



Conodont biostratigraphy of the Muschelkalk (Middle Triassic) in the central part of the Polish Lowlands

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Conodonts have been found in the Muschelkalk intervals in seven deep wells located in the central part of the Polish Middle Triassic basin. Total number of 80 specimens has been ascribed to 18 form-species. The presence of *Paragondolella hanbulogi* and *Neogondolella balcanica* is reported for the first time in Polish sections. *Germanica* and *kockeli* Zones of the late early Anisian, Pelsonian and ?earliest Illyrian have been found in the Lower Muschelkalk deposits. The Middle Muschelkalk corresponds to the Illyrian without its latest part, and to ?latest Pelsonian. Presence of the Zones 1, 2 and 4, found in the Upper Muschelkalk, allowed to correlate these deposits with the late Illyrian, Fassanian and earliest Longobardian. Analysis of geographical distribution of the investigated species revealed that only cosmopolitan conodonts occur in the Lower Muschelkalk whereas its upper part contains also forms endemic for the German Province.

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INTRODUCTION

In the Middle Triassic the present area of the Polish Lowlands (Fig. 1) formed an eastern part of the vast epicontinental basin with prevailing carbonate-evaporitic sedimentation, extending from eastern France and Germany (see e.g. R. Dadlez *et al.*, 1998). The deposits of this basin are traditionally defined as the Muschelkalk. Contrary to the deeply buried Polish Lowlands sediments, the Muschelkalk of the southern basin margin occurs in the shallow subsurface or even forms surface exposures in the Holy Cross Mountains, Miechów Upland and in Silesia (Fig. 1). They were studied in detail with respect to i.a. biostratigraphy, which led to distinction of the standard conodont zones as well as the Middle Triassic stages and substages (J. Trammer, 1971, 1972, 1975; K. Zawadzka, 1975, 1984; A. Siewniak-Witruk, 1978). Deep subsurface well-sections of the Polish Lowlands lack equally precise studies so far. In most cases the Muschelkalk has been generally subdivided into the lower, middle and upper parts (I. Gajewska, 1964, 1971, 1973, 1997; H. Senkowiczowa, 1985, 1997). More detailed subdivisions were made

only in selected well-sections of the Fore-Sudetic Monocline, including Książ IG 2 section (I. Gajewska, 1971, 1997, table 18; H. Senkowiczowa, 1985). Limited conodont studies were conducted only in the Radziatków 5 well-section (J. Głazek *et al.*, 1973). In other sections, such as Książ IG 2, Konary IG 1, Jeżów IG 1 and Krośniewice IG 1, biostratigraphic investigations were based either on few determinations of non-index taxa: ostracods (O. Styk, 1982), acritarchs (T. Orłowska-Zwolińska, 1983), molluscs (H. Senkowiczowa, 1985) and brachiopods (H. Senkowiczowa, 1985, 1993), or on rather broad, generic, determinations of cephalopods (I. Gajewska, 1973; H. Senkowiczowa, 1985).

The aim of the present investigations is the application of conodonts, belonging together with cephalopods and forams to the most important Middle Triassic index fossils, to detailed biostratigraphic zonation in 9 selected well sections in the Polish Lowlands (see Fig. 1 for a location). Distinction of the standard conodont zones (H. Kozur, 1968, 1972, 1980; K. Budurov, E. Trifonova, 1984, 1995) allows to constrain the age of the previously described lithostratigraphic units and to provide time correlation with the earlier described sections of the southern basin margin.

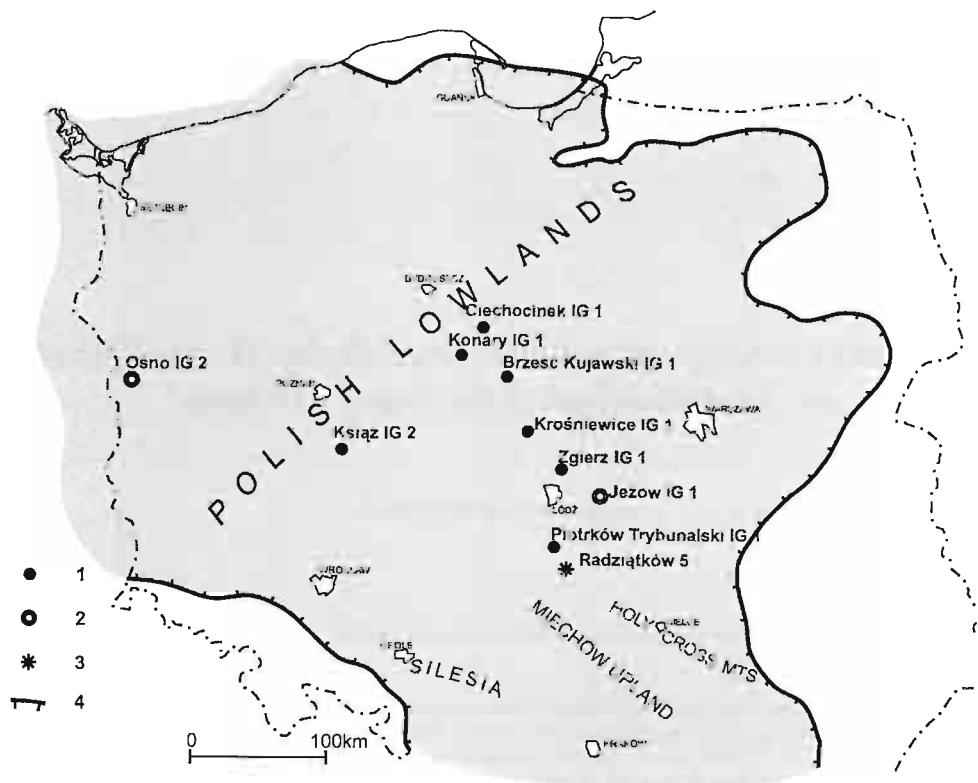


Fig. 1. Location of the investigated wells against the extent of the Lower Muschelkalk basin in Poland

Wells sampled for the present study: 1 — positive, 2 — barren; 3 — well studied by J. Głazek *et al.* (1973); 4 — extent of the Lower and Middle Muschelkalk basin (after I. Gajewska *et al.*, 1997)

OCCURRENCE OF CONODONTS IN THE INVESTIGATED SECTIONS

Investigated samples were collected from the Röt, Muschelkalk and Lower Keuper deposits during 1997 to 1998. Processing embraced 107 samples *ca.* one kilogram each. Figure 2¹ shows most of the sampled depth intervals except for some barren samples from the lower part of the Röt in the Brześć Kujawski IG 1 and Konary IG 1, and upper part of the Lower Keuper in the Brześć Kujawski IG 1, Zgierz IG 1 and Krośniewice IG 1. All the processed samples from the Röt (11 samples), Middle Muschelkalk (3) and Lower Keuper (30) appeared negative. Conodonts have been found only in the Lower (6) and Upper Muschelkalk (8) deposits. They yielded total number of 80 specimens whose occurrence and frequency in particular well sections is presented in Table 1. Collected material is rather scarce. On average, one kilogram of rock yielded 6 specimens whereas e.g. in the Holy Cross Mts. an average Upper Muschelkalk 300-gram sample yielded *ca.* 50 specimens (J. Trammer, 1972). In the investi-

gated material the maximum conodont frequency was found in the samples from the Konary IG 1 well, depth 1883.2 m (19 specimens) and Brześć Kujawski IG 1, depth 2434.1 m (21 specimens). In other samples number of conodonts did not exceed ten specimens. In some cases taxonomic determinations were difficult due to strongly broken and/or corroded specimens. In the wells Konary IG 1 (Pl. I, Figs. 2, 3) and Piotrków Trybunalski IG 1 (Pl. I, Fig. 4) the Lower Muschelkalk conodonts have strongly corroded surfaces. This is probably related to activity of circulating dolomitizing fluids. Petrological studies carried out by K. Wołkowicz (in print) revealed strong dolomitization in several well-sections of the Muschelkalk in the Kujawy area, including Konary IG 1 (depth 1884.4–1886.3 and 2031.2 m), Byczyna 1, Zgierz IG 1, and, slightly weaker, in the Brześć Kujawski IG 1. In the Piotrków Trybunalski IG 1 section such studies were not undertaken and it is impossible to explain the alteration of conodont surfaces there. Observed alterations are very similar to those illustrated for the Middle Triassic conodonts from the Cracow–Silesia area, and attributed to activity of ore-forming Zn- and Pb-rich fluids (J. E. Repetski, M. Narkiewicz, 1996).

Eighteen species belonging to eight genera were described in the studied conodont assemblage (Tab. 1). The genera *Neogondolella*, *Paragondolella* and *Nicoraella* were determined basing on a development of a lower surface of specimens (H. Kozur, 1989a). Specific determinations were based

¹Lithology and stratigraphy of particular sections (Fig. 2) has been presented after well descriptions stored in the Central Geological Archive.

Conodont occurrence and frequency in the investigated Muschelkalk well sections

Table 1

Conodont taxa	Well name; depth [m]													
	Książ IG 2		Konary IG 1			C. IG 1	B. Kuj. IG 1	Krośniewice IG 1			Z. IG 1	Piotrków Trybunalski IG 1		
	1439.0	1427.3	2061.4	2027.5	1883.2	1687.3	2434.1	4658–4657	4656.5	4514–4510	3856.5	3547.3	3545.4–3545	3356
<i>Cornudina ?latidentata</i>														
<i>Diplodella bidentata</i>						1					3		1	
<i>Enantiognathus zieglerei</i>														
<i>Neogondolella balcanica</i>									2					
<i>Neogondolella constricta</i>									3	1				
<i>Neogondolella cornuta</i> juvenile									1					
<i>Neogondolella cornuta</i> → <i>mesotriassica</i>										1				
<i>Neogondolella haslachensis</i>		3			5									
<i>Neogondolella haslachensis</i> juvenile					6									1
<i>Neogondolella</i> cf. <i>N. haslachensis</i>		1												
<i>Neogondolella media</i> → <i>haslachensis</i>					2									
<i>Neogondolella</i> cf. <i>N. acuta</i>	1													
<i>Neogondolella mombergensis</i>	1								2					
<i>Neogondolella</i> cf. <i>N. mombergensis</i>		1			1									
<i>Neogondolella prava</i>									1					
<i>Neogondolella</i> cf. <i>N. prava</i>									1	2				
<i>Neogondolella regale</i>														
<i>Neogondolella regale</i> juvenile													1	
<i>Neogondolella</i> sp. juvenile form of <i>constricta</i> → <i>mombergensis</i> stage													1	
<i>Neogondolella</i> sp. juvenile form of <i>constricta</i> stage									3					
<i>Neogondolella</i> sp. juvenile					3				2					
<i>Neogondolella</i> sp. indet.					2				5	2	4		2	
<i>Neohindeodella riegei</i>			1											
<i>Neohindeodella</i> cf. <i>N. riegei</i>											1			
<i>Neohindeodella triassica</i>											1			
<i>Nicoraella</i> cf. <i>N. kockeli</i>				1										
<i>Ozarkodina tortilis</i>									1					
<i>Paragondolella</i> cf. <i>hanbulogi</i>														
<i>Paragondolella trammeri</i>		1												
<i>Paragondolella</i> sp. indet.									1					
<i>Prioniodina muelleri</i>									1					
Ramiform elements										1			1	

C. — Ciechocinek, B. Kuj. — Brześć Kujawski, Z. — Zgierz

on the papers by U. Tatge (1956), H. Kozur (1968), H. Kozur *et al.* (1994), S. Kovács and H. Kozur (1980), K. Budurov and S. Stefanov (1972), H. Kozur and H. Mostler (1972), M. Sudar and K. Budurov (1979), J. Trammer (1975) and K. Zawadzka (1975).

In the **Książ IG 2 well** conodonts have been found at the depths 1439.0 and 1427.3 m (Fig. 2). In the lower sample only two conodonts have been found (Tab. 1): *Neogondolella mombergensis* (Tatge) and *N. cf. N. acuta* (Kozur) (Pl. I, Fig. 12). Characteristic features of the former species are: a development of a carina in which middle denticles are lower than posterior and anterior ones, and a basal cavity somewhat displaced anteriorly relative to a keel termination (H. Kozur, 1968, 1989a; H. Kozur *et al.*, 1994). *Neogondolella acuta*

(Kozur) is distinguished by a strong bending of a posterior denticle towards the platform termination (P. Mietto, M. Petroni, 1980). From the depth 1427.3 m six conodonts have been obtained (Tab. 1) and determined as *Neogondolella haslachensis* (Tatge), *N. mombergensis* (Tatge) and *Paragondolella trammeri* Kozur. First species is an index species of the Zone 4 (H. Kozur, 1968, 1980). Specimen determined as *Neogondolella* cf. *N. mombergensis* (Tab. 1) has a broken anterior part of the platform. Specific affinity is evidenced by a location of a basal cavity and development of a carina. *Paragondolella trammeri* Kozur (Pl. III, Fig. 2) is a juvenile form and therefore difficult for a determination on a subspecific level. At this stage of an ontogenetic development, with the carina displaying small denticle behind the cusp, and with

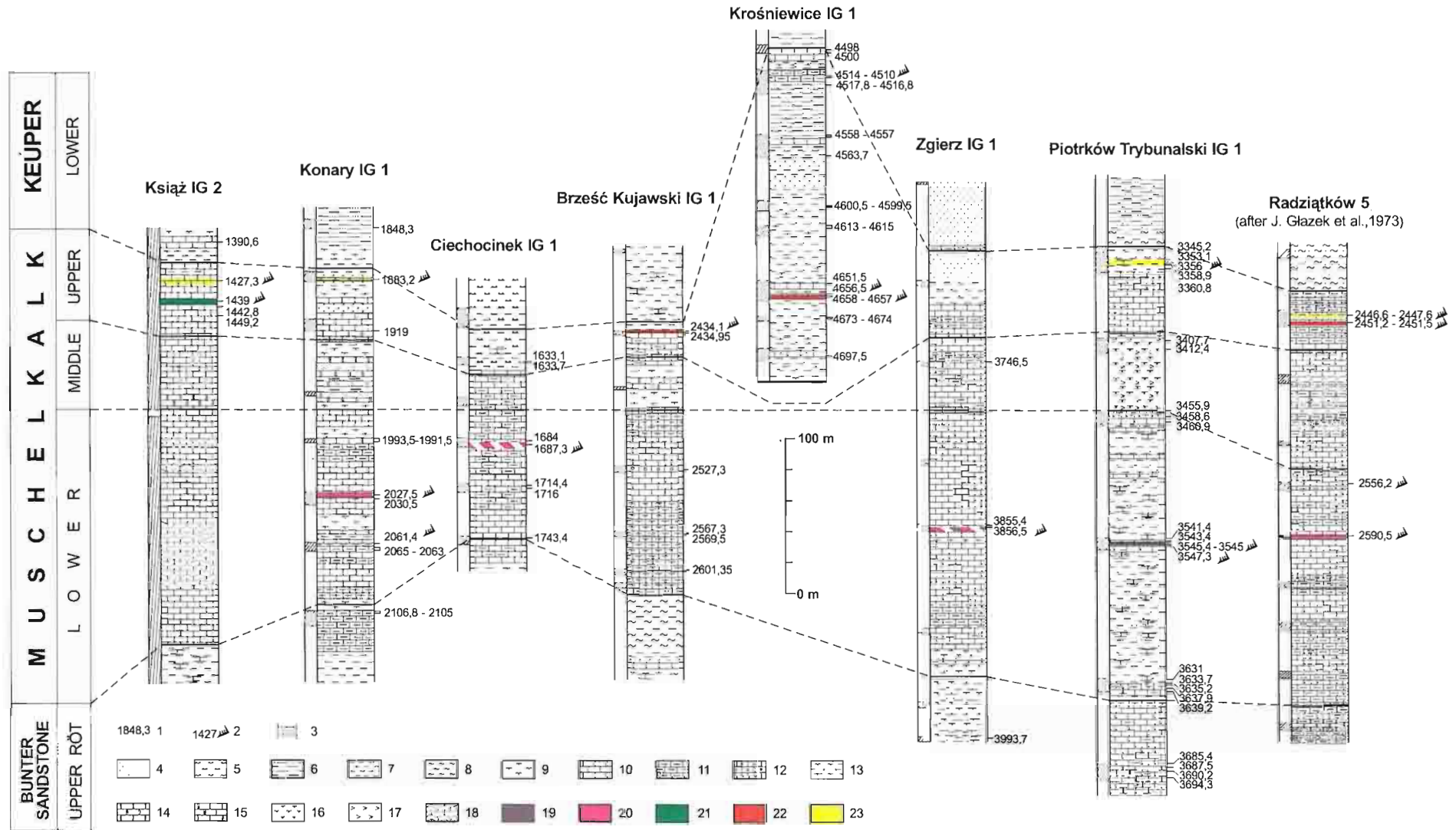


Fig. 2. Conodont zones distinguished in the investigated well-sections against the lithostratigraphic correlation of the Muschelkalk

1 — sample depth (in meters), 2 — positive samples, 3 — cored intervals, 4 — sandstones, 5 — siltstones, 6 — sandstone-claystone intercalations, 7 — claystones, 8 — mudstones, 9 — marls, 10 — limestones, 11 — clayey and marly limestones, 12 — oolitic limestones, 13 — clayey marls and marly claystones, 14 — dolostones, 15 — dolomitic limestones and calcareous dolostones, 16 — dolomitic claystones, 17 — anhydrites, 18 — wavy-bedded limestones, 19 — *germanica* Zone, 20 — *kockeli* Zone, 21 — Zone 1, 22 — Zone 2, 23 — Zone 4

the narrow elevated keel and only slightly narrower basal cavity, it is difficult to separate *Paragondolella trammeri praetrammeri* (Kozur et Mostler) from *P. trammeri trammeri* (Kozur et Mock). *P. trammeri* is one of the most important forms indicative of the Ladinian stage (H. Kozur *et al.*, 1994).

In the **Konary IG 1 well** conodonts have been found both in the Lower and Upper Muschelkalk. Sample from 2061.4 m yielded only one specimen of *Neohindeodella riegeli* (Mosher) (Pl. I, Fig. 2) which is a long-ranging species, not suitable for biostratigraphic purposes. Single specimen has been obtained also from the depth 2027.5 m and is illustrated on Plate I, Figure 3. Due to strongly corroded surface of the conodont the photograph does not show outlines of denticles which, however, are visible under a microscope. The main cusp is distinctly larger than the other denticles. Due to the poor preservation of the specimen it has been determined as *Nicoraella* cf. *N. kockeli* (Tatge). It is an index species for the Pelsonian (H. Kozur, H. Mostler, 1972; K. Budurov, S. Stefanov, 1972). The most abundant conodont assemblage (19 specimens) has been found in the sample from 1883.2 m (Tab. 1). The age of the sample is constrained by the presence of *Neogondolella haslachensis* (Tatge) (Pl. III, Fig. 1) which, as mentioned above, is indicative of the Zone 4. The index species is accompanied by *N. cf. N. mombergensis* (Tatge) (Pl. III, Fig. 7) and *N. media*→*haslachensis* (Pl. III, Figs. 5, 6). The first form displays a *mombergensis*-like carina and basal cavity slightly displaced anteriorly relative to a keel termination. From the typical representatives of *Neogondolella mombergensis* (Tatge) it differs in a development of a platform being narrowest in its middle part. The specimen determined as *N. media*→*haslachensis* is characterised by a still relatively long platform with a carina composed of numerous denticles (ca. 12) of a more or less equal height, like in *N. media* (Kozur). The last denticle in the posterior part of a platform is considerably larger than remaining ones, which is a characteristic feature of *N. haslachensis* (Tatge).

In the **Ciechocinek IG 1 well** the single positive sample is from the depth 1687.3 m, from the deposits ascribed to the Lower Muschelkalk (Tab. 1 and Fig. 2). The conodonts have been identified as *Paragondolella* cf. *P. hanbulogi* Sudar and Budurov (Pl. I, Figs. 5, 6), *Enantiognathus zieglerei* (Diebel) (Pl. I, Fig. 8) and *Prioniodina muelleri* (Tatge) (Pl. I, Fig. 9). The last two species are ramiform conodonts with wide stratigraphic ranges. Characteristic feature of the genus *Paragondolella* is a very high carina in the anterior part of a platform and a presence of a free blade. Unfortunately, the illustrated specimen of *Paragondolella* cf. *P. hanbulogi* Sudar et Budurov has a broken anterior part of the platform. Posterior part is rounded and well-visible platform margins are parallel (Pl. I, Fig. 6). Basal field (Pl. I, Fig. 5) is widened, with a straight posterior margin (see the description by B. Vrielynck, 1987, p. 139). The basal cavity is so narrow that it is hardly discernible from the basal groove. This species has been determined for the first time in Poland. It is to be stressed, however, that B. Vrielynck (1987) after revision of the determinations by J. Trammer (1975) from the Holy Cross Mts. and by K. Zawadzka (1975) from Silesia, included into the described species some of the forms determined by the Polish authors as *Gondolella bifurcata* Budurov et Stefanov.

In the **Brześć Kujawski IG 1 well** conodonts have been obtained only from the depth 2434.1 m, from detrital skeletal limestone ascribed to the Upper Muschelkalk. This sample yielded the most abundant conodont assemblage (21 specimens). Following platform species have been found: *Neogondolella mombergensis* (Tatge) (Pl. II, Figs. 4, 5), *N. prava* (Kozur) (Pl. II, Figs. 6, 7), *N. cornuta* Budurov et Stefanov, *N. constricta* Mosher et Clark (Pl. II, Figs. 1–3, 8–10) and *N. balcanica* Budurov et Stefanov (Pl. II, Figs. 12–14). Moreover, two ramiform species have been determined: *Ozarkodina tortilis* Tatge (Pl. II, Fig. 11) and *Prioniodina muelleri* (Tatge) (Pl. II, Fig. 16). Characteristic feature of *Neogondolella cornuta* Budurov et Stefanov is a horn-like main cusp located at the posterior platform termination and fused with its margin, and a basal cavity developed at the keels termination. In Poland this species has been recognised previously in both the Holy Cross Mts. and Silesia area. However, when considering a development of a lower platform surface, and, in particular, location of a basal cavity relative to a keels termination (H. Kozur *et al.*, 1994), some of the determinations should be verified.

The specimen determined by J. Trammer (1975, pl. 22, fig. 9a, b) as *Gondolella cornuta* (Budurov et Stefanov), with the basal cavity considerably shifted anteriorly relative to the keels termination, but still with downward bent posterior platform, is most probably transitional between *Neogondolella cornuta cornuta* Budurov et Stefanov and *N. cornuta ladinica* Kozur, Krainer et Mostler (H. Kozur *et al.*, 1994). Also the specimen determined as *Gondolella cornuta* (Budurov et Stefanov) by K. Zawadzka (1975, pl. 43, fig. 8a, b) belongs most probably to *N. cornuta ladinica* Kozur, Krainer et Mostler in its intermediate ontogenetic stage with a characteristic *mombergensis*-like carina (H. Kozur *et al.*, 1994). *Neogondolella constricta* Mosher et Clark occurring in the described sample is characterized by a variety of forms whose common feature is also a location of a basal cavity at a keels termination (H. Kozur *et al.*, 1994). One may distinguish two forms of this species (H. Kozur *et al.*, 1994). Form (A) has a *mombergensis*-type of a carina with a cusp which, if present, is placed at a platform termination and fused with its posterior margin but not protruding in a horn-like fashion (Pl. II, Figs. 9, 10). Form (B) has a cusp surrounded by a brim (Pl. II, Figs. 1, 2). Cusp is almost vertical and a brim is visible behind it. Such conodonts are very rare in the northern part of the Tethys. According to H. Kozur *et al.* (1994) form B may be identical with the *balcanica* morphotype (A. Nicora, S. Kovács, 1984). Another representative of the described species illustrated in Plate II, Figure 8 is very similar to *Neogondolella longa* Budurov et Stefanov in a carina development and in having indistinctly developed cusp. However, the development of a very narrow keel with an elevated basal cavity at its posterior end evidences that specimen still belongs to *N. constricta* Mosher et Clark. *N. balcanica* Budurov et Stefanov (Pl. II, Figs. 12–14) has been found in Poland for the first time. It is characterised by a protruding cusp which is not fused with a platform termination (Pl. II, Figs. 13, 14) and a basal cavity distinctly shifted posteriorly relative to a keels termination (Pl. II, Fig. 12). This species is characteristic for the Ladinian (H. Kozur *et al.*, 1994). Ramiform conodonts found in the

Table 2

Geographic distribution of the selected conodont species occurring in the central part of the Polish Lowlands

Species	Provinces										
	German				Austro-Alpine	Dinaride		Asian			Nevadan
	Polish Lowlands	Holy Cross Mts.	Silesia	Germany		Yugoslavia	Bulgaria	Turkey	Greece	Sikhote-Alin	
<i>Neogondolella regale</i>	•	•				•	•	•	•	•	•
<i>Nicoraella kockeli</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Paragondolella hanbulogi</i>	•	•	•		•	•	•	•	•		
<i>Neogondolella constricta</i>	•	•	•		•	•	•	•	•		
<i>Neogondolella cornuta</i>	•	•	•		•	•	•			•	
<i>Neogondolella mombergensis</i>	•	•	•	•							
<i>Neogondolella prava</i>	•	•	•	•						•	
<i>Neogondolella haslachensis</i>	•	•	•	•							
<i>Neogondolella bulcanica</i>	•				•		•			•	
<i>Paragondolella trammeri</i>	•	•			•	•					

sample were not used in biostratigraphic analysis due to their wide ranges.

In the **Krośniewice IG 1 well** positive samples were only those from the Upper Muschelkalk. The sample from the depth 4658.0–4657.0 m yielded 8 specimens determined as *Neogondolella* cf. *N. prava* (Kozur) (Pl. III, Fig. 8), *N. constricta* Mosher et Clark (Pl. III, Fig. 9) and *N. cornuta*→*mesotriassica* (Pl. III, Figs. 3, 4). The latter form has a basal cavity distinctly shifted anteriorly relative to a keels termination (Pl. III, Fig. 3) as in typical *N. mesotriassica* (Kozur et Mostler) but a development of the posterior platform (Pl. III, Fig. 4) is not yet typical for that species. Conodonts found in the samples from 4656.5 and 4514.0–4510.0 m were either too much damaged or revealing too early stages of ontogenetic development to be determined on a specific level (Pl. III, Figs. 14, 15).

In the **Zgierz IG 1 well** only single sample from the depth 3856.5 m appeared positive. The assemblage consists of rami-form conodonts ascribed to *Neohindeodella riegeli* (Mosher), *N. triassica* (Müller) (Pl. I, Fig. 10) and *Diplodella bidentata* (Tatge) (Pl. I, Fig. 7). The species are characterized by wide stratigraphic ranges, with first two appearing probably already in the Scythian (Early Triassic) and ranging up to Norian (Late Triassic) (H. Kozur, J. Mostler, 1972). *Diplodella bidentata* (Tatge) appears in the Anisian and ranges to the Carnian (Late Triassic).

In the **Piotrków Trybunalski IG 1 well** conodonts were obtained from three samples but only two yielded material suitable for the biostratigraphic analysis. From the depth 3545.4–3545.0 m five conodonts were obtained (Tab. 1), two of which were determined as *Cornudina ?latidentata* Kozur et Mostler (Pl. I, Fig. 4) and *Neogondolella regale* Mosher (Pl. I, Fig. 1), respectively. The former species is typical for the early Anisian of the German Basin (Fig. 3). Although its uppermost occurrence ranges up to the Tuvlian (Late Trias-

sic), it appears very rarely later than in the Pelsonian (H. Kozur, H. Mostler, 1972). In Poland, *Cornudina ?latidentata* Kozur et Mostler has been reported from the Pelsonian of the Holy Cross Mts. (J. Trammer, 1975) and Miechów Upland area (K. Zawidzka, 1984), and from the lower Anisian of Silesia (K. Zawidzka, 1975).

Neogondolella regale Mosher occurs only in the eastern (Polish) part of the German Basin, in the *germanica* Zone (H. Kozur, 1980) (Fig. 3). This species has been described from the early Anisian of the Holy Cross Mts., from the Wellenkalk and Łukowa Beds (J. Trammer, 1972). However, the specimen illustrated by J. Trammer (1972, pl. 2, fig. 2) from the Łukowa Beds, with a characteristic deflected posterior and anterior part of the platform, in the light of later investigations in Bulgaria (K. Budurov, S. Stefanov, 1975a, b) does not belong to *N. regale* Mosher, but rather to *Paragondolella bulgarica* Budurov et Stefanov or it may represent a transitional form between these two species. *Neogondolella regale* Mosher is a short-ranging species with a widespread global distribution. It was found in Nevada, U.S.A. (L. C. Mosher, 1970; A. Nicora, 1976) in British Columbia, Canada (L. C. Mosher, 1973), Sikhote-Alin, Russia (T. W. Klec, 1995; G. I. Buryi, 1997), as well as in the Tethys area in Greece and Turkey (A. Nicora, 1976, 1977; H. Kozur, 1980), Bulgaria and Yugoslavia (K. Budurov, 1976; M. Sudar, 1986).

From the depth 3356 m only one conodont has been obtained. It represents an early ontogenetic stage of *Neogondolella haslachensis* (Tatge) (Pl. III, Fig. 13). Carina is of *constricta*-type, i.e. all denticles are of more or less the same height, inclined posteriorly, and there is a smaller denticle in front of the cusp. Similar specimens have been observed in the sample from the Konary IG 1 well, depth 1883.2 m. Those are also typical of early ontogenetic stages of *N. haslachensis* (Tatge). The presence of this species has been also reported

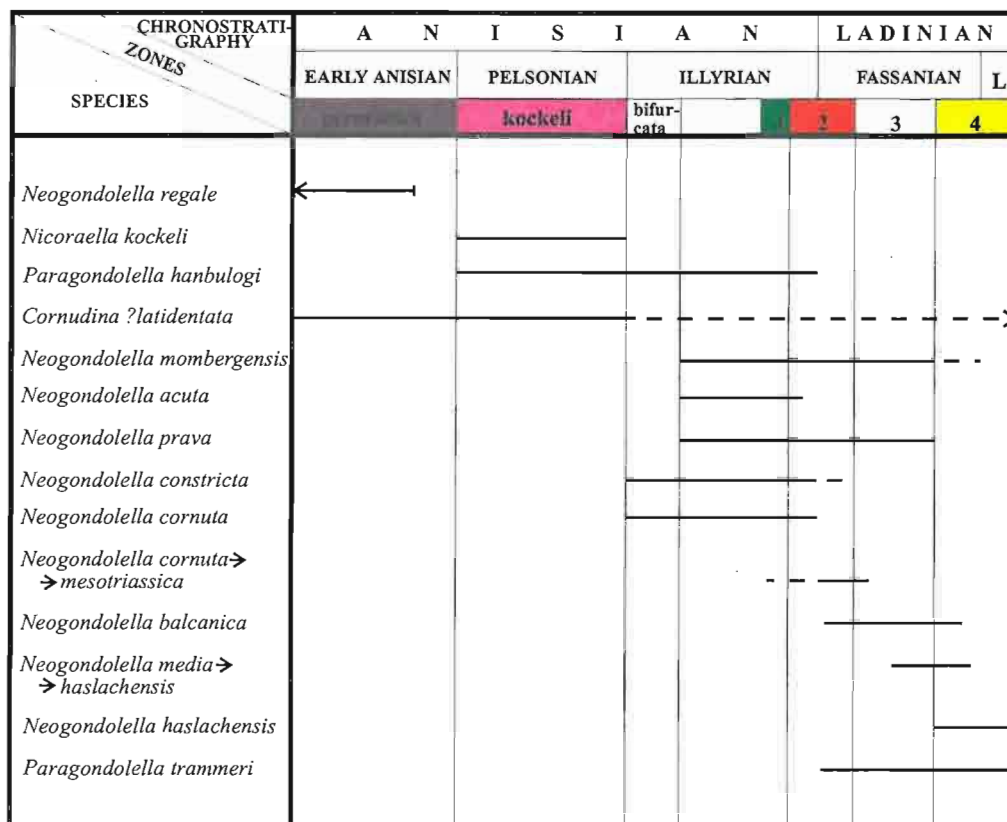


Fig. 3. Stratigraphic ranges of selected Middle Triassic conodonts (after H. Kozur, 1968, 1972, 1980; H. Kozur *et al.*, 1994; M. Sudar, K. Budurov, 1979; B. Vrielynck, 1987)

L. — Longobardian

from the closest located well Radziątków 5 at depth 2446.6–2447.6 m (J. Głazek *et al.*, 1973).

CONODONT ZONES AND CHRONOSTRATIGRAPHY

Chronostratigraphic subdivision of the Middle Triassic (Fig. 3) is correlated with the conodont zonation established by H. Kozur (1968, 1972, 1980) for the German Province. In Germany, three conodont zones have been distinguished in the Lower Muschelkalk interval, and seven zones in the Upper Muschelkalk. The Lower Muschelkalk zones start with the *germanica* Zone corresponding to the late part of the early Anisian. However, in the pelagic Euro-Asian realms of the Tethys the Middle Triassic starts with the *Chiosella timorensis* Zone embracing the Aegean substage without its uppermost part (H. Kozur, 1989b). Conodont zonation of the Upper Muschelkalk is based on the rapidly evolving phylogenetic lineage *Neogondolella mombergensis*–*N. media*–*N. haslachensis*–*Celsigondolella watznaueri* (H. Kozur, 1968, 1973, 1980; J. Trammer, 1974). In Poland, in the Upper Muschelkalk only four lower zones have been found, which is related to an early appearance of environmental conditions adverse

for conodont-bearing animals (J. Trammer, 1975; K. Zawidzka, 1975).

Basing on stratigraphic ranges of selected taxa (H. Kozur, 1968; H. Kozur, H. Mostler, 1972; S. Kovács, H. Kozur, 1980; H. Kozur *et al.*, 1994; B. Vrielynck, 1987) five conodont zones have been found in the studied Polish Lowlands sections (Figs. 2, 3). In the Lower Muschelkalk, the *germanica* and *kockeli* Zones have been distinguished, whereas in the Upper — Zones 1, 2 and 4. No conodonts characteristic for the *bifurcata* Zone and Zone 3 have been found. Due to a poor coring in most of the investigated wells (see Fig. 2) and to unsuitable facies development the collected data is rather limited. In general it was impossible to trace a sequence of consecutive conodont zones. Only in the Książ IG 2 and Radziątków 5 well-sections (J. Głazek *et al.*, 1973) more than one zone has been found in the Upper Muschelkalk (Fig. 2). In the first section samples ascribed to the Zones 1 and 4 are separated by a depth interval 12 m, whereas in the second one Zones 2 and 4 are separated by 5 m. It appeared impossible to define any zones in the Ciechocinek IG 1 and Zgierz IG 1 well-sections.

Application of the conodont zonation established by H. Kozur (1968, 1972, 1980) appears difficult in the case of the Polish Lower Muschelkalk due to the fact that platform conodonts occurring in the Polish sections are lacking in the German part of the basin. However, when applying the above

zonation in the case of deposits with *Neogondolella regale* Mosher (Piotrków Trybunalski IG 1 well, depth 3545.0–3545.4 m) one can ascribe them to the *germanica* Zone (Figs. 2, 3). H. Kozur (1980) defined the age of the zone as a late part of the early Anisian basing on the range of the index species *Nicoraella germanica* (Kozur). *N. germanica* (Kozur), which is a very common species in the German Basin, has not been found in the Polish Lowlands material. However, it has been found in the Holy Cross Mts. where it appears in the Pelsonian just before the first occurrence of *Nicoraella kockeli* (Tatge) (J. Trammer, 1975), and in Silesia, in the lower Anisian (K. Zawadzka, 1975; A. Siewniak-Witruk, 1978). In the German Basin *Neogondolella regale* Mosher was found only in its eastern, Polish part in the *germanica* Zone (H. Kozur, 1980). In the Holy Cross Mts. its presence has been indicated below the occurrence of *Nicoraella germanica* (Kozur), in the Wellenkalk Beds corresponding to the early Anisian (J. Trammer, 1972).

Outside the German Basin representatives of *Neogondolella regale* Mosher are abundant and widespread (Tab. 2). *N. regale* Mosher is the index species of the *Gondolella regalis* Zone in Turkey and Greece (Gebze and Isle of Chios, respectively), in Canada (British Columbia) and U.S.A. (Nevada). The age of the zone is defined as late Aegean (the substage pre-dating Bithynian) and earliest Bithynian (H. Kozur, 1980). Similar age interval (Aegean without its earliest part and Bithynian without its latest part) has been determined for the *Neogondolella regale* Zone also by the Bulgarian authors (K. Budurov, E. Trifonova, 1984) who proposed the standard conodont subdivision for Bulgaria and eastern part of Balcan area. This universal subdivision made it possible to correlate the Triassic deposits in the entire area of Bulgaria and former Yugoslavia (M. Sudov, 1986). However, in the later paper K. Budurov and E. Trifonova (1995) defined the age of the *Paragondolella regale* Zone (= *Neogondolella regale*) as the latest Aegean and early Pelsonian. It has been found that in Bulgaria and former Yugoslavia strata with *N. regale* Mosher occur below the deposits yielding *Nicoraella germanica* (Kozur). It must be stressed, however, that in these regions of the Tethys realm *N. germanica* (Kozur) is regarded as a junior synonym of *Nicoraella kockeli* (Tatge) (M. Sudar, 1986). In Poland, *Neogondolella regale* Mosher is the oldest species found in the Muschelkalk.

The *kockeli* Zone has been defined in Konary IG 1 well-section at the depth 2027.5 m (Fig. 2) and in Radziątków 5 at the depth 2590.5 and 2556.2 m (J. Głazek *et al.*, 1973). Its age is indicated by the range of *Nicoraella kockeli* (Tatge) embracing entire Pelsonian (H. Kozur, 1972, 1980) (see Fig. 3). Some authors consider, however, that the above species occurs only in the upper Pelsonian, in the *Paragondolella bulgarica* Zone (M. Sudar, 1986; K. Budurov, E. Trifonova, 1984, 1995). In Poland, the species has been found also in the Holy Cross Mts. (J. Trammer, 1971, 1972, 1975), in Silesia (K. Zawadzka, 1975; A. Siewniak-Witruk, 1978) and in the Miechów Upland area (K. Zawadzka, 1984). *N. kockeli* (Tatge) has a widespread global distribution (Tab. 2). It has been found in conodont assemblages of the Tethys and Pacific areas (A. Nicora, 1976, 1977).

The age of the deposits sampled in Ciechocinek IG 1 at the depth 1687.3 m is constrained by the stratigraphic range of *Paragondolella hanbulogi* Sudar et Budurov. The representatives of this species have been recognized in Yugoslavia and Bulgaria (M. Sudar, K. Budurov, 1979), and also in Greece and Turkey (B. Vrielynck, 1987; T. Steuber, 1992). Its stratigraphic range spans the Pelsonian and entire Illyrian (M. Sudar, K. Budurov, 1979; B. Vrielynck, 1987) (see Fig. 3). In Poland, however, this species has been found only in the Lower Muschelkalk deposits corresponding to the Pelsonian (B. Vrielynck, 1987). It has not been found in the Middle to Upper Muschelkalk interval corresponding to the Illyrian. This may indicate that the species most probably did not survive the crisis related to an environmental turnover recorded as the Lower/Middle Muschelkalk boundary. Thus, the age of the described deposits should be defined rather as Pelsonian and perhaps earliest Illyrian.

In the Zgierz IG 1 well the age of the investigated sample may be rather widely defined basing on the conodont data, as earlier Anisian to Longobardian. However, J. Trammer (1972) in the course of his investigations in the Holy Cross Mts. noticed that *Neohindeodella triassica* (Müller) commonly occurring in the Lower and Middle Muschelkalk of Germany, in Poland is present mainly in the Lower Muschelkalk. In the Upper Muschelkalk only single specimens have been found. Similar relationships are observed also in Silesia. According to J. Trammer (1972) a proliferation of *N. triassica* (Müller) has been hampered by different environmental conditions prevailing in Poland during the Upper Muschelkalk deposition. If this conclusion is correct, it may be supposed that the ramiform conodont assemblage found in the Zgierz IG 1 well is also limited to the Lower Muschelkalk whose age would range from the early Anisian probably to earliest Illyrian.

It was possible to distinguish three conodont zones in the Upper Muschelkalk of the Polish Lowlands. **Zone 1** can be defined only in the Książ IG 2 well at the depth 1439 m, in the deposits ascribed by H. Senkowiczowa (1985, 1993) to the Middle *Ceratites* Beds. According to H. Kozur (1968, 1980) this zone is defined by the co-occurrence of *Neogondolella mombergensis* (Tatge) and *Chirodella dinodoides* (Tatge). The lower zonal boundary is determined by the appearance of *N. mombergensis* (Tatge), while the upper one is characterized by the disappearance of *Ch. dinodoides* (Tatge) as well as *Cornudina breviramulis* (Tatge), *C. pandodontata* (Budurov) and *Diplodella meissneri* (Tatge). The age of the zone has been attributed to the late Illyrian (H. Kozur, 1980) (Fig. 3). In the investigated deposits not found were the conodonts typical for the Zone 1, such as *Chirodella dinodoides* (Tatge) or *Cornudina breviramulis* (Tatge). It was thus defined basing on the presence of *Neogondolella mombergensis* (Tatge) and *N. acuta* (Kozur). The latter is, according to H. Kozur (1980) an important species accompanying the diagnostic *N. mombergensis* (Tatge). In the Holy Cross Mts. *Neogondolella acuta* (Kozur) was found in *Pecten discites* Beds spanning Zones 1 and 2, and thus time interval from the late Illyrian to earliest Fasnian (J. Trammer, 1971, 1972, 1975). The Zone 1 has been distinguished both in the Holy Cross Mts. (J. Trammer, 1971, 1972, 1975) and in Silesia (K.

Zawidzka, 1975) basing on the presence of the species defining the zone.

The **Zone 2** has been found in the following well-sections: Brześć Kujawski IG 1 (depth 2434.1 m), Krośniewice IG 1 (4657–4658 m), and Radziątków 5 (2451.2–2451.5 m; J. Głazek *et al.*, 1973) (Fig. 2). The stratigraphic range of the zone comprises latest Illyrian and earliest Fassanian (H. Kozur, 1980) (Fig. 3). Its lower boundary runs above the last appearance of *Chirodella dinodoides* (Tatge), *Cornudina breviramulis* (Tatge), *C. pandodentata* (Budurov) and *Diplodella meissneri* (Tatge). The zonal definition stresses mass-occurrence of *Neogondolella mombergensis* (Tatge) without other *Neogondolella* forms and without *Chirodella dinodoides* (Tatge) (H. Kozur, 1980). However, the cited author, among the important conodonts accompanying the diagnostic species in the Zone 2, mentions *Neogondolella prava* (Kozur) in the first place. In all the above mentioned sections both *N. mombergensis* (Tatge) and *N. prava* (Kozur) have been found.

As the stratigraphic ranges of both *N. mombergensis* (Tatge) and *N. prava* (Kozur) are very similar (see Fig. 3) and the boundary between the Zones 1 and 2 is not clear due to a lack of the conodonts diagnostic for the former zone, the ranges of other accompanying forms have been analysed. In the Brześć Kujawski IG 1 well-section these are *Neogondolella cornuta* Budurov et Stefanov, *N. constricta* Mosher et Clark and *N. balcanica* Budurov et Stefanov, whereas in the Krośniewice IG 1 — *N. constricta* Mosher et Clark and *N. cornuta* → *mesotriassica*. *N. cornuta* Budurov et Stefanov is abundant in conodont assemblages of the southern Tethys areas (H. Kozur *et al.*, 1994). Basing on its stratigraphic occurrence the *Pridaella cornuta* (= *Neogondolella cornuta*) Zone has been defined. It corresponds to entire Illyrian in Yugoslavia and Bulgaria where the Triassic is developed in shallower-water facies (K. Budurov, S. Stefanov, 1972; K. Budurov, E. Trifonova, 1984, 1995; M. Sudar, 1986). In Poland, *N. cornuta* Budurov et Stefanov has been found in the Holy Cross Mts. (J. Trammer, 1975) and Silesia (K. Zawidzka, 1975), in the intervals corresponding, according to the cited authors, to the Zones 1–4. It must be stressed, however, that the stratigraphic range of this species in both the areas, should be corrected in the light of new taxonomical data. According to H. Kozur *et al.* (1994) the upper range-limit of *N. cornuta* Budurov et Stefanov does not overstep the Illyrian/Fassanian boundary.

Neogondolella constricta Mosher et Clark is also widespread in southern Tethys. It was used as a diagnostic species to establish the *Pridaella constricta* (= *Neogondolella constricta*) range-zone defined in eastern and southeastern Bulgaria, where the Middle Triassic is developed in deeper-water facies (K. Budurov, E. Trifonova, 1995). The stratigraphic range of this species spans entire Illyrian and earliest Fassanian. According to H. Kozur *et al.* (1994), however, the upper range-limit of *N. constricta* Mosher et Clark does not overstep the Illyrian/Fassanian boundary. *N. balcanica* Budurov et Stefanov — a very rare species in northern Tethys — is characteristic for the Ladinian (H. Kozur *et al.*, 1994). As may be concluded from the above data, the described species in the Brześć Kujawski IG 1 well occur at the Illyrian/Fassanian boundary, and thus in the interval corresponding to the Zone

2. The transitional forms *N. cornuta* → *mesotriassica* with one representative identified in the Krośniewice IG 1 well have been found in the southern Tethys areas in the uppermost *Paraceratites trinodosus* Zone (H. Kozur *et al.*, 1994) corresponding to a latest Illyrian. From the cited data it appears that the occurrence of *N. cornuta* → *mesotriassica* in the Krośniewice IG 1 well indicates the presence of the Zone 2. This zone has been documented in the Holy Cross Mts. (J. Trammer, 1971, 1972, 1975) and Silesia (K. Zawidzka, 1975; A. Siewniak-Witruk, 1978).

The **Zone 4**, comprising the earliest Fassanian and latest Longobardian (H. Kozur, 1980) has been distinguished in the Książ IG 2 well, at the depth 1427.3 m (Middle *Ceratites* Beds according to H. Senkowiczowa, 1985, 1993), Konary IG 1 at the depth 1848.3 m, Piotrków Trybunalski IG 1 (3356.0 m) and Radziątków 5 (2446.6–2447.6 m; J. Głazek *et al.*, 1973) (Fig. 2). The identification of the zone is simple owing to the presence of the key species *Neogondolella haslachensis* (Tatge). In Poland this zone has been distinguished in the Holy Cross Mts. (J. Trammer, 1972, 1975) and in Silesia (K. Zawidzka, 1975). It seems characteristic that in most cases in which the zone has been reported, it occurred close to the top of the Upper Muschelkalk.

In the area of the Muschelkalk distribution in Poland, the standard stage and substage boundaries have been traced in the sections of the Holy Cross Mts. and Silesia (J. Trammer, 1972, 1975; K. Zawidzka, 1975; J. Trammer, K. Zawidzka, 1976). In the former area the Lower Muschelkalk has been attributed to the early Anisian, Pelsonian and earliest Illyrian. In the remaining area the relationships are not clear. In Silesia there are two variants of locating the Pelsonian/Illyrian boundary. Basing on her conodont studies, K. Zawidzka (1976) argued that the age of the Lower Muschelkalk is the same as in the Holy Cross Mts. On the other hand, Z. Kotański (1994), basing on his *Diplopora* studies, has shown that the uppermost part of the Lower Muschelkalk and the lowermost part of the overlying *Diplopora* Dolomite still corresponds to the Pelsonian. Unfortunately, the present results are not sufficient for more precise location of the chronostratigraphic boundaries in the studied sections. The Lower Muschelkalk deposits can be attributed to a later part of the early Anisian, entire Pelsonian and, by analogy with the Holy Cross Mts., to ?earliest Illyrian. The Middle Muschelkalk deposits correspond to the Illyrian but without its late part, and ?late Pelsonian. The Upper Muschelkalk probably corresponds, similarly as in the above mentioned areas, to a late Illyrian, entire Fassanian and earliest Longobardian.

REMARKS ON PALAEOBIOGEOGRAPHY

Spatial differentiation of the Middle Triassic conodont fauna has been a subject of numerous studies for at least 40 years. L. C. Mosher (1968) suggested the presence of three conodont provinces: the Germanic Muschelkalk, Alpine and North-American. In turn, H. Kozur (1980) distinguished 6 provinces: Asian, Dinaride (with the Balkan subprovince),

Austro-Alpine, Western Mediterranean–Arabian, German and Nevada. The investigations by M. Sudar (1986) evidenced exchange of conodont faunas between particular regions in the early Anisian and Pelsonian. The cited author suggested the presence of a single widespread Tethyan-Pacific province during that time. However, the Israeli investigator, F. Hirsch (1994) distinguished 5 conodont provinces: main boreal Panthalassan, Tethyan, Sephardian, German and boreal-American. By definition, faunal province is characterized by different taxa on specific and generic levels. But it was already E. C. Druce (1973) who, citing examples of long-distance faunal migrations and proving lack of characteristic conodont forms in different assemblages from the same area, noticed that there do not exist widely accepted univocal criteria of defining faunal provinces with regard to the Triassic conodont fauna. According to the cited author, the Middle Triassic conodont provincialism has been based on a frequency of characteristic taxa rather than on their clear distinctness. Therefore, he suggests the presence of the Middle Triassic conodont biofacies, stressing at the same time that biofacies recognition may appear difficult as there were many factors controlling lateral distribution of the fauna. One of the important steps in biofacies recognition is a detailed study of lithological context of the fauna.

In order to investigate possible palaeobiogeographic patterns in the occurrence of selected conodont species described in the course of the present studies, their geographic distribution has been compiled from available literature (Tab. 2). First three species, *Neogondolella regale* Mosher, *Nicoraella kockeli* (Tatge) and *Paragondolella hanbulogi* Sudar et Budurov, have been found in the Lower Muschelkalk. Their widespread distribution points to an easy faunal exchange between the particular regions. Remaining species have been found in the Upper Muschelkalk. *Neogondolella constricta* Mosher et Clark, *N. cornuta* Budurov et Stefanov, as well as *N. balcanica* Budurov et Stefanov or *Paragondolella trammeri* Kozur occur abundantly in the deposits of both southern and northern Tethys. On the other hand, *Neogondolella mombergensis* (Tatge) (see H. Kozur *et al.*, 1994), as well as *N. prava* (Kozur) and *N. haslachensis* (Tatge) were regarded as endemic species, confined to the German Province. However, the investigations in the Sikhote–Alin area (southeasternmost part of Asian Russia) revealed the presence of *N. mombergensis* (Tatge) and *N. haslachensis* (Tatge) in the Middle Triassic deposits (T. W. Klec, 1995; G. I. Buryi, 1997, pl. I, fig. 16). As the areas of occurrence of both the species are very distant from each other we may suppose that either both species are cosmopolitan, freely migrating between both areas, or we are dealing with an example of a parallel evolution in similar environmental conditions which led to a development of similar forms (morphotypes).

SUMMARY AND CONCLUSIONS

During the present investigations, the Muschelkalk conodonts have been found in seven deep wells in the Polish

Lowlands area. 14 positive samples yielded 80 specimens ascribed to 18 species. Majority of identified species has been previously described from the Polish Middle Triassic. *Neogondolella balcanica* Budurov et Stefanov and *Paragondolella hanbulogi* Sudar et Budurov have been found in Poland for the first time. The stratigraphically most important species are *Nicoraella kockeli* (Tatge) diagnostic for the conodont Zone *kockeli*, and *Neogondolella haslachensis* (Tatge) diagnostic for the Zone 4. The investigated sections were correlated with the biostratigraphic subdivision by H. Kozur (1968, 1980) and with stages and substages of the Middle Triassic.

The conodonts studies enabled the author to establish the age of the subdivisions of the Muschelkalk in terms of the conodont zonation and standard chronostratigraphy. The Lower Muschelkalk is correlated with the late early Anisian, Pelsonian and ?earliest Illyrian. The presence of *germanica* and *kockeli* Zones has been determined there. Chronostratigraphic position of the upper boundary of the Lower Muschelkalk is not clear. The Middle Muschelkalk corresponds to ?latest Pelsonian and the Illyrian but without its latest part. The Upper Muschelkalk corresponds to the late Illyrian, Fasnian and earliest Longobardian. The presence of the Zones 1, 2 and 4 has been found in this interval. In the Książ IG 2 well the Zones 1 and 4 occur in the upper part of the Upper Muschelkalk, distinguished by H. Senkowiczowa (1985, 1993) as the Middle *Ceratites* Beds. The Fasnian/Longobardian boundary runs close the lithostratigraphic boundary between the Muschelkalk and Keuper.

The analysis of geographic distribution of investigated species shows that exclusively cosmopolitan forms occur in the Lower Muschelkalk. This confirms the suggested existence of a single widespread faunal province during the late Anisian (M. Sudar, 1986), which included also the Polish basin area. On the other hand, in the Upper Muschelkalk, the endemic conodonts characteristic solely for the German Province, like *Neogondolella prava* (Kozur) and *N. media* (Kozur), occur in addition to widely distributed forms. Presented data confirm earlier observations by J. Głazek *et al.* (1973), J. Trammer (1972, 1975) and K. Zawadzka (1975) on a connection between the Polish basin and the northwestern Tethyan shelf area during the deposition of the Lower and Upper Muschelkalk.

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BIOSTRATYGRAFIA KONODONTOWA WAPIENIA MUSZŁOWEGO (TRIAS ŚRODKOWY) W CENTRALNEJ CZĘŚCI NIŻU POLSKIEGO

Streszczenie

Utwory wapienia muszłowego zbadano w 9 otworach wiertniczych (fig. 1). Do badań biostratygraficznych wytypowano 107 próbek z utworów retu, wapienia muszłowego dolnego, środkowego i górnego oraz kajpru dolnego. Konodonty stwierdzono tylko w 14 próbkach pochodzących z utworów dolnego i górnego wapienia muszłowego. Zgromadzona kolekcja konodontowa liczy około 80 okazów należących do 8 rodzajów i 18 gatunków (tab. 1). Wśród nich znaleziono po raz pierwszy w Polsce dwa taksony: *Neogondolella balcanica* i *Paragondolella hanbulogi*.

Na podstawie pionowych zasięgów występowania konodontów o znaczeniu stratygraficznym wyróżniono 5 poziomów konodontowych według podziału zaproponowanego dla prowincji germańskiej przez H. Kozura (1968, 1972, 1980) (fig. 3). W utworach dolnego wapienia muszłowego stwierdzono dwa poziomy: *germanica* odpowiadający wyższej części wczesnego anizyku oraz *kockeli* w całości odniesiony do pelsonu. W utworach górnego wapienia muszłowego wyróżniono natomiast trzy poziomy: poziom 1 wiekowo odpowiadający późnemu illyrowi, poziom 2 — najmłodszemu illyrowi i najstarszemu fassanowi oraz poziom 4 — najmłodszemu fassanowi i najstarszemu longobardowi. Najstarszy poziom *germanica* stwierdzono w otworze Piotrków Trybunalski IG 1 (fig. 2). Określono go na podstawie występowania gatunku *Neogondolella regale* (fig. 3). Poziom *kockeli* obecny w otworze Konary IG 1 (fig. 2), wydzielono na podstawie gatunku przewodniego dla tego poziomu *Nicoraella kockeli* (fig. 3). Poziom 1 stwierdzono w otworze Książ IG 2 (fig. 2). Charakteryzują go gatunki *Neogondolella mombergensis* i *N. acuta* (fig. 3). Poziom 2 stwierdzony w otworach Brześć Kujawski IG 1 i Krośnice IG 1 (fig. 2) wydzielono na podstawie współwystępowania gatunków *Neogondolella mombergensis*, *N. prava*, *N. con-*

stricta, *N. cornuta* i *N. balcanica* (fig. 3). Poziom 4 stwierdzono w otworach Książ IG 2, Konary IG 1 i Piotrków Trybunalski IG 1 (fig. 2). Określono go na podstawie gatunku przewodniego dla tego poziomu *Neogondolella haslachensis* (fig. 3). Badane utwory w otworze Ciechocinek IG 1 odniesiono do pelsonu i ?najstarszego illyru, a w otworze Zgierz IG 1 udało się je zaliczyć tylko ogólnie od wcześniejszego anizyku do ?najstarszego illyru.

Wyniki uzyskane z Niżu Polskiego są niewystarczające dla dokładniejszego określenia granic chronostratygraficznych. Porównując je z granicami pięter i podpięter wyznaczonych w profilach Gór Świętokrzyskich i Śląska (J. Trammer, 1972, 1975; K. Zawidzka, 1975; J. Trammer, K. Zawidzka, 1976) utwory dolnego wapienia muszłowego wiekowo odpowiadałyby wyższej części wczesnego anizyku, pelsonowi i ? najstarszemu illyrowi. Utwory środkowego wapienia muszłowego odpowiadałyby illyrowi bez jego późnej części i ?najpóźniejszemu pelsonowi. Pozycja chronostratygraficzna dolnej granicy środkowego wapienia muszłowego jest niejasna. Utwory górnego wapienia muszłowego odpowiadałyby późnemu illyrowi, fassanowi i najstarszemu longobardowi.

Analiza rozprzestrzenienia geograficznego badanych konodontów wskazuje, że zgodnie z wcześniejszymi poglądami (J. Trammer, 1972, 1975; J. Glazek i in., 1973; K. Zawidzka, 1975) istniało połączenie między basenem polskim a oceanem Tetydy w czasie powstawania utworów dolnego i górnego wapienia muszłowego. W wapieniu muszłowym dolnym stwierdzono wyłącznie formy kosmopolityczne, a w górnym również endemiczne dla prowincji germańskiej.

EXPLANATIONS OF PLATES

PLATE I

Fig. 1. *Neogondolella regale* Mosher, 1970
Piotrków Trybunalski IG 1, 3545.4–3545.0 m, x 120

Fig. 2. *Neohindeodella riegeli* (Mosher, 1968)
Konary IG 1, 2061.4 m, x 220

Fig. 3. *Nicoraella* cf. *N. kockeli* (Tatge, 1956)
Konary IG 1, 2027.5 m, x 260

Fig. 4. *Cornudina ?latidentata* Kozur et Mostler, 1970
Piotrków Trybunalski IG 1, 3545.4–3545.0 m, x 440

Figs. 5, 6. *Paragondolella* cf. *P. hanbulogi* Sudar et Budurov, 1979
Fig. 5 — lower view, Fig. 6 — upper view; Ciechocinek IG 1, 1687.3 m, x 180

Fig. 7. *Diplodella bidentata* (Tatge, 1956)
Zgierz IG 1, 3856.5 m, x 160

Fig. 8. *Enantiognathus zieglerei* (Diebel, 1956)
Ciechocinek IG 1, 1687.3 m, x 160

Fig. 9. *Prioniodina muelleri* (Tatge, 1956)
Ciechocinek IG 1, 1687.3 m, x 200

Fig. 10. *Neohindeodella triassica* (Müller, 1956)
Zgierz IG 1, 3856.5 m, x 130

Fig. 11. *Neogondolella* sp.
Juvenile form of the *constricta*-type; Ciechocinek IG 1, 1687.3 m, x 240

Fig. 12. *Neogondolella acuta* (Kozur, 1972)
Książ IG 2, 1439.0 m, x 200

Dark oblique lines in Figs. 2 and 9 are artifacts. Conodonts illustrated in Figs. 1–11 are from the Lower Muschelkalk, whereas the one from Fig. 12 is from the Upper Muschelkalk

PLATE II

Figs. 1–3. *Neogondolella constricta* Mosher et Clark, 1965
 Fig. 1 — side view, Fig. 2 — upper view, Fig. 3 — lower view; x 130

Figs. 4, 5. *Neogondolella mombergensis* (Tatge, 1956)
 Fig. 4 — upper view, Fig. 5 — lower view; x 130

Figs. 6, 7. *Neogondolella prava* (Kozur, 1968)
 Fig. 6 — upper view, x 110; Fig. 7 — lower view, x 200

Figs. 8–10. *Neogondolella constricta* Mosher et Clark, 1965
 Fig. 8 — upper view, x 85; Fig. 9 — upper view, x 150; Fig. 10 — form A, lower view, x 150

Fig. 11. *Ozarkodina tortilis* Tatge, 1956
 x 180

Figs. 12–14. *Neogondolella balcanica* Budurov et Stefanov, 1975
 Fig. 12 — lower view, Fig. 13 — side view, Fig. 14 — upper view; x 130

Fig. 15. *Neogondolella* sp.
 Juvenile form of the *constricta*-type, x 260

Fig. 16. *Prioniodina muelleri* (Tatge, 1956)
 x 240

Conodonts illustrated in Figs. 1–16 are from the Brześć Kujawski IG 1 well, depth 2434.1 m, Upper Muschelkalk

PLATE III

Fig. 1. *Neogondolella haslachensis* (Tatge, 1956)

Konary IG 1, 1883.2 m, x 240

Fig. 2. *Paragondolella trammeri* Kozur, 1972
 Książ IG 2, 1427.3 m, x 260

Figs. 3, 4. *Neogondolella cornuta*→*mesotriassica*
 Fig. 3 — lower view, Fig. 4 — upper view; Krośniewice IG 1, 4658.0–4657.0 m, x 180

Figs. 5, 6. *Neogondolella media*→*haslachensis*
 Fig. 5 — upper view, x 180; Fig. 6 — side view, x 200; Konary IG 1, 1883.2 m

Fig. 7. *Neogondolella* cf. *N. mombergensis* (Tatge, 1956)
 Konary IG 1, 1883.2 m, x 220

Fig. 8. *Neogondolella* cf. *N. prava* (Kozur, 1968)
 Krośniewice IG 1, 4658.0–4657.0 m, x 220

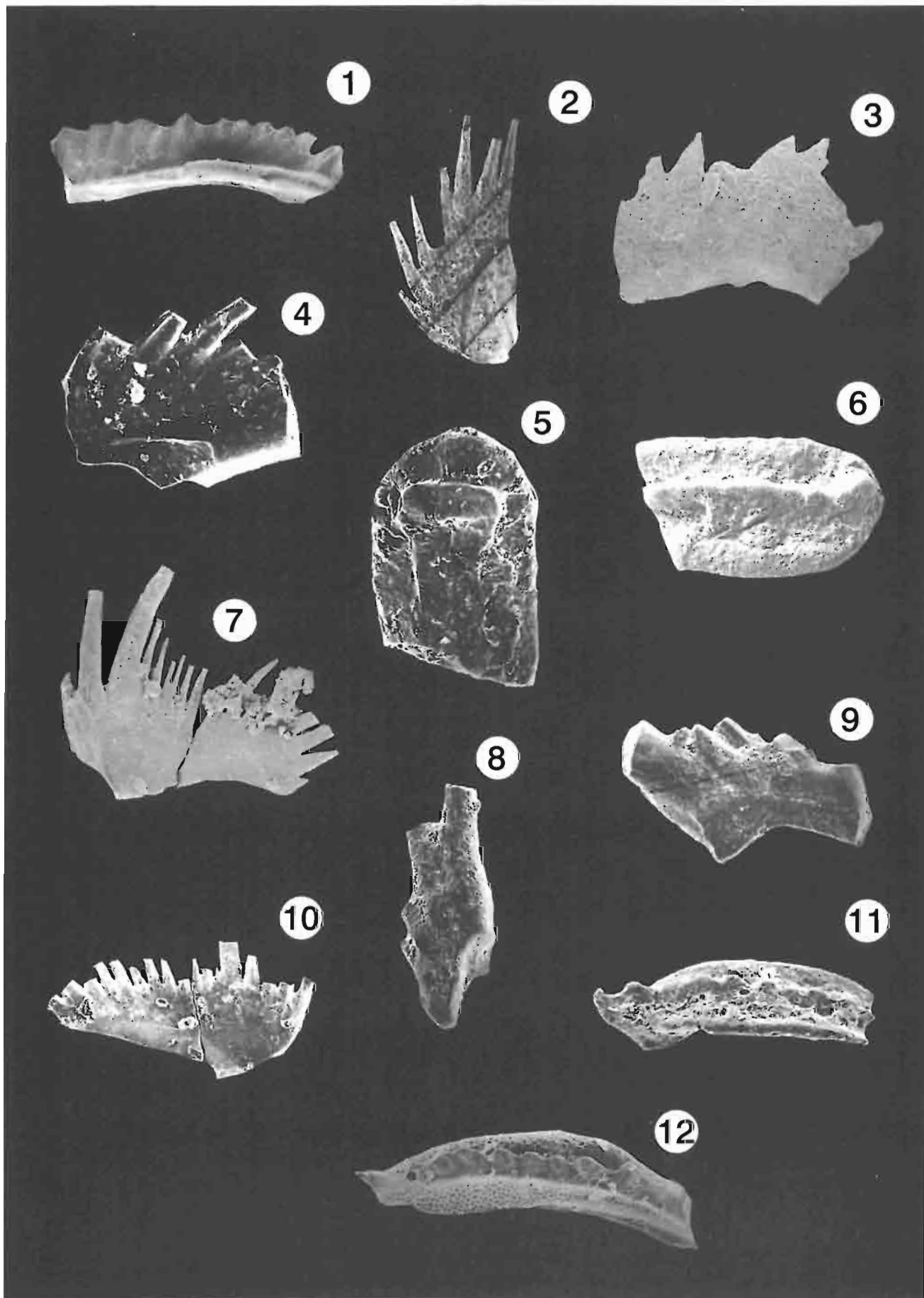
Fig. 9. *Neogondolella constricta* Mosher et Clark, 1965
 Krośniewice IG 1, 4658.0–4657.0 m, x 200

Figs. 10, 13. *Neogondolella haslachensis* (Tatge, 1956)
 Juvenile form of the *constricta*-type; Fig. 10 — Konary IG 1, 1883.2 m, x 240; Fig. 13 — Piotrków Trybunalski IG 1, 3356.0 m, x 220

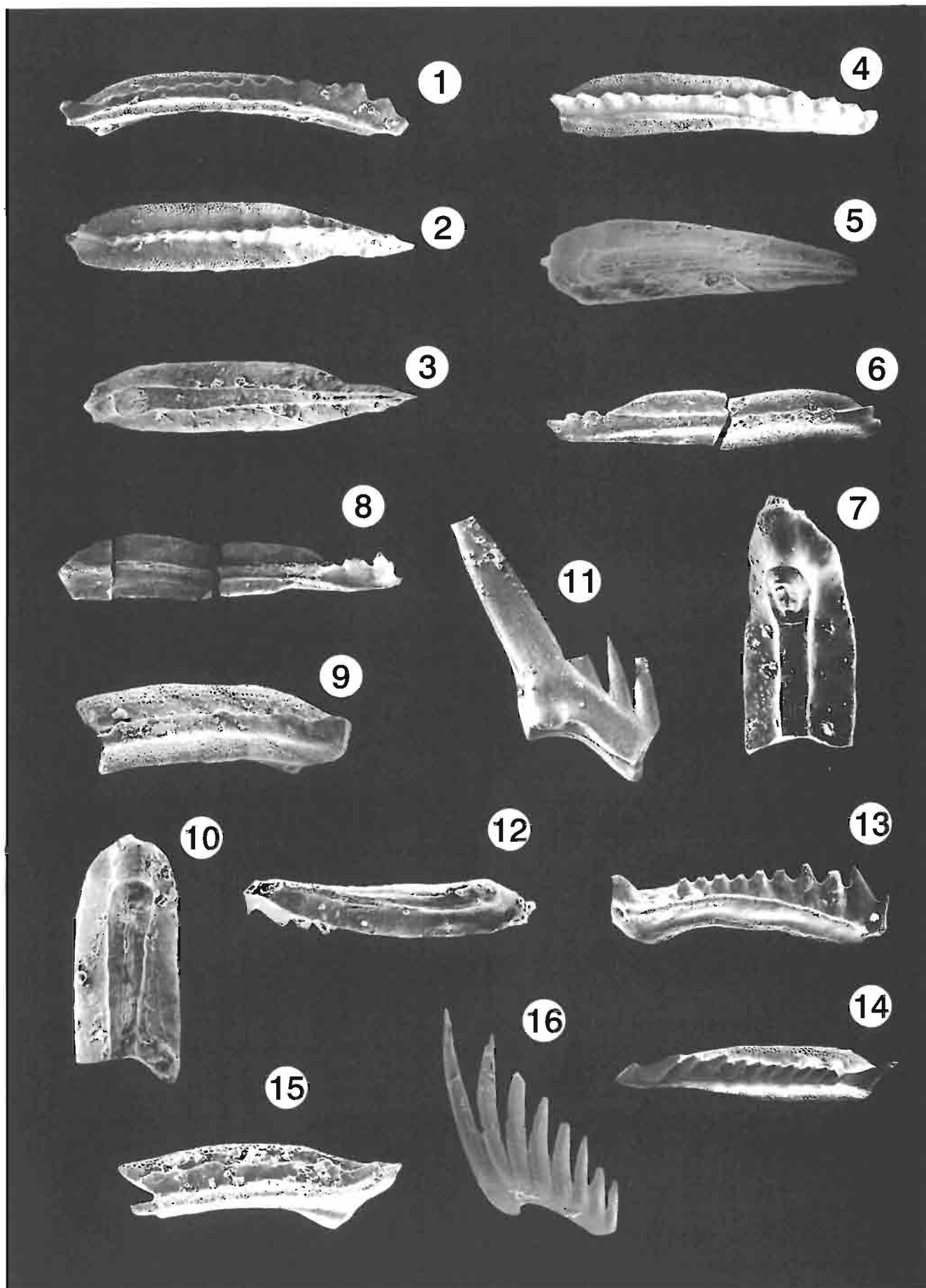
Figs. 11, 12. *Neogondolella* sp.
 Juvenile form of the *constricta*-type, Krośniewice IG 1, 4658.0–4657.0 m, x 300

Figs. 14, 15. *Neogondolella* sp.
 Fig. 14 — upper view, Fig. 15 — lower view; Krośniewice IG 1, 4514.0–4510.0 m, x 220

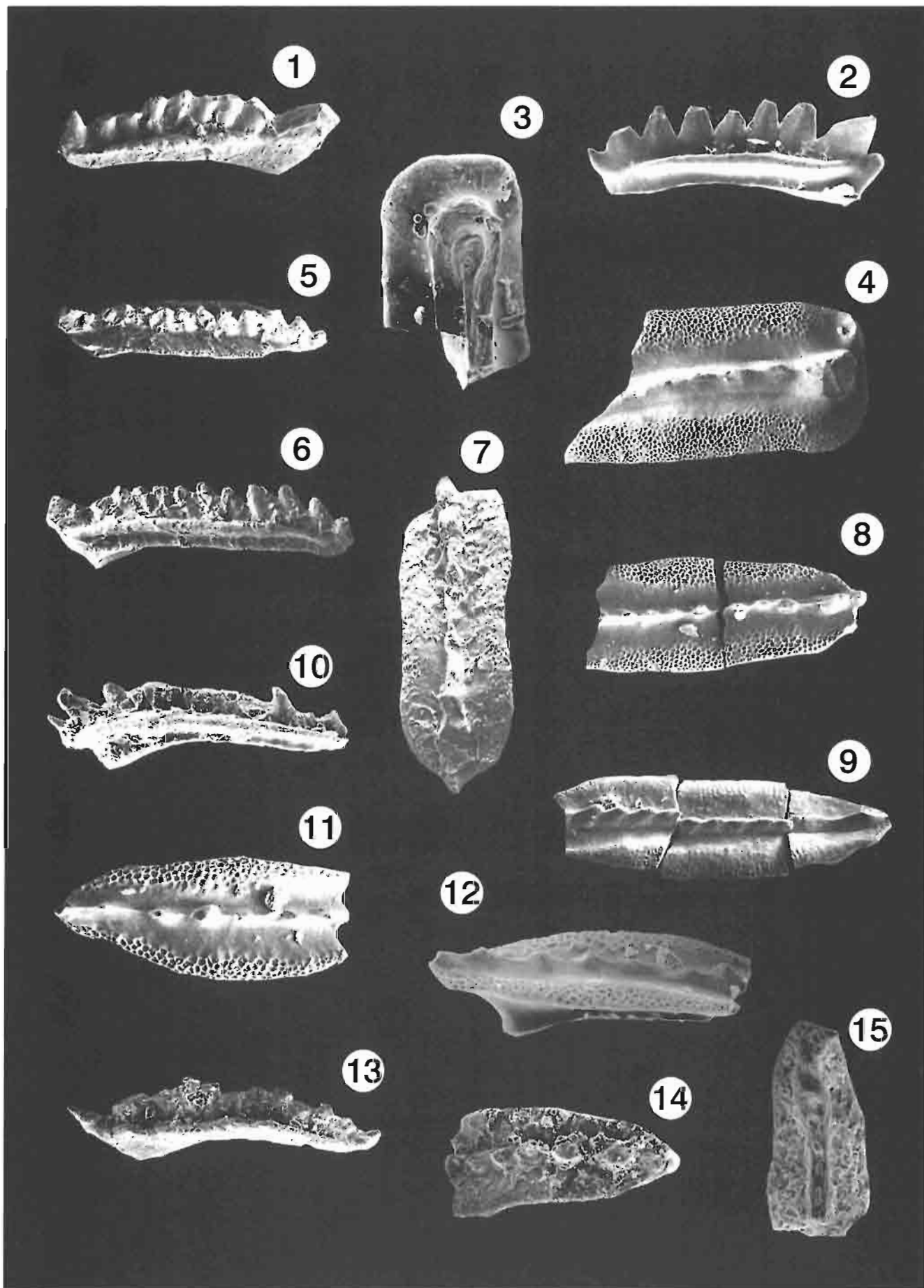
Conodonts illustrated in Figs. 1–15 are from the Upper Muschelkalk



Katarzyna NARKIEWICZ — Conodont biostratigraphy of the Muschelkalk (Middle Triassic) in the central part of the Polish Lowlands



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