

# Testing the congruence of the macrofossil versus microfossil record in the Turonian–Coniacian boundary succession of the Wagon Mound–Springer composite section (NE New Mexico, USA)

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## ABSTRACT:

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The Turonian–Coniacian boundary succession from the Wagon Mound–Springer composite section in the US Western Interior shows a virtually identical macrofaunal record to that revealed in the proposed candidate Coniacian GSSP in the Salzgitter–Salder–Stupia Nadbrzeżna composite section in central Europe, with easy identification in both regions of the base of the Coniacian Stage, as defined by the first appearance of the inoceramid bivalve species, *Cremnoceramus deformis erectus* (Meek). The macrofaunal boundary definition is additionally confirmed by foraminiferal and nannofossil data, demonstrating the high potential of the inoceramid marker for the base of the Coniacian. The former claims concerning distinct diachroneity between macrofossil and microfossil dates in the trans-Atlantic correlations, resulted from methodological deficiencies, and have no factual basis.

**Key words:** Turonian; Coniacian; Europe; Western Interior of North America; Inoceramids; Macrofauna; Microfauna; Correlations; GSSP.

## INTRODUCTION

The Wagon Mound section in northeast New Mexico, USA (US Western Interior) was one of the two main proposals as a GSSP for the base of the Coniacian Stage during the Cretaceous Symposium in Brussels (Kauffman *et al.* 1996). However, as was subse-

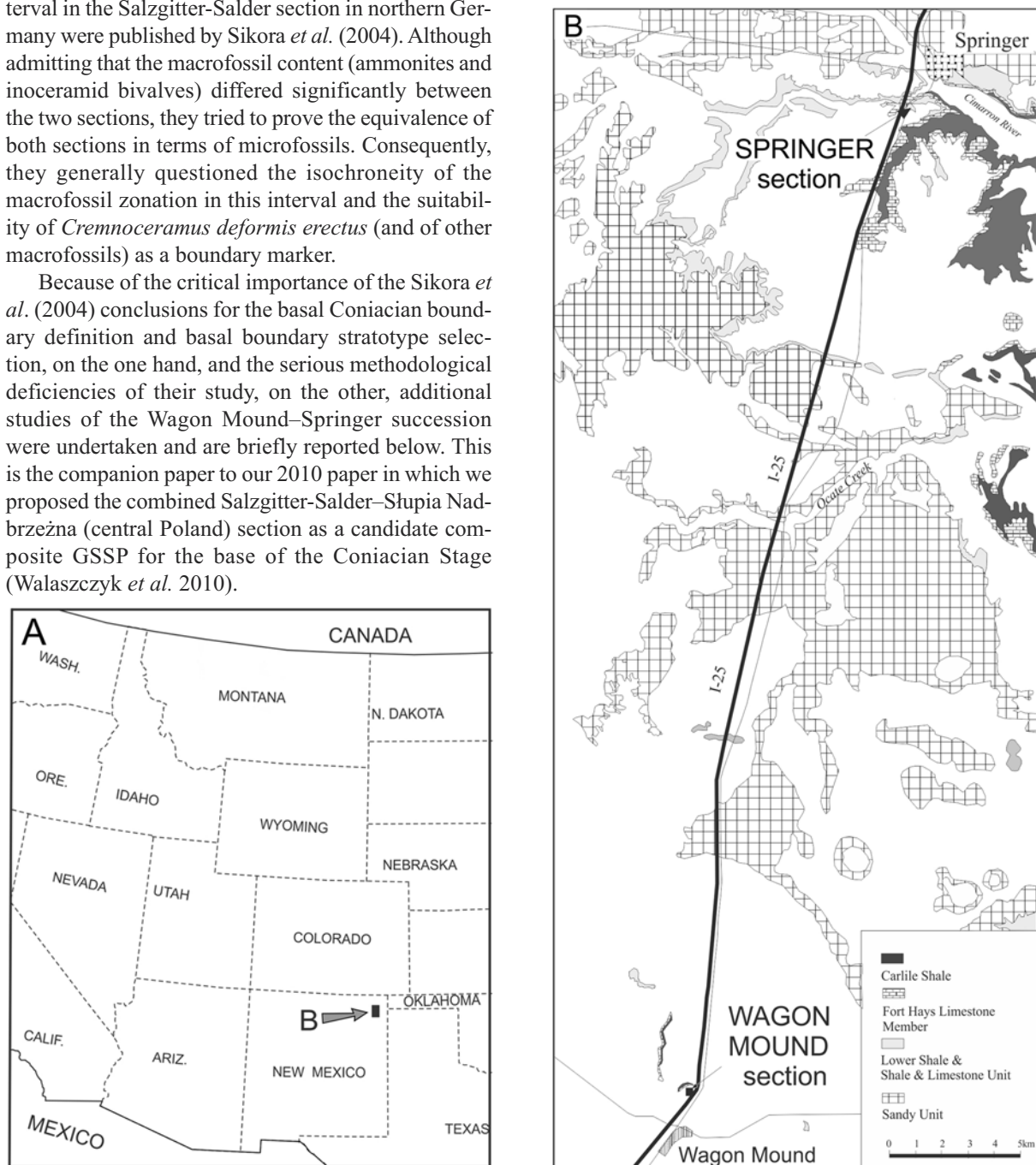
quently shown by Walaszczyk and Cobban (1999, 2000), based on both inoceramid bivalves and ammonites, the succession exposed in a road-cutting near the town of Wagon Mound is entirely Turonian. This is additionally confirmed by observations on the Springer section (located about 25 miles north [=40 km] of Wagon Mound), where the succession ranges

higher, up to the base of the Coniacian, dated directly with inoceramid and *Didymotis* bivalves. As may be judged from the faunal lists, the mis-correlation of the Wagon Mound section resulted from differences in the species concepts applied to the early *Cremnoceramus* taxa. Subsequently, however, a return to the original stratigraphical interpretation of the Wagon Mound section and claims about its stratigraphical equivalence to the Turonian–Coniacian boundary interval in the Salzgitter–Salder section in northern Germany were published by Sikora *et al.* (2004). Although admitting that the macrofossil content (ammonites and inoceramid bivalves) differed significantly between the two sections, they tried to prove the equivalence of both sections in terms of microfossils. Consequently, they generally questioned the isochroneity of the macrofossil zonation in this interval and the suitability of *Cremnoceramus deformis erectus* (and of other macrofossils) as a boundary marker.

Because of the critical importance of the Sikora *et al.* (2004) conclusions for the basal Coniacian boundary definition and basal boundary stratotype selection, on the one hand, and the serious methodological deficiencies of their study, on the other, additional studies of the Wagon Mound–Springer succession were undertaken and are briefly reported below. This is the companion paper to our 2010 paper in which we proposed the combined Salzgitter–Salder–Słupia Nadbrzeżna (central Poland) section as a candidate composite GSSP for the base of the Coniacian Stage (Walaszczyk *et al.* 2010).

## THE SUCCESSION AND MACROFOSSIL RECORD

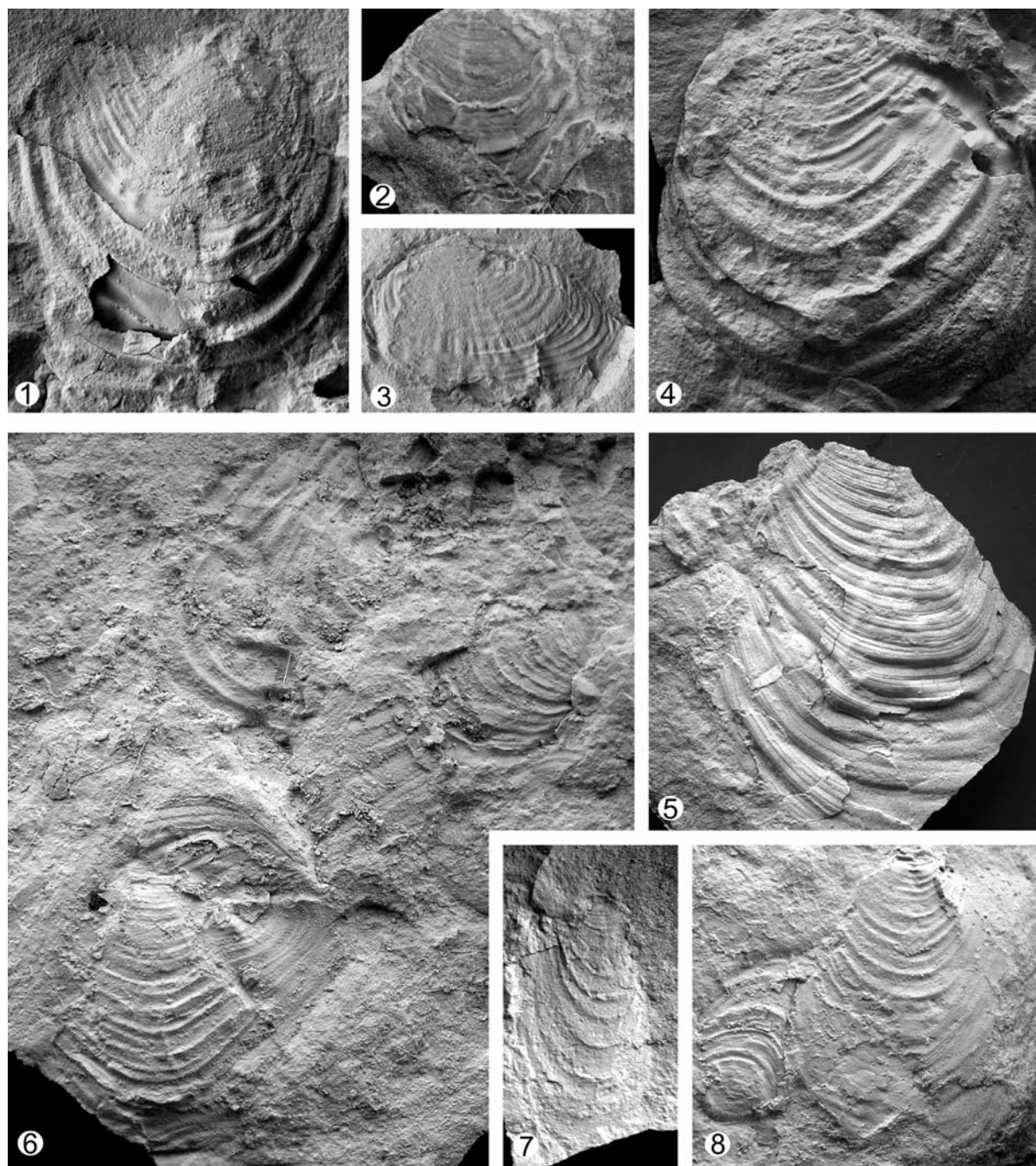
In inoceramid bivalve terms, the Wagon Mound section ranges to a level within the *Mytiloides scupini* Zone, and a corresponding horizon is indicated by ammonites (*Prionocyclus germari* Zone) (Walaszczyk and Cobban 1998, 2000). The higher part of the succession, ranging up to the *Cremnoceramus deformis erectus* Zone, is not exposed in Wagon Mound, but is readily accessible in the



Text-fig. 1. Geographical location of the Wagon Mound–Springer composite section in the USA (A) and in the Wagon Mound–Springer area (B)

nearby section in Springer, about 25 miles [=40 km] to the north (Text-fig. 1). Because the upper part of the succession exposed in Wagon Mound is also well exposed in Springer, the correlation between the two sections is straightforward (see Text-figs 1, 2; see also Scott *et al.* 1986; Walaszczyk and Cobban 1998). Macrofaunally, the basal Coniacian boundary in the Springer section is well

documented by the inoceramid bivalve succession and confirmed additionally by the record of the thin-shelled bivalve *Didymotis*, which is characteristic of the Turonian–Coniacian boundary interval (Text-figs 2, 3; see Wood *et al.* 1984, 2004; Kauffman *et al.* 1996). It also contains the record of the sequence of events, known from the entire Euramerican biogeographic region



Text-fig. 3. Inoceramids and *Didymotis* bivalves of the topmost Turonian and basal Coniacian part of the Springer section. 1, 4 – *Cremnoceramus deformis erectus* (Meek, 1877), 1 – USNM 544534, 4 – USNM 544533; 2 – *Cremnoceramus waltersdorfensis waltersdorfensis* (Andert, 1911), USNM 544527, *waltersdorfensis* Event; 3 – *Didymotis* sp., USNM 544532, *Didymotis* I Event; 5, 6, 8 – *Mytiloides* sp., 5 – USNM 544531, 6 – USNM 544530, 8 – USNM 544529; *herbichi* Event; 7 – *Mytiloides scupini* (Heinz 1929), USNM 544528, *herbichi* Event; all specimens are natural size



(Wood *et al.* 1984, 2004; Walaszczyk 2000), that spans the Turonian–Coniacian boundary (Text-fig. 2): *Mytiloides herbichi* Event; *Didymotis* I Event; *Cremnoceramus waltersdorfensis waltersdorfensis* and *Didymotis* II events; *Cremnoceramus erectus* I Event.

Sikora *et al.* (2004) analysed only the Wagon Mound section and compared it with the *C. deformis erectus* interval in Salzgitter-Salder. Why, aiming to demonstrate the diachroneity of the first occurrence (FO) of *C. deformis erectus* they did not sample the *C. deformis erectus* interval, which is well exposed in Springer, remains unclear. To check the microfossil vs. macrofossil record between Salzgitter-Salder and the US Western Interior, and to confirm or disprove the Sikora *et al.* (2004) conclusions about the diachroneity of the inoceramid bivalve marker for the base of the Coniacian, we sampled the topmost Turonian and the *C. deformis erectus* interval in the Springer section in order to provide the planktonic foraminiferal and nannofossil record.

The microfossils and nannofossils were studied from an 8-m thick interval spanning the uppermost Turonian and lowermost Coniacian (as defined by inoceramid bivalves) strata exposed in the railway-cutting east of Highway 25, just south of the town of Springer (Text-fig. 1; see also Scott *et al.* 1986, fig. 7; the Springer section in Walaszczyk and Cobban 1998, 2000). The Turonian–Coniacian boundary, defined by the first appearance of

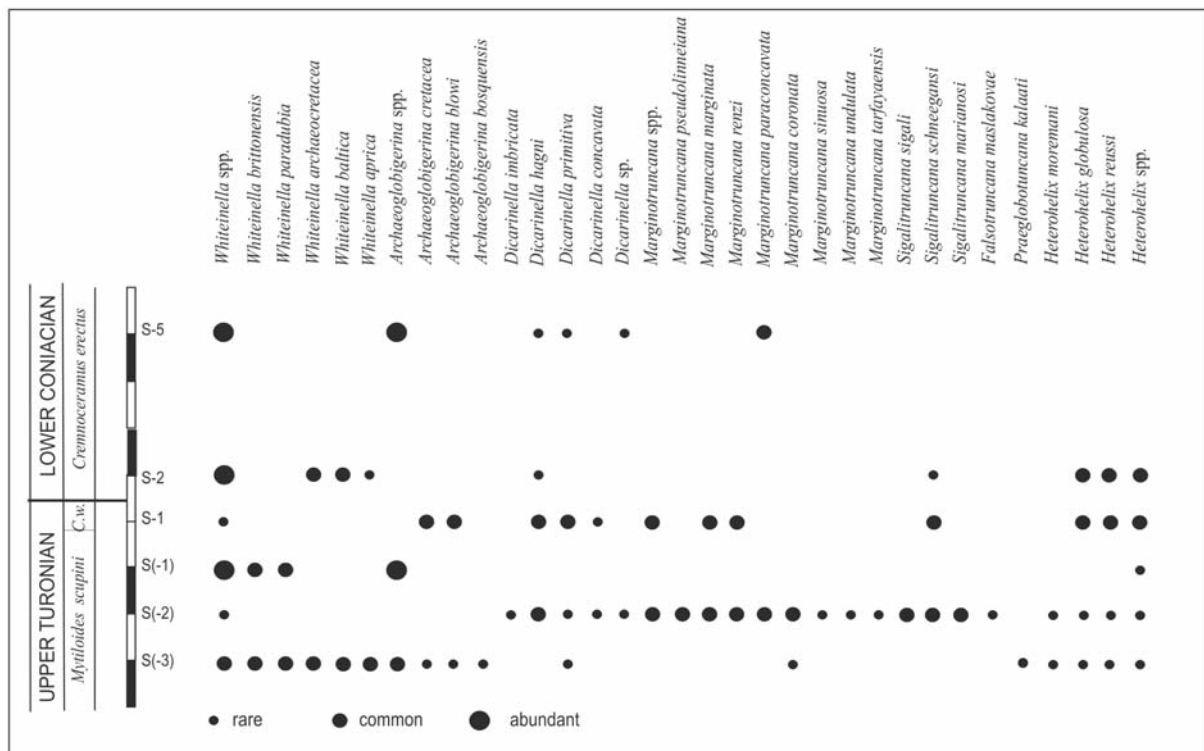
*C. deformis erectus*, is located in the middle part of the interval studied, slightly above sample 1 (Text-fig. 2).

## MICROFOSSIL RECORD

### Planktonic foraminifera (D. Peryt)

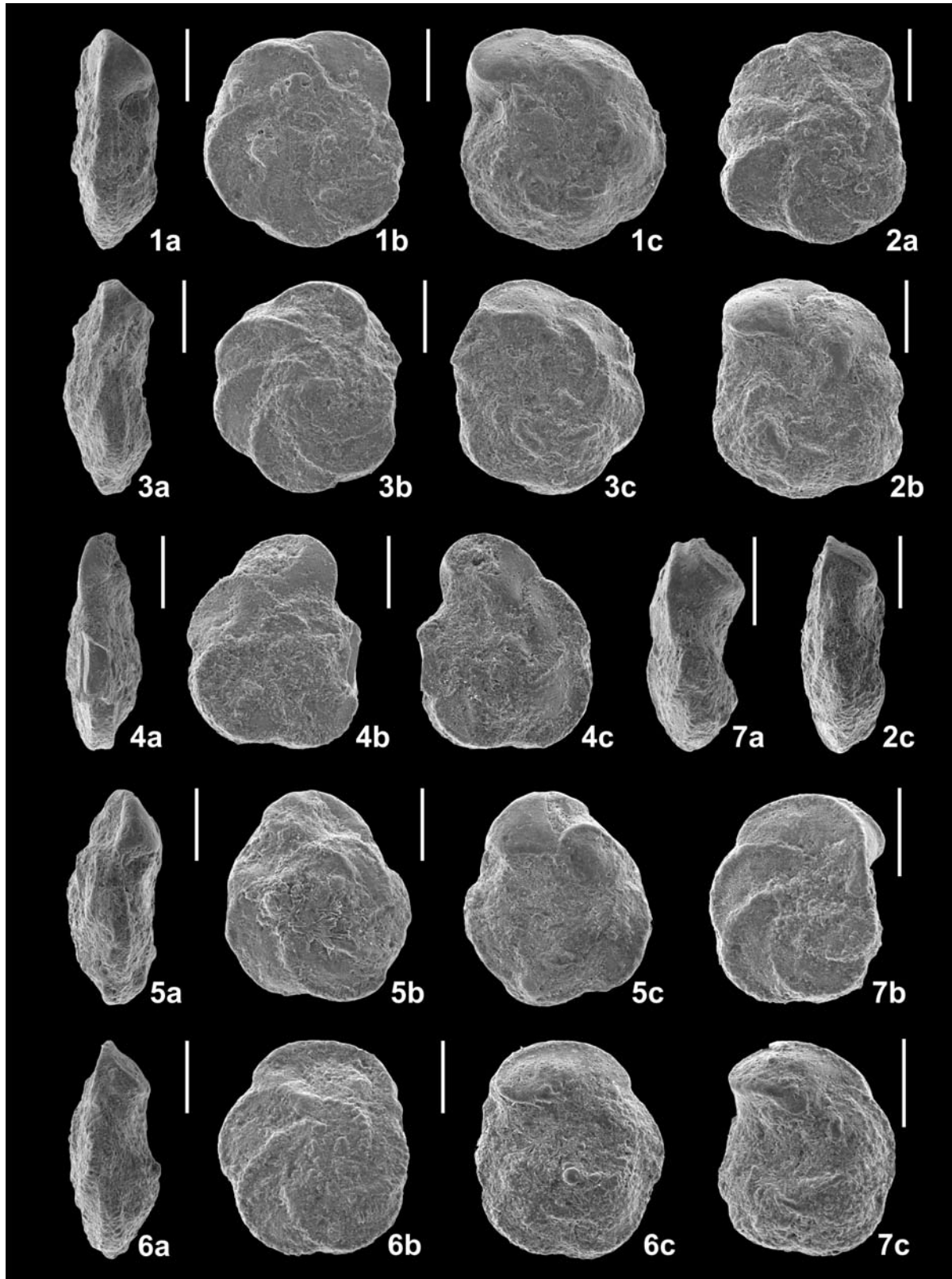
The samples yield abundant, moderately to highly diverse, poorly preserved planktonic foraminifera (Text-figs 4–9). They form 95–98% of the foraminiferal assemblages. The very low contribution of benthic foraminifera may be due to oxygen-depleted bottom waters.

The lowest sample [S(-3)] is dominated by whiteinellids and common small-sized heterohelicids. Representatives of double-keeled *Marginotruncana* and *Dicarinella* are very rare. The most diverse assemblage appears one sample higher [S(-2)], which is dominated by *M. coronata* (Bolli), *M. pseudolinneiana* Pessagno, *M. marginata* (Reuss), *M. renzi* (Gandolfi), *M. paraconavata* Porthault, *M. undulata* (Lehmann) and *M. sinuosa* Porthault. Also common are biconvex dicarinellids: *Dicarinella hagni* (Scheibnerova), *D. imbricata* (Mornod) and *Dicarinella* sp. Single-keeled *Sigalitruncana sigali* (Reichel), *S. marianosi* (Douglas) and *S. schneegansi* (Sigal), as well as *Praeglobotruncana kalaati* Gonzales-Donoso and Linares are rare, as are plano-convex *Di-*

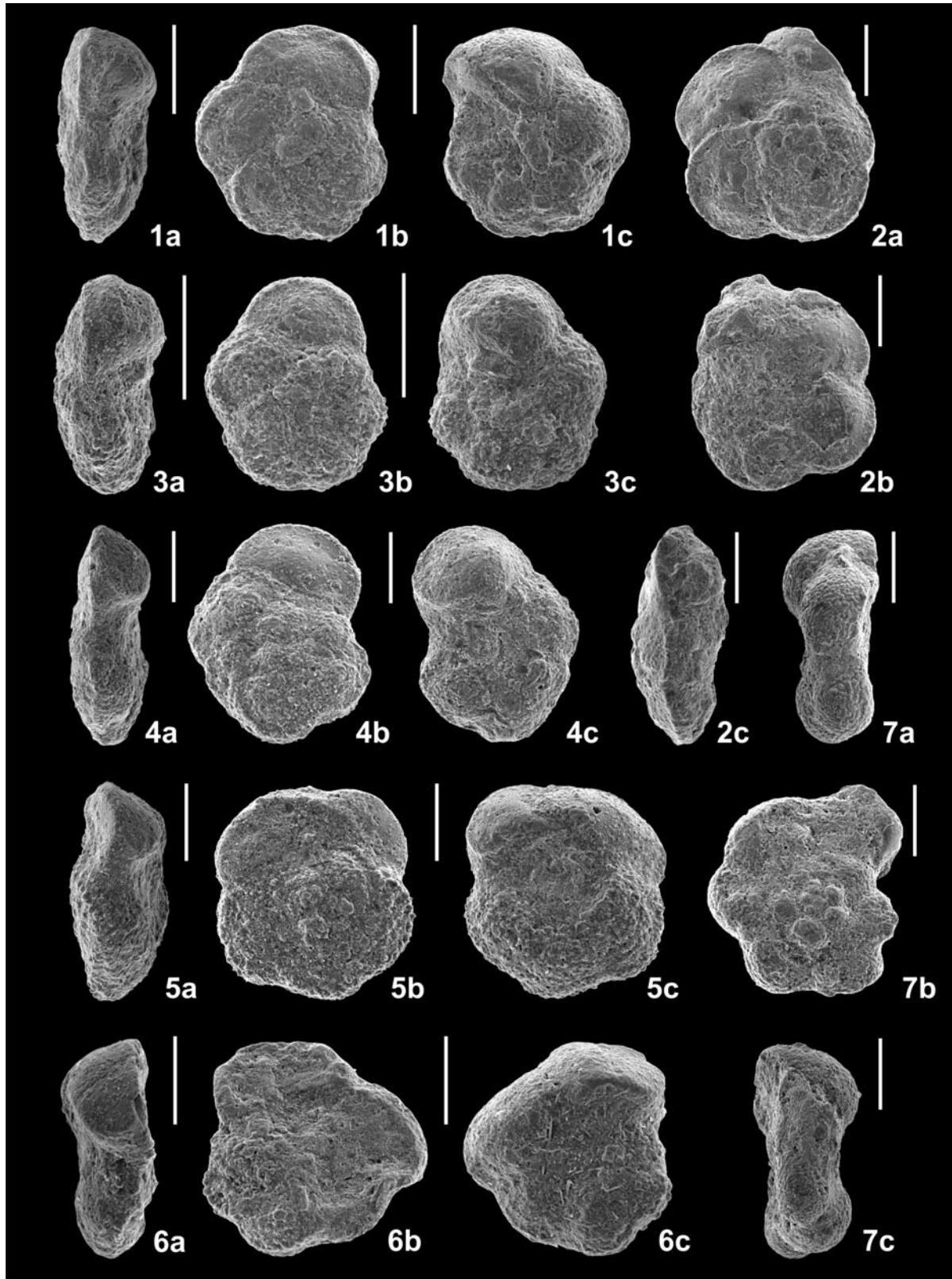


Text-fig. 4. Stratigraphical distribution of planktonic foraminifera in the Upper Turonian – lowermost Coniacian boundary interval in the Springer section;

*C.w.* – *Cremnoceramus waltersdorfensis waltersdorfensis* Zone

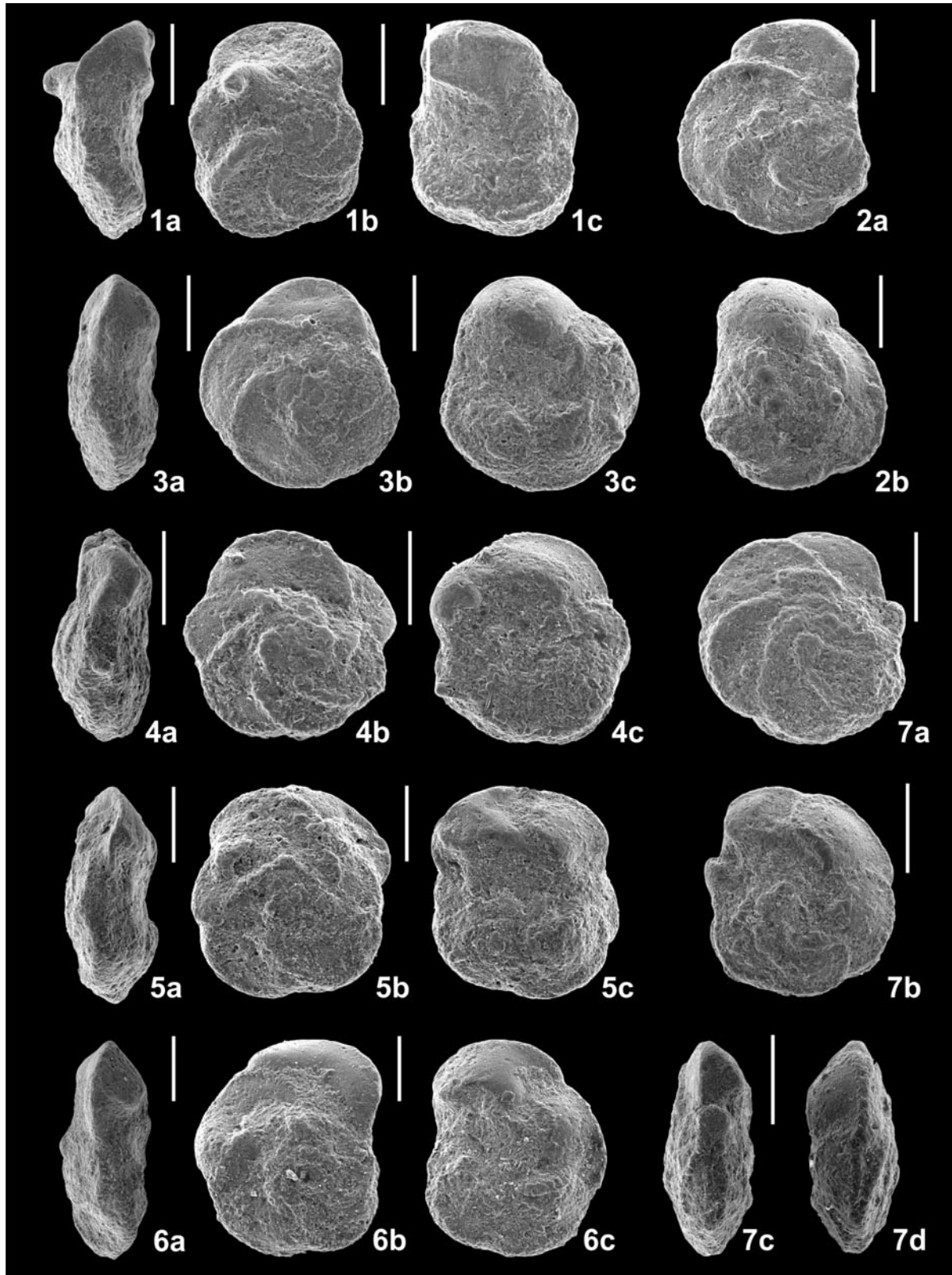


Text-fig. 5. 1a-c – *Marginotruncana paraconcavata* Porthault, 1970, sample Spr-2; 2a-c – *Sigalit truncana marianosi* (Douglas, 1969), sample Spr-2; 3a-c – *Marginotruncana coronata* (Bolli, 1945), sample Spr-2; 4a-c – *Marginotruncana pseudolinneiana* Pessagno, 1967, sample Spr-2; 5a-c – *Marginotruncana tarfayaensis* (Lehmann, 1963), sample Spr-2; 6a-c – *Marginotruncana renzi* (Gandolfi, 1942), sample Spr-2; 7a-c – *Marginotruncana sinuosa* Porthault, 1970, sample Spr-2. Scale bar = 200  $\mu$ m

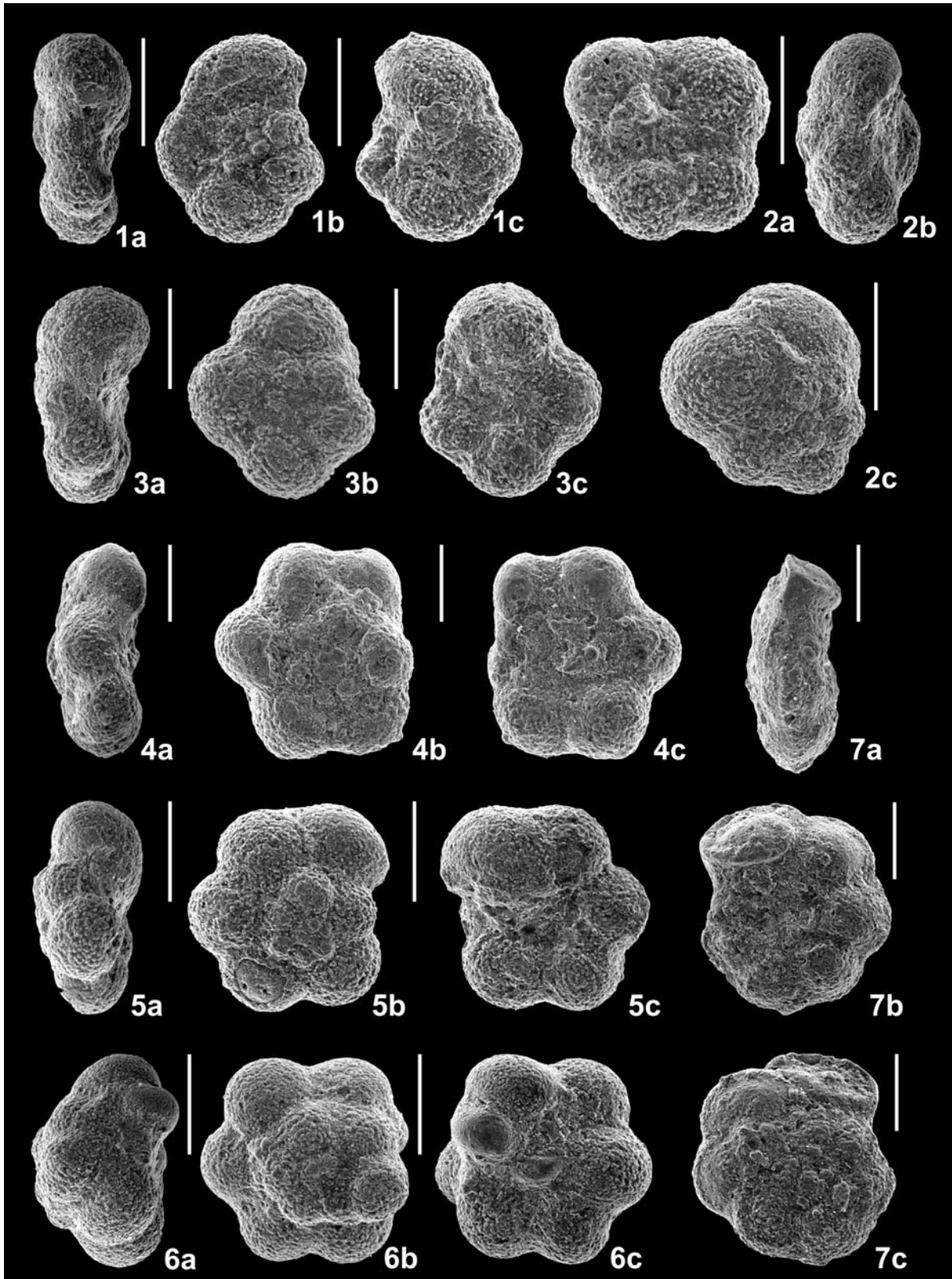


Text-fig. 6. 1a-c – *Dicarinella hagni* (Scheibnerova, 1962), sample Spr-2; 2a-b – *Dicarinella imbricata* (Mornod, 1970), sample Spr-2; 3a-c – *Dicarinella hagni* (Scheibnerova, 1962), sample Spr-2; 4a-c – *Marginotruncana undulata* (Lehmann, 1963), sample Spr-2; 5a-c – *Dicarinella concavata* (Brotzen, 1934), sample Spr-2; 6a-c – *Dicarinella concavata* (Brotzen, 1934), sample Spr-2; 7a-c – ?*Dicarinella concavata* (Brotzen, 1934), sample Spr-2. Scale bar = 200  $\mu$ m



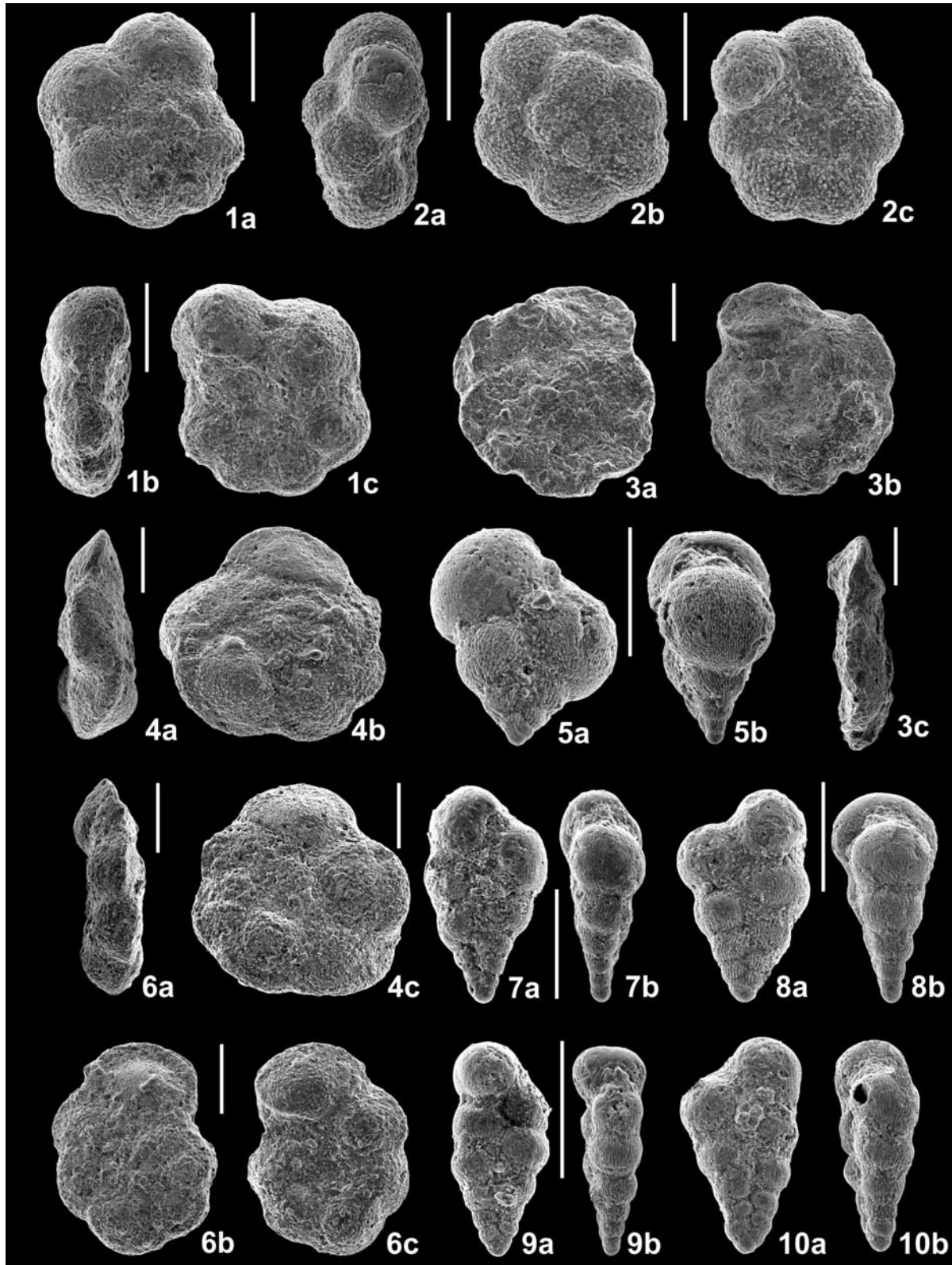


Text-fig. 7. 1a-c – *Falsotruncana maslakovae* Caron, 1981, sample Spr-2; a-c – *Marginotruncana sinuosa* Porthault, 1970, sample Spr-2; 3a-c – *Marginotruncana renzi* (Gandolfi, 1942), sample Spr-2; 4a-c – *Marginotruncana sinuosa* Porthault, 1970, sample Spr-2; 5a-c – *Marginotruncana undulata* (Lehmann, 1963), sample Spr-2; 6a-b – *Marginotruncana sinuosa* Porthault, 1970, sample Spr-2; 7a-c – *Marginotruncana renzi* (Gandolfi, 1942), sample Spr-2. Scale bar = 200  $\mu$ m



Text-fig. 8. 1a-b – *Whiteinella archaeocretacea* Pessagno, 1967, sample Spr-3; 2a-b – *Whiteinella baltica* Douglas and Rankin, 1969, sample Spr-3; 3a-c – *Archaeoglobigerina blowi* Pessagno, 1967, sample Spr-3; 4a-b – *Whiteinella aprica* (Loeblich and Tappan, 1961), sample Spr-3; 5a-c – *Whiteinella brittonensis* (Loeblich and Tappan, 1961), sample Spr-3; 6a-c – *Whiteinella paradubia* (Sigal, 1952), sample Spr-3; 7a-c – *Marginotruncana marginata* (Reuss, 1845), sample Spr1. Scale bar = 200  $\mu$ m





Text-fig. 9. 1a-b – *Archaeoglobigerina cretacea* (d'Orbigny, 1840), sample Spr-3; 2a-b – *Whiteinella brittonensis* (Loeblich and Tappan, 1961), sample Spr5; 3a-c – *Sigalitroncanaa schneegansi* (Sigal, 1952), sample Spr-2; 4a-b – *Praeglobotruncana kalaati* Gonzalez Donoso and Linares, 1990, sample Spr1; 5a-c – *Heterohelix reussi*, sample Spr-3; 6a-c – *Dicarinella* sp., sample Spr1; 7a-c – *Heterohelix globulosa* (Ehrenberg, 1840), sample Spr2; 8a-c. *Heterohelix globulosa* (Ehrenberg, 1848), sample Spr-3; 9a-b – *Heterohelix moremani* (Cushman, 1938), sample Spr1; 10a-b – *Heterohelix moremani* (Cushman, 1938), sample Spr2. Scale bar = 200  $\mu$ m

*carinella. Falsotruncana maslakovae* Caron is recorded only in this level. Whiteinellids and small-sized heterohelicids are minor components of the assemblage.

In the next samples, the assemblages change from those dominated by non-keeled globular (*Whiteinella*) and weakly double-keeled (*Archaeoglobigerina*) forms, to assemblages dominated by double-keeled forms. It is worth noting that in the topmost sample *Dicarinella hagni*, *D. imbricata*, *Dicarinella* sp. and *Dicarinella primitiva* (Dalbiez) are still present.

The interval studied represents the lower part of the *Dicarinella concavata* Zone.

None of the three main planktonic foraminiferal datums that formed the basis of the Sikora *et al.* (2004) correlation of part of the Wagon Mound section with the *Cremonoceras deformis erectus* interval of the Salzgitter-Salder section are supported by the present study (see discussion below).

- (1) The FO of *Archaeoglobigerina blowi*: this is first noted in the middle Fort Hays Member in the Wagon Mound section, in the *Mytiloides scupini* inoceramid bivalve Zone; it also appears in the same zone in the Salzgitter-Salder section, albeit distinctly lower than reported by Sikora *et al.* (2004), i.e., in bed 40 instead of bed 52 (Lower Coniacian).
- (2) The last occurrence (LO) of *Dicarinella hagni*: in contrast to Sikora *et al.* (2004), who reported this datum from the upper Fort Hays Member in the Wagon Mound section, the species is still present together with *C. deformis erectus* in the Springer section.
- (3) The FO of *Dicarinella concavata* at the base of the Smoky Hill Member: the correlation potential of this datum cannot be tested as no convincing specimen of *Dicarinella concavata* is known from the Salzgitter-Salder section.

Besides these three datums, the results of our study call into question some of the other arguments used by Sikora *et al.* (2004) in support of their correlation. Among these are:

- (1) the reported presence of *Hastigerinoides subdigitata* (Carman) in Bed 43 and *Marginotruncana marianosi* (Douglas) in Bed 41 in the Salzgitter-Salder section could not be confirmed;
- (2) *Dicarinella* cf. *primitiva* (Dalbiez), one of the other datums taken by Sikora *et al.* (2004) and claimed to start right at the boundary (bed 45) in the Salzgitter-Salder section, was shown to start markedly lower (Bed 38), still within the *M. scupini* Zone;
- (3) *Whiteinella aprica* (Loeblich and Tappan), which was claimed to have its LO in the middle Smoky Hill Member as exposed in the Wagon Mound section, actually ranges higher and is still present in the Springer section.

## Nannofossils (J. Lees)

The nannofossils in the Springer section (Text-fig. 10) are more poorly-preserved than in the Salzgitter-Salder section, but it was still possible to identify the essential marker, *Broinsonia parca* subsp. *expansa*, which places the base of the Coniacian Stage, as defined by the FO of the inoceramid bivalve *Cremonoceras deformis erectus*, in Nannofossil Subzone UC9c (where it should be, according to Lees 2008).

In contrast to Sikora *et al.* (2004), the nannofossil assemblages in the Salzgitter-Salder section appear to be quite variable and sufficiently well preserved (see Lees 2008) to allow recognition of the critical taxa and establish a reliable biostratigraphy. As shown by Lees (2008), the base of the Coniacian, as defined by the FO of *C. deformis erectus*, falls in UC9c, the base of which is defined by the FO of *B. parca expansa* and its top by the FO of *M. staurophora* (= base Nannofossil Zone UC10). Thus the nannofossils support a correlation between the Salzgitter-Salder and the Springer sections around the Turonian/Coniacian boundary.

## CONCLUSIONS

Summing up, it may be stated that there is no macrofaunal, microfaunal or calcareous nannofossil evidence to support the suggestion by Sikora *et al.* (2004) that the succession exposed in the Wagon Mound section incorporates the base of the Coniacian; it is actually entirely Upper Turonian. Moreover, there is no discrepancy between the macrofaunal and microfossil biostratigraphies of the Wagon Mound section and the *Cremonoceras deformis erectus* interval of the Salzgitter-Salder section, the former is simply stratigraphically older. Both the planktonic foraminiferal and calcareous nannofossil data from the Wagon Mound section are in accord with the inoceramid bivalve data and show that the base of the Coniacian is located higher in the succession, as can be demonstrated in the nearby Springer section. The erroneous biostratigraphic ages and correlations of Sikora *et al.* (2004) result from mistaking partial ranges of the marker-taxa for actual ranges and then basing a comparison of the two sections upon these. As a result, all of their reservations concerning the stratigraphic potential of the macrofauna can be rejected. Consequently, their whole subsequent discussion of the apparent discrepancy between the macrofaunal and microfossil biostratigraphy, as well as the diachroneity of the basal boundary biomarker, *C. deformis erectus*, has no factual basis.





Fossil	AGE-DIAGNOSTIC NANNOFOSSIL EVENTS										NANNOFOSSIL ZONE	STAGE
	after Lees (2008)											
												Turonian/ Coniacian boundary interval
<i>Micula adumbrata?</i>												
<i>Placozygus fibuliformis</i>												
<i>Prediscosphaera columnata</i>												
<i>Prediscosphaera cretacea</i>												
<i>Prediscosphaera ponticula</i>												
<i>Radioithus planus</i>												
<i>Reinhardtites anthophorus</i>												
<i>Retecapsa angustiflorata</i>												
<i>Retecapsa crenulata</i>												
<i>Retecapsa surrella</i>												
<i>Staurolithes crux</i>												
<i>Staurolithes cf. S. dortii</i>												
<i>Staurolithes ellipticus</i>												
<i>Staurolithes halifanii</i>												
<i>Staurolithes laffitei</i>												
<i>Tranolithus minimus</i>												
<i>Tranolithus orionatus</i>												
<i>Watznaueria barnesiae</i>												
<i>Watznaueria diaphanae</i>												
<i>Watznaueria fossacincta</i>												
<i>Watznaueria manivillae</i> s.l.												
<i>Zeugrhabdotus birescens</i>												
<i>Zeugrhabdotus biperforatus</i>												
<i>Zeugrhabdotus cf. Z. diplogrammus</i>												
<i>Zeugrhabdotus diplogrammus</i>												
<i>Zeugrhabdotus noelliae</i>												
<i>Zeugrhabdotus scutula</i>												
<i>Zeugrhabdotus trivectis</i>												

Text-fig. 10b. Nannofossil distribution and zonation of the Turonian/Coniacian boundary interval of the Springer section



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