and western parts of the region (Text-figs 15, 16). The Porzecze Formation predominates in the north-western part of the Kielce Region; however, similar deposits occur also in its north-central and even north-eastern parts (Tarnowska 1976; Malec 1986; Fijałkowska-Mader and Malec 2011). Three units: the Dębska Wola, Dąbrowa and Brzeziny members are limited to the western part of the Kielce Region. Their occurrence does not cross the Daleszyce tectonic lineament (see Konon 2006), and they are absent in the Bardo Syncline, Jurkowice-Budy section, and in the vicinity of Łagów. The units correspond to the Janczyce and Jurkowice members distinguished in the eastern part of the region. The Wojciechowice Formation is the first unit that occurs broadly in the whole area of the Kielce Region (compare Narkiewicz 1991 and Narkiewicz and Narkiewicz 2010; sea also Text-figs 15, 16).

Among the many differences in the uppermost Emsian and Eifelian succession between the eastern and western parts of the Kielce Region, one more has to be emphasized – the thickness of the succession. Although the difference is most accentuated within the Winna Formation, in which the thickness varies from 2 m in the western part to 200 m in the eastern part (compare Głazek *et al*. 1981; Romanek and Rup 1990 with Tarnowska 1976), it is also pronounced within the overlying carbonate units. Below the Wojciechowice Formation, a ca. 70 m thick succession in the western part (Porzecze, Dębska Wola, Dąbrowa, Brzeziny members) corresponds to ca. 130 m thick carbonates in the eastern part of the region (Janczyce and Jurkowice members). This disproportion gradually decreases in younger strata. The differences in lithology and thickness of particular units are also visible in their lateral organization (Text-fig. 16). It is well exemplified in the western part of the Kielce Region, in which the thickness of the Dąbrowa Member is highest in the north-western and south-western parts (up to 40 m) and gradually decreases in the central part, where the member disappears completely: in the vicinity of the towns of Chęciny and Dyminy, the Brzeziny Member directly overlies the Winna Formation (Głazek *et al.* 1981).

If the lithostratigraphical divisions of the uppermost Emsian and Eifelian between the Łysogóry and Kielce regions are compared, there are only two lithostratigraphical units having clear analogies (compare Text-fig. 3 with Text-fig. 15). The first is the Dąbrowa Member, which in the Łysogóry Region belongs to the Grzegorzowice Formation, and which in the Kielce Region is incorporated into the Barania Góra Formation. The second unit is the Wojciechowice Formation. The carbonates between the Winna and Kowala formations, with thickness ranging from ca. 130 m in the western part, to ca. 200 m in the eastern part of the Kielce Region, correspond to ca. 450 m thick deposits of the Grzegorzowice and Wojciechowice formations in the Łysogóry Region.

The last issue, which needs to be addressed, is the stratigraphical position of the studied succession. This is broadly discussed in Wójcik (2013) and will be presented in separate papers (Wójcik in preparation), and is only briefly discussed in the present paper. All the distinguished lithostratigraphical units have diachronous boundaries. The most important boundary is the base of the carbonate succession. Generally, carbonate units appear earlier in the western part of the region, especially in the north-western and south-western areas, in the *Polygnathus costatus partitus* conodont Zone in the early Eifelian or even earlier. In the eastern part of the region, the carbonates start close to the *Polygnathus costatus partitus*/*Polygnathus costatus costatus* boundary. A younger position of the top of the Winna Formation in the eastern part of the Kielce Region is also confirmed by Eifelian conodonts found by Malec (1984b, see also Fijałkowska-Mader and Malec 2011) within the upper part of the unit in the Zaręby 2 borehole core.

## CONCLUSIONS

The Emsian/Eifelian transition in the Kielce Region of the Holy Cross Mts. includes various lithological units, which overlie the Lower Devonian clastics of the Winna Formation and underlie the Middle Devonian stromatoporoid-coral dolomites and limestones of the Kowala Formation. The units were deposited during an early stage of the Devonian transgression. A lithological description of nine sections and a proposed formal lithostratigraphical division are presented. Six members are distinguished within a newly defined Barania Góra Formation. In the western part of the Kielce Region these are: the Porzecze, Dębska Wola, Dąbrowa, and Brzeziny members, with a total thickness reaching ca. 70 m. The Janczyce and Jurkowice members, ca. 130 m thick, are distinguished in the eastern part. These strata correspond to the Grzegorzowice Formation in the Łysogóry Unit. Above that, the Wszachów and Nowy Staw members, with a total thickness ranging from ca. 60 to 90 m, are distinguished within the Wojciechowice Formation.

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## PLATE 1
Zbrza section

**A** – The boundary between the Winna Formation and the Barania Góra Formation; eastern wall of the trench.
**B** – Dolomites of the Dębska Wola Member (Barania Góra Formation); western wall of the trench.
**C** – The boundary between the Dębska Wola and Dąbrowa members (Barania Góra Formation); western wall of the trench.
**D** – Middle part of the Dąbrowa Member (Barania Góra Formation); western wall of the trench.


A
Dębska Wola Mb
unit 8
unit 9
unit 7
unit 6
WINNA Fm
unit 5
C
Dąbrowa Member
unit 11
unit 10
Dębska Wola
Mb
B
Dębska Wola Member
unit 9
D
Dąbrowa Member
unit 13
unit 14

## PLATE 2

Brzeziny section

**A** – Panoramic view of the Siedliskowa Hill with location of the trench and distribution of lithostratigraphical units.
**B** – Dolomites of the Dębska Wola Member (Barania Góra Formation).
**C** – The boundary between the Dębska Wola and Dąbrowa members (Barania Góra Formation).
**D** – Dolomites of the Brzeziny Member (Barania Góra Formation).


B
Dębska Wola Mb
unit 4
bed 27
bed 26
bed 25
C
Dębska Wola Mb
unit 5
Dąbrowa Mb
unit 6
D
Brzeziny Mb
unit 8
A
Church
Sideliskowa Hill
crosscut
Dębska Wola Mb
Dąbrowa Mb
Brzeziny Mb
BARANIA GÓRA Fm
KOWALA Fm

## PLATE 3

Jurkowice quarry section

**A** – Panoramic view of the north-eastern part of the quarry with lithostratigraphical subdivision.

**B**, **C** – Lower and middle part of the Jurkowice Member (Barania Góra Formation).

**D** – Upper part of the Jurkowice Member (Barania Góra Formation) and lower part of the Wojciechowice Formation with lithostratigraphical subdivision.

**E** – Stromatolite horizon within the Wszachów Member (Wojciechowice Formation).


A
B
C
D
E
unit 6 (Nowy Staw Member)
unit 5
(Wszachów Member)
unit 4
stromatolite layer
unit 1
unit 2
unit 3
WOJCIECHOWICE Formation
BARANIA GÓRA Formation
Jurkowice Member
u. 5
u. 6
unit 4
unit 5
N

# PLATE 4

Wszachów quarry section

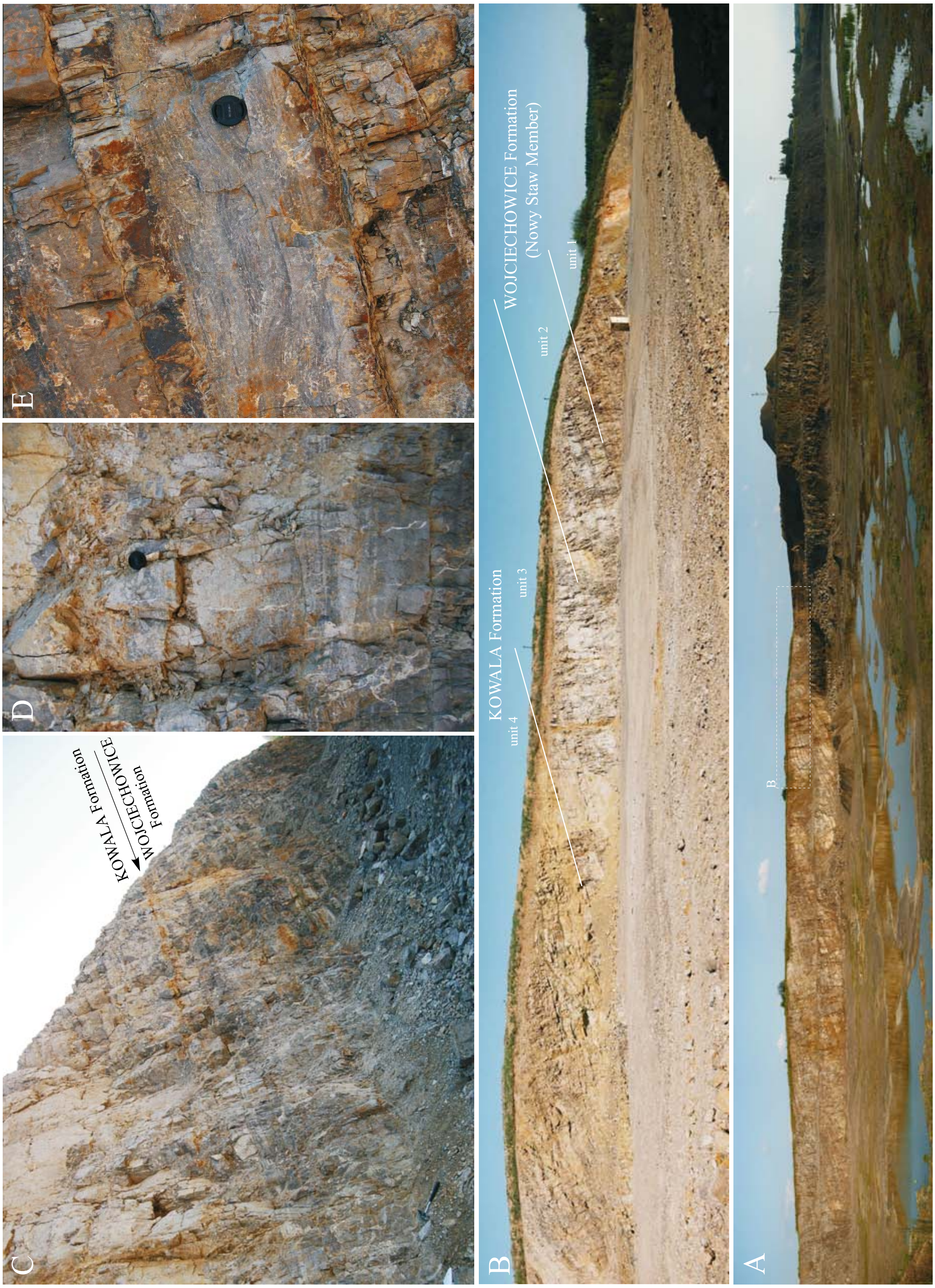
**A** – Panoramic view of the western part of the quarry with lithostratigraphical subdivision.
**B** – Nodular dolomites of the Jurkowice Member (Barania Góra Formation).
**C** – Dark dolomicrites of the Wszachów Member (Wojciechowice Formation).
**D** – Variegated siltstones within the Nowy Staw Member (Wojciechowice Formation).


D
C
B
A
WOJCIECHOWICE Formation
unit 4
Nowy Staw Member
unit 3
Wszachów Member
unit 2
unit 1
BARANIA GÓRA Formation
Jurkowice Member

## PLATE 5

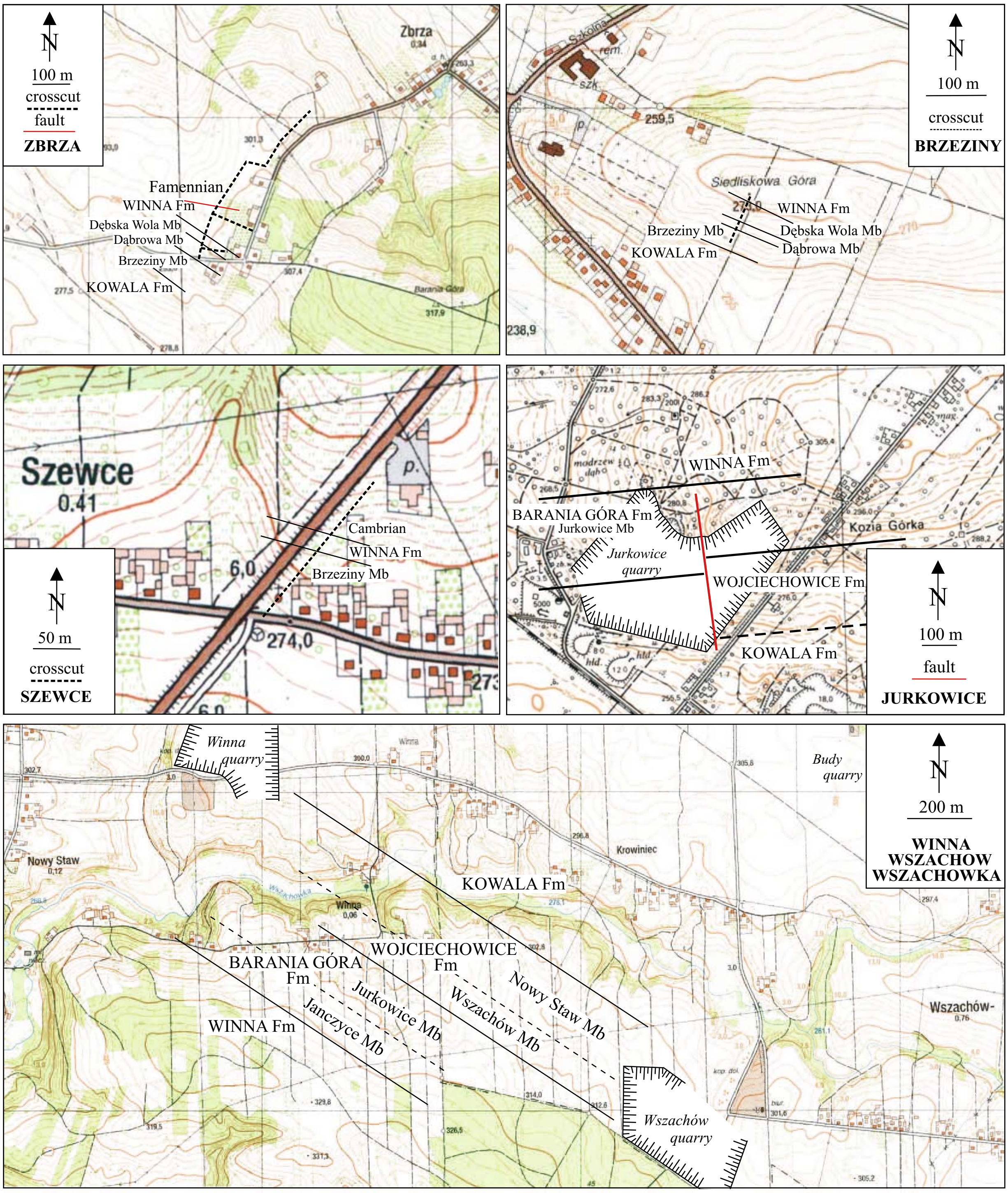
Winna quarry section

**A** – Panoramic view of the south-eastern part of the quarry.
**B** – Southern part of the eastern wall of the quarry with lithostratigraphical subdivision.
**C** – The boundary between the Wojciechowice and Kowala formations.
**D** – The uppermost part of the Wojciechowice Formation: intraformational breccias/conglomerates with iron-oxides coating.
**E** – Wavy-laminated/smudgy oolite-intraclast dolomite of the Nowy Staw Member (Wojciechowice Formation).


C
KOWALA Formation
WOJCIECHOWICE Formation
D
E
B
KOWALA Formation
unit 4
unit 3
unit 2
unit 1
WOJCIECHOWICE Formation
(Nowy Staw Member)
A
B

# PLATE 6

Location of the investigated sections and distribution of major lithostratigraphical units on the Topographic Map of Poland 1: 10 000 (Dębska Wola, Brzeziny, Jaworznia, Łagów and Wszachów sheets) and 1 : 25 000 (Staszów sheet) published by the General Department of Geodesy and Cartography of Poland.


N
100 m
crosscut
fault
ZBRZA
Zbrza
Famennian
WINNA Fm
Dębska Wola Mb
Dąbrowa Mb
Brzeziny Mb
KOWALA Fm
Barania Góra
N
100 m
crosscut
BRZEZINY
Siedliskowa Góra
WINNA Fm
Dębska Wola Mb
Dąbrowa Mb
Brzeziny Mb
KOWALA Fm
Szewce
0.41
Cambrian
WINNA Fm
Brzeziny Mb
N
50 m
crosscut
SZEWCE
WINNA Fm
BARANIA GÓRA Fm
Jurkowice Mb
Jurkowice quarry
Kozia Górka
WOJCIECHOWICE Fm
KOWALA Fm
N
100 m
fault
JURKOWICE
Winna quarry
Budy quarry
N
200 m
WINNA
WSZACHOW
WSZACHOWKA
Nowy Staw
Krowiniec
KOWALA Fm
WOJCIECHOWICE Fm
BARANIA GÓRA Fm
Nowy Staw Mb
Wszachów Mb
Jurkowice Mb
Janczyce Mb
WINNA Fm
Wszachów quarry
Wszachów-