

AMBIGUITIES IN CONCHOSTRACAN BIOSTRATIGRAPHY: A CASE STUDY OF THE PERMIAN–TRIASSIC BOUNDARY

Anna BECKER

Polish Geological Institute-National Research Institute, 4 Rakowiecka Str., 00-975 Warszawa, Poland;
e-mail: anna.becker@pgi.gov.pl

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Abstract: In recent years, conchostracan biostratigraphy has become a popular tool for the recognition of the Permian–Triassic boundary and for the chronostratigraphic subdivision of the Triassic in intracontinental settings, including also the bone-bearing Keuper strata of Poland. The ambiguous nature of the new bio-chronostratigraphic approach was characterized in a case study of the Permian–Triassic boundary interval. The most important problems were: (1) the lack of documentation of the index species, (2) the indirect correlation with the conodont stratigraphy in marine reference sections through the sporomorph spectra, (3) the lack of definition and documentation of supporting palynologic zones, and (4) difficulties in reliable taxonomic determination of Conchostraca. Testing and, if necessary, revision of the zonation by several independent research groups is suggested.

Key words: Conchostraca, stratigraphy, Permian–Triassic boundary.

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INTRODUCTION

Conchostraca, in the Polish literature known as *Estheria*, are small phyllopod crustaceans with a chitinous bivalved carapace (Webb, 1979). They are numerous in the gray and red sediments of the intracontinental Triassic basins of Europe, otherwise lacking in fossils. Therefore, they became a source of interest as an easily accessible and effective biostratigraphic tool (see Kozur and Seidel, 1983b), and for the dating of the key bone-bearing sections of Upper Silesia (Olempska, 2004; Dzik and Sulej, 2007; Kozur and Weems, 2010; Sulej *et al.*, 2011; see review in Szulc *et al.*, 2015).

Conchostracan zones were defined for the first time by Kozur and Seidel (1983b) for the Zechstein–Buntsandstein boundary interval of central Germany. Further development enabled the construction of a complete conchostracan zonation scheme for the entire Triassic succession of Central Europe and other intracontinental basins of the northern hemisphere (see Kozur and Weems, 2010).

Despite its efficiency, the biostratigraphic tool still remains controversial. This is mainly because of insufficient documentation and ambiguous chronostratigraphic interpretation. The aim of the paper is to outline the fundamental problem with regard to the conchostracan biostratigraphy of the Permian–Triassic boundary interval. The following critical discussion is the modified version of an article already published in Polish (Becker, 2014).

CONCHOSTRACAN ZONES OF THE PERMIAN–TRIASSIC BOUNDARY INTERVAL

The Permian–Triassic boundary (PTB) has been defined at Meishan, China, by the first occurrence of the conodont *Hindeodus parvus* (Kozur and Pjatakova) in an open-shelf carbonate succession (Yin *et al.*, 2001; Gradstein *et al.*, 2004). According to Bachmann and Kozur (2004), Kozur and Bachmann (2005) and Ogg (2012), it coincides with the boundary between the *Falsisca postera* and *Falsisca verchojanica* conchostracan zones (Fig. 1). Both zones were established from the *Falsisca eotriassica* Zone after Kozur and Seidel (1983b), the first conchostracan zone encompassing the Zechstein–Buntsandstein transition, where the PTB was expected to occur. The *Falsisca eotriassica* Zone *sensu* Kozur and Seidel (1983b) was subdivided into three subzones: the lowermost subzone I with the characteristic species *F. eotriassica eotriassica* Kozur and Seidel, the middle subzone II with the guide species *F. eotriassica postera* Kozur and Seidel and the uppermost subzone III with a diagnostic unrecognized form between *F. eotriassica* n. subsp. and *F. n. sp. aff. verchojanica* (Molin) (Fig. 2). After Kozur and Seidel (1983a, b), the characteristic conchostracan forms for all subzones around the PTB were subspecies of *F. eotriassica* Kozur and Seidel. This implies the similarity of them.

Kozur (1999) modified the conchostracan stratigraphy, establishing new, separate zones from the former subzones.

	Conodonts	Conchostraca	Sporomorphs
T	I. isarcica	Falsisca verchojanica	L. willmotti- L. hexagona
	Hindeodus parvus		
P	Hindeodus praeparvus	Flasica postera	L. obsoleta- L. noviaulensis
		Flasica eotriassica	
			Triquirites proratus

Fig. 1. Stratigraphy of the Permian–Triassic boundary interval in conodont, conchostracan and palynologic zonations after Bachmann and Kozur (2004, fig. 1) and Kozur and Bachmann (2005). Arrows mean continuation of zones beyond the figure.

Subzone I became the Falsisca eotriassica Zone, subzone II the Falsisca postera Zone and subzone III the Falsisca n. sp. aff. *F. verchojanica* Zone. It is noteworthy that all index forms were unrelated species and the range of the *F. eotriassica* Zone was reduced to its former first subzone (Fig. 3). Kozur (1999) placed the PTB at the boundary between the *F. postera* and the *F. n. sp. aff. F. verchojanica* zones. Kozur (1998a, b) discussed two conchostracan forms with respect to the PTB, i.e. *F. postera* and *F. verchojanica* (not the *F. n. sp. aff. F. verchojanica*), which probably was what led him to rename the *F. n. sp. aff. F. verchojanica* Zone as *F. verchojanica* Zone (see e.g., Bachmann and Kozur, 2004). Eventually Bachmann and Kozur (2004) established two “verchojanica” zones: the *F. verchojanica* Zone from the uppermost part of the *F. postera* Zone (see Kozur, 1993, fig. 1 and Bachmann and Kozur, 2004, fig. 11) and the Falsisca cf. *verchojanica* Zone from the former *F. n. sp. aff. F. verchojanica* Zone (Kozur, 1993, 1999; Bachmann and Kozur, 2004). So Bachmann and Kozur (2004) placed the PTB lower than Kozur (1999) had done, at the boundary of the *F. postera* and *F. verchojanica* zones, without providing an explanation (Fig. 3). Kozur and Weems (2010) finally stressed that lowermost part of the *F. verchojanica* Zone could be

Permian in age, but nonetheless placed the PTB at the boundary of *F. postera* and *F. verchojanica* zones.

CORRELATION OF CONCHOSTRACAN-BASED PTB WITH CONODONT STANDARD ZONATION

The methods and pathways of chronostratigraphic correlation, which allowed the conchostracan PTB to be established are summarized in Figure 4, on the basis of an analysis of the publications of Kozur (1987, 1989, 1993, 1998a, b, 1999). The publications discussed the age interpretation of the diagnostic conchostracan species: *Falsisca eotriassica*, *F. postera* and *F. verchojanica* (not the *F. n. sp. aff. F. verchojanica*).

Falsisca eotriassica, found in the Nadaskut Dolomite Member in Hungary, was dated as late Chnagsingian, with reference to the accompanying sporomorph assemblage, which resembled the assemblage from the alpine Tesero Oolite, dated as late Changsingian by means of conodonts (Kozur, 1987). The age interpretation of *Falsisca postera* and *F. verchojanica* was more complicated. Both species were found in Dalongkou, Tien-Shan, co-occurring with vertebrates of the genera *Dicynodon* and *Lystrorhynchus*. There was a discussion in the literature of the region, as to whether the PTB should be placed at the last-appearance datum of *Dicynodon* or at the first occurrence of *Lystrorhynchus* (Cheng *et al.*, 1989, *vide* Kozur, 1998a), because both genera coexist in a transitional zone. The conchostracan sequence of *Falsisca postera* followed by *F. verchojanica* was found precisely in such a transitional zone.

The first conclusion, based on the superposition of both species in the Tien-Shan vertebrate profile, was that *F. verchojanica* is younger than *F. postera* and most probably Triassic in age. Furthermore, *F. verchojanica* was found in south-eastern Siberia, occurring together with a sporomorph assemblage of Permian aspect, but including the Triassic form *Lunatisporites hexagonalis* (Jansonius). This was enough for Kozur (1998a) to interpret the age of the assemblage as Early Triassic. So, thanks to the sporomorph assemblage from south-eastern Siberia, *F. verchojanica* became Early Triassic in age. The older *F. postera* was dated as late Changsingian, on the basis of its co-occurrence with *Dicynodon*. The last-appearance datum of *Dicynodon* was chosen as a PTB indicator, based on conchostracans (Kozur, 1998a). It is worth noting that the position of the PTB in vertebrate sections is still discussed in recent papers (Lucas, 2009; Metcalfe *et al.*, 2009). Metcalfe *et al.* (2009) found the placement of the PTB in the Dalongkou section to be equivocal after extensive multiproxy studies, including the documentation of conchostracans.

Falsisca eotriassica Zone		
Subzone I	Subzone II	Subzone III
<p><i>F. eotriassica eotriassica</i></p> <p><i>F. eotriassica postera</i> (only in the upper part of the subzone I)</p> <p><i>Euestheria gutta gutta</i></p> <p><i>Palaeolimnadia</i> sp. aff. <i>cishycranica</i> (only in the lower part of the subzone I)</p>	<p><i>F. eotriassica postera</i></p> <p><i>Euestheria gutta gutta</i></p> <p><i>Euestheria gutta oertlii</i></p> <p><i>Euestheria jakutica</i></p>	<p><i>Euestheria gutta gutta</i></p> <p><i>Euestheria gutta oertlii</i></p> <p><i>F. eotriassica</i> n. subsp. 1</p> <p><i>F. n. sp. aff. verchojanica</i></p>

Fig. 2. Assemblages of conchostracan taxa occurring in Permian–Triassic boundary interval, after Kozur and Seidel (1983a, b). Index taxa are given in bold print.

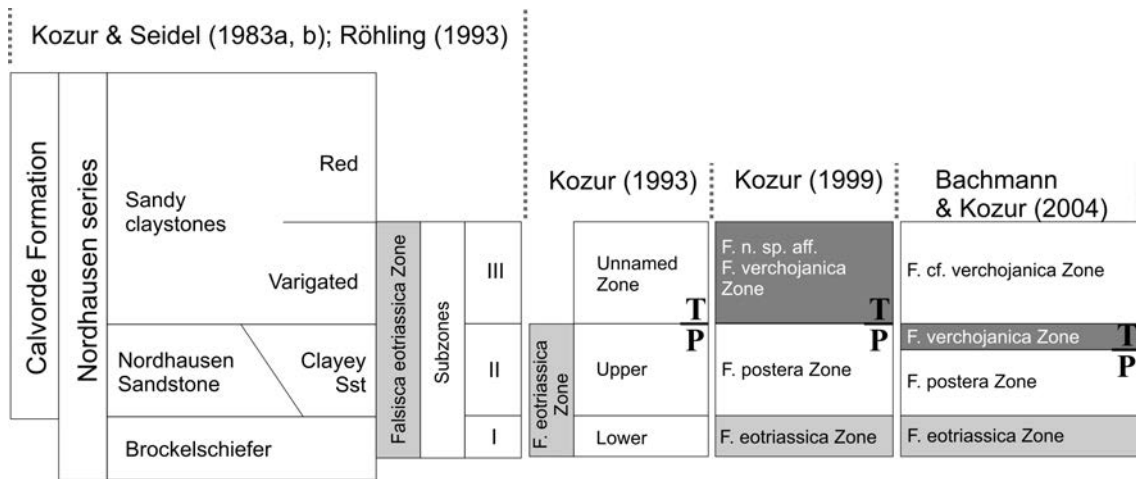


Fig. 3. Evolution of conchostracan zonation of the Permian–Triassic boundary interval, after Kozur and Seidel (1983a, b), Kozur (1993, 1999), Röhling (1993) and Bachmann and Kozur (2004, fig. 11).

PALYNOSTRATIGRAPHY SUPPORTING THE CONCHOSTRACAN STRATIGRAPHY

The fundamental publications, in terms of the chronostratigraphy of the palynological zones of the Permian–Triassic transition, are the works of Balme (1979) from Greenland and of Orłowska-Zwolińska (1984) from Poland (see Kürschner and Hengreen, 2010). The Early Triassic *Lundbladispora obsoleta* – *Protohaploxylinus pantii* Zone of Orłowska-Zwolińska (1984) was often discussed critically in terms of conchostracan stratigraphy. Orłowska-Zwolińska (1984) documented and defined the zone carefully, providing a broad discussion of the possible chronostratigraphic

interpretation. Later authors acknowledged its credibility (e.g., Ecke, 1986; Reitz, 1988; Kürschner and Hengreen, 2010).

In publications based on conchostracan stratigraphy or cited therein, another palynostratigraphic zonation has been favoured (e.g., Kozur, 1989, 1998a, b, 1999; Szurlies *et al.*, 2003; Bachmann and Kozur, 2004). The two following palynostratigraphic zones enabled the recognition of the Permian and Triassic successions, i.e.: the *Lundbladispora obsoleta* – *Lunatisporites noviaulensis* Zone of Permian age and the *Lundbladispora willmotti* – *Lunatisporites hexagona* Zone (or – *L. hexagonalis* Zone; see Fig. 1) of Triassic age. During the preparation of this paper, it was impossible

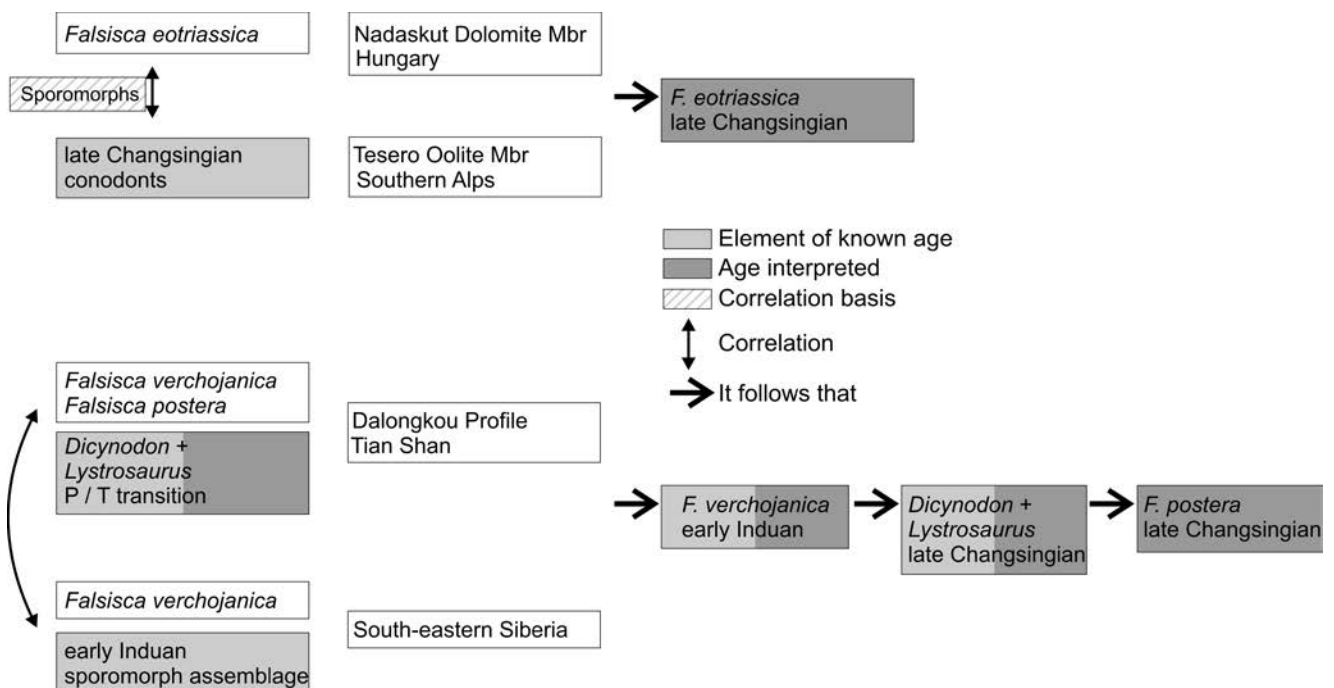
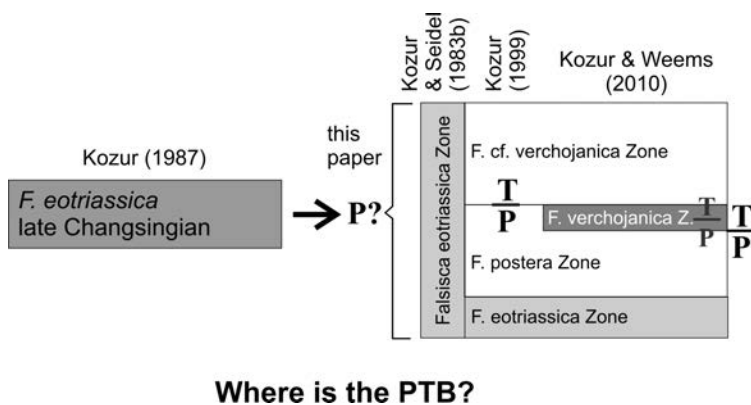


Fig. 4. Diagram of chronostratigraphic interpretation of conchostracan index taxa for the Permian–Triassic boundary, based on Kozur (1987, 1989, 1993, 1998a, b, 1999).



Where is the PTB?

Fig. 5. Uncertainties arising from unresolved problems of conchostracan stratigraphy of the Permian–Triassic transition.

to find a publication, where both zones were precisely defined, documented and discussed. The list of species of the *Lundbladispora obsoleta* – *Lunatisporites noviaulensis* assemblage with a short commentary could be found only in figure caption 1 (*sic!*) by Kozur (1994). It is not clear what makes the difference between the two zones and the *L. obsoleta* – *P. pantii* Zone. In Western Poland, *Lunatisporites noviaulensis* (Leschik) de Jersey can be found up to the Upper Buntsandstein and *Lundbladispora willmotti* was found in all samples with the *Lundbladispora obsoleta* – *Protohaploxypinus pantii* assemblage (Orłowska-Zwolińska, 1984).

PROBLEMS OF CONCHOSTRACAN TAXONOMIC DETERMINATION

The taxonomic identification of conchostracans appears to be difficult. The most successful results on conchostracan biostratigraphy were those published by Heinz Kozur and co-workers. The publications of independent teams are scarce. Kozur's team was forced to correct the taxonomic determinations of others. Ptaszyński and Niedźwiedzki (2004, 2006) were corrected by Kozur and Weems (2010, p. 365), and Orlova (1990, *vide* Kozur and Weems, 2011) was corrected by Kozur and Weems (2011, pp. 24–25). Even the determinations in the standard publication of Kozur and Seidel (1983a) had to be revised (Kozur and Weems, 2010, p. 364). Kozur and Weems (2010) repeatedly stressed the high susceptibility of conchostracan carapaces or their imprints to plastic deformation in fine-grained deposits, which caused erroneous determinations. The lack of informed discussion of the taphonomically-controlled changes, possibly influencing taxonomic determination, is a basis for additional doubts as to which interpretation is actually correct.

CONCLUSIONS

The study of conchostracan biostratigraphy of the Permian–Triassic boundary interval yielded a number of unresolved problems, summarized below.

1. In the literature on conchostracan stratigraphy, the taxonomic determination of index forms is imprecise and insufficiently documented. It is unclear if index species for the Permian–Triassic boundary interval are the subspecies of one species or unrelated species.

2. The ranges of conchostracan zones were changed without explanation and commentary, e.g. in the case of the *F. eotriassica* Zone, making the refined analysis of zonal documentation almost impossible.

3. The definition of the base of the Triassic is unclear in conchostracan stratigraphy (Fig. 5). The first Triassic *F. verchojanica* Zone can be partly Permian in age (Kozur and Weems, 2010) and *F. eotriassica*, originally thought to be diagnostic for the whole Permian–Triassic transitional

zone (Kozur and Seidel, 1983b), is late Changhsingian in age after Kozur (1987).

4. The correlation of conchostracan zonation with the conodont-based Permian–Triassic boundary in marine successions was carried out indirectly using sporomorph assemblages and vertebrates from different parts of the world. The correlation tools frequently suffer from doubtful documentation and imprecise resolution.

5. An analysis of literature shows that a reliable taxonomic determination of conchostracans is difficult to achieve, raising doubts to its usefulness in stratigraphy. One of the reasons reported by Kozur and Weems (2010) themselves can be the variable preservation of conchostracan carapaces.

These conclusions cast doubt on the results achieved by the biostratigraphic approach reported for zonation of the Upper Triassic, as well. Maron *et al.* (2015) recently highlighted speculative terrestrial-marine correlations in the case of late Carnian conchostracan-based stratigraphy. Therefore, there is an urgent need to test and possibly revise the Triassic conchostracan zonation for a credible and efficient biostratigraphic method, which could be very helpful for further research on the intracontinental Triassic basins.

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