

The stratigraphically earliest record of *Diplomoceras cylindraceum* (heteromorph ammonite) – implications for Campanian/Maastrichtian boundary definition

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A fragmentary specimen of the diplomoceratid heteromorph *Diplomoceras cylindraceum*, one of three ammonite markers used for the definition of the base of the Maastrichtian Stage, is recorded from the Middle Campanian of the Roztocze Hills, south-east Poland. The new find, well-constrained by associated ammonites and inoceramid bivalves, represents the earliest well-dated occurrence of this species worldwide to date. Therefore, the first occurrence (FO) of *D. cylindraceum* is conspicuously below the traditional base of the Maastrichtian as defined by the FO of the belemnite *Belemnella lanceolata*. Indeed, this is also far below the boundary designated in the Global Stratotype Section at Tercis les Bains (Landes, France). A comparison of the FOs of *D. cylindraceum* in sections across Europe clearly shows a significant diachroneity, which diminishes its value for definition of the Campanian/Maastrichtian boundary.

Key words: Diplomoceratidae, Late Cretaceous, diachroneity, stratigraphy, Poland.

INTRODUCTION

The heteromorph ammonite *Diplomoceras cylindraceum* (Defrance, 1816) is highly distinctive on account of its paperclip-like coiling, dense transverse ribbing and large size (Kennedy, 1987; Olivero and Zinsmeister, 1989; Klinger and Kennedy, 2003a, b; Machalski, 2012). The species is characterized by worldwide distribution (Klinger and Kennedy, 2003a) and a remarkably long stratigraphic range, encompassing the entire Maastrichtian and part of the Campanian, provided that the taxonomy proposed by Klinger and Kennedy (2003a) is accepted. However, according to Olivero and Zinsmeister (1989) and Machalski (2012), *D. cylindraceum* is replaced during the Late Maastrichtian by *Diplomoceras maximum* Olivero and Zinsmeister, 1989, which is characterized by a much lower rib index at diameters above 55 mm. *Diplomoceras* is amongst the stratigraphically youngest ammonites globally, being represented in numerous latest Maastrichtian faunas (Landman et al., 2014).

In spite of its rather long range (by ammonite standards), *D. cylindraceum* is an important species for Late Cretaceous stratigraphy. In 2001, the International Commission on Stratigraphy

(Odin, 2001; Odin and Lamaurelle, 2001) proposed a new definition of the Campanian/Maastrichtian boundary, which is here referred to as the Tercis definition throughout. The Global Stratotype Section and Point (GSSP) for the base of the Maastrichtian Stage was defined at Tercis les Bains (near Dax, Landes, south-west France) by an arithmetic mean of twelve biomarkers and placed at the 115.2 m level in that section (Odin and Lamaurelle, 2001). The new criteria for defining the Campanian/Maastrichtian boundary include several bioevents that are based on the first or last occurrences (FOs, LOs) of selected ammonite, inoceramid bivalve and foraminiferal taxa (Odin, 2001). The FO of *D. cylindraceum*, recognized at Tercis at the 111 ± 3 m level (Odin and Lamaurelle, 2001), has been proposed as one of three ammonite-based boundary criteria.

The Tercis definition of the Campanian/Maastrichtian boundary differs significantly from its traditional definition. Historically, the base of the Maastrichtian Stage in the Boreal Realm was placed at the entry level of the belemnite species *Belemnella lanceolata* (von Schlotheim) (see e.g., Arkhangel'sky, 1912; Jeletzky, 1951a, b). Alternatively, on the eastern European Platform, that base usually was equated with the entry of "primitive" *Belemnella*, i.e., *Bln. licharewi* Jeletzky, the FO of which appears to correspond to that of *Bln. lanceolata* (compare Naidin, 1979). In the GSSP section at Tercis, the FO of the ammonite *Pachydiscus neubergicus* (von Hauer) has been recorded just 0.9 m [116.1 m] above the Campanian/Maastrichtian boundary as defined at the level 115.2 m (Odin, 2001; Odin and Lamaurelle, 2001), and was originally considered to be separated by not more than 0.2 myr

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from the FO of *Bln. lanceolata* (Christensen et al., 2000; Christensen, 2001). In contrast, Walaszczyk (2004) suggested that the FO of *Bln. lanceolata* could be much older which was confirmed by Niebuhr et al. (2011) and Remin (2012), who equated the Tercis-defined boundary with the base of *Bln. obtusa*–*Bln. vistulensis* Zone, being c.a. 400–450 kyr older than the boundary at Tercis.

Some doubts over the value of *D. cylindraceum* as a marker for the base of the Maastrichtian were expressed by one of us (ZR) during the Geological Society of America, Annual Meeting at Minneapolis, Minnesota (Remin, 2011), mainly on account of the diachroneity of its FOs in sections across Europe. Here we document *D. cylindraceum* from the Middle Campanian (in the three-fold subdivision of Walaszczyk et al., 2001) of the Roztocze Hills (Poland) and discuss the significance of this record for the definition of the Campanian/Maastrichtian boundary. The specimen is housed in the collections of the S.J. Thugutt Geological Museum, Faculty of Geology, at the University of Warsaw, under registration number MWGUW ZI/46/04.

GEOLOGICAL SETTING

Specimen ZI/46/04 was collected by one of us (ZR) from the Roztocze Hills in south-east Poland (Fig. 1). These hills form a prominent range along the southwesterly margin of the Kościerzyna–Puławy Syncline; to the south it borders the Carpathian Foredeep. The hills are made up of Campanian and Maastrichtian sediments, unconformably overlain by Miocene deposits (e.g., Pożaryski, 1956).

The section that yielded *Diplomoceras* is situated in the Hutniczo-Siarkowa railroad cutting, about 4 km south-west of Zwierzyniec, close to the village of Szozdy (Fig. 1). The sequence, made up of sandy (quartzose) limestone or limy quartz-sandstone dip at a low angle to the north-east. The interval studied has yielded rich fossil assemblage, comprising ammonites, belemnites, inoceramid bivalves, echinoids as well as diverse gastropods and non-inoceramid bivalves. Ammonites include representatives of *Didymoceras* Hyatt, *Acanthoscaphites tuberculatus* (Giebel), *Menuites portlocki posterior* Błaszkiwicz, *Pachydiscus* cf. *koeneni* de Grossouvre, and small baculitids. Amongst belemnites, specimens of *Belemnitella* ex gr. *langei* Jeletzky, have been noted. This assemblage assigns a Middle Campanian date to the Szozdy section, and more precisely places it in the lower/middle portion of the *Didymoceras donezianum* ammonite Zone (sensu Błaszkiwicz, 1980).

Inoceramid bivalves are represented by “*Inoceramus*” *borilensis* Jolkicev, and *Cataceramus gandjaeformis* Walaszczyk, Cobban & Harries, indicative of the “*Inoceramus*” *tenuilineatus* Zone (Fig. 2; I. Walaszczyk, pers. comm., March, 2015), and, in particular, the middle part of that zone. Therefore, the interval studied at Szozdy is easily correlated with the equivalent interval in the Middle Vistula River section (see Fig. 2; see Walaszczyk, 2004). A similar stratigraphic position can be derived from benthic foraminifera (Z. Dubicka, pers. comm., March, 2015; cf. also Peryt and Dubicka, 2015), the presence of *Globorotalites michelinianus* (d’Orbigny) *Globorotalites emdyensis* Vasilenko, *Bolivinoidea sidestrandensis* Barr (early form by Dubicka and Peryt, 2016), *Bolivina incassata* Reuss, allowing correlation of the Szozdy section

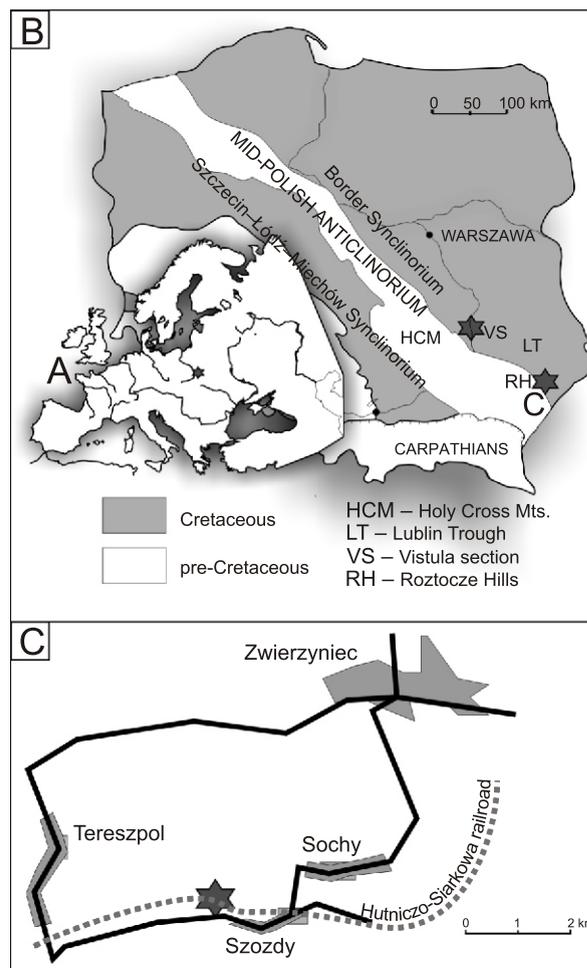


Fig. 1A – location of the Middle Vistula River section and the Roztocze Hills in east-central Europe; B – Upper Cretaceous deposits in extra-Carpathian Poland (after Pożaryski, 1974); C – schematic map of the Szozdy area, source area of *Diplomoceras cylindraceum* as here recorded

with intervals exposed at Ciszyca in the Middle Vistula River section (cf. Fig. 2).

IDENTIFICATION

Specimen ZI/46/04 is a small fragment of a straight phragmocone shaft, measuring about 30 mm in greatest length and preserved as a three-dimensional composite mould (Fig. 3). It shows the typical diplomoceratid ornament of annular ribs separated by shallow interspaces of comparable width to the ribs. No constrictions or bullae are seen. Whorl height and whorl breadth are 45 and 36 mm, respectively (Wb/Wh ratio 0.8).

Although markedly incomplete, the specimen differs in no significant respects from better-preserved material of *D. cylindraceum* from various localities (for recent accounts and synonymies, see Kennedy, 1987; Klinger and Kennedy, 2003a, b; Machalski, 2012). The ovoid cross section, and the complex,

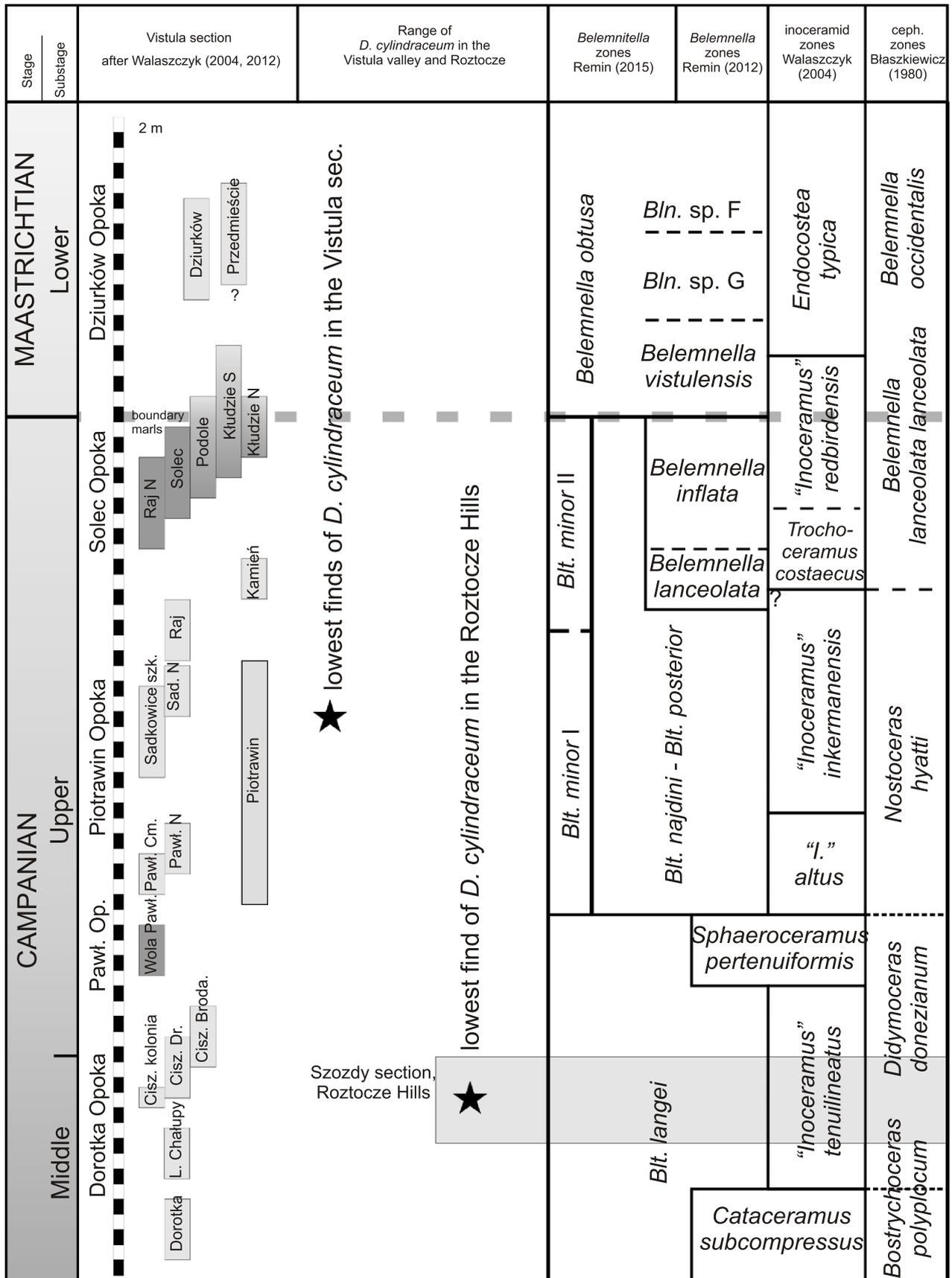


Fig. 2. Stratigraphic range and position of the Szozdy section in the Roztocze Hills, SE Poland correlated with the Middle Vistula section, central Poland

Left-hand columns illustrate the base of the Maastrichtian Stage according to the GSSP, Tercis les Bains; *Blt.* – *Belemnitella*; *Bln.* – *Belemnella*

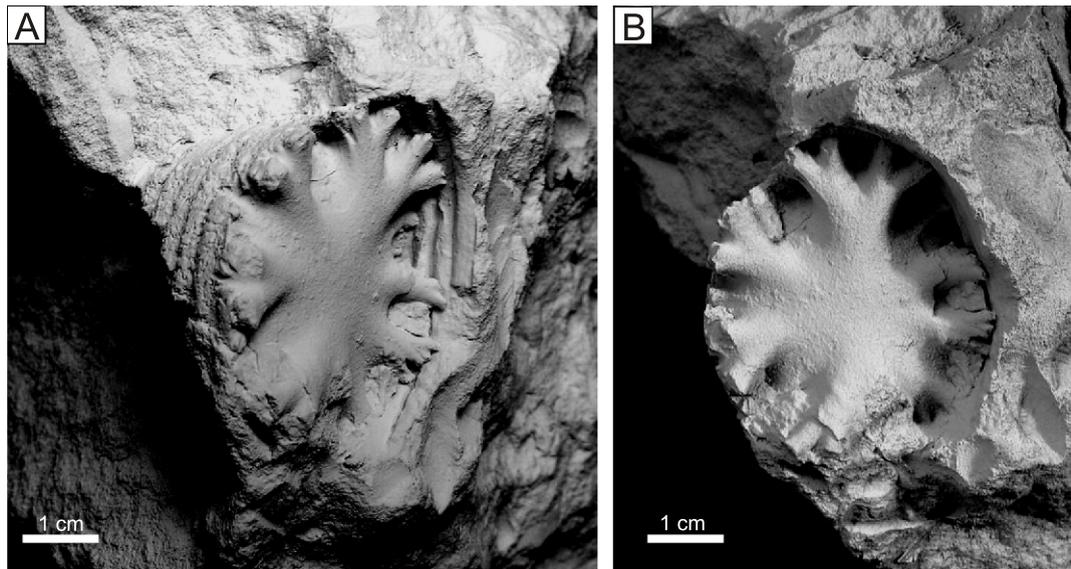


Fig. 3. *Diplomoceras cylindraceum* (Defrance, 1816), specimen MWGUW ZI/46/04

A – composite mould, showing typical diplomoceratid ornament of annular ribs with shallow interspaces of equal width; B – ovoid cross section

		cephalopod Vistula	inocerams Vistula	inocerams/cephalopods Tercis	
Maastrichtian	Lower	<i>Belemnella</i> sp. F ----- <i>obtusa</i> sp. G ----- <i>vistulensis</i>	<i>Endocostea</i> <i>typica</i>	<i>Endocostea</i> <i>typica</i>	<i>Pachydiscus</i> <i>neubergicus</i>
		<i>Bln. inflata</i>	“ <i>Inoceramus</i> ” <i>redbirdensis</i>	“ <i>Inoceramus</i> ” <i>redbirdensis</i>	
		<i>Bln. lanceolata</i>	----- <i>T. costaeus</i>	<i>T. costaeus</i>	
					level of first <i>Belemnella</i> or its equivalent = traditional Cam/Maast. boundary
Campanian	Upper	<i>Nostoceras</i> <i>hyatti</i>	“ <i>Inoceramus</i> ” <i>inkermanensis</i>	“ <i>Inoceramus</i> ” <i>oblongus</i>	<i>Nostoceras</i> <i>hyatti</i>
		-----	“ <i>Inoceramus</i> ” <i>altus</i>	“ <i>Inoceramus</i> ” <i>altus</i>	
		<i>Didymoceras</i> <i>donezianum</i>	----- “ <i>Inoceramus</i> ” <i>tenuilineatus</i>	<i>Sphaeroceras</i> <i>pertenuiformis</i>	<i>Didymoceras</i> <i>donezianum</i>
		<i>B. polyplocum</i>	----- <i>Cataceramus</i> <i>subcompressus</i>		<i>B. polyplocum</i>
Middle					

Fig. 4. First occurrences (FOs) of *Diplomoceras cylindraceum* in four areas, i.e., the Roztocze Hills, Poland (oldest); the Middle Vistula River section, Poland; Kronsmoor, northern Germany and the Tercis les Bains section, France (youngest) showing its diachronic appearance across Europe

Inoceramid zonation at Tercis after Walaszczyk et al. (2002a, b); approximate position of *Bostrychoceras polyplocum*, *D. donezianum* and *N. hyatti* zones at Tercis are based on cross-correlation with inocerams recognized in the Vistula and Tercis sections; for details of zonation for the Vistula, cf. Figure 2; arrows mark the exact provenance of *D. cylindraceum* in mentioned sections and its approximate position in the Tercis section (left column)

“dendritic” sutures clearly distinguish this specimen from coeval heteromorphs. On the whole, the present specimen matches densely ribbed specimens recorded by Kennedy (1987), Birkelund (1993), Jagt (1995), Klinger and Kennedy (2003a, b) and Machalski (1996, 2012) well. *Diplomoceras maximum* is in-

distinguishable at the whorl height of the present fragment (the critical value being 55 mm; see Machalski, 2012). However, this chronospecies, probably a direct descendant of *D. cylindraceum*, is restricted to the Late Maastrichtian (Machalski, 2012). As stated by Machalski (2012: p. 107), in view of the lack

of contradictory evidence, “It is ... reasonable to assign all pre-late European Maastrichtian records of *Diplomoceras* to *D. cylindraceum*, even if they are partly based on specimens of smaller whorl height than the critical value of 55 mm”.

STRATIGRAPHIC IMPLICATIONS

Typically, *D. cylindraceum* has been recorded exclusively from the traditionally defined Maastrichtian Stage (Błaszkiwicz, 1980; Kennedy and Summesberger, 1986, 1987; Ward and Kennedy, 1993). Records from the Campanian (as traditionally defined) generally are rare; these were summarized by Klinger and Kennedy (2003a). In Europe, examples of *D. cylindraceum* from the Upper Campanian (as traditionally defined) have been recorded from northern Spain (Gallemí et al., 1983) and central Poland (Machalski, 1996, 2012). KÜchler and Odin (2001) also recorded it from the Upper Campanian of France, but it should be noted that they used the Tercis definition of the Campanian/Maastrichtian boundary. Antarctic counterparts of *D. cylindraceum* have been dated as Late Campanian and Early Maastrichtian (Olivero and Zinsmeister, 1989), while the Indo-Pacific region has yielded a few Late Campanian records, mainly from Japan, Zululand and South Africa; for an overview, reference is made to Klinger and Kennedy (2003a). The most difficult record to interpret is that from Sakhalin (Far East Russia), which was dated as early Campanian by Alabushev and Wiedmann (1997). Klinger and Kennedy (2003a) were critical in their assessment of this particular record and noted that the juvenile specimen illustrated by Alabushev and Wiedmann (1997: pl. 4, fig. 1) could not be identified to genus, and represented either *Diplomoceras* or *Glyptoxoceras*. In view of this, we here exclude this record from the discussion.

An essential point that arises from correlations based on inoceramid bivalves and belemnites between the Vistula sections, the Roztocze Hills and sections at Tercis les Bains and Krons Moor (northern Germany) is that in Poland *D. cylindraceum* first appears well below the entry level of *Bln. lanceolata*, a traditional Campanian/Maastrichtian boundary marker (Fig. 4). This contrasts markedly to the FOs of this species at Tercis les Bains and Krons Moor, which are both above the entry level (or its equivalent) of *Bln. lanceolata* (Fig. 4).

To date, the lowest records of *D. cylindraceum* in the Vistula River valley section are those from the upper third of the section exposed at the disused Piotrawin Quarry (Machalski, 1996, 2012). Other material is from the localities Raj, Raj North, Kamień South and Kamień North and Dziurków, where Upper Campanian to Lower Maastrichtian strata are exposed (Fig. 2). These records correspond to the middle part of the “*Inoceramus*” *inkermanensis* Zone of Walaszczyk (2004), a

level equating with the middle part of the “*Inoceramus*” *oblongus* Zone, between 80–88 m and 97.6 m, at Tercis les Bains (Walaszczyk et al., 2002a, b; cf. Figs. 2 and 4).

The lowest occurrence of *D. cylindraceum*, as here documented from the Szozdy section, is from the interval that encompasses the lower/middle part of the *Didymoceras donezianum* ammonite Zone, which roughly corresponds to the middle part of the “*Inoceramus*” *tenuilineatus* inoceramid Zone of Walaszczyk (2004; cf. Figs. 2 and 4). At Tercis les Bains, “*Inoceramus*” *tenuilineatus* Zone is not distinguished and falls within “unzoned” interval (cf. Walaszczyk et al., 2002a, b). Since the “*I.*” *tenuilineatus* Zone is overlain by the *Sphaeroceras pertenuiformis* Zone (Figs. 2 and 4), which starts at Tercis at 47 m, the equivalent of the Szozdy section should be located below this level (47 m at Tercis). At Krons Moor, the lowest specimen of *D. cylindraceum* known to date is from +7 m above the first *Belemnella* [= level F600] (Niebuhr, 2003; Niebuhr et al., 2011), which equals the lower part of the *Belemnella inflata* Zone (Remin, 2012; see Figs. 2 and 4). The lowest occurrence of *D. cylindraceum* at Tercis les Bains, as currently known, is from the 111 ± 3 m level (Odin and Lamaurelle, 2001), i.e., in the lower/middle part of the “*Inoceramus*” *redbirdensis* Zone (cf. Walaszczyk et al., 2002b; see also Figs. 2 and 4), close to or at the base of the *Belemnella obtusa*–*Bln. vistulensis* Zone as recognised recently by Remin (2012) and Keutgen et al. (2012). Thus, both at Krons Moor and Tercis les Bains, the record of *D. cylindraceum* is markedly above the entry level of *Belemnella*, a traditional marker for the base of the Maastrichtian Stage (Fig. 4).

In summary, specimen ZI/46/04 demonstrates that the FO of *D. cylindraceum* is within the middle Campanian (Figs. 2 and 4), in the lower/middle part of the *Didymoceras donezianum* ammonite Zone, which is equivalent to the middle part of the “*Inoceramus*” *tenuilineatus* inoceramid Zone. This new find, well-constrained by ammonite and inoceramid stratigraphy, represents the lowest, well-dated occurrence of this species worldwide. A comparison with other sections across Europe has demonstrated a clear diachroneity in the FOs of *D. cylindraceum*. Whether this reflects original migratory patterns through time, collection bias or palaeoenvironment, is a matter of speculation. Whatever the reason may be, the marked inter-regional disparity in the FO of *D. cylindraceum* significantly diminishes its value as a marker species for the definition of the Campanian/Maastrichtian boundary.

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REFERENCES

- Alabushev, A., Wiedmann, J., 1997. Upper Cretaceous ammonites from southern Sakhalin and northwestern Kamchatka (north-east Russia). *Palaeontographica*, **A244**: 1–36.
- Arkhangelsky, A.D., 1912. Verkhnemelovyye otlozheniya vostochno-evropeyskoy Rosii (in Russian). *Materialy dlia Geologii Rossii*, **25**: 1–631.
- Birkelund, T., 1993. Ammonites from the Maastrichtian White Chalk of Denmark. *Bulletin of the Geological Society of Denmark*, **40**: 33–81.
- Błaszkiwicz, A., 1980. Campanian and Maastrichtian ammonites of the Middle Vistula River valley, Poland: a stratigraphic and paleontological study. *Prace Instytutu Geologicznego*, **92**: 1–63.

- Christensen, W.K., 2001.** The Campanian–Maastrichtian Stage boundary. *Bulletin of the Geological Society of Denmark*, **48**: 208.
- Christensen, W.K., Hancock, J.M., Peake, N.B., Kennedy, W.J., 2000.** The base of the Maastrichtian. *Bulletin of the Geological Society of Denmark*, **47**: 81–85.
- Defrance, M.J.L., 1816.** Dictionnaire des Sciences Naturelles, dans lequel on traite méthodiquement des différents êtres de la nature, **3**: 1–492, Levrault, Paris/Strasbourg.
- Dubicka, Z., Peryt, D., 2016.** *Bolivinooides* (benthic foraminifera) from the Upper Cretaceous of Poland and western Ukraine: taxonomy, evolutionary changes and stratigraphic significance. *Journal of Foraminiferal Research*.
- Gallelli, J., Martínez, R., Pons, J.M., 1983.** Coniacian–Maastrichtian of the Tremp Area (south central Pyrenees). *Newsletters on Stratigraphy*, **12**: 1–17.
- Jagt, J.W.M., 1995.** A Late Maastrichtian ammonite fauna in flint preservation from northeastern Belgium. *Mededelingen Rijks Geologische Dienst*, **53**: 21–47.
- Jeletzky, J.A., 1951a.** The place of the Trimmingham and Norwich Chalk in the Campanian–Maastrichtian succession. *Geological Magazine*, **88**: 197–208.
- Jeletzky, J.A., 1951b.** Die Stratigraphie und Belemnitenfauna des Obercampan und Maastricht Westfalens, Nordwestdeutschlands und Dänemarks, sowie einige allgemeine Gliederungs-Probleme der jüngeren borealen Oberkreide Eurasiens. *Beihefte zum Geologischen Jahrbuch*, **1**: 1–142.
- Kennedy, W.J., 1987.** The ammonite fauna of the type Maastrichtian with a revision of *Ammonites colligatus* Binkhorst, 1861. *Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre*, **56**: 151–267 [dated 1986].
- Kennedy, W.J., Summesberger, H., 1986.** Lower Maastrichtian ammonites from Neuberg, Steiermark, Austria. *Beiträge zur Paläontologie von Österreich*, **12**: 181–242.
- Kennedy, W.J., Summesberger, H., 1987.** Lower Maastrichtian ammonites from Nagoryany, Ukrainian SSR. *Beiträge zur Paläontologie von Österreich*, **13**: 25–78.
- Keutgen, N., Remin, Z., Walaszczyk, I., 2012.** Early representatives of the belemnite genus *Belemnella* (Cephalopoda) from the uppermost Campanian–Lower Maastrichtian of the Middle Vistula River section, central Poland. *Acta Geologica Polonica*, **62**: 535–559.
- Klinger, H.C., Kennedy, W.J., 2003a.** Observations on the systematics, geographic and stratigraphic distribution and origin of *Diplomoceras cylindraceum* (Defrance, 1816) Cephalopoda: Ammonoidea). *Annals of the South African Museum*, **110**: 171–198.
- Klinger, H.C., Kennedy, W.J., 2003b.** Cretaceous faunas from Zululand and Natal, South Africa. The ammonite families Nostoceratidae Hyatt, 1894 and Diplomoceratidae Spath, 1926. *Annals of the South African Museum*, **110**: 219–336.
- Küchler, T., Odin, G.S., 2001.** Upper Campanian–Maastrichtian ammonites (Nostoceratidae, Diplomoceratidae) from Tercis les Bains (Landes, France). *Developments in Palaeontology and Stratigraphy*, **19**: 500–528.
- Landman, N.H., Goolaerts, S., Jagt, J.W.M., Jagt-Yazykova, E.A., Machalski, M., Yacobucci, M., 2014.** Ammonite extinction and nautilid survival at the end of the Cretaceous. *Geology*, **42**: 707–710; doi: 10.1130/G35776.1
- Machalski, M., 1996.** *Diplomoceras cylindraceum* (Defrance, 1816): a typically Maastrichtian ammonite in the Piotrawin section, Central Poland. *Przegląd Geologiczny*, **44**: 953–954.
- Machalski, M., 2012.** Stratigraphically important ammonites from the Campanian–Maastrichtian boundary interval of the Middle Vistula River section, central Poland. *Acta Geologica Polonica*, **62**: 91–116.
- Naidin, D.P., 1979.** Vergleichende Stratigraphie der Oberen Kreide der Russischen Tafel und West-Europas. In: *Aspekte der Kreide Europas* (ed. J. Wiedmann). *International Union of Geological Sciences*, **A6**: 497–510.
- Niebuhr, B., 2003.** Late Campanian and Early Maastrichtian ammonites from the white chalk of Krons Moor (northern Germany) – taxonomy and stratigraphy. *Acta Geologica Polonica*, **53**: 257–281.
- Niebuhr, B., Hampton, M.J., Gallagher, L.T., Remin, Z., 2011.** Integrated stratigraphy of Krons Moor (northern Germany), an international reference section for the base of the Maastrichtian in the Boreal Realm. *Acta Geologica Polonica*, **61**: 193–214.
- Odin, G.S., ed., 2001.** The Campanian–Maastrichtian boundary: characterisation at Tercis les Bains (France): correlation with Europe and other continents. *Developments in Palaeontology and Stratigraphy Series*, **19**.
- Odin, G.S., Lamaurelle, M.A., 2001.** The global Campanian–Maastrichtian stage boundary. *Episodes*, **24**: 229–238.
- Olivero, E.B., Zinsmeister, W.J., 1989.** Large heteromorph ammonites from the Upper Cretaceous of Seymour Island, Antarctica. *Journal of Paleontology*, **63**: 626–636.
- Peryt, D., Dubicka, Z., 2015.** Foraminiferal bioevents in the Upper Campanian to lowest Maastrichtian of the Middle Vistula River section, Poland. *Geological Quarterly*, **59** (4): 814–830.
- Požaryski, W., 1956.** Kreda (in Polish). In: *Regionalna geologia Polski* (eds. M. Książkiewicz and S. Dżułyński), **2**. *Polskie Towarzystwo Geologiczne; Państwowe Wydawnictwo Naukowe, Kraków*.
- Požaryski, W., 1974.** Tektonika, cz. 1. Niż Polski (in Polish). In: *Budowa geologiczna Polski* (ed. W. Pożaryski): 2–34. *Wyd. Geol., Warszawa*.
- Remin, Z., 2011.** *Diplomoceras maximum* and *D. cylindraceum* – the giant Upper Cretaceous heteromorph ammonites and their stratigraphic significance. *Geological Society of America Annual Meeting, Minneapolis, Minnesota USA, 9–12 October 2011, Abstracts with Programs*, **43**: 640.
- Remin, Z., 2012.** The *Belemnella* stratigraphy of the Campanian–Maastrichtian boundary: a new methodological and taxonomic approach. *Acta Geologica Polonica*, **62**: 495–533.
- Remin, Z., 2015.** The *Belemnella* stratigraphy of the Upper Campanian–basal Maastrichtian of the Middle Vistula section, central Poland. *Geological Quarterly*, **59** (4): 783–813.
- Walaszczyk, I., 2004.** Inoceramids and inoceramid biostratigraphy of the Upper Campanian to basal Maastrichtian of the Middle Vistula River section, central Poland. *Acta Geologica Polonica*, **54**: 95–168.
- Walaszczyk, I., 2012.** Integrated stratigraphy of the Campanian–Maastrichtian boundary succession of the Middle Vistula River (central Poland) section; introduction. *Acta Geologica Polonica*, **62**: 485–493.
- Walaszczyk, I., Cobban, W.A., Harries, P.J., 2001.** Inoceramids and inoceramid biostratigraphy of the Campanian and Maastrichtian of the United States Western Interior Basin. *Revue de Paleobiologie*, **20**: 117–234.
- Walaszczyk, I., Cobban, W.A., Odin, G.S., 2002a.** The inoceramid succession across the Campanian–Maastrichtian boundary. *Bulletin of the Geological Society of Denmark*, **49**: 53–60.
- Walaszczyk, I., Odin, G.S., Dhondt, A.V., 2002b.** Inoceramids from the Upper Campanian and Lower Maastrichtian of the Tercis section (SW France), the Global Stratotype Section and Point for the Campanian–Maastrichtian boundary; taxonomy, biostratigraphy and correlation potential. *Acta Geologica Polonica*, **52**: 269–305.
- Ward, P.D., Kennedy, W.J., 1993.** Maastrichtian ammonites from the Biscay region (France, Spain). *The Paleontological Society Memoir*, **34**: 1–58.