

## PRACTICAL APPLICABILITY OF A ZONATION WITH BENTHONIC FORAMINIFERA IN THE WORLDWIDE LOWER CRETACEOUS

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### SUMMARY

Presentation of a new zonation chart with benthonic foraminifera, valid for the worldwide Lower Cretaceous, Berriasian to Albian, in the temperate and tethyan facies realms. Divisions, sections and zones comprise 22 foraminifera columns with 36 species of different stratigraphic value.

### INTRODUCTION

With the publication of Bettenstaedt and Wicher (1955) for the first time — as far as we know — a possible worldwide correlation in the marine Lower and Upper Cretaceous, based on foraminifera had been presented for discussion. So far the interest had been focussed mainly on the Upper Cretaceous and especially on its planktonic foraminifera about which rather much was known.

For the Lower Cretaceous, however, and especially for its benthonic foraminifera, apart from Germany and some neighbouring countries, a worldwide applicable stratigraphy remained out of consideration. Only seven years later with the publication of Bartenstein and Bettenstaedt (1962) a worldwide correlation of the Lower Cretaceous (with the exception of the Berriasian) was proposed in which the northern temperate (boreal) and the tethyan (mediterranean) facies realms were combined. Of the 76 species of benthonic foraminifera described (the total number of index fossils being 92) at least 49 species occurred both in the boreal and the tethyan realms. This proves already the importance of these foraminifera for the Lower Cretaceous. In Bettenstaedt and Wicher (1955) only 25 benthonic foraminifera species were indicated as index fossils, but in Bartenstein, Bettenstaedt and Bolli (1957) already 39.

The newly added abundance of worldwide data also enabled to present at the same time an exact stratigraphy for the temperate and the tethyan facies realms which had to be modified only slightly in later publications (Bartenstein, Bettenstaedt and Bolli 1966; Bartenstein, Bettenstaedt and Kovatcheva 1971;

Bartenstein 1974 and 1976) essentially just a complementation by new observations from previously unknown occurrences.

As the exploration for oil and gas has to put great weight on the exact age determination in the stratigraphic interpretation of its deep wells — in this case interpretation of the marine Lower Cretaceous — it appears desirable to present this now valid zonation model for the man in the field. At this time it represents only a somewhat simplified working model for practical purposes, but it is our intention to enlarge, complement and thus improve it at a later date.

### WORLDWIDE ZONATION WITH BENTHONIC FORAMINIFERA

In the zonation chart (fig. 1) 22 foraminifera columns are presented, comprising in parts several species. Three groups of columns, differing in their stratigraphic importance, are separated as

*Divisions* for a general vertical division in more than 2 stages,

*Sections* for a less general vertical division with 1.5-2 stages,

*Zones* for a relatively fine vertical division in less than 1.5 stages.

The different time span of the species offers the possibility for a quick orientation and stratigraphic fixation in the Lower Cretaceous; the co-existence of some species enables an additional subdivision of the geological stages.

All used species have been checked on their worldwide distribution within the Lower Cretaceous and could be proved to occur *at the same time* in the northern temperate and in the tethyan realms. Only in the southern temperate realm samples and data are often insufficient, thus enabling a correlation and worldwide comparison in the Upper Valanginian to Lower Hauterivian, Upper Hauterivian and Barremian (pars), and Lower Aptian, until now only sporadically and locally (Aubert and Bartenstein 1976, in preparation).

With the partition in divisions, sections and zones, as presented here, it is striking at once, that in the higher Lower Cretaceous, from Barremian upwards, relatively short time

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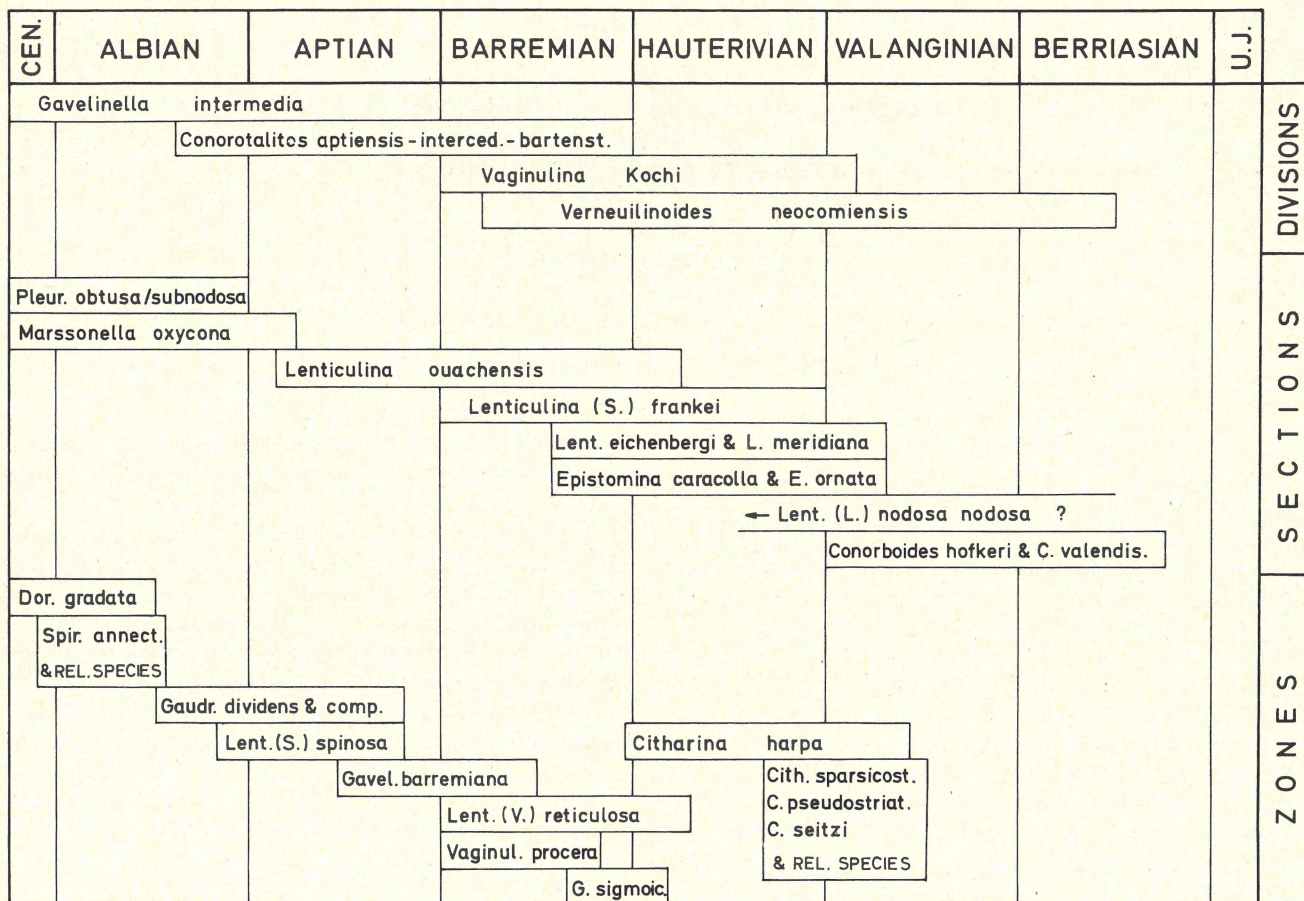


Fig. 1  
Range of selected benthonic index foraminifera in the worldwide Lower Cretaceous.  
Rel. Species = Related Species.

Concerning the abbreviations of genus and/or species names (Pleur., C. valendis., etc.) see the full words in the systematic catalogue.

spans of benthonic foraminifera are available in sufficient numbers. Further species groups are available any time, if an even more intensive concentration of index foraminifera is desired.

For the deeper Lower Cretaceous, from Hauterivian downwards, this is not so: short lived and well determinable species, in addition occurring in the temperate and the tethyan realms, are relatively rare. They become rarer towards Lower Valanginian and Berriasian respectively, where genuine worldwide index foraminifera are lacking so far. The reason for this rests partly in a lack of well differentiable species in this stratigraphic unit, partly in the often not yet clarified separation of (Lower) Valanginian and Berriasian and in their much rarer outcrops in comparison with the younger Lower Cretaceous. To close this lack of knowledge between Upper Jurassic and Lower Cretaceous, should be an urgent aim of the paleontology.

## SYSTEMATIC CATALOGUE

All index foraminifera represent well known species. Therefore only a single taxonomic list is given with one or several references. (Sequence of the species according to the divisions, sections, and zones)

*Gavelinella intermedia* (BERTHELIN 1880). – Reference: Michael 1966, Senck. lethaea, 47, 432, pl.50, figs. 4-13.

*Conorotalites aptiensis* (BETTENSTAEDT 1952). – Reference: Bartenstein, Bettenstaedt & Bolli 1966, Eclogae geol. Helv., 59/1, 162, pl.4, figs. 357-359.

*Conorotalites intercedens* (BETTENSTAEDT 1952). – Reference: Bartenstein, Bettenstaedt & Kovatcheva 1971, N.Jb. Geol. Paläont. Abh., 139/2, 142, pl.3, figs. 41-46.

*Conorotalites bartensteini* (BETTENSTAEDT 1952). – Reference: Michael 1967, Palaeontographica, suppl. 12, 80, pl.11, figs. 16-17.

*Vaginulina kochi* ROEMER 1841. – Reference: Bartenstein, Bettenstaedt & Kovatcheva 1971, N.Jb. Geol. Paläont. Abh., 139/2, 140, pl.2, fig. 31.

- Verneuilinoides neocomiensis* (MJATLIUK 1939). — Reference: Michael 1967, *Palaeontographica*, suppl. 12, 28, pl.2, fig. 18.
- Pleurostomella obtusa* BERTHELIN 1880. — Reference: Bartenstein & Bettenstaedt 1962, *Leitfoss. Mikropaläont.*, B7, 290, table 18, pl.36, fig. 19. — Other authors prefer the following species name: *Pleurostomella subnodosa* REUSS 1860. — Reference: Moullade 1966, *Doc. Lab. Géol. Fac. Sci. Lyon*, 15, 63, pl.6, figs. 9-12.
- Marssonella oxycona* (REUSS 1860). — Reference: Bartenstein & Bolli 1973, *Eclogae geol. Helv.*, 66/2, 396, pl.2, fig. 62.
- Lenticulina* (*L.*) *ouachensis* (SIGAL 1952). — Reference: Bartenstein & Bettenstaedt 1962, *Leitfoss. Mikropaläont.*, B7, 270, table 18, pl.38, fig. 15.
- Lenticulina* (*S.*) *frankei* DAM 1946. — Reference: Michael 1967, *Palaeontographica*, suppl. 12, 40, pl. 4, figs. 5,7.
- Lenticulina* (*L.*) *eichenbergi* BARTENSTEIN & BRAND 1951. — Reference: Bartenstein & Kaefer 1973, *Senck. lethaea*, 54/2-4, 222, pl.2, figs. 15-18. — *L. (L.) eichenbergi* is the boreal facies equivalent to *L. (L.) meridiana* in the tethyan facies realm. Both species have the same stratigraphic distribution.
- Lenticulina* (*L.*) *meridiana* BARTENSTEIN, BETTENSTAEDT & KOVATCHEVA 1971, *N.Jb. Geol. Paläont. Abh.*, 139/2, 133, pl.1, figs. 15-21 and others. — Tethyan facies form with *L. (L.) eichenbergi* as boreal facies equivalent.
- Epistomina caracolla* (ROEMER 1841). — Reference: Bartenstein, Bettenstaedt & Kovatcheva 1971, *N.Jb. Geol. Paläont. Abh.*, 139/2, 137, pl.2, fig. 28.
- Epistomina ornata* (ROEMER 1841). — Reference: Bartenstein, Bettenstaedt & Kovatcheva 1971, *N.Jb. Geol. Paläont. Abh.*, 139/2, 138, pl. 2, fig. 29. — *Epistomina caracolla* and *E. ornata* have the same stratigraphic distribution.
- Lenticulina* (*L.*) *nodosa nodosa* (REUSS 1863). — Reference: Bartenstein 1974, *Eclogae geol. Helv.*, 67/3, 539. — Aubert & Bartenstein 1976, *Bull. Centre Rech. Pau-SNPA 10* (in preparation). — Joint occurrences of *L. (L.) nodosa nodosa* in the north temperate, the tethyan and the south temperate facies realm until now have been established only in the Upper Berriasian through Lower Hauterivian.
- Conorboides hofkeri* (BARTENSTEIN & BRAND 1951). — Reference: Dieni & Massari 1966, *Palaeontogr. ital.*, 61 (n.s.31) 176, pl. 8, fig. 22.
- Conorboides valendisensis* (BARTENSTEIN & BRAND 1951). — Reference: Bartenstein & Bettenstaedt 1962, *Leitfoss. Mikropaläont.*, B7, 253, table 17, pl. 35, fig. 5. — Jenkins et al. 1974, *Geol. Surv. Canada*, pap. 74-61, 12.
- Dorothia gradata* (BERTHELIN 1880). — Reference: Bartenstein & Bettenstaedt 1962, *Leitfoss. Mikropaläont.*, B7 296, table 18, p. 39, fig. 11.
- Spiroplectinata annectens* (PARKER & JONES 1863) and related species: *Spiroplectinata lata* GRABERT 1959; *Spiroplectinata complanata* (REUSS 1860). — Reference: Grabert 1959, *Abh. senck. natf. Ges.*, 498, 12-16. — Bartenstein & Bettenstaedt 1962, *Leitfoss. Mikropaläont.*, B7 291-294, fig. 23.
- Gaudryina dividens* GRABERT 1959 and *Gaudryina compacta* GRABERT 1959. — Reference: Grabert 1959, *Abh. Senck. natf. Ges.*, 498, 9-11. — Bartenstein, Bettenstaedt & Bolli 1966, *Eclogae geol. Helv.*, 59/1, 141, pl.1, figs. 56-57. — *Gaudryina compacta* is the mediterranean equivalent of *G. dividens* which has been reported from the boreal and the tethyan facies realms.
- Lenticulina* (*S.*) *spinos* (EICHENBERG 1935). — Reference: Bartenstein, Bettenstaedt & Bolli 1966, *Eclogae geol. Helv.*, 59/1, 151, pl. 3, figs. 238-242, 256-259.
- Gavelinella barremiana* BETTENSTAEDT 1952. — Reference: Bartenstein, Bettenstaedt & Kovatcheva 1971, *N.Jb. Geol. Paläont. Abh.*, 139/2, 142, pl. 2, figs. 35-40.
- Lenticulina* (*V.*) *reticulosa* (DAM 1946). — Reference: Bartenstein & Kaefer 1973, *Senck. lethaea*, 54/2-4, 225, pl. 2, figs. 32-33.
- Vaginulina procera* ALBERS 1952. — Reference: Michael 1967, *Palaeontographica*, suppl. 12, 54, pl. 5, fig. 19 (non 20); pl. 14, figs. 2-5, 11, 18.
- Gavelinella signoicosta* (DAM 1948). — Reference: Bartenstein & Bettenstaedt 1962, *Leitfoss. Mikropaläont.*, B7, table 18, pl. 37, fig. 6; pl. 38, fig. 12.
- Citharina harpa* (ROEMER 1841). — Reference: Michael 1967, *Palaeontographica*, suppl. 12, 48, pl. 7, fig. 8; pl. 8, fig. 3.
- Citharina sparsicostata* (REUSS 1863). — Reference: Bartenstein & Bettenstaedt 1962, *Leitfoss. Mikropaläont.*, B7, 263, table 17, pl. 35, fig. 16.
- Citharina pseudostriatula* BARTENSTEIN & BRAND 1951, *Abh. senck. natf. Ges.*, 485, 298, pl. 7, fig. 182; pl. 12A, fig. 339.
- Citharina seitzi* BARTENSTEIN & BRAND 1951. — Reference: Bartenstein & Bettenstaedt 1962, *Leitfoss. Mikropaläont.*, B7, 261, table 18, pl. 35, fig. 15.
- Species related to Citharina sparsicostata, C. pseudostriatula and C. seitzi: Citharina cristellarioides* (REUSS 1863). Reference: Bartenstein & Brand 1951, *Abh. senck. natf. Ges.*, 485, 298, pl. 7, figs. 177-179. — *Citharina striatula* (ROEMER 1842). Reference: Bartenstein 1956, *Senck. lethaea*, 37/5-6, 518, pl. 2, figs. 26, 28. — *Citharina laffittei* MARIE 1938, *Bull. Soc. géol. France* (5) 8, 98, pl. 8, fig. 7. This species, described from the Albian in France by Marie, may also be an index foraminifer for the worldwide Upper Valanginian to Lower Hauterivian by various authors. — *Citharina orthonota* (REUSS 1863). Reference: Bartenstein & Brand 1951, *Abh. senck. natf. Ges.*, 485, 298, pl. 7, figs. 180-181.

The proposed stratigraphic chart in this first model comprises now

4 division columns with altogether 6 index foraminifer species

8 section columns with altogether 11 index foraminifer species

10 zone columns with altogether 19 index foraminifer species.

The number of zones, as mentioned previously, should be much more detailed yet for the the deeper Lower Cretaceous. Only then the screen of stratigraphic determination would be sufficiently tight and useful. Nevertheless this chart of benthonic index foraminifera only represents a relatively subjective selection of important species, although easily to be proved in cuttings and cores.

This stratigraphic chart can and will find a decisive completion in a similar one of *index ostracodes*, as they have been reported lately for the Lower Cretaceous of E Canada, Berriasian to Albian, by Jenkins et al. (1974) and for parts of the Lower Cretaceous. Hauterivian to Aptian, of the North Sea and of Heligoland by Bartenstein and Oertli (1975). Only the combination of the two microfossil groups guarantees a good worldwide correlation in the marine Lower Cretaceous.

On account of new experiences a list just as the one presented here, has all the time to be kept up to date for the petroleum geology, because, besides the onshore oil exploration, the offshore drilling activity for Mesozoic deposits in the shelf areas and along the continental borders gains even more in importance. Here also the Lower Cretaceous with potential reservoirs represents within the current stresses of petroleum exploration a focus of interest. A connection of

the marine Lower Cretaceous within the northern transition zone of the tethyan and the north temperate facies realm between E Canada via Europe to the Caucasus over a distance of approximately 9000 km has become known so far. The improvement of our knowledge in the mediterranean and in the tethyan facies realms, finally in the southern hemisphere and the respective south temperate facies realm by the activities in the shelf areas of the South Continents and in the oceans, also within the frame of the Deep Sea Drilling Project, adds decisively to the completion of the facies picture of the worldwide Lower Cretaceous.

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