Geologia Sudetica, 2008, 40: 33–50.

A new Lower Coniacian fauna from the Jerzmanice Zdrój region of the North Sudetic Basin, SW Poland

Alina Chrząstek

Institute of Geological Sciences, Wrocław University, Maksa Borna 9, 50-204 Wrocław, Poland,
e-mail: alina.chrzastek@ing.uni.wroc.pl

Key words: Lower Coniacian, Upper Cretaceous, North Sudetic Basin, inoceramids, bivalves, palaeoenvironment, West Sudetes.

Abstract This paper describes and interprets a newly discovered Lower Coniacian (lower Upper Cretaceous) macro- and microfossil fauna (vertebrate and invertebrate remains) from sedimentary rocks of the Jerzmanice Zdrój region of the North Sudetic Basin of SW Poland. Several inoceramid bivalve taxa that previously were only known from other parts of the North Sudetic Basin were recovered from light grey, marly sandstones of Early Coniacian age. A fragment of ammonite was also discovered, as was a shark's tooth from the family Cretoxyrhinidae: this may be ?*Cretoxyrhina mantelli* Agassiz, 1843, a species not hitherto known from the Lower Coniacian (Emscherian *sensu* Scupin (1912–13)) of the North Sudetic Basin. Abundant foraminifers were observed in thin sections. The newly discovered inoceramid bivalves – *Cremnoceramus deformis erectus* Meek, 1877, *Cremnoceramus waltersdorfensis waltersdorfensis* Andert, 1911 and *Inoceramus lusatiae* Andert, 1911 – fit into the current biostratigraphic scheme for the region. The inoceramids can all be assigned to the *Cremnoceramus deformis erectus* Zone, which correlates with the *Gavelinella moniliformis* foraminiferal Zone and thereby confirms an Early Coniacian age. The Turonian–Coniacian boundary in the North Sudetic Basin can now be placed between the respective inoceramid zones of *Inoceramus costellatus* Woods, 1912 (actually *Mytiloides costellatus* Woods, 1912) and *Inoceramus schloenbachi* Böhm, 1911 (actually *Cremnoceramus crassus crassus* Petrascheck, 1903). The macrofossils found in the Jerzmanice section suggest that the host sediments were laid down in a Late Cretaceous epicontinental basin, under the North Sudetic Sea, that had deepened during the Early Coniacian. This interpretation agrees with the global bathymetric curve for the Late Cretaceous in Europe.

Manuscript received 5 June 2008, accepted 20 December 2008

INTRODUCTION

The Jerzmanice Zdrój area occurs in the southern part of the North Sudetic Synclinorium (Żelaźniewicz & Aleksandrowski, 2008) in which there is the Leszczyna–Jerzmanice half-graben that contains Cenomanian–Coniacian (lower Upper Cretaceous) deposits (Chrząstek, 1995) (Figs 1, 2). Within the Jerzmanice Zdrój area there is an outcrop near the village of Jerzmanice Zdrój of Lower Coniacian sediments (Figs 1, 2, 3A) from which a rich fossil assemblage (Tab. 1) can be extracted. This assemblage comprises some 16 taxa, mainly bivalves, and includes a fragment of probable ammonite and also a shark's tooth from the family Cretoxyrhinidae (?*Cretoxyrhina mantelli*, Agassiz, 1843). Such shark's teeth were previously unknown from the Lower Coniacian of the North Sudetic Basin, though teeth of *Cretoxyrhina mantelli* have been described from the Cenomanian and Turonian near Lwówek Śląski (Scupin, 1912–13; Kühn & Zimmermann, 1919). In the Cenomanian and Turonian of the North Sudetic Basin, teeth of 6 shark species have been recognised (Scupin, 1912–13; Kühn & Zimmermann, 1919). Scupin (1912–13) described Lower Coniacian bivalves from other parts of the North Sudetic Basin, mostly in the vicinity of Warta Bolesławiecka, and mentioned only 3 taxa from Jerzmanice Zdrój: *Pectenculus geinitzi* d'Orbigny, 1843–47, *Cucullaea* sp., and *Inoceramus latus* Mantell, 1822. Palaeogeographic reconstructions, based on detailed lithostratigraphic and biostratigraphic analyses of the Upper Cretaceous deposits, were given by both Scupin (1912–13) and, later, by Milewicz (1958; 1967; 1973a, b; 1979; 1997; 1998) who envisaged two islands in the Late Cretaceous sea delivering detritus into the North Sudetic Basin. This paper reports on new macro- and microfauna assemblages from the marly sandstones of the Jerzmanice Zdrój section, confirms an Early Coniacian age for these deposits, and offers a palaeogeographic reconstruction of the sedimentary environment of these rocks.

GEOLOGICAL SETTING

The North Sudetic Synclinorium occurs at the NE rim of the Bohemian Massif in the western part of the Fore-Sudetic Block. The basement of this synclinorium comprises the ?Ediacaran to Mississippian low-grade metamorphic rocks of the Kaczawa Complex (Baranowski *et al.*, 1990; Chrząstek *et al.*, 2004), on which rest incomplete successions of Upper Palaeozoic (Carboniferous (Pennsylvanian) and Permian), Mesozoic (Triassic and Upper Cretaceous) and Cenozoic platform sediments. These platform sediments were gently folded and faulted during the Palaeogene when the North Sudetic Basin underwent tectonic inversion to produce the present-day North Sudetic Synclinorium.

Triassic deposits paraconformably underlie the Upper Cretaceous succession (Milewicz, 1997). In the southern part of the basin, it is the Lower and Middle Buntsand-

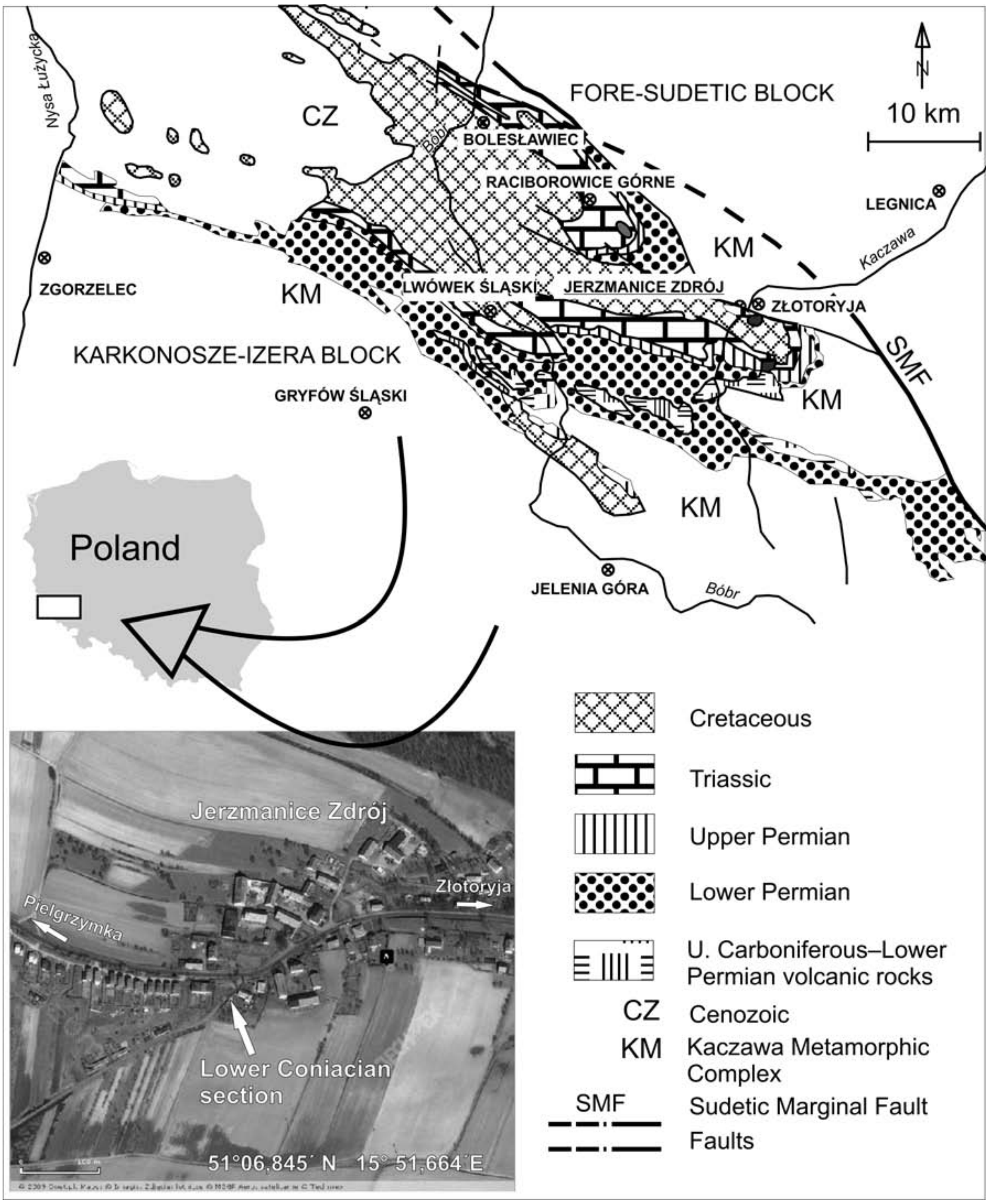

Fig. 1. Geological map of the North Sudetic Basin (modified after Sawicki, 1995).

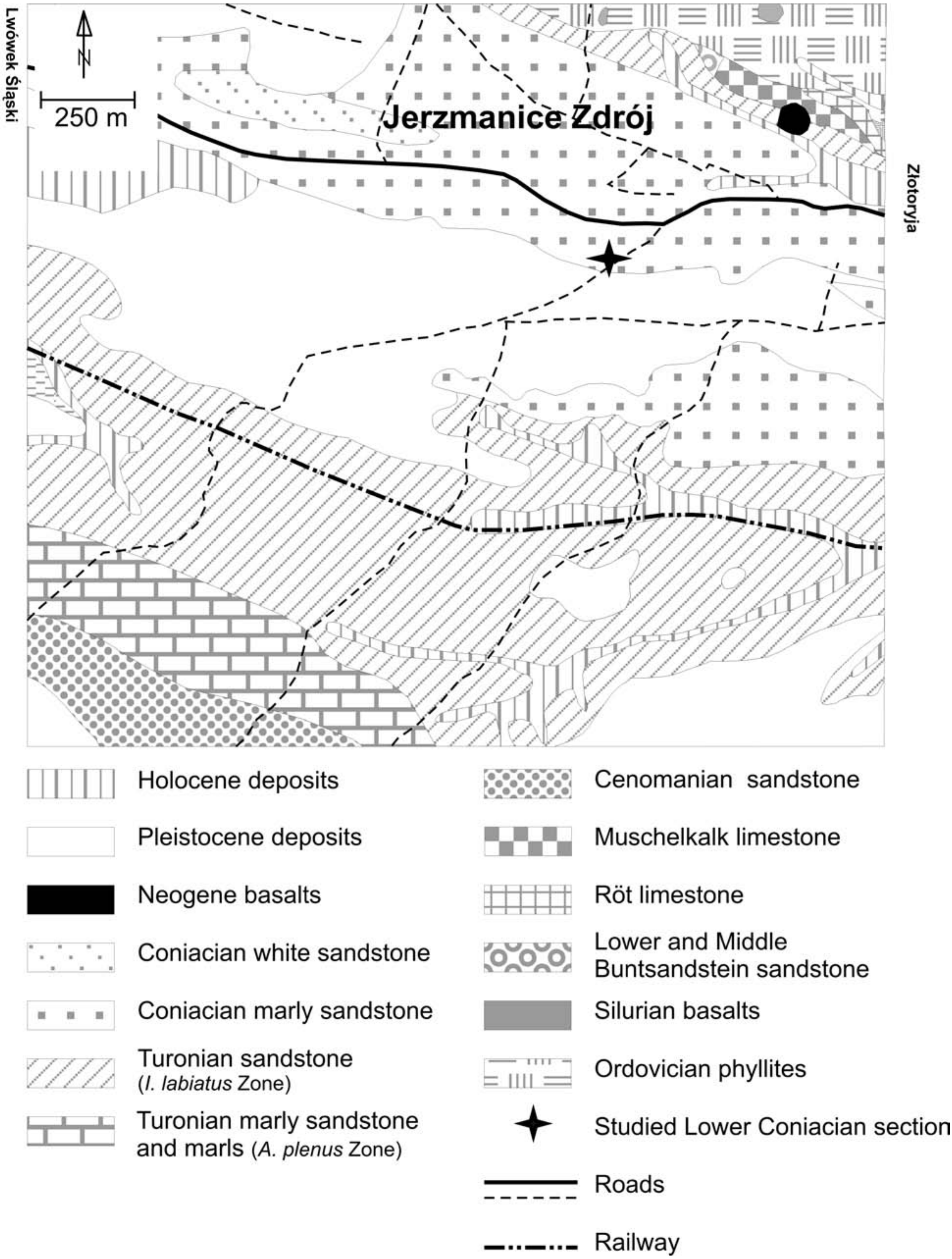

Fig. 2. Geological sketch map of the Jerzmanice Zdrój area of the North Sudetic Basin (modified after Milewicz & Jerzmański, 1956–57).

Table 1
Fossil taxa in the Lower Coniacian at Jerzmanice Zdrój (North Sudetic Basin)

No	Taxa
1	*Anatina (Cercomya) lanceolata* Geinitz, 1871-75
2	*Crasatella arcacea* Roemer, 1841
3	*Cremnoceramus deformis erectus* Meek, 1877
4	*Cremnoceramus waltersdorfensis waltersdorfensis* Andert, 1911
5	*Cucullaea* sp.
6	*Cytherea* sp.
7	*Granocardium cf. drescheri* Böhm, 1911
8	*Inoceramus latus* Mantell, 1822
9	*Inoceramus lusatiae* Andert, 1911
10	*Inoceramus* sp.
11	*?Lima haidingeri* Zittel, 1878
12	*Ostrea (Alectryonia) sudetica* Scupin, 1912-13
13	*Panopea depressa* Scupin, 1912-13
14	*Panopea muelleri* Scupin, 1912-13
15	*Tellina strigata* Goldfuss, 1834-40
16	*?Cretoxyrhina mantelli* Agassiz, 1843

stein, whereas in the northern part Röt and Muschelkalk rocks are in evidence at the nonconformity. Locally, in the Wleń Trough, the Upper Cretaceous sediments cover the Rotliegendes and metamorphic rocks of the Kaczawa Complex (Gorczyca-Skała, 1977; Śliwiński *et al.*, 2003).

The Upper Cretaceous of the North Sudetic Basin is divided into 3 formations: the Rakowice Wielkie Formation (Cenomanian–Coniacian), Czerna Formation (Santonian) and Węgliniec Formation (Santonian) described by Milewicz (1997), Śliwiński *et al.* (2003), Chrząstek *et al.* (2004).

In the North Sudetic Basin, Late Cretaceous sedimentation occurred from the Cenomanian to the Santonian (Milewicz, 1973a, b; 1997). The thickness of the Upper Cretaceous deposits ranges between 600 m and 1,100 m, the Coniacian deposits themselves being up to ~310 m thick (Milewicz, 1973a, b; Baranowski *et al.*, 1990). In the borehole known as Węgliniec IG 1, located in the western part of the North Sudetic Basin, Lower Coniacian rocks ~130 m thick were drilled (Milewicz, 1988). The Upper Cretaceous sediments of the Cenomanian, Turonian and Coniacian of the North Sudetic Basin are mostly sandstones and marls, whereas the Santonian sediments are of mudstones and sandstones with intercalations of claystones and coals (Baranowski *et al.*, 1990; Chrząs- tek, 2002; Śliwiński *et al.*, 2003; Leszczyński & Chodowska, 2008). Sandstones dominate in the eastern part of the North Sudetic Basin, whereas mudstones and marls dominate its western part (Śliwiński *et al.*, 2003). As a result of the axis of the North Sudetic Synclinorium plunging toward the WNW, the youngest sediments now outcrop in the northwest part of the basin (Milewicz, 1997). Coniacian marly sandstones from the North Sudetic Basin have been described by Milewicz (1997, 1998). The lower part of the Lower Coniacian succession contains fine-grained sandstones, the upper part contains medium-grai- ned sandstones (Milewicz, 1998), and all the sandstones pass laterally into carbonate deposits. According to Milewicz (1997, 1998), the Lower Coniacian sandstones contain the smallest grain-size sand (0.2 mm) of all the Cretaceous sandstones in the North Sudetic Basin.

LITHOSTRATIGRAPHY AND BIOSTRATIGRAPHY

The biostratigraphic subdivision of the Upper Cretaceous of the North Sudetic Basin is based on inoceramids (Milewicz, 1997). According to Milewicz (1997), the Lower Coniacian belongs to the *Inoceramus koeneni* horizon. The division of the Upper Cretaceous sediments of Poland, Germany, England, Central European Russia and the United States has been further refined by Walaszczyk (1992), Walaszczyk & Wood (1998), Walaszczyk & Cobban (2004), Tröger & Wejda (1998), Tröger (2004), Walaszczyk *et al.* (2004) and Wood *et al.* (2004).

At the boundary between the Turonian and Coniacian in Poland and Germany, Walaszczyk & Wood (1998) claim that the bivalves *Mytiloides* and *Inoceramus* are replaced by *Cremnoceramus*, the latter being most common in the uppermost Turonian and Lower Coniacian. According to Walaszczyk & Wood (1998), the boundary between the Turonian and the Coniacian is the base of the *Cremnoceramus deformis erectus* Zone and is marked by the first appearance of *Cremnoceramus deformis erectus* Meek, 1877. The Turonian–Coniacian boundary in Poland corresponds to the former *Cremnoceramus brogniarti* Zone (Walaszczyk, 1992), *Cremnoceramus deformis erectus* Meek, 1877 being a synonym of *Cremnoceramus rotundatus* Zone (Walaszczyk & Wood, 1998; Walaszczyk & Cobban, 1998). The boundary between the Turonian and the Lower Coniacian in other parts of Europe – Saxony (Germany), European part of Russia, England and the United States – is marked by the lower boundary of the *Cremnoceramus deformis erectus* Zone (Tröger & Wejda 1998; Walaszczyk & Cobban, 1998; Walaszczyk & Wood, 1998; Walaszczyk *et al.*, 2004; Wood *et al.*, 2004). The base of the *Cremnoceramus rotundatus* Zone in Japan, however, is equivalent to the base of the *Cremnoceramus deformis erectus* Zone (Noda & Matsumoto, 1998).

Inoceramids provide the basis for the subdivision of the Lower Coniacian into 5 zones (Walaszczyk & Wood, 1998; Wood *et al.*, 2004), which are as follows: *Cremnoceramus deformis erectus*; *Cremnoceramus waltersdorfensis hannovrensis*; *Cremnoceramus crassus inconstans*; *Cremnoceramus crassus* + *Cremnoceramus deformis deformis*; and *Inoceramus gibbosus*.

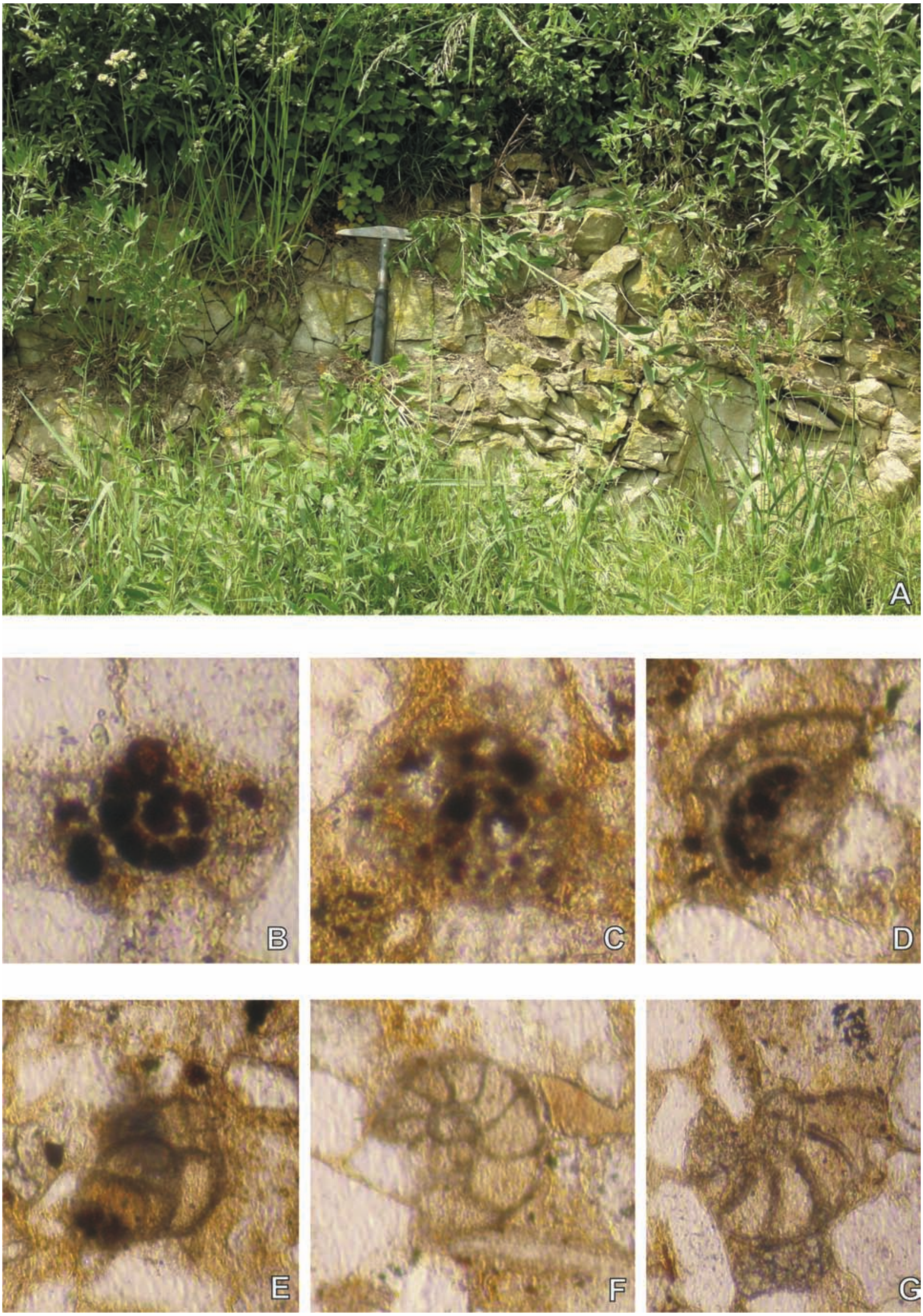

Fig. 3. The Lower Coniacian section in Jerzmanice Zdrój, North Sudetic Basin. **(A)** Rock exposure at Jerzmanice Zdrój; **(B–D)** Foraminifer *Ammodiscus cretaceous* Reuss, 1845; **(E)** Foraminifer *Gaudryina laevigata* Franke, 1914; **(F, G)** Foraminifer *Gavelinella ammonoides* Reuss, 1845. In B–G the photo height is 2 mm.

Table 2

Foraminifers in the Upper Cretaceous of the North Sudetic Basin.

No	taxa	Cenomanian	Turonian d	Turonian s	Turonian g	Coniacian d	Coniacian s	Coniacian g	Santonian d	Santonian s	Santonian g	Campanian	Maastrichtian
1	*Ammodiscus cretaceous* Reuss, 1845	■	■	■	■	■	■	■	■	■	■		
			▒	▒	▒	▒	▒	▒	▒				
2	*Gaudryina laevigata* Franke, 1914		■	■	■	■	■	■	■				
			▒	▒	▒	▒							
3	*Gavelinella ammonoides* Reuss, 1845		■	■	■	■	■	■					
			▒	▒	▒	▒							
4	*Gavelinella moniliformis* Reuss, 1845		■	■	■								
			▒	▒	▒	▒							
5	*Globotruncana bulloides* Vögler, 1941		■	■	■	■	■	■	■	■	■	■	■
			▒	▒	▒	▒	▒	▒					
6	*Heteroxelix striata* Ehrenberg, 1840		■	■	■	■	■	■	■	■	■	■	■
			▒	▒	▒	▒							

■ Stratigraphic range according to Teisseyre (1992)

▒ Stratigraphic distribution in the North Sudetic Basin according to Teisseyre (1992), slightly changed by the author

LOWER CONIACIAN IN JERZMANICE ZDRÓJ

The Lower Coniacian sediments of the Rakowice Wielkie Formation in the Jerzmanice Zdrój section are fine-grained greyish marly sandstones with intercalations of sandy limestone. Thin sections of the marly sandstones show that grain size varies from 0.05 mm to 0.2 mm; that there is a predominance of subrounded quartz grains, only a minority being subangular to angular; that glauconite is present; and that there are a few plagioclases and some isolated flakes of muscovite. The marly sandstones contain 10–20% carbonate; clay minerals, such as kaolinite, can also be observed. Present throughout the Lower Coniacian sequence are microcrystalline SiO_2, some Fe and Ti oxides and phosphates, such as collophane: the heavy minerals rutile and zircon are rare. The cement (matrix) for these sandstones is a carbon-rich clay, the clay minerals themselves constituting up to 50% of the matrix. In agreement with classification of sedimentary rocks (Lorenc, 1978; Manecki & Muszyński, 2008), the majority of the Lower Coniacian rocks may be classified as marly sandstones.

A minority of the Lower Coniacian rocks, however, should be classified as sandy limestones. Thin sections of these sandy limestones demonstrate that carbonates, mostly in the form of sparite cement, dominate over quartz (20–25%,) and clay minerals (about 10%). Sometimes the sandy limestones show directional textures and clear laminations, which are marked by the horizontal orientation of longitudinal skeletal elements.

It is the marly sandstones of the Jerzmanice Zdrój section that contain the fossils described in this paper: the inoceramid bivalves, the probable fragment of ammonite, and the Cretoxyrhinidae shark's tooth (?*Cretoxyrhina mantelli* Agassiz, 1843) (Tab. 1). Thin sections of the marly sandstone reveal the abundant foraminifers and some less common gastropods (Tab. 2).

SYSTEMATIC PALAEONTOLOGY OF FOSSILS

This section presents the systematic palaeontology of the newly found inoceramids and the vertebrate remains from the Lower Coniacian Jerzmanice Zdrój outcrop (Table 1). Other fossil taxa are only briefly mentioned. Fossils descriptions are based on papers by Scupin (1912–13); Andert (1934); Gawor-Biedowa (1980); Cappetta (1987); Walaszczyk (1988, 1992): Tarkowski (1991); Teisseyre (1992); Noda & Matsumoto (1998);Walaszczyk & Wood (1998); Cicimurri (2001a, b); Walaszczyk *et al.*, (2004); Wiese *et al.*, (2004); Wood *et al.*, (2004) and Zonova & Yazykowa (1998). All the described specimens (catalogue numbers starting MGU.Wr) are deposited in the collections of the Geological Museum of the University of Wrocław.

Genus Cremnoceramus Cox, 1969
Cremnoceramus deformis erectus Meek, 1877
Fig. 4H–I

MGU.Wr – 5442s

1988 *Cremnoceramus rotundatus* Fiege, 1930; Walaszczyk; Pl. 7, figs 1-6.

1992 *Cremnoceramus brongniarti* Mantell, 1822; Walaszczyk; p. 48–52, Pl. 22, figs 1–2; Pl. 23, figs 1–5; Pl. 24, figs 1–5; Pl. 25, figs 1–5; Pl. 30, fig. 2.

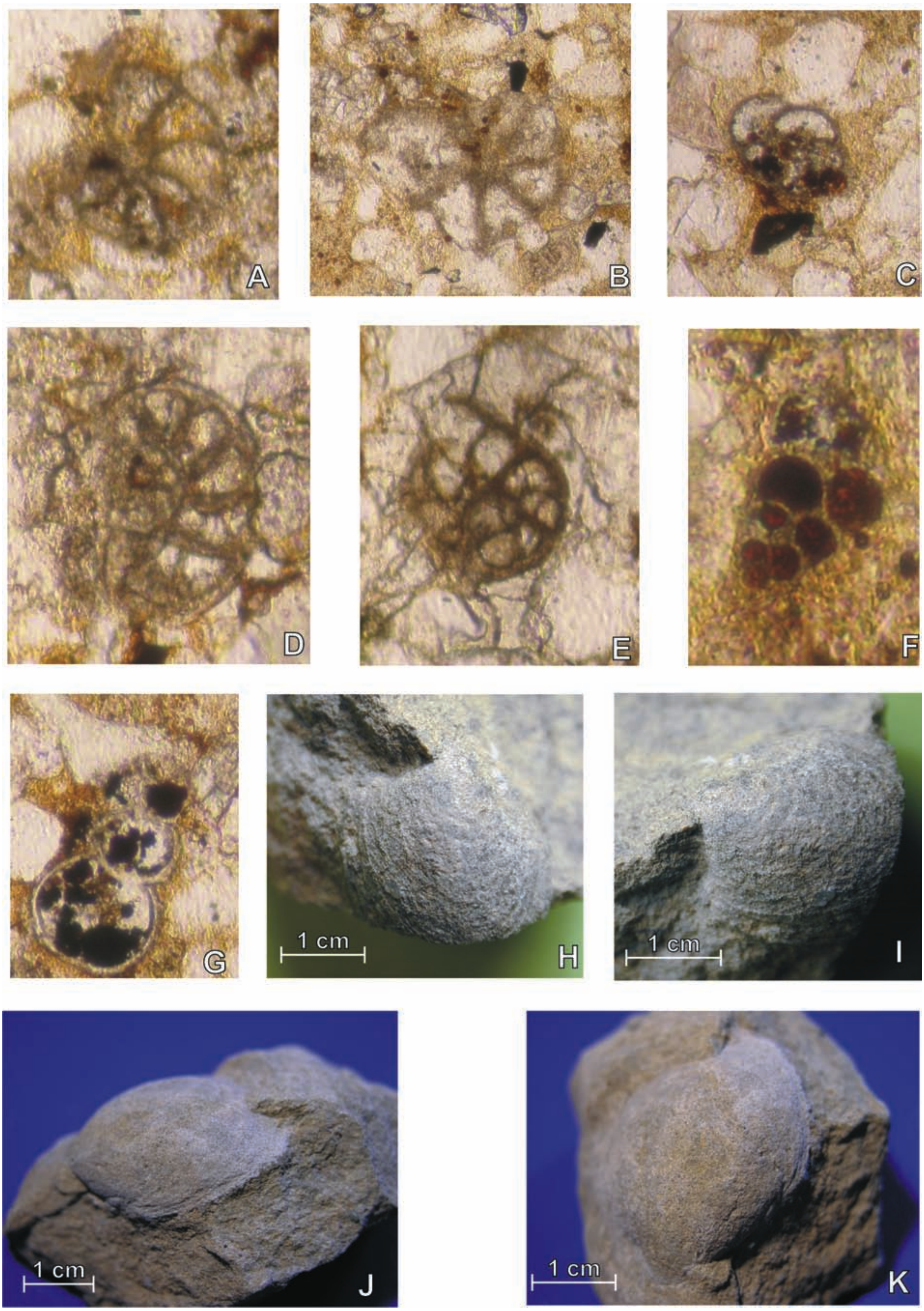

Fig. 4. Foraminifers, gastropod and inoceramids from Jerzmanice Zdrój. **(A–C)** Foraminifer *Gavelinella moniliformis* Reuss, 1845; **(D, E)** Foraminifer *Globotruncana bulloides* Vögler, 1941; **(F)** Foraminifer *Heteroxelix striata* Ehrenberg, 1840; **(G)** Gastropod in a thin section; **(H, I)** Inoceramid *Cremnoceramus deformis erectus* Meek, 1877 (MGU.Wr – 5442s); **(J, K)** Inoceramid *Cremnoceramus waltersdorfensis waltersdorfensis* Andert, 1911 (MGU.Wr – 5443s). In A–G the photo height is 2 mm.

1998 *Cremnoceramus deformis erectus* Meek, 1877; Walaszczyk & Wood; p. 415–416; Pl. 5, fig. 14; Pl. 6, figs 1–6, 8; Pls 7–8; Pl. 9, figs 1, 3–6; Pl. 10, figs 1–4, 6; Pl. 11, figs 1, 3, 5–7; Pl. 13, fig. 1; Pl. 15, fig. 6.
2004 *Cremnoceramus deformis erectus* Meek, 1877; Wood *et al.*; Pl. 3, figs 6, 10.
2004 *Cremnoceramus deformis erectus* Meek, 1877; Walaszczyk *et al.*; fig. 4.*7*.

Material: One specimen of a single shell, ventral part damaged.
Description: Very convex, average size, strong beak. Beak angle 125°. Axial length cannot be established because shell is broken. Secondary axis is 2.2 cm. Anterior margin is about 1 cm, slightly convex. Preserved ventral margin is gently rounded. Hinge line not easily visible. Ornamentation of the shell consists of concentric and regular rugae (lines and ribs). The specimen does not differ from similar specimens described by Walaszczyk & Wood (1998) and Wood *et al.* (2004).
Occurrence: In the Lower Coniacian, the Rakowice Wielkie Formation, at Jerzmanice Zdrój (North Sudetic Basin). *Cremnoceramus deformis erectus* Meek is known from the Lower Coniacian of Europe, North America, and Japan (Walaszczyk & Wood, 1998). Wood *et al.* (2004), Walaszczyk *et al.* (2004) reported *C. deformis erectus* from the lowermost Coniacian of England and Russia.

Cremnoceramus waltersdorfensis waltersdorfensis Andert, 1911
Fig. 4J, K

MGU.Wr – 5443s
1991 *Inoceramus waltersdorfensis waltersdorfensis* Andert, 1911; Tarkowski, p. 117–118, Tab. 16.*4*.
1992 *Cremnoceramus waltersdorfensis* Andert, 1911; Walaszczyk, p. 41–46, Pls 16–17, Pl. 18, figs 1–3.
1998 *Cremnoceramus waltersdorfensis waltersdorfensis* Andert, 1911; Walaszczyk & Wood, p. 413–414; Pl. 5, figs. 1, 3–7, 9–13, 15–18; Pl. 15, figs 1–3; Pl. 17, fig. 3.
2004 *Cremnoceramus waltersdorfensis waltersdorfensis* Andert, 1911; Walaszczyk *et al.*; fig. 4.*4,* fig. 5.*1–2, 4–5, 7*.
2004 *Cremnoceramus waltersdorfensis waltersdorfensis* Andert, 1911; Wood *et al.*, Pl. 3, figs. 1–5, 7–9, 11–14.

Material: Single specimen, single shell.
Description: Shell slightly convex, moderate in size, elongated. Axial length is 3.5 cm, the secondary axis is 2.7 cm. Beak angle is 105°. Flat umbo, indistinct beak. Ornamentation developed as delicate growth lines.
Occurrence: In the Lower Coniacian Rakowice Wielkie Formation in Jerzmanice Zdrój (North Sudetic Basin). Tarkowski (1991) described specimens of this species from the Upper Turonian and Lower Coniacian in the Opole region where they occur in deposits of the same age as in Germany and Russia. According to Walaszczyk (1992) and Walaszczyk & Wood (1998), in the uppermost Turonian–Lower Coniacian (*Cremnoceramus waltersdorfensis* Zone–*Cremnoceramus hannovrensis* Zone), known from Europe, western Asia and North America. *Cremnoceramus waltersdorfensis* is most abundant in the Lower Coniacian of Europe (Walaszczyk, 1992; Walaszczyk & Wood, 1998). It is also known from the uppermost Turonian and Coniacian of Russia and England (Walaszczyk *et al.*, 2004; Wood *et al.*, 2004).

Genus Inoceramus Sowerby, 1814
Inoceramus latus Mantell, 1822
Fig. 5A

MGU.Wr – 5444s
1912-13 *Inoceramus latus* Sowerby, 1812-26; Scupin, Tab. XI, figs 5–6.
1991 *Inoceramus latus* Mantell, 1822; Tarkowski, p.112–113, Tab. 10.*3*.

Material: One specimen, individual shell.
Description: Average size. Axial length is 1.8 cm; secondary axis is 1.6 cm. Length of anterior margin about 1 cm. The shell is slightly convex with a sharp beak. Beak angle is 110°. Poorly preserved delicate growth lines are more conspicuous on its ventral part. This specimen is very similar to one described by Scupin (1912–13).
Occurrence: In the Lower Coniacian Rakowice Wielkie Formation in Jerzmanice Zdrój, North Sudetic Basin (Scupin, 1912–13). Tarkowski (1991) reported *I. latus* from the Middle Turonian of the Opole Trough and quoted the occurrence of similar specimens from the Upper Turonian of Great Britain, Germany and Russia, as well as from the Coniacian of the Intra-Sudetic Basin.

Inoceramus lusatiae Andert, 1911
Fig. 5B–D

MGU.Wr – 5445s and MGU.Wr – 5446s

1934 *Inoceramus lusatiae* Andert, 1911; Andert; p. 126–128; fig. 14*a*, *b*.
1988 *Inoceramus lusatiae* Andert, 1911; Walaszczyk; Pl. 5.*8*.
1991 *Inoceramus lusatiae* Andert, 1911; Tarkowski, p.113; Tab 7.*4*.
1992 *Inoceramus lusatiae* Andert, 1911; Walaszczyk; Pl. *27.1–6*.
1998 *Inoceramus lusatiae* Andert, 1911; Walaszczyk & Wood; p. 421–424; Pl. I, figs 9–13; Pl. II, figs 1–4; Pl. 3, figs 1, 3–6.
1998 *Inoceramus (Inoceramus) lusatiae* Andert, 1911; Noda & Matsumoto; Pl. 4, figs 1–4.
2004 *Inoceramus lusatiae* Andert, 1911; Wood *et al.*; Pl. 1, figs 7–8.
2004 *Inoceramus lusatiae* Andert, 1911; Walaszczyk *et al.*; fig. 1.*1, 3, 5*; fig. 2.*1, 3, 8*.

Material: Two individual shells.
Description: Medium-sized, slightly convex. Beak angle of 87°. Axial length is 3.6 cm; the secondary axis cannot be measured because the shell is broken. Anterior margin straight, about 1.5 cm in length, passing into well rounded ventroanterior margin, which is slightly damaged. Ornamentation occurs in the pattern of delicate, dense growth lines.
Occurrence: Reported from the Lower Coniacian Rakowice Wielkie Formation in the Jerzmanice Zdrój area

Fig. 5. Inoceramids and other bivalves from Jerzmanice Zdrój. **(A)** Inoceramid *Inoceramus latus* Mantell, 1822 (MGU.Wr – 5444s); **(B, C)** Inoceramid *Inoceramus lusatiae* Andert,1911 (MGU.Wr – 5445s); **(D)** Inoceramid *Inoceramus lusatiae* Andert,1911 (MGU.Wr – 5446s; **(E, F)** Inoceramid *Inoceramus* sp. (MGU.Wr – 5447s); **(G, H)** Bivalve *Anatina (Cercomya) lanceolata* Geinitz, 1871–1875 (MGU.Wr – 5448s; MGU.Wr – 5449s).

(North Sudetic Basin). According to Tarkowski (1991) *I. lusatiae* occurs in the Upper Turonian of the Opole Region. It has also been found in the following countries: in the Middle and Upper Turonian of France and NW Germany; in the Upper Turonian of the Czech Republic, Germany (Saxony), Russia, and the United States; and in the Upper Turonian and Coniacian of Russia (Tarkowski 1991). Walaszczyk & Wood (1998) described specimens of *I. lusatiae* from the uppermost Turonian (*Mytiloides scupini–Cremnoceramus waltersdorfensis* Zones) to the lowermost Coniacian (*Cremnoceramus erectus* Zone) of Central Europe. Wood *et al.* (2004) reported *I. lusatiae* from the higher part of the Upper Turonian of England, whereas Walaszczyk *et al.* (2004) reported it from the uppermost Turonian and the Lower Coniacian of Russia. Noda & Matsomoto (1998) described *I. lusatiae* from the uppermost Turonian to Lower Coniacian of Japan.

Inoceramus sp.
Fig. 5E, F

MGU.Wr – 5447s

Material: One double-valved specimen.

Description: The whole shell is preserved. The umbo cannot be seen. The shell is smooth with little ornamentation. Only delicate growth lines are visible. Axial length is 3.4 cm; the second axis 2.6 cm. Shell thickness nearly 2 cm. Shape and appearance suggests that it belongs to *Inoceramus*; however, the poorly preserved top does not allow for precise classification.

Occurrence: In the Lower Coniacian, the Rakowice Wielkie Formation in the Jerzmanice Zdrój area (North Sudetic Basin).

Class: Chondrichthyes Huxley, 1880
Subclass: Elasmobranchii Bonaparte, 1838
Cohort: Euselachii Hay, 1902
Subcohort: Neoselacheii Compagno, 1977
Superorder: Squalomorphi Buen, 1926
Order: Lamniformes Berg, 1958
Family: Cretoxyrhinidae Glückman, 1958

?*Cretoxyrhina mantelli* Agassiz, 1843
Fig. 7H

MGU.Wr – 5466s

Material: One rootless tooth.

Description: The tooth is relatively tall and narrow, blade flat and smooth. It does not differ significantly from the teeth described by Williamson *et al.*, (1993) and Cicimurri (2001a, b). The shape suggests an affinity to the Cretoxyrhinidae family, most probably ?*Cretoxyrhina mantelli* Agassiz, 1843. The specimen is 1.5 cm long and 0.5 cm wide.

Occurrence: Lower Coniacian of the Jerzmanice Zdrój area (North Sudetic Basin). If this tooth is of *Cretoxyrhina mantelli*, then it is of a species that has been previously described by Scupin (1912–13) and Kühn & Zimmerman (1919) from older (Cenomanian–Turonian) deposits of the North Sudetic Basin. Niedźwiedzki & Kalina (2003) and Niedźwiedzki (2004) reported Cretoxyrhinidae teeth from the Turonian of the Opole region. According to Cappetta (1987) and Mustafa (2000), *Cretoxyrhina mantelli* Agassiz, 1843 is the most widespread species of this shark family, appearing in Cenomanian–Santonian sediments of Europe, North and South America, Madagascar and Russia. *C. mantelli* is present in the Upper Santonian of Jordan (Mustafa, 2000). Similar teeth were observed by Cicimurri (2001a, b; 2004) in the Lower Cenomanian and Middle Turonian of the United States (Black Hills Region of South Dakota and Wyoming). Willamson *et al.* (1993) described *C. mantelli* from the Upper Cenomanian to Lower Turonian of Arizona, Nebraska, Texas, Great Britain, Belgium, and Lithuania. According to Williamson *et al.* (1993), this taxon was also reported from the Coniacian of Canada. Radwański and Marcinowski (1996) found *C. mantelli* in the Upper Turonian and Coniacian of the Mangyshlak Mountains, Western Kazakhstan.

Although Cappetta (1987) suggested that *C. mantelli* did not survive into the Campanian, Thies & Müller (1993) reported the presence of this species from the Lower Campanian of the Aachen area at the German–Belgian border, and Mustafa (2000) states that this species was founf and described from the Campanian of Sweden.

In addition to the newly described inoceramid and vertebrate remains, the Lower Coniacian marly sandstones of the Jerzmanice Zdrój section also contain foraminifera and bivalves (see also Gawor-Biedowa, 1980; Teisseyre, 1992; Scupin, 1912–1913). Thin section observations from this study revealed the following foraminifera: *Ammodiscus cretaceous*, Reuss, 1845 (Fig. 3B–D), *Gaudryina laevigata*, Franke, 1914 (Fig. 3E), *Gavelinella ammonoides*, Reuss, 1845 (Fig. 3F, G), *Gavelinella moniliformis*, Reuss, 1845 (Fig. 4A–C), *Globotruncana bulloides*, Vögler, 1941 (Fig. 4D, E), *Heterohelix striata*, Ehrenberg, 1840 (Fig. 4F).

The bivalves recognised in the Jerzmanice Zdrój section (Tab. 1) are as follows: *Anatina (Cercomya) lanceolata* Geinitz, 1871–75 (Figs 5G, H, 6A); *Crasatella arcaea* Roemer, 1841 (Fig. 6B, C); *Cucullaea* sp. (Fig. 6D, E); *Cytherea* sp. (Fig. 6F); *Granocardium* cf. *drescheri* Böhm, 1911 (Fig. 6G–I); ?*Lima haidingeri* Zittel, 1878 (Fig. 7A); *Ostrea (Alectryonia) sudetica* Scupin, 1912–13 (Fig. 7B); *Panopea depressa* Scupin, 1912–13 (Fig. 7C); *Panopea muelleri* Scupin, 1912–13 (Fig. 7D); *Tellina strigata* Goldfuss, 1834–40 (Fig. 7E, F). The majority of these taxa were described by Scupin (1912–13) from other outcrops of the Lower Coniacian in the North Sudetic Basin. Also from the Jerzmanice Zdrój section are single gastropod remains (Fig. 4G; Tab. 2) and a single probable fragment of ammonite (Fig. 7G).

Fig. 6. Bivalves from Jerzmanice Zdrój. **(A)** *Anatina (Cercomya) lanceolata* Geinitz, 1871–1875 (MGU.Wr – 5450s); **(B, C)** *Crasatella arcacea* Roemer, 1841 (MGU.Wr – 5451s; 5452s); **(D, E)** *Cucullaea* sp. (MGU.Wr – 5453s; MGU.Wr – 5454s); **(F)** *Cytherea* sp. (MGU.Wr – 5455s); **(G–I)** *Granocardium* cf. *dresecheri* Böhm, 1911 (MGU.Wr – 5456s; MGU.Wr – 5457s; MGU.Wr – 5458s).

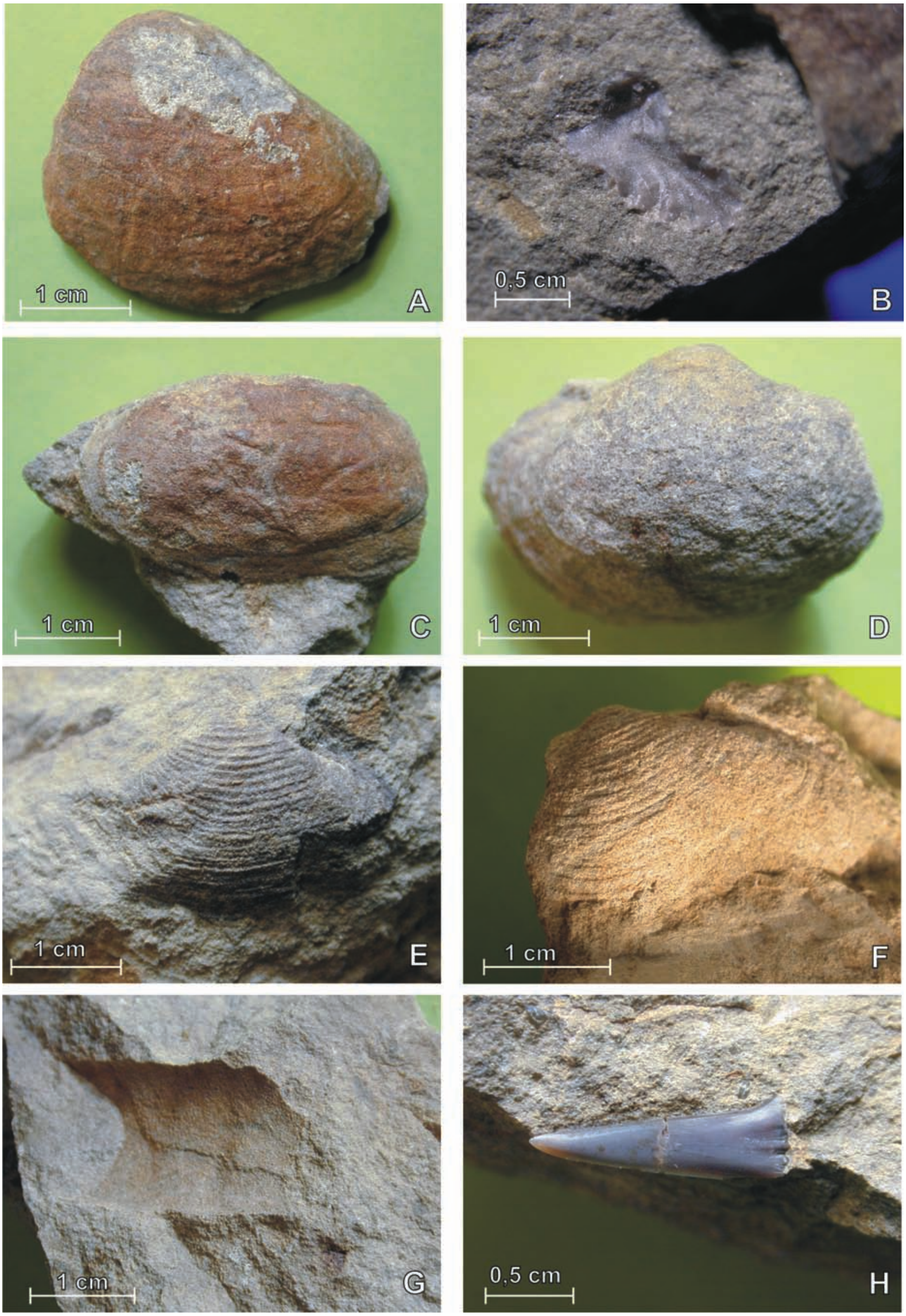

Fig. 7. Bivalves and other fossils from Jerzmanice Zdrój. **(A)** ?*Lima haidingeri* Zittel, 1865 (MGU.Wr – 5459s); **(B)** *Ostrea (Alectryonia) sudetica* Scupin, 1912–1913 (MGU.Wr – 5460s); **(C)** *Panopea depressa* Scupin, 1912–1913 (MGU.Wr – 5461s); **(D)** *Panopea muelleri* Scupin,1912–1913 (MGU.Wr – 5462s); **(E, F)** *Tellina strigata* Goldfuss,1834–1840 (MGU.Wr – 5463s; MGU.Wr – 5464s); **(G)** A fragment of ammonite (MGU.Wr – 5465s); **(H)** Shark tooth ?*Cretoxyrhina mantelli* Agassiz, 1843 (MGU.Wr – 5466s).

AGE ASSIGNMENT OF THE JERZMANICE ZDRÓJ SECTION

The following inoceramids have been recognised by Scupin (1912–13), Walaszczyk (1992) and Walaszczyk & Wood (1998) as typical for the lowest part of the Lower Coniacian: *Inoceramus lusatiae* Andert, 1911; *Cremnoceramus waltersdorfensis waltersdorfensis* Andert, 1911; *Cremnoceramus deformis erectus* Meek, 1877; *Inoceramus (Cr.) rotundatus* Fiege, 1930; *C. websteri* Mantell, 1822; *I. hoepeni* Heinz, 1933 and *I. latus* Mantell, 1822.

Among the inoceramids described in the present study (Tab. 1), *Cremnoceramus deformis erectus* Meek is known only from the Lower Coniacian, and *Cremnoceramus waltersdorfensis waltersdorfensis* Andert only from the Lower and Middle Coniacian. *Inoceramus lusatiae* Andert and *I. latus* Mantell have a slightly broader stratigraphic range, from the Middle Turonian to the lowest Coniacian. The inoceramid assemblage of the Jerzmanice Zdrój section confirms an Early Coniacian age for the marly sandstone (Tab. 1) and indicates deposition during the *Cremnoceramus deformis erectus* Zone (Walaszczyk, 1992; Walaszczyk & Wood, 1998). The foraminiferal assemblage is also typical for the Lower Coniacian (Tab. 2). The marly sandstone may belong to the *Gavinella moniliformis* Zone of the uppermost Lower Turonian–Lower Coniacian, recognised from the North Sudetic Basin by Teisseyre (1992). The strata probably correlate with the *Stensioina exsculpta exsculpta* Zone (upper part of the Early Turonian until Early Coniacian) of the Intra-Sudetic Basin. Their equivalent in the Nysa Kłodzka Graben is the *Epistomina spinulifera polypioides* Zone from the uppermost part of the Upper Turonian and Lower Coniacian (Gawor-Biedowa, 1980). According to Witwicka (1958), the boundary between Turonian and Coniacian is marked by the appearance of *Stensioina exsculpta* in the Nysa Trough. However, *Stensioina* was not found in the North Sudetic Basin, either by Teisseyre (1992) or the present author.

Identifying the boundary between Turonian and Coniacian sediments in the North Sudetic Basin is a complex problem and will require further investigations. The previous inoceramid zonation schemes (Mitura *et al.*, 1969; Milewicz, 1979) placed the *Inoceramus schloenbachi* Zone as the uppermost Upper Turonian. Modern biostratigraphy, however, considers *Inoceramus schloenbachi* Böhm, 1911 as a synonym of *Cremnoceramus crassus crassus* Petrascheck, 1903: this suggests the upper part of the Lower Coniacian.

The literature to date on the Late Cretaceous stratigraphy of the North Sudetic Synclinorium leaves many questions still open. Although *Inoceramus schloenbachi* Böhm has been most often ascribed to the Upper Turonian (Milewicz 1970; 1971; 1979; 1988; 1997; Mitura *et al.*, 1969), it is regarded as Coniacian by Milewicz (1967). And despite *I. schloenbachi* being found in the Coniacian of the Nysa Kłodzka Graben (Radwańska 1962), Mitura *et al.* (1969) claim that it was redeposited from the Turonian.

The inoceramids found by Scupin (1912–13) and Milewicz (1958, 1966, 1970, 1997) in the Coniacian sediments of the North Sudetic Basin – *Inoceramus kleini* Müller, 1887, *I. koeneni* Müller, 1887, *I. rotundatus* Fiege, 1930, *I. involutus* Sowerby 1812-26, *I. percostatus* Müller, 1887, *I. lusatiae* Andert, 1911; *I. crassus* Petrascheck, 1903, *I. latus* Sowerby, 1812–26 – suggest an Early to Middle Coniacian age. Milewicz (1997) placed the Lower Coniacian inoceramids into the *Inoceramus rotundatus* Zone of Keller (1982).

Based on the fossil analyses in this paper, the Jerzmanice Zdrój marly sandstones can be placed into the *Cremnoceramus deformis erectus* Zone, which is Lower Coniacian. As the base of Emscherian is not synchronous with the base of Coniacian, and *Inoceramus schloenbachi* Böhm, 1911 (actually *Cremnoceramus crassus crassus* Petrascheck, 1903) signifies the upper part of the Lower Coniacian, and the Turonian–Coniacian boundary in the North Sudetic Basin should now be placed between the *Inoceramus costellatus* Zone and the *Inoceramus schloenbachi* Zone, as defined by Milewicz (1979) (Tab. 3).

SEDIMENTARY ENVIRONMENT

The East and West Sudetic islands in the Late Cretaceous sea of the North Sudetic Basin constituted a source area for the Coniacian sandstones of the Jerzmanice Zdrój area. These islands were of granite, gneisses and other metamorphic rocks (Radwański, 1968; Milewicz, 1998). The East-Sudetic Island had already appeared in the Early Turonian (Biernacka & Józefiak, 2008) and by the Early Coniacian this island separated the Nysa Kłodzka Graben from the Opole Basin (Kędzierski, 2005).

Thin section observations of the Jerzmanice Zdrój Coniacian marly sandstones and sandy limestone intercalations reveal a paucity of feldspars and the presence of angular and subangular to subrounded quartz grains: a short transportation distance is implied.

The inoceramid-dominated fossil assemblage, and probable ammonite prescence, suggests some deepening of the North Sudetic Sea during the Early Coniacian. The fossil tooth of a shark from the family Cretoxyrhinidae (?*Cretoxyrhina mantelli*) suggests that *C. mantelli* was large: this is because carcharhinid sharks are considered as the modern guild counterparts for *C. mantelli* (Shimada, 1997), and this guild includes the modern *Carcharodon carcharias* (great white shark), which can be up to 6 m in length. Pelagic lamniformes like *Cretoxyrhina mantelli* were active predators feeding on fast-swimming fish and reptiles (Shimada, 1997; Niedźwiedzki & Kalina, 2003). The presence of *C. mantelli* in the Coniacian sandstones in Jerzmanice Zdrój is significant because teeth of this species

Table 3

Stratigraphic division of the Turonian and Coniacian in the North Sudetic Basin

<table>
<tr><th colspan="3">Scupin 1912-13</th><th colspan="3">Milewicz 1958</th><th colspan="3">Milewicz 1979</th><th colspan="2">Chrząstek</th></tr>
<tr><td rowspan="2" colspan="2">Emscher</td><td rowspan="2">Upper Quader sandstone
Nowa Warta Beds</td><td rowspan="2" colspan="2">Coniacian</td><td rowspan="2">Quader sandstone</td><td rowspan="2">Coniacian</td><td>Upper</td><td>marl and sandstone (Inoceramus fasciculatus)</td><td rowspan="3">Coniacian</td><td rowspan="3">Jerzmanice Zdrój marly sandstone (Cremnoceramus deformis erectus Zone)</td></tr>
<tr><td>Lower</td><td>marl and sandstone (Inoceramus koeneni)</td></tr>
<tr><td rowspan="4">Turonian</td><td rowspan="2">Upper</td><td rowspan="2">Upper Rakowice marls, Chmielno sandstone</td><td rowspan="4">Turonian</td><td rowspan="2">Upper</td><td rowspan="2">clay-siliceous</td><td rowspan="4">Turonian</td><td rowspan="2">Upper</td><td>marl and sandstone (Inoceramus schloenbachi)</td></tr>
<tr><td>sandstone (Inoceramus costellatus)</td><td rowspan="3">Turonian</td><td rowspan="3"></td></tr>
<tr><td>Middle</td><td>Jerzmanice and Upper Lwówek marly sandstone</td><td>Middle</td><td>sandstone, marly sandstone</td><td rowspan="2">Lower</td><td>limestones and sandstones (Inoceramus lamarcki)</td></tr>
<tr><td>Lower</td><td>Lwówek Lower marly sandstone; Jerzmanice sandstone</td><td>Lower</td><td>sandstone, marl, clay</td><td>limestone and marl (Inoceramus labiatus)</td></tr>
</table>

are found mainly in a deep-water palaeoenvironment and are absent, or only rarely occur, in near-shore deposits (Niedźwiedzki & Kalina, 2003). Nevertheless, Cicimurri (2001a, b; 2004) has described *C. mantelli* teeth from a shallow marine environment in the United States (South Dakota, Wyoming), but even he claimed that this shark preferred off-shore habitats. Thus, it seems quite probable that the epicontinental Early Coniacian sea was deep enough for sharks to reach the North Sudetic Basin.

PALAEOGEOGRAPHY

During the Late Cretaceous, the North Sudetic Basin belonged to the set of Circum-Sudetic Trap Basins together with the Opole Basin, Saxonian Basin and North Bohemian Basin (Walaszczyk, 1992). Lithostratigraphic and palaeogeographic studies suggest that these basins, including the Intra-Sudetic Basin, must all have been interconnected (e.g. Radwański, 1966, 1968; Jerzykiewicz, 1971, 1975; Gawor-Biedowa, 1980; Teisseyre, 1992; Milewicz, 1997; Wojewoda, 1997; Kędzierski 2005; Biernacka & Józefiak, 2008).

The Cretaceous marine sediments in the North Sudetic Basin and the adjacent basins record an Early Turonian and a Late Turonian–Early Coniacian transgression maxima (Gawor-Biedowa, 1980; Jaskowiak-Schoeneichowa & Krassowska, 1988; Teisseyre, 1992; Jubitz (1995); Milewicz, 1997; Wojewoda, 1997; Rotnicka, 2007).

Previous studies on the Opole Basin suggested that there was only one transgression, either in the Middle Turonian (Alexandrowicz, 1974) or in the Late Turonian (Tarkowski, 1991). However, trace-fossil evidence proved that there had been two episodes of sea-deepening, one in the Middle Turonian and one from the Late Turonian to the Early Coniacian (Kędzierski & Uchman, 2001). The Middle Turonian transgression is further supported by evidence of deep-water sharks' teeth (Niedźwiedzki & Kalina, 2003).

As had happened during the Turonian, the marine transgression reached another maximum in the Sudetes during the Early Coniacian. According to Wojewoda (1997), Jerzykiewicz (1971, 1975) and Don & Gotowała (2008), from the uppermost Late Turonian onwards, the palaeodepth increased significantly in the Nysa Kłodzka Graben. Niedźwiedzki & Salamon (2005) also believe that the maximum transgression in the Nysa Kłodzka Graben occurred in the Early Coniacian (*Cremnoceramus deformis erectus* Zone–*Cremnoceramus crassus crassus* Zone). Teisseyre (1992) and Milewicz (1997) came to the conclusion that the North Sudetic sea deepened in the Early Coniacian and became connected with the Intra-Sudetic Basin (Don & Gotowała, 2008). Similarly, Jubitz (1995) suggested that in Brandenburg (Germany), the transgressive peak took place during the Early Coniacian, whereas in the Bohemian Massif the peak occurred during the middle Late Turonian (Skoček & Valečka, 1983).

Kędzierski & Uchman (2001) correlated the Late Cretaceous transgression cycles in the Opole Basin with the more general European bathymetric curve of Haq *et al.* (1987). The transgressive–regressive cycles of the Cretaceous North Sudetic Sea also agree with the bathymetric curves of Haq *et al.* (1987) and Hancock (1990). Hancock (1990), however, proposed that the two transgression maxima were almost equally important. But in the North Sudetic and adjacent basins, the Late Turonian–Early Coniacian peak was more pronounced, which is in line with the curve of Haq *et al.* (1987).

SUMMARY AND CONCLUSIONS

The marly sandstones and their sandy limestone intercalations, exposed in the Jerzmanice Zdrój area, possess petrographic features that indicate a proximal source area, probably from the West-Sudetic and East-Sudetic Islands of the Late Cretaceous North Sudetic Sea. Sedimentation took place in an epicontinental basin, the North Sudetic Basin, which must have been deep enough to encourage the shark *Cretoxyrhina mantelli* to live there during the Early Coniacian. In the Early Coniacian, as had happened previously during the Early Turonian, the sea reached its maximum transgressive extent in the Sudetes. In the North Sudetic Basin and adjacent areas, the Late Turonian–Early Coniacian transgression was more pronounced, a feature which corresponds with the global bathymetric curve for the Late Cretaceous proposed by Haq *et al.* (1987).

Neither the sharks nor most of the bivalves and inoceramid taxa described in this paper were previously known from the Lower Coniacian rocks (Emscherian, after Scupin (1912–13)) in the North Sudetic Synclinorium. The inoceramids and foraminifers confirm an Early Coniacian age for the Jerzmanice Zdrój sandstones (*Cremnoceramus deformis erectus* Zone; *Gavelinella moniliformnis* Zone). The new findings, when allied to the stratigraphic scheme of Milewicz (1979), imply that the Turonian–Coniacian boundary in the North Sudetic Basin should now be placed between the *Inoceramus costellatus* Zone and the *Inoceramus schloenbachi* Zone.

Acknowledgements

The author would like to thank Paweł Raczyński for photographing the specimens, Robert Niedźwiedzki for providing the literature on vertebrates, and Joanna Kostylew and Marek Awdankiewicz for petrographic consultations. Under the supervision of the author, MSc student Wojciech Krupa collected a number of the fossils used in this paper. The author extends particular thanks to Mariusz Kędzierski for his careful and insightful review. Patrick Roycroft and Andrzej Żelaźniewicz are thankfully acknowledged for meticulous editorial work.

REFERENCES

AGASSIZ, L., 1843. *Recherches sur les Poissons Fossiles*, 3, I-VIII. Imprimerie de Petitpierre, Neuchâtel, 390 pp.

ALEXANDROWICZ, S. W., 1974. Kreda opolska. In: Rutkowski, J. (Ed.), *Przewodnik XLVI Zjazdu Polskiego Towarzystwa Geologicznego, Opole, 12–14 września*. Wydawnictwa Geologiczne, Warszawa, 29–38. {in Polish only}

ANDERT, H., 1911. Die Inoceramen des Kreibitz-Zittauer Sandsteingebirges. *Festschrift des Humboldtvereins zur Feier seines 50 jährigen Bestehens*, Ebersbach, 33–64.

ANDERT, H., 1934. Die Kreideablagerungen zwischen Elbe und Jeschken, Teil III: *Die Fauna der obersten Kreide in Sachsen, Böhmen und Schlesien*. Abhandlungen der Preuischen Geologischen Landesanstalt, Neue Folge, Berlin, 477 pp.

BARANOWSKI, Z., HAYDUKIEWICZ, A., KRYZA, R., LORENC, S., MUSZYŃSKI, A., SOLECKI, A. & URBANEK, Z., 1990. Outline of the geology of the Góry Kaczawkie (Sudetes Poland). *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 179: 223–257.

BERG L. S., 1958. System rezenten und fossilen Fischartigen und Fisch. *Hochschulbüher für Biologie,* 4. Berlin, 310 pp.

BIERNACKA, J. & JÓZEFIAK, M., 2008. Kilka uwag o tzw. wyspie wschodnioudeckiej na podstawie piaskowców z Jerzmanic Zdroju (dolny turon, niecka północnosudecka). In: Wojewoda, J. (Ed.), *Baseny śródgórskie, kontekst regionalny środowisk i procesów sedymentacji POKOS'3*, 15–21.09.08, Kudowa Zdrój; Wind, Wrocław, 1–2. {in Polish only}

BÖHM, J., 1911. Über Inoceramus cuvieri Sowerby. *Zeitschrift der Deutschen Geologischen Gesellschaft*, 63: 569–570. Berlin.

BONAPARTE, C. L. J. L., 1838. Synopsis vertebratorum systematis. *Nuovi Annali delle Scienze Naturali*, 2: 105–133.

BUEN, F., 1926. Catalogo ictiologico del Mediterraneo Español y de Marruecos, recopilando lo publicado sobre peces de las costas mediterraneas y proximas del Atlantico (Mar de España). *Resultados de las Campafias Realizadas por Acuerdos Internacionales, Instituto Español de Oceanografia*, 221 pp.

CAPPETTA, H., 1987. *Chondrichthyes II. Mesozoic and Cenozoic Elasmobranchii. Handbook of Palaeoichthyology, 3B.* Gustav Fischer Verlag-Stuttgart-New York, 193 pp.

CHRZĄSTEK, A., 1995. Wapień muszlowy w Jerzmanicach Zdroju [The Muschelkalk from Jerzmanice Zdrój]. *Acta Universitatis Wratislaviensis, 1607, Prace Geologiczno-Mineralogiczne*, 48: 43–79.

CHRZĄSTEK, A., 2002. Stratygrafia i warunki sedymentacji retu oraz dolnego wapienia muszlowego niecki północnosudeckiej. [Stratigraphy and sedimentation condition of Röt and Lower Muschelkalk of the North Sudetic Basin]. *Acta Universitatis Wratislaviensis, 2383, Prace Geologiczno-Mineralogiczne*, 73: 1–128.

CHRZĄSTEK, A., KOSAREWICZ, U. & RACZYŃSKI, P., 2004. Cechsztyn i trias w niecce północnosudeckiej. In: Muszer, J. (Ed.), *Zapis paleontologiczny jako wskaźnik paleośrodowisk. XIX Konferencja Naukowa Paleobiologów i Biostratygrafów PTG poświęcona 300-leciu Uniwersytetu Wrocławskiego, 16–18.09.2004*, Uniwersytet Wrocławski, Wrocław, 108–112.

CICIMURRI, D., 2001a. Fossil Selachians from the Belle Fourche Shale (Cretaceous, Cenomanian), Black Hills Region of South Dakota and Wyoming. *The Mountain Geologist*, 38: 181–192.

CICIMURRI, D. J. 2001b. Cretaceous Elasmobranchs of the Greenhorn Formation (Middle Cenomanian-Middle Turonian), Western South Dakota. In: Santuci, V. L. & McClelland, L. (Eds). *Proceedings of the 6 Fossil Resource Conference, September 2001.* National Park Service, Washington D.C., 27–43.

CICIMURRI, D., 2004. Late Cretaceous Chondrichthyans from the Carlile Shale (Middle Turonian to Early Coniacian) of the Black Hills Region, South Dakota and Wyoming. *The Mountain Geologist*, 41: 1–16.

COMPAGNO, L. J. V., 1977. Phyletic relationships of living sharks and rays. American Zoologist, 17: 303–322.

COX, L. R., 1969. Family Inoceramidae Giebel, 1852. In: Moore, R. C., Teichert, C., Mc Cormic, L. & Williams, R. B. (Eds.), *Treatise on invertebrate paleontology, Pt. N,1, Mollusca 6, Bivalvia*. Geol. Soc. Am. & University Kansas. Lawrence, Kansas, 314–321.

DON, J. & GOTOWAŁA, R. 2008 Tectonic evolution of the late Cretaceous Nysa Kłodzka Graben, Sudetes, SW Poland. *Geologia Sudetica*, 40: 51–63.

EHRENBERG, C., G., 1840. Über die bildung der Kreidefelsen und des Kreidemergels durch ubsichtbare Organismen. *Abhandlungen Keiserische Preussische Akademie der Wissenschaften.* Berlin 1838: 59–147.

FIEGE, K., 1930. Über die Inoceramen des Oberturon mit besonderer Berücksichtigung de rim Rheinland und Westfalen vorkommenden Formen. *Palaeontographica*, 20: 1–210.

FRANKE, A., 1914. Die Foraminiferen und Ostracoden des Emscheres, besonders von Obereving und Derne nördlich Dortmund. *Zeitschrift der Deutschen Geologischen Gesellschaft*, 66: 428–443.

GAWOR-BIEDOWA, E., 1980. Turonian and Coniacian Foraminifera from the Nysa Trough, Sudetes, Poland. *Acta Palaeontologica Polonica*, 25: 3–54.

GEINITZ, H. B., 1871–75. Das Elbthalgebirge in Sachsen von Hanns Bruno Geinitz. 1. Teil: Der untere Quader. *Palaeontographica*, 20: 310 pp

GLÜCKMAN, L. S., 1958. Rates of evolution in lamnoid sharks. *Akademia Nauk SSSR*, 123: 568–571.

GOLDFUSS, A., 1834–40. *Petrefakta Germaniae tam ea, quae in museo*. Düsseldorf. 312 pp.

GORCZYCA-SKAŁA, J., 1977. Budowa geologiczna rowu Wlenia. [Geologic structure of the Wleń Graben]. *Geologia Sudetica*, 12: 71–100.

HANCOCK, J. M., 1990. Sea-level changes in the British region during the Late Cretaceous. *Proceedings of the Geologists' Association*, 100: 565–594.

HAQ, B., HARDENBOL, J. & VAIL, P., 1987. Chronology of fluctuating sea levels since the Triassic. *Science*, 235: 1156–1167.

HAY, O. P., 1902. Bibliography and catalogue of the fossil vertebrata of North America. *Bulletin of the United States Geological Survey*, 179, 868 pp.

HEINZ, R., 1933. Inoceramen von Madagascar und ihre Bedeutung für die Kreide-Stratigraphie (Beiträge zur Kenntnis der Inoceramen XII). *Zeitschrift der Deutschen Geologischen Gesellschaft*, 85: 241–259.

HUXLEY, T. H., 1880. On the application on the laws of evolution to the arrangement of the Vertebrata and more particularly of the Mammalia. *Zoological Society of London, Scientific Memoires*, 4: 457–472.

JASKOWIAK-SCHOENEICHOWA, M. & KRASSOWSKA, A., 1988. Paleomiąższości, litofacje i paleotektonika epikontynentalnej kredy w Polsce [Palaeothickness, lithofacies and palaeotectonics of the epicontinental Upper Cretaceous in Poland]. *Kwartalnik Geologiczny*, 32: 177–198.

JERZYKIEWICZ, T., 1971. A flysch/littoral succession in the Sudetic Upper Cretaceous. *Acta Geologica Polonica*, 21: 165–200.

JERZYKIEWICZ, T. 1975. Pozycja geologiczna osadów górnokredowych depresji śródsudeckiej i rowu Nysy Kłodzkiej. In: Grocholski, A. (Ed.), *Przewodnik XLVII Zjazdu Polskiego Towarzystwa Geologicznego, Świdnica, 22–24 czerwca*, Wydawnictwa Geologiczne, Warszawa, 225–254. {in Polish only}

JUBITZ, K.-B., 1995. Zur Entwicklung der Kreide in Ostbrandenburg. In: Schroeder, J. H. (Ed.), Fortschritte in der Geologie von Rüdersdorf. *Nachlese vom und Ergänzungen zum Rüdersdorf-Symposium der "Geowissenschaftler in Berlin und Brandenburg e.V." Berliner Geowissenschaftliche Abhandlungen*, 168: 55–78.

KELLER, S., 1982. Die Oberkreide der Sach-Mulde bei Alfed (Cenoman-Unter Coniac); Lithologie, Biostratigraphie und Inoceramen. *Geologisches Jahrbuch, Abhandlungen*, 64: 1–171.

KĘDZIERSKI, M. 2005. Paleogeografia wschodniej części basenu wokółsudeckiego w cenomanie, turonie i koniaku. In: Skoczylas, J. (Ed.), *Referaty XIV, Polskie Towarzystwo Geologiczne*, Uniwersytet Adama Mickiewicza, Poznań, 49–58. {in Polish only}

KĘDZIERSKI, M. & UCHMAN, A. 2001. Ichnofabric of the Upper Cretaceous marlstones in the Opole region, southern Poland. *Acta Geologica Polonica*, 51: 81–91.

KÜHN, B. & ZIMMERMANN, E., 1919. *Erläuterungen zur Geologischen Karte von PreuBen und benachbarten Bundesstaaten. Blatt Lähn*. Geologische Preussische Landes-Anstalt, Berlin, 58 pp.

LESZCZYŃSKI, S. & CHODOWSKA, M., 2008. Ichnological record of a T-R Cycle in Santonian of North Sudetic Basin, Poland. In: Pieńkowski, G. & Uchman, A. (Eds.), *The Second International Congress on Ichnology. Abstract Book and the Intra-Congress Field Trip Guidebook, Kraków, Poland, August 29-September 8.* Polish Geological Institute, Warsaw, p. 67.

LORENC, S., 1978. *Petrografia skał osadowych*. Wydawnictwa Uniwersytetu Wrocławskiego, Wrocław, 176 pp. {in Polish only}

MANECKI, A. & MUSZYŃSKI, M., 2008. *Przewodnik do petrografii.* Akademia Górniczo-Hutnicza, Uczelniane Wydawnictwa Naukowo – Dydaktyczne, Kraków, 552 pp. {in Polish only}

MANTELL, G. 1822. Fossils of the South Downs; or illustrations of the geology of Sussex, 320 pp., London.

MEEK, F. B., 1877. Paleontology. Report of the geological exploration of the 40-th paralel. *Professional Papers of the Engineer Department of the United States Army*, 184: 142–148.

MILEWICZ, J., 1958. Podział stratygraficzny osadów kredowych w niecce północnosudeckiej. *Przegląd Geologiczny*, 4: 186–190. {in Polish only}

MILEWICZ, J., 1966. Kreda z głębokiego otworu Węgliniec

IG-1. *Kwartalnik Geologiczny*, 10: 1144–1146. {in Polish only}
MILEWICZ, J. 1967. Kreda depresji północnosudeckiej w świetle nowych badań. In: Teisseyre, H. (Ed.), *Przewodnik XL Zjazdu Polskiego Towarzystwa Geologicznego. Geologia i surowce mineralne Sudetów Zachodnich. Zgorzelec, 24-27 sierpnia.* Wydawnictwa Geologiczne, Warszawa, 119–129. {in Polish only}
MILEWICZ, J. 1970. Kreda rowu jerzmanickiego [The Cretaceous of the Jerzmanice Graben]. *Z badań geologicznych regionu dolnośląskiego, Tom 19. Biuletyn Instytutu Geologicznego*, 239: 37–66.
MILEWICZ, J., 1971. Kreda północnoczeska a wschodniobrandenburska. [Relation between the North Sudetic Basin and East-Brandenburg Cretaceous formations]. *Kwartalnik Geologiczny*, 15: 122–136.
MILEWICZ, J., 1973a. Próba poznania struktury depresji północnosudeckiej. *Przegląd Geologiczny*, 1: 6–13. {in Polish only}
MILEWICZ, J., 1973b. Przekrój geologiczny przez depresję północnosudecką [Geological section through the North Sudetic Depression]. *Kwartalnik Geologiczny*, 17: 45–56.
MILEWICZ, J., 1979. Rozmieszczenie osadów kredowych w basenie północnosudeckim [Distribution of Cretaceous Rocks in the North Sudetic Basin]. *Kwartalnik Geologiczny*, 23: 819–826
MILEWICZ, J., 1988. Makrofauna z osadów kredowych otworu wiertniczego Węgliniec IG 1 [Cretaceous macrofauna in the Węgliniec IG 1 borehole]. *Kwartalnik Geologiczny*, 32: 389–396.
MILEWICZ, J., 1997: Górna kreda depresji północnosudeckiej (lito- i biostratygrafia, paleogeografia, tektonika oraz uwagi o surowcach [Upper Cretaceous of the North Sudetic depression (litho-and biostratigraphy, paleogeography, tectonics and remarks on raw materials)]. *Acta Universitatis Wratislaviensis No 1971, Prace Geologiczno-Mineralogiczne*, 61: 1–58.
MILEWICZ, J., 1998. Rozprzestrzenienie piaskowców koniackich w basenie północnosudeckim [Distribution of Coniacian sandstones in the North Sudetic Basin]. *Acta Universitatis Wratislaviensis No 2004, Prace Geologiczno-Mineralogiczne*, 64: 101–109.
MILEWICZ, J & JERZMAŃSKI, J. 1956-57. *Szczegółowa Mapa Geologiczna Sudetów w skali 1:25 000, Arkusz Pielgrzymka*. Wydawnictwa Geologiczne, Warszawa. {in Polish only}
MITURA, F., CIEŚLIŃSKI, S. & MILEWICZ, J., 1969. Inoceramy górnokredowe z niecki północnosudeckiej [Upper Cretaceous inoceramids from the North Sudetic Basin]. *Z badań geologicznych regionu dolnośląskiego, Tom 15. Biuletyn Instytutu Geologicznego*, 217: 171–181.
MÜLLER, G., 1887. Beitrag zur Kenntniss der oberen Kreide am nordlichen Harzrande. *Jahrbuch Preussische Geologische Landes-Anstalt*, 8: 372–456.
MUSTAFA, H., 2000. Fish teeth from the Upper Umm Ghudram Formation (Late Santonian) of NW-Jordan. *Neues Jahrbuch für Geologie und Paläontologie, Monatshefte*, 10: 595–612.
NIEDŹWIEDZKI, R. & KALINA, M., 2003. Late Cretaceous sharks in the Opole Silesia region (SW Poland). *Geologia Sudetica*, 35: 13–24.
NIEDŹWIEDZKI, R., 2004. Skamieniałości rekinów w kredzie górnej południowo-zachodniej Polski i ich znaczenie dla rekonstrukcji środowiska. In: Muszer, J. (Ed.), *Zapis paleontologiczny jako wskaźnik paleośrodowisk. XIX Konferencja Naukowa Paleobiologów i biostratygrafów PTG poświęcona 300-leciu Uniwersytetu Wrocławskiego. 16-18 września*, Wrocław, 80–81.
NIEDŹWIEDZKI, R. & SALAMON, A., 2005. Late Cretaceous crinoids from the Sudetes (southern Poland). *Freiberger Forschungshefte*, C507: 1–9.
NODA, M. & MATSUMOTO, T., 1998. Paleontology and stratigraphy of the inoceramid species from the mid-Turonian through upper Middle Coniacian in Japan. *Acta Geologica Polonica*, 48: 435– 482.
d'ORBIGNY, A., 1843-47. *Palèontologie Francaise. Terrains Crètacès*, 3. Paris, 807 pp.
PETRASCHECK, W., 1903. Ueber Inoceramen aus der Kreide Böhmens and Sachsen. *Jahresberichte der Kaiserlisch-Königlichen Geologischen Reichsanstalt*, 53(1), 153–168. Wien.
RADWAŃSKA, Z., 1962. Fauna spągowych warstw strefy *Inoceramus schloenbachi* z Wilkanowa (Dolny Śląsk) [The fauna of the bottom beds of *Inoceramus schloenbachi* zone from Wilkanów (Lower Silesia)]. *Z badań geologicznych regionu dolnośląskiego, Tom 10. Biuletyn Instytutu Geologicznego*, 173: 129–167.
RADWAŃSKI, S., 1966. Facje osadowe i charakterystyka faunistyczna górnej kredy Środkowych Sudetów [Upper Cretaceous Facies and Faunas in the Central Part of the Sudety Mountains]. *Rocznik Polskiego Towarzystwa Geologicznego. Annales de la Société Géologique de Pologne*, XXXVI, 2: 99–119.
RADWAŃSKI, S., 1968. Górnokredowe osady w Sudetach i wpływ tektoniki na sedymentacje [Upper Cretaceous deposits in Sudetes and influence of tectonics upon their sedimentation]. *Kwartalnik Geologiczny*, 12: 607–619.
RADWAŃSKI, A. 1975. Kreda Sudetów Środkowych w świetle wyników nowych otworów wiertniczych [Upper Cretaceous of the Central Poland of the Sudetes in the light of new borehole materials]. *Z badań geologicznych regionu dolnośląskiego, Tom XXIV, Biuletyn Instytutu Geologicznego*, 287, 5–50.
RADWAŃSKI, A. & MARCINOWSKI, R., 1996. Elasmobranch teeth from the mid-Cretaceous sequence of the Mangyshlak Mountains, Western Kazakhstan. *Acta Geologica Polonica*, 46: 165–169.
REUSS, A. E., 1845. *Die versteinerungen der Böhmischen Kreideformation. Abt. I.* Stuttgart, 58 pp.
ROEMER, F. A., 1841. *Die Versteinerungen des nord-deutschen Kreidegebirges*. Hannover. 145 pp.
ROTNICKA, J., 2007. Cykle transgresywne i regresywne w drobnoziarnistych sukcesjach osadowych na przykładzie górnokredowych margli plenerskich (Góry Stołowe, Sudety) [Transgressive and regressive cycles in fine-grained rocks successions: an example from the Upper Cretaceous Planermergel, Góry Stołowe Mts. Sudetes]. In: Wojewoda, J. (Ed.), *Review of Permian sedimentary successions of Boskovice Trough, Nachod Basin and Trutnov Basin. Sedimentologica*, 1: 18–30.
SAWICKI L., 1995. Mapa geologiczna regionu dolnośląskiego z przyległymi obszarami Czech i Niemiec. Państwowy Instytut Geologiczny, Warszawa. {in Polish only}
SCUPIN, H., 1912–1913. *Die Lowenberger Kreide und ihre Fauna*. Stuttgart, 275 pp.
SHIMADA, K., 1997. Paleoecological relationships of the Late Cretaceous lamniform shark, *Cretoxyrhina mantelli* (Agassiz). *Journal of Paleontology*, 71: 926–933.
SKOČEK, V. & VALEČKA, J., 1983. Paleogeography of the Late Cretaceous Quadersandstein of Central Europe. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 44: 71–92.
SOWERBY, J., 1812-1826. Mineral-Conchologie Grossbritaniens. *Verlag von Jent & Gassman*, Solothurn, 7 pp.
ŚLIWIŃSKI, W., RACZYŃSKI, P. & WOJEWODA, 2003.

Sedymentacja utworów epiwaryscyjskiej pokrywy osadowej w basenie północnosudeckim. In: Ciężkowski, W., Wojewoda, J. & Żelaźniewicz, A. (Eds.). *Sudety Zachodnie: od wendu do czwartorzędu. LXXIV Zjazd Polskiego Towarzystwa Geologicznego, 11-13.09.2003, Cieplice Śląskie Zdrój.* Wind, Wrocław, 119–126. {in Polish only}

TARKOWSKI, R., 1991. Stratygrafia, makroskamieniałości i paleogeografia utworów górnej kredy niecki opolskiej [Stratigraphy, macrofossils and palaeogeography of the Upper Cretaceous from the Opole Trough]. *Zeszyty Naukowe, Akademia Górniczo-Hutnicza im. S. Staszica, Kraków, Geologia*, 51: 1–156.

TEISSEYRE, B., 1992. Otwornice kredy górnej z niecki północnosudeckiej (Sudety Zachodnie) [Upper Cretaceous foraminifers from the North Sudetic Basin (Western Sudetes)]. *Prace Geologiczno-Mineralogiczne*, 34: 1–78.

THIES, D. & MÜLLER, A., 1993. A neoselachian fauna (Vertebrata, Pisces) from the Late Cretaceous (Campanian) of Höver, near Hannover (NW Germany). *Paläontologische Zeitschrift*, 67: 89–107.

TRÖGER, K.A. & WEJDA, M., 1998. The Turonian/Coniacian (T/C) boundary in the Upper Cretaceous of the Elbe Valley/Saxony (Germany). *Acta Geologica Polonica*, 48: 387– 394.

TRÖGER, K. A., 2004. Cenomanian through Lower Coniacian events in the Upper Cretaceous of Saxony, Germany. *Acta Geologica Polonica*, 54: 629–638.

VÖGLER, J., 1941. Beitrage zur Geologie von Niederländisch-Indien. Obere Jura und Kreide von Misol. *Palaeontolographica, Suppl*., Bd. IV, Abt. IV. Kassel. Stuttgart, 245–293.

WALASZCZYK, I., 1988. Inoceramid stratigraphy of the Turonian and Coniacian strata in the environs of Opole (Southern Poland). *Acta Geologica Polonica*, 38: 51–61.

WALASZCZYK, I., 1992. Turonian through Santonian deposits of the Central Polish Uplands; their facies development, inoceramid paleontology and stratigraphy. *Acta Geologica Polonica*, 42: 1–122.

WALASZCZYK, I. & COBBAN, W. A., 1998. The Turonian-Coniacan boundary in the United States Western Interior. *Acta Geologica Polonica*, 48: 495–507.

WALASZCZYK, I. & WOOD C. J., 1998. Inoceramids and biostratigraphy at the Turonian/Coniacian boundary; based on the Salzgitter-Salder Quarry, Lower Saxony, Germany, and the Słupia Nadbrzeżna section, Central Poland. *Acta Geologica Polonica*, 48: 395–434.

WALASZCZYK, I., KOPAEVICH, L. F. & OLFERIEV, A., 2004. Inoceramid/foraminiferal succession of the Turonian and Coniacan (Upper Cretaceous) of the Briansk region (Central European Russia). *Acta Geologica Polonica*, 54: 597–609.

WIESE, F., ČECH, S., EKRT, B., KOŠT'AK, M., MAZUCH, M. & VOIGT, S., 2004. The Upper Turonian of the Bohemian Cretaceous Basin (Czech Republic) exemplified by the Upohlavy working quarry: integrated stratigraphy and palaeoceanography of a gateway to the Tethys. *Cretaceous Research*, 25: 329–352.

WILLIAMSON, T. E., KIRKLAND, J. I. & SPENCER, G. L., 1993. Selachians from the Greenhorn Cyclothem ("Middle" Cretaceous: Cenomanian-Turonian), Black Mesa, Arizona, and the paleogeographic distribution of Late Cretaceous Selachians. *Journal of Paleontology*, 67: 447–474.

WITWICKA, E., 1958. Stratygrafia mikropaleontologiczna kredy górnej wiercenia w Chełmie [Micropalaeontological stratigraphy of Upper Cretaceous of the Chełm Borehole (Lublin Upland)]. *Biuletyn Instytutu Geologicznego*, 121: 177–267.

WOJEWODA, J., 1997. Upper Cretaceous litttoral-to-shelf succession in the Intrasudetic Basin and Nysa Trough, Sudety Mts. In: Wojewoda, J. (Ed.), *Obszary ródłowe. Zapis w osadach.VI Krajowe Spotkanie Sedymentologów, 26-28.09.1997, Lewin Kłodzk.* Wind, Wrocław, 81–96.

WOOD, C. J., WALASZCZYK, I., MORTIMORE, R. & WOODS, M., 2004. New observations on the inoceramid biostratigraphy of the higher part of the Upper Turonian and the Turonian-Coniacan boundary transition in Poland, Germany and the UK. *Acta Geologica Polonica*, 54: 541–549.

WOODS, H., 1912. A monograph of the Cretaceous lamellibranchia of England. *Palaeontographical Society*, 2: 262–340.

ŻELAŹNIEWICZ, A. & ALEKSANDROWSKI, P., 2008. Regionalizacja tektoniczna Polski – Polska południowo-zachodnia [Tectonic subdivision of Poland: southwestern Poland]. *Przegląd Geologiczny*, 56: 904–911.

ZITTEL, K. A., 1865. Die Bivalven der Gosaugebilde in den Nordöstlichen Alpen. *Denkschriften k. Akademie der Wissenschaften Wien, math. – nat. Kl*., 24: 105-179.

ZONOWA, T. D. & YAZYKOWA, E. A., 1998. Biostratigraphy and correlation of the Turonian-Coniacian succession and the Turonian-Coniacian boundary problem in the Far East Russia based on ammonites and inoceramids. *Acta Geologica Polonica*, 48: 483–494.