Lenticulina (Lenticulina) nodosa (Reuss 1863) and its subspecies : worldwide index foraminifera in the Lower Cretaceous

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Lenticulina (*Lenticulina*) *nodosa* (REUSS 1863) and its subspecies – worldwide index foraminifera in the Lower Cretaceous

By HELMUT BARTENSTEIN[1])

SUMMARY

The worldwide occurrences of *Lenticulina* (*Lenticulina*) *nodosa* (REUSS 1863) and its subspecies within the northern Temperate Realm (Boreal), the Tethyan and the southern Temperate Realm (Antiboreal) are described. A further argument for the validity of Alfred Wegener's continental drift theory for the connection of South Africa and the southern part of South America during earlier Lower Cretaceous is submitted. Nomination of a neotype for *Lenticulina* (*Lenticulina*) *nodosa* and a new subspecies *Lenticulina* (*Lenticulina*) *nodosa hilseana* are made.

A survey is made of the occurrences in Germany of the species *Lenticulina* (*Astacolus*) *humilis* (REUSS 1863), its subspecies and of *Lenticulina* (*Astacolus*) *neopachynota* BARTENSTEIN & KAEVER 1973, closely related to *Lenticulina* (*Lenticulina*) *nodosa*. Nomination of a neotype for *Lenticulina* (*Astacolus*) *humilis*.

The importance of all the above mentioned species and subspecies in the Lower Cretaceous stratigraphic sequences of Germany and the world are discussed.

In the English Upper Albian *Lenticulina* (*Lenticulina*) *angulosa* (CHAPMAN 1896) has been determined as an independent species.

ZUSAMMENFASSUNG

Beschreibung der weltweiten Vorkommen von *Lenticulina* (*Lenticulina*) *nodosa* (REUSS 1863) und ihrer Unterarten innerhalb der nördlichen Gemässigten Zone (Boreal), der Tethys und der südlichen Gemässigten Zone (Antiboreal). Anführung eines weiteren Belegs zur Gültigkeit von Alfred Wegeners Kontinentalverschiebungstheorie für die Verbindung von Südafrika und der Südspitze Südamerikas in der tieferen Unterkreide. Aufstellung eines Neotypus für *Lenticulina* (*Lenticulina*) *nodosa* und einer neuen Unterart *Lenticulina* (*Lenticulina*) *nodosa hilseana*.

Übersicht über die deutschen Vorkommen der mit *Lenticulina* (*Lenticulina*) *nodosa* nahe verwandten Arten von *Lenticulina* (*Astacolus*) *humilis* (REUSS 1863), ihrer Unterarten wie von *Lenticulina* (*Astacolus*) *neopachynota* BARTENSTEIN & KAEVER 1973. Aufstellung eines Neotypus für *Lenticulina* (*Astacolus*) *humilis*.

Diskussion der Bedeutung sämtlicher aufgeführten Arten und Unterarten für die stratigraphische Gliederung der deutschen und der weltweiten Unterkreide.

Im englischen Ober-Alb wurde *Lenticulina* (*Lenticulina*) *angulosa* (CHAPMAN 1896) als selbständige Art herausgestellt.

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CONTENTS

Introduction

Within the framework of modern microfaunal analyses for the stratigraphical differentiation of sedimentary sequences of a certain area, it has become more and more the rule to publish lists of foraminifera as long as possible, to give pictures of extensive foraminiferal associations and describe them taxionomically, even though only a very few index foraminifera have been used to determine the sequence.

It is no difference in the Lower Cretaceous. In addition there are the boundaries of the biogeoprovinces between the Boreal Sea of the Northern Hemisphere, the dividing Tethys and the Antiboreal Sea[2]) of the Southern Hemisphere. Paleogeographically and paleoecologically these boundaries have been discussed for a long time and are relatively easy to map and to describe.

Such investigations, understandably, are far more convenient than systematic investigations, which suppose much scientific exactness, for example in order to fix geographically and stratigraphically a species or subspecies of worldwide distribution. It is intended to do exactly this in this paper with one species, *L.* (*L.*) *nodosa* (REUSS 1863)[3]) and its variations in the Lower Cretaceous occurrences throughout the world. Perhaps this publication will provide a stimulous for future work which would certainly be of value for specialists working on the Lower Cretaceous.

Systematic descriptions

The material shown in the figures is available at the "Naturhistorisches Museum, Basel" under the code numbers C 30169–C 30214. The code numbers are to be found in the description of the plates.

Lenticulina (*Lenticulina*) *nodosa* (REUSS 1863)

Pl. I, Fig. 1–2; Textfig. 6

*1863 *R. nodosa* m. – REUSS, Hils u. Gault: 78; Tf. 9, Fig. 6.

Neotype: Specimen Pl. I, Fig. 1. – Basal Lower Hauterivian, so-called "Hilskonglomerat", former quarry N.W. Berklingen (Asse), topographic sheet Schöppenstedt No. 3830, Gauss-Krüger coordinates R: 4413080, H: 5777760. Length: 0.5 mm, width: 0.41 mm, thickness: 0.25 mm, number of chambers: 11.

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[2]) Boreal Sea–Antiboreal Sea in relation to the present division of the land and sea areas around the North and South Pole: Arctic–Antarctic.

[3]) In repetitions of *Lenticulina* and *Astacolus* in the text we shorten the full genus resp. subgenus name to the first letter.

Further material from the type locality: Specimen Pl. I, Fig. 2. Length: 0.6 mm, width: 0.45 mm, number of chambers: 10.

Most important features of the test: Nearly orbicular, laterally compressed, with distinct knot-like thickenings of the ledges on the keel edge. Umbilicus slightly extruding.

Remarks: None of REUSS's documented material from the "norddeutscher Hils und Gault" 1863 is preserved (BARTENSTEIN & BRAND 1951: 264). Also, the stratigraphical horizon and locations mentioned in his publication are in many cases uncertain, even if they can be located today geographically relatively exactly. This is because REUSS did not collect his German material himself, but obtained it from various sources and with imprecise stratigraphic control (REUSS 1863: 6, 7, 9, 15).

Nowadays our modern detailed stratigraphy and well documented micropaleontology of the N.W. German Lower Cretaceous (BARTENSTEIN & BRAND 1951, BARTENSTEIN & BETTENSTAEDT 1962, BARTENSTEIN & KAEVER 1973, BETTENSTAEDT 1952, GRABERT 1959, ZEDLER 1961) enables us to eliminate such mistakes. For example it is understandable that a grave stratigraphic mistake which was made in the ease of *Hechtina antiqua* (REUSS 1863:35), pointed out in BARTENSTEIN & BRAND (1949: 670), no longer represents a stratigraphic problem: this important index form of the Hauterivian to Barremian was put by REUSS and by the people who supplied him with the material additionally in the Dogger (*coronatum* beds = Bajocian) although we now know it appears for the first time in the Hauterivian!

The only specimen of *L.* (*L.*) *nodosa* according to REUSS (1863: 78) comes from the "oberer Hilsthon" N.W. Berklingen [*non* Bercklingen in REUSS (1863: 9) and others] which approximately corresponds with the uppermost Hauterivian to Barremian. This outcrop is also an important type locality of F.A. ROEMER (see also BARTENSTEIN 1966: 596–597) which today, however, appears only as an old and mostly filled trash deposit pit[4]), which the last time it was excavated (MICHAEL & PAPE 1971: 53) showed a profile 3.1 m thick within the so-called "Hilskonglomerat" (= basal Lower Hauterivian).[5])

A further outcrop at E. Berklingen, the so-called "Tackwelle"[6]) contained according to REUSS 1863: 9 layers of the "mittlerer Hils" which should be more or less equivalent to the Hauterivian though its exact top and bottom limits can not be determined.

We are therefore confronted with the insoluble problem of finding *L.* (*L.*) *nodosa* in the "oberer Hilsthon", which is approximately equivalent to Uppermost Hauterivian to Lower Barremian (the position of the boundary between the Upper and Middle

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[4]) Today, in the age when ecological polution is being concentrated on, it may sound like bitter irony to a geologist, to say that the simplest method of easily finding clay pits (especially in the Liassic and the Lower Cretaceous) and limestone quarries (especially Malm) in the N.W. German Mittelgebirge (area between Celle–Braunschweig–Harz Mountains in the East and Minden–Bielefeld in the West as proven example) is by using an official map of licensed trash dumping pits! Not one known original occurrence remains and no "geological Monument" is exempted from this, unless the pit is too small or its location is too remote for it to be filled economically!

[5]) Exact location: Topographic sheet Schöppenstedt No. 3830, Gauss-Krüger coordinates R: 4413080, H: 5777760 (= center of the pit).

[6]) Exact location: Topographic sheet Schöppenstedt No. 3830, Gauss-Krüger coordinates R: 4415000, H: 5777360 (= center of the field), that means 1600 m E. of the center of the village of Berklingen.

Barremian can not be determined exactly), which today no longer outcrops in Berklingen and perhaps was *never visible*. Furthermore the relatively small shell (maximum diameter 0.3 mm), described and pictured by REUSS 1863, corresponds to forms from the sequence Middle Valanginian[7]) to Lower Hauterivian, but not from the Middle Barremian as illustrated by MICHAEL 1967.

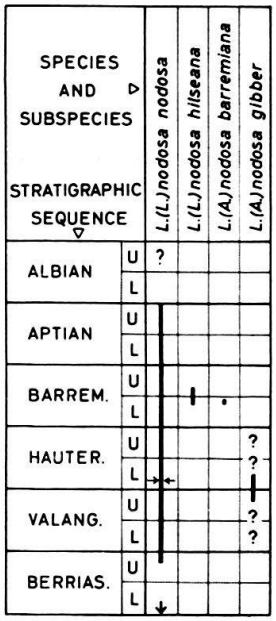


Fig. 1. Stratigraphic distribution of *Lenticulina* (*Lenticulina*) *nodosa* (REUSS 1863) and its subspecies.
The formations are only divided in two, in a lower and an upper part, according to international use. For Germany this means that a middle stage has to be inverted between "Lower" and "Upper" in Valanginian, Barremian, and Albian.
Horizontal arrows = Type formation of *L.* (*L.*) *nodosa* (REUSS 1863). Vertical arrow = Pre-Berriasian occurrence in Somalia. ? = Occurrence not certain.

We therefore select the Neotype from the clayish-marly intervals of the "Hilskonglomerat" at the type locality of Berklingen and from material for which we thank Prof. E. Michael. This is the same type locality and the same type horizon as for *L.* (*A.*) *humilis* (REUSS 1863).

Occurrence: N.W. Germany, Middle Valanginian to Lower Hauterivian.

Lenticulina (*Lenticulina*) *nodosa nodosa* (REUSS 1863)

Pl. I, Fig. 3–17; Pl. II, Fig. 5–6, 9–12, 16–17; Textfig. 1–7

Derivation of name, holotype, type locality and type horizon as above-mentioned by *L.* (*L.*) *nodosa* (REUSS).

1896 *Cristellaria nodosa* REUSS sp.? – CHAPMAN, Folkestone *VIII*: 4; Pl. 1, Fig. 5 (? BARTENSTEIN).
1896 *Cristellaria secans* REUSS var. *angulosa* nov. – CHAPMAN, Folkestone *VIII*: 3; Pl. 1, Fig. 4.
v· 1938 *Cristellaria* D 92 – HECHT, Unterkreide: Tf. 18 b, Fig. 17; Tf. 20 a, Fig. 45–54; Tf. 20 b, Fig. 43–47; Tf. 21, Fig. 27.
v· 1949 *Lenticulina* aff. *nodosa* (REUSS) – BRAND, Dogger u. Valendis: 345; Abb. 4.
· 1950 *Lenticulina pilicensis* n.sp. – LISZKA, Crétacé inf.: 187; Pl. 5, Fig. 1–3.
v· 1951 *Lenticulina nodosa* (REUSS) – BARTENSTEIN & BRAND, Valendis: 281; Tf. 4, Fig. 103.
v· 1952 *Lenticulina nodosa* (REUSS) – BARTENSTEIN, Hauterive-Nomenklator: 177, 179, 180.
v· 1954 *Lenticulina nodosa* – BARTENSTEIN & BURRI, schweiz. Faltenjura: Tf. 28.
· 1957 *Lenticulina nodosa* (REUSS) – SZTEJN, Low. Cretac.: 38, 215; Pl. 4, Fig. 24.
v· 1957 *Lenticulina* (*Lenticulina*) *nodosa* (REUSS) – BARTENSTEIN, BETTENSTAEDT & BOLLI, Trinidad 1: 24; Tf. 3, Fig. 49; Tf. 4, Fig. 66–67.

[7]) In the area of the type locality of Berklingen, no Valanginian is developed or preserved. The transgression of the Lower Cretaceous upon the Jurassic begins here with the Lower Hauterivian.

· 1958 *Lenticulina nodosa* (REUSS) – POZARYSKI, BIELECKA & SZTEJN, Radom: 161; Table 2.
· 1958 *Lenticulina nodosa* (REUSS) – SZTEJN, Low. Cretac.: 21: Fig. 38.
· 1960 *Lenticulina nodosa* – GRADER, REISS & KLUG, Low. Cretac.: Fig. 3–4.
· 1960 *Lenticulina nodosa* (REUSS) – SZTEJN, Low. Cretac.: 969; Table 1.
v· 1962 *Lenticulina* (*Lenticulina*) *nodosa* (REUSS) – BARTENSTEIN & BETTENSTAEDT, Boreal u. Tethys: 256; Tab. 17; Tf. 35, Fig. 10.
· 1962 *Lenticulina nodosa* REUSS – FLANDRIN, MOULLADE & PORTHAULT, Crét. inf.: 218; Pl. 2, Fig. 10.
· 1962 *Lenticulina nodosa* (REUSS) – KHAN, Low. Cretac.: 388.
· 1963 *Lenticulina nodosa* (REUSS) – SIGAL, Crét. inf.: 294.
· 1963 *Lenticulina* cf. *pilicensis* LISZKA – ESPITALIÉ & SIGAL, Majunga: 36; Pl. 13, Fig. 1–2.
· 1963 *Lenticulina* cf. *secans* var. *angulosa* CHAPMAN? – ESPITALIÉ & SIGAL, Majunga: 36; Pl. 13, Fig. 3 (?BARTENSTEIN).
· 1963 *Lenticulina* sp. – ESPITALIÉ & SIGAL, Majunga: 40; Pl. 17, Fig. 1.
· 1963 *Lenticulina nodosa* (REUSS) – GEROCH & NOWAK, Low. Cretac.: 247.
1963 *Lenticulina* (*Lenticulina*) aff. *nodosa* (REUSS)? – KEMPER, Rheine-Ahaus: 473 (? BARTENSTEIN).
· 1964 *Lenticulina nodosa* (REUSS) – SZTEJN, Low. Cretac.: Table 1.
· 1965 *Lent.* (*Lent.*) *nodosa* (REUSS) – BACH, Unterkreide: Tab. 2.
v· 1965 *L.* (*L.*) *nodosa* (REUSS) – BARTENSTEIN, Alb-Nomenklator: 357.
· 1965 *Lenticulina nodosa* (REUSS) – HAEFELI et al., Valang. u. Haut.: 54, 72.
· 1965 *Lenticulina nodosa* (REUSS) – SIGAL, Crét. inf.: Table.
· 1966 *Lenticulina* (*Lenticulina*) *nodosa* (REUSS) – DIENI & MASSARI, Valang. sup.: 118; Pl. 3, Fig. 14–15.
· 1966 *Lenticulina nodosa* (REUSS) – MOULLADE, Crét. inf.: 51; Pl. 4, Fig. 9–12.
v· 1967 *Lenticulina* (*Lenticulina*) *nodosa* (REUSS) – BETTENSTAEDT, Süd Moçambique: 296.
· 1967 *Lenticulina nodosa* (REUSS) – GEROCH, Silesian Series: 373, 375.
· 1967 *Lenticulina* (*Lenticulina*) *nodosa* (REUSS) – SZTEJN, Low. Cretac.: Fig. 12.
v· 1967 *Lenticulina* (*Lenticulina*) *nodosa* (REUSS) – MICHAEL, Barrême I: 34.
v· 1968 *Lenticulina nodosa* (REUSS) – KOVATCHEVA, Barr. and Aptian: Table 1.
· 1968 *Lenticulina* (*Lenticulina*) *nodosa* (REUSS) – SZTEJN, Low. Cretac.: Table 4–5.
· 1968 *Lenticulina* (*L.*) *nodosa* (REUSS) – MICHAEL, Barremian: 297.
· 1969 *Robulus nodosus nodosus* (REUSS) – ANTONOVA, Kaukasus: 44; Pl. 5, Fig. 4 [see chapter 4].
1969 *Robulus nodosus posterioris* subsp. nov. – ANTONOVA, Kaukasus: 45; Pl. 5, Fig. 5–6 [see chapter 4].
· 1969 *Lenticulina nodosa* (REUSS) – KALANTARI, N.E. Iran: 147; Pl. 12, Fig. 3–7.
v· 1969 *Lenticulina nodosa* – KOVATCHEVA, Urgonian: Fig. 2–4.
· 1969 *Lenticulina nodosa* (REUSS) – SZTEJN, Valang.: 60, 61; Fig. 3–4.
v· 1970 *L.* (*L.*) *nodosa* – BARTENSTEIN & KOVATCHEVA, Barrême: Fig. 2.
· 1970 *Lenticulina nodosa* (REUSS) – NEAGU, Aptian: 155; Textfig. 1 (16–17).
· 1970 *Lenticulina nodosa* (REUSS) – NEAGU, Upp. Cretac.: 51; Pl. 10, Fig. 21–22.
· 1970 *Lenticulina roemeri* (REUSS) – NEAGU, Upp. Cretac.: 52; Pl. 11, Fig. 1, 5 [*non* Fig. 2]. [The same locality like *Lenticulina nodosa* by NEAGU 1970*b*: 51!].
v· 1971 *Lenticulina* (*Lenticulina*) *nodosa* (REUSS) – BARTENSTEIN, BETTENSTAEDT & KOVATCHEVA, bulg. Barrême: 141; Abb. 2, Fig. 33.
· 1971 *Lenticulina* (*Lenticulina*) *nodosa* (REUSS) – FUCHS, tief. Mittel-Barrême: 21; Tf. 5, Fig. 9.
v· 1971 *Lent. nodosa* – MICHAEL & PAPE, Unt.-Hauterivium: 62.
· 1971 *Lenticulina nodosa* (REUSS) – RISCH, höh. Unterkreide: 40.
1971 *Lenticulina nodosa* (REUSS) – DOUGLAS, Leg. 6: 1035.
· 1972 *Lenticulina nodosa* (REUSS) – NEAGU, Eo-Cretaceous: 204; Pl. 5, Fig. 1–6.
· 1972 *Lenticulina* (*Lenticulina*) *nodosa* (REUSS) – BRIEGEL, Alviergruppe: 443, 444, 447, 448.
v· 1973 *Lenticulina* (*Lenticulina*) *nodosa* (REUSS) – BARTENSTEIN & KAEVER, Helgoland: 234; Abb. 5.
· 1973 *Lenticulina nodosa* (REUSS) – MALUMIAN & MASIUK, Argentina: 437.
· 1973 *Lenticulina* (*L.*) *nodosa* (REUSS) – FLETCHER, Speeton Clay: 165; Fig. 2.

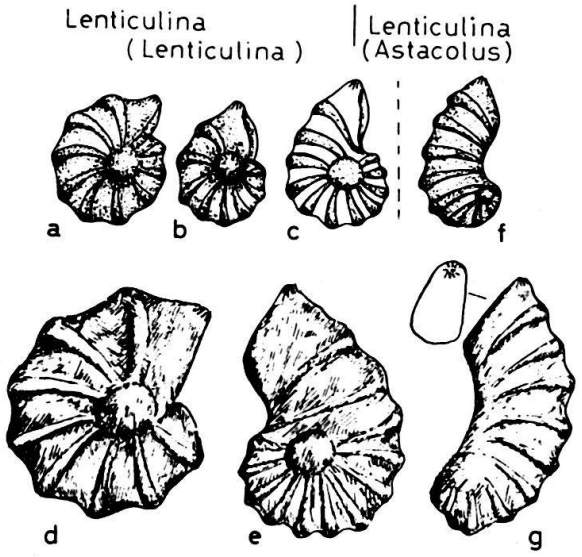


Fig. 2. Variability of tests of *Lenticulina* (*Lenticulina*) *nodosa* (REUSS 1863) and its subspecies.
a, b, d: Involute stages of *Lenticulina*.
c, e: Beginning of uncoiling = transitional stage of *Lenticulina* to *Astacolus*.
f, g: Uncoiled stage of *Astacolus* (possibly already transition to *Vaginulinopsis*).
e = MICHAEL 1967: Pl. 3, Fig. 8, holotype of *L.* (*L.*) *nodosa hilseana* n. subsp.
d = MICHAEL 1967: Pl. 3, Fig. 11, paratype of *L.* (*L.*) *nodosa hilseana* n. subsp.
g = MICHAEL 1967: Pl. 3, Fig. 9, holotype of *L.* (*A.*) *nodosa barremiana* MICHAEL.

Remarks and variability of tests: Very little has to be added to the description by REUSS (1863: 78). The almost always circular, not evolute growing shell is the characteristic of the subspecies.

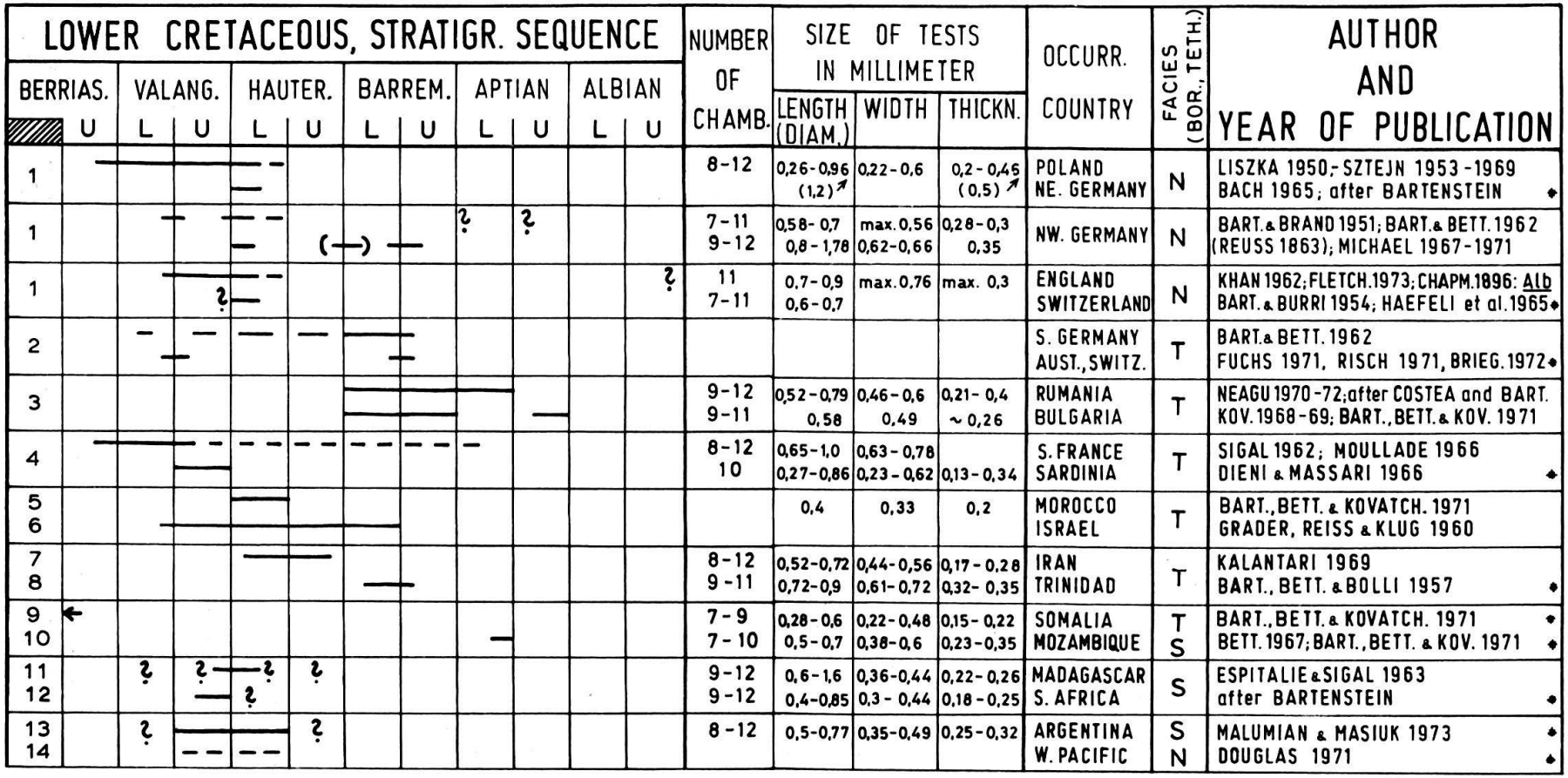
The relatively small size and thickness of the shell is recognizable in all worldwide occurrences. Inspite of this, locally, considerable differences and extreme sizes in the shell dimensions can be observed when the species occurs in an abundant development, as proved by the following statistical evaluation of rich material from a small core in Upper Valanginian 1 of the well Siedenburg 2, N.W. Germany:

Table 1

Length	*Width*	*Thickness*	*Number of chambers*
0.38 mm	0.30 mm	0.17 mm	7
0.40	0.31–0.33	0.18–0.22	8
0.50	0.40	0.25	8–9
0.53	0.45	0.23	8
0.55	0.40	0.25	8–9
0.62–0.65	0.50–0.55	0.27–0.33	8–10
0.75	0.57–0.62	0.26–0.35	9–10
0.75–0.85	0.55–0.69	0.35–0.39	9–10
1.00	0.75–0.77	0.33–0.37	10
1.02	0.72	0.38	11[8])
1.02	0.85	0.41	8
1.00–1.20	0.80–0.90	0.42–0.50	9–12

As can be seen in Textfigures 3–5, *L.* (*L.*) *nodosa nodosa* exceeds a length of 0.88 mm only in a few exceptions. The same applies to a shell thickness of more than 0.38 mm; dimensions which *L.* (*L.*) *nodosa hilseana* n. subsp. exceeds almost always.

[8]) A simple, slightly evolute test with *one* chamber separated from the spire. This shows that the subgenus *Lenticulina* and *Astacolus* represent only *artificial* constructions within the systematics of the Lagenidae.



NUMBER OF CHAMB.	SIZE OF TESTS IN MILLIMETER: LENGTH (DIAM.)	WIDTH	THICKN.	OCCURR. COUNTRY	FACIES (BOR., TETH.)	AUTHOR AND YEAR OF PUBLICATION
8-12	0,26-0,96 (1,2)↗	0,22-0,6	0,2-0,45 (0,5)↗	POLAND NE. GERMANY	N	LISZKA 1950,- SZTEJN 1953-1969 BACH 1965; after BARTENSTEIN ◆
7-11 9-12	0,58-0,7 0,8-1,78	max. 0,56 0,62-0,66	0,28-0,3 0,35	NW. GERMANY	N	BART.& BRAND 1951; BART.& BETT. 1962 (REUSS 1863); MICHAEL 1967-1971
11 7-11	0,7-0,9 0,6-0,7	max. 0,76	max. 0,3	ENGLAND SWITZERLAND	N	KHAN 1962; FLETCH. 1973; CHAPM. 1896: Alb BART.& BURRI 1954; HAEFELI et al. 1965◆
				S. GERMANY AUST., SWITZ.	T	BART.& BETT. 1962 FUCHS 1971, RISCH 1971, BRIEG. 1972◆
9-12 9-11	0,52-0,79 0,58	0,46-0,6 0,49	0,21-0,4 ~0,26	RUMANIA BULGARIA	T	NEAGU 1970-72; after COSTEA and BART. KOV. 1968-69; BART., BETT.& KOV. 1971
8-12 10	0,65-1,0 0,27-0,86	0,63-0,78 0,23-0,62	0,13-0,34	S. FRANCE SARDINIA	T	SIGAL 1962; MOULLADE 1966 DIENI & MASSARI 1966 ◆
	0,4	0,33	0,2	MOROCCO ISRAEL	T	BART., BETT. & KOVATCH. 1971 GRADER, REISS & KLUG 1960
8-12 9-11	0,52-0,72 0,72-0,9	0,44-0,56 0,61-0,72	0,17-0,28 0,32-0,35	IRAN TRINIDAD	T	KALANTARI 1969 BART., BETT. & BOLLI 1957 ◆
7-9 7-10	0,28-0,6 0,5-0,7	0,22-0,48 0,38-0,6	0,15-0,22 0,23-0,35	SOMALIA MOZAMBIQUE	T S	BART., BETT. & KOVATCH. 1971 ◆ BETT. 1967; BART., BETT. & KOV. 1971 ◆
9-12 9-12	0,6-1,6 0,4-0,85	0,36-0,44 0,3-0,44	0,22-0,26 0,18-0,25	MADAGASCAR S. AFRICA	S	ESPITALIE & SIGAL 1963 after BARTENSTEIN ◆
8-12	0,5-0,77	0,35-0,49	0,25-0,32	ARGENTINA W. PACIFIC	S N	MALUMIAN & MASIUK 1973 ◆ DOUGLAS 1971 ◆

Fig. 3. Stratigraphic distribution, worldwide occurrences, most important features of tests and concerning references of *Lenticulina* (*Lenticulina*) *nodosa* (REUSS 1863) and its subspecies.

* = Inclusion of a profile stratigraphically limited, which cannot be regarded as representative for the entire Lower Cretaceous of the described area.

? = Occurrence of the species uncertain.

(REUSS 1863) = Misinterpretation of the stratigraphic age.

(1,2) = Extraordinary length or thickness of particular specimens.

N = North Temperate Realm

S = South Temperate Realm

T = Tethyan Realm

← = Occurrence pre-Berriasian (Kimmeridgian to Portlandian) in Somalia.

1–14 (left column) = Numbers of countries identical with localities on Textfig. 6.

Remarks to the size of tests: When data were not given in the text, we determined the relative size from the illustrations.

Uncoiled *Astacolus*-growth almost always causes a lesser growth in thickness of the spire than with *Lenticulina*, as is seen later especially with *L.* (*A.*) *nodosa barremiana* (Fig. 4, right).

MICHAEL (1967: 14, 35, 41) writes correctly that *L.* (*L.*) *nodosa* must represent a modification of *L.* (*L.*) *muensteri* or other closely related species, formed iteratively. That means that in *geologically* different times and in *geographically* different parts of the world, occurrences of forms similar to *L.* (*L.*) *nodosa* could be developed.

Thus *Cristellaria nodosa* REUSS sp. and *Cristellaria secans* REUSS var. *angulosa* nov., both described by CHAPMAN (1896: 3–4) from the Upper Albian of Folkestone, appear to be iterative forms of *L.* (*L.*) *gaultina* (BERTHELIN 1880) rather than from *L.* (*L.*) *muensteri* (ROEMER 1839), especially as *L.* (*L.*) *gaultina* occurs in the same British material with the same shell form, however without keel-knots. And *L.* (*L.*) *muensteri* with its typical shell form in the N.W. German Lower Cretaceous is absent in the British material. Both our specimens (Pl. II, Fig. 3–4) from the British Lower Gault of Cambridge correspond to the forms of CHAPMAN, where the especially large central portion of the shells presents an additional character of *L.* (*L.*) *gaultina*.

Also as *L.* (*L.*) *nodosa* has *never so far* been observed in the Albian, we think it justified, to present CHAPMAN's new variety as an *independent* species *L.* (*L.*) *angulosa* (CHAPMAN 1896) and as a stratigraphically important local form of the British Upper Albian: both forms according to CHAPMAN occur in the same Upper Albian horizon of the Zone XI (especially "6 ft. from the top").[9])

Also the geographically isolated Barremian occurrences in Trinidad (Pl. I, Fig. 17) seem to have shell development different from the other Tethyan occurrences. However, with the little material available we are not yet in a position to stress such individualities sufficiently to justify the nomination of a new subspecies.

An occurrence of *L.* (*L.*) aff. *nodosa* in the Lower Aptian (*bodei* zone) of Lambertimark in the Emsland, reported by KEMPER (1963: 473), could not be checked, however it is doubtless neither identical with *L.* (*L.*) *nodosa nodosa* from the Valanginian/Hauterivian nor with *L.* (*L.*) *nodosa hilseana* or *L.* (*A.*) *nodosa barremiana* from the Middle Barremian, because representatives of *L. nodosa* (REUSS) have not been proved so far in the N.W. German Aptian[9]).

Especially important concerning the worldwide distribution of *L.* (*L.*) *nodosa* within the northern Temperate Realm was the discovery by DOUGLAS (1971: 1035) from deep sea drilling cores of Leg 6, Site 49 (32° 24.1′ N, 156° 35′ E), drilled in the course of the Deep Sea Drilling Project. If the determination of *L.* (*L.*) *nodosa* can be confirmed, then DOUGLAS' age determination as Neocomian can be narrowed down to the stratigraphic age of Valanginian to Lower Hauterivian.

Occurrence: In N.W. Germany Middle Valanginian to Lower Hauterivian. The same in the areas neighbouring N.W. Germany with Boreal facies like Poland (which begins here in the Upper Berriasian), in England, Switzerland, and in The Netherlands. In the extreme East of the northern Temperate Realm, in the West Pacific and east of Japan in the Neocomian (probably Valanginian to Lower Hauterivian).

In S. and E. Europe and in other continents with Tethyan facies from Upper Berriasian through Upper Aptian.

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[9]) See also the remarks on p. 559 concerning such iterative forms in the N.W. German Aptian.

An interesting deviation from the stratigraphically widespread occurrences within the Tethys is shown by the discovery of *L.* (*L.*) *nodosa nodosa* in Somalia (Pl. II, Fig. 16–17; Textfig. 1, 3, 7) by F. Plumhoff and F. Bettenstaedt. According to the verbal communication of Dr. F. Plumhoff-Wietze, the shells belong to the stratigraphic range Kimmeridgian to Portlandian, which means in the higher Upper Jurassic. This stratigraphically *old* occurrence, so far the *only* one (Textfig. 7, locality 9) is surprising! This opens up the possibility of *L.* (*L.*) *nodosa nodosa* occurring in the Upper Jurassic in the southern regions of the earth in the frontier area between the Tethyan Realm and southern Temperate Realm. This at the same time implicates that certain determination rules of the foraminifera fauna, based on the deeper Lower Cretaceous, might have to be revised![10])

In the southern Temperate Realm of Africa and S. America[11]) from Valanginian to Hauterivian, and in Mozambique in the Lower Aptian[12]).

Lenticulina (*Lenticulina*) *nodosa hilseana* n. subsp.

Pl. II, Fig. 26–27; Textfig. 1–2, 4–5, 7

· 1933 *Lenticulina secans* REUSS, var. *angulosa* CHAPMAN? – EICHENBERG, Barrême: 172; Tf. 20, Abb. 4 [? BARTENSTEIN].
v· 1967 *Lenticulina* (*Lenticulina*) *nodosa* (REUSS) – MICHAEL, Barrême I: 14, 34; Tf. 3, Fig. 8, 11.
v· 1973 *Lenticulina* (*Lenticulina*) *nodosa* (REUSS) – BARTENSTEIN & KAEVER, Helgoland: 234; Abb. 5.

Derivation of name: Derived from the old name "Hils" for the marine deeper Lower Cretaceous in N.W. Germany.

Holotype: MICHAEL 1967, Barrême I: Pl. 3, Fig. 8. Length: 1.3 mm.

Paratype: MICHAEL 1967, Barrême I: Pl. 3, Fig. 11. Diameter: 1.0 mm.

Type locality: Flemming Brickyard near Berenbostel, Hannover.

Type horizon: Middle Barremian.

Diagnosis: A subspecies of *L.* (*L.*) *nodosa* with characteristic separation of the youngest chambers from the spire.

Description: Test similar to *L.* (*L.*) *nodosa nodosa* with the same characteristics of the back-knots, however additionally characterized by the separation of the youngest two chambers from the spire, whereby a transition is indicated to the subgenus *Astacolus*. Number of chambers 12.

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[10]) The material from Somalia with *L.* (*L.*) *nodosa nodosa*, which I received after the compilation of this publication, contains the following sizes of its shells (measurements in millimetres):
- length from 0.28 mm to 0.6 mm
- width from 0.22 mm to 0.48 mm
- thickness from 0.15 mm to 0.22 mm (maximum thickness: 0.35 mm)
- number of chambers 7 to 9

[11]) According to verbal communications and written notes by N. Malumian, Argentina, F. Bettenstaedt and E. Michael, Hannover, and to the recent publication by MALUMIAN & MASIUK (1973: 437).

The above experts determined from Argentinian drilling material, from the Valanginian to Hauterivian of the "Tierra del Fuego Island", amongst other foraminifera the closely related group *L.* (*L.*) *nodosa*, *L.* (*A.*) *gibber*, *L.* cf. *pilicensis* and *L.* cf. *secans* var. *angulosa*.

According to my latest investigations the mentioned species (Pl. II, Fig. 9–15) belong to *L.* (*L.*) *nodosa nodosa* (REUSS) and to *L.* (*A.*) *nodosa gibber* ESPITALIÉ & SIGAL: see also the detailed informations in the text on *L.* (*A.*) *nodosa gibber* and its distribution.

[12]) If Mozambique really belongs to the southern Temperate Realm (Textfig. 3, 6) this would be the *youngest occurrence within all the temperate realms*. The upper limit of *L.* (*L.*) *nodosa nodosa* was regarded as being (Lower) Hauterivian but this Lower Aptian occurrence now raises its upper boundary by 10–12 million years.

Remarks and variability of tests: The tests of the new subspecies in the N.W. German Middle Barremian are altogether larger, thicker and more strongly sculptured than the tests of the nominate-subspecies (Textfig. 4–5) in the Valanginian to Lower Hauterivian, however, they possess the same number of chambers. The separation of the youngest chamber(s) from the spire occurs only in some specimens, when it does it, distinguishes it clearly from *L. (L.) nodosa nodosa* and points to the relationship with *L. (A.) nodosa barremiana.*

Lenticulina nodosa nodosa					*L. nodosa hilseana*				*L. nodosa barremiana*			
OCCURR.	NUMBER CHAMBERS	LENGTH	WIDTH	THICKNESS	LENGTH	WIDTH	THICKN.	NUMB. CHAM.	LENGTH	WIDTH	THICKN.	NUMB. CHAM.
					0,38	0,3	0,23	9[1]				
P	(8-12)	(0,26)	(0,22)	(0,2)								
G	(8)	(0,27)	(0,23)									
									0,58	0,35	0,25	10[1]
G	(8)	0,35	0,25	0,17	0,63	0,53	0,39	10				
A	8-9	0,38	0,28		0,7	0,6	0,43	10				
MR	9	0,4	0,33	0,2	0,75	0,6	0,48	10	0,73	0,4		9-10
G	9-10	0,43	0,31*	0,23*					0,75	0,35	0,3	12
					0,83	0,73	0,45	10	0,8	0,4		11
G	10	0,48	0,43	0,25					0,88	0,4	0,28	12-13
A,G,MC,S	8-11	0,5-0,53	0,38-0,41	0,23-0,25								
P	10-11	0,55	0,42	0,26	1,0	0,83	0,58	9-10	1,0	0,48		12
F	9	0,55	0,42	0,3					1,03	0,57		13
B,G	8-11	0,57-0,58	0,43-0,5	0,3	1,08	0,9	0,57	11	1,08	0,45	0,33	14
G,R	8-11	0,6-0,63	0,45-0,6	0,26-0,37					1,13	0,5		12
E,T	9-11	0,63	0,58	0,3					1,18	0,65		12
F,G	9-11	0,64	0,5-0,6	0,33					1,2	0,58	0,4	14-15
F	9	0,65	0,55	0,38					1,25	0,58	0,42	14-16
					(1,3)	(0,83)		(12)	1,3	0,57-0,7	0,44-0,5	13-15
G,MC,T	9-10	0,7	0,58-0,6	0,3-0,37					1,33	0,52	0,45	12
									1,38-1,4	0,55-0,57		15-16
G	9	0,75	0,58-0,65	0,35					1,42-1,45	0,53-0,58	0,45	14-15
G	9-10	0,75-0,83	0,55-0,6	0,35-0,38								
G,R	9-11	0,79-0,82	0,55-0,65	0,35-0,36								
E,G,S	9-11	0,8 -0,83	0,63-0,64	0,35-0,38								
E,G,S	10-11	0,86	0,63	0,45					1,63	0,55	0,4	15-16
G	9-10	0,85-0,88	0,63-0,8	0,36-0,38					1,7	0,5		13
G	9-12	1,0-1,2	0,8-0,9	0,42-0,5					1,75	0,55	0,42	16[1]
G	10	1,04	0,86	0,52					(1,78)	(0,66)	(0,35)	(16)
R	10	1,13	1,0	0,58								
G	11-12	1,2	0,9-0,97	0,47-0,5					1,93	0,6		17

Fig. 4. Own measurements of tests on German and worldwide Lower Cretaceous samples of *Lenticulina (Lenticulina) nodosa nodosa* (Reuss 1863) and on German samples from Middle Barremian of *Lenticulina (Lenticulina) nodosa hilseana* n. subsp. and of *Lenticulina (Astacolus) nodosa barremiana* Michael 1967 (all numbers in millimeter).

* = Mean value of various numbers.
( ) = Particular numbers according to publications.
[1]) = Juvenile specimen.
Left chart, special symbols: A = (South) Africa, B = Bulgaria, E = England, F = (South) France, G = Germany, MC = Mozambique, MR = Morocco, P = Poland, R = Rumania, S = Switzerland, T = Trinidad. – The scale distance is changing below 0,8.

All German occurrences belong to the stratigraphic interval of Upper Valanginian to Lower Hauterivian, the same as for Poland, South Africa, Morocco, Switzerland and South France. Bulgaria and Trinidad = Barremian; Rumania and Mozambique = Aptian; England = Albian.

The distinct stratigraphic break between Lower Hauterivian and Middle Barremian, which separates the occurrences of *L.* (*L.*) *nodosa nodosa* from *L.* (*L.*) *nodosa hilseana* in N.W. Germany and which comprises a time interval of about 5–7 million years and, in addition, the lack so far of *L.* (*L.*) *nodosa hilseana* being found in the Lower Cretaceous outside Germany, stresses the justification for the independence of this local form, at least as new subspecies.

Occurrence: The new subspecies has so far only been found in the N.W. German Middle Barremian.

Beyond this it might be present in the Barremian within the Boreal facies of the N.W. European Lower Cretaceous Basin.

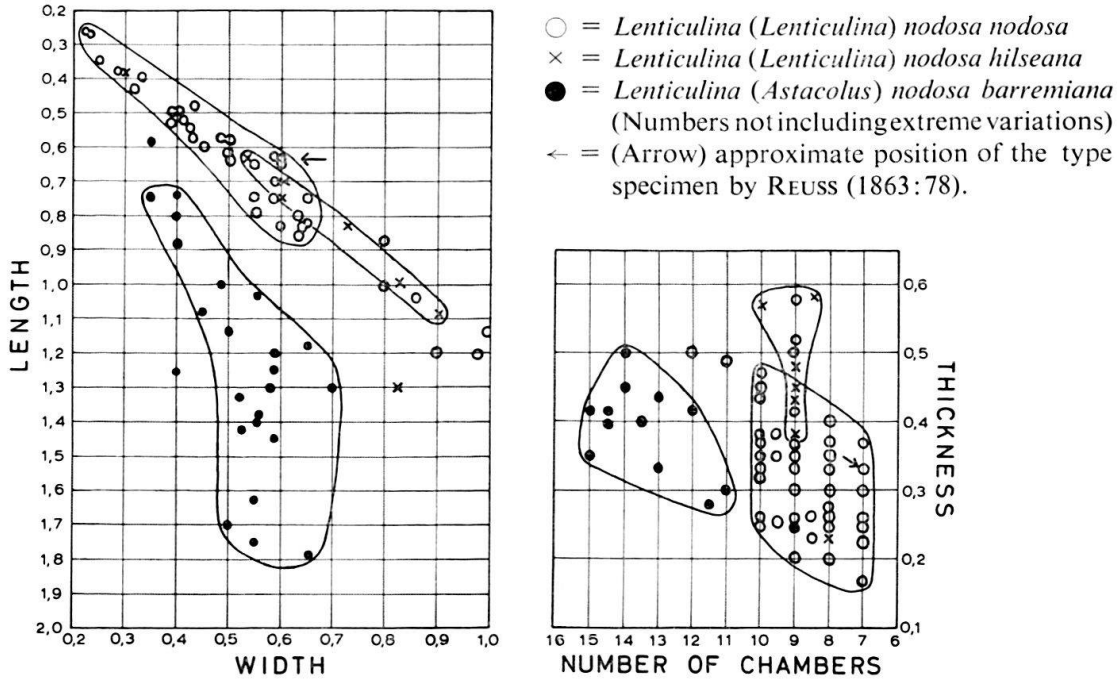

Fig. 5. Diagrammatic chart showing the numbers of Textfig. 4.

Lenticulina (*Astacolus*) *nodosa barremiana* MICHAEL 1967

Pl. II, Fig. 26–29; Textfig. 1–5, 7

· 1933 *Robulus* sp. – EICHENBERG, Barrême: 172; Tf. 17, Abb. 12.
1963 *Lenticulina* (*Vaginulinopsis*) *pachynota* DAM – KEMPER, Rheine-Ahaus: 451, 458 [nach MICHAEL 1967: 41].
v* 1967 *Lenticulina* (*Astacolus*) *barremiana* n. sp. – MICHAEL, Barrême I: 14, 41; Tf. 3, Fig. 9.
v· 1973 *Lenticulina* (*Astocolus*) *barremiana* MICHAEL – BARTENSTEIN & KAEVER, Helgoland: 230; Tf. 4, Fig. 67–68; Abb. 4, 7.

Remarks and variability of tests: Very little has to be added to the very extensive description of MICHAEL (1967: 41).

Some of the tests show a good development of the spire, especially in juvenile stages, whereas in other tests with very stretched growth a normal spire is lacking and the oldest chambers are only adjacent to the younger ones (MICHAEL 1967: Pl. 3, Fig.

9; our Textfig. 2g). MICHAEL (1967: Pl. 20, Fig. 85–86, 91, 108) shows good examples of many tests of this extreme variant of *L.* (*L.*) *nodosa.*

Size relationship and number of chambers differ clearly from the other two subspecies *L.* (*L.*) *nodosa nodosa* and *L.* (*L.*) *nodosa hilseana* (Textfig. 4–5).

Inspite of this a relationship exists with *L.* (*L.*) *nodosa hilseana*, not only based on the stratigraphically almost equal age of both subspecies in the same occurrence within N.W. Germany and in the uncoiling evolute tendency of *L.* (*L.*) *nodosa hilseana* towards an *Astacolus* stage (MICHAEL 1967: Pl. 3, Fig. 8, holotype). This uncoiling tendency testifies, as also MICHAEL (1967: 7, 14, 41) stresses, once again the artificial systematics used in the determination of the subgenera *Lenticulina*, *Astacolus* and *Vaginulinopsis*.

Occurrence: Occurring in a relatively small stratigraphic extension of the lowermost Middle Barremian. So far found only in N.W. Germany.

This subspecies, like *L.* (*L.*) *nodosa hilseana*, should be found beyond this local occurrence in the Middle Barremian of the Boreal facies of the N.W. European Lower Cretaceous Basin. In both cases confirmation of discoveries is lacking.

Lenticulina cf. *barremiana* MICHAEL by DAILEY (1973: 50) from the Barremian in California is not identical with the type species and with the German occurrences.

Lenticulina (*Astacolus*) *nodosa gibber* ESPITALIÉ & SIGAL 1963

Pl. II, Fig. 7–8, 13–15; Textfig. 1, 3, 6

*· 1963 *Astacolus gibber* n. sp. – ESPITALIÉ & SIGAL, Majunga: 36; Pl. 13, Fig. 8–11.
· 1963 *Astacolus* sp. – ESPITALIÉ & SIGAL, Majunga: 40; Pl. 17, Fig. 2.
· 1973 *Astacolus gibber* (ESPITALIÉ & SIGAL) – MALUMIAN & MASIUK, Argentina: 437.

Remarks and variability of tests: Only very little has to be added to the extensive description of ESPITALIÉ & SIGAL (1963: 36). Whereas the coiled tests (*Lenticulina* stage) usually possess 9–10 chambers, the uncoiled tests (*Astacolus* stage) reach 12–13 chambers.

The relatively close relationship to *L.* (*L.*) *nodosa nodosa* (in ESPITALIÉ & SIGAL: *L.* cf. *pilicensis* LISZKA and *L.* cf. *secans* var. *angulosa* CHAPMAN) is already proven in the Lower Cretaceous material from Madagascar by the fact that the subspecies mentioned occur at the same stratigraphic horizons *E* and *F* (Upper Valanginian and later).

Essentially in determining the systematic position of the subspecies is the development of a *complete* spire. Only individual, *very stretched* tests (ESPITALIÉ & SIGAL 1963: Pl. 13, Fig. 11? – spire broken off) may possess an incomplete spire as with *L.* (*A.*) *nodosa barremiana.*

Forms with *incomplete* spire, where only the oldest chambers are *adjacent* to the younger ones, come close to *L.* (*A.*) *humilis* (REUSS 1863). They occur in the deeper Lower Cretaceous of Madagascar and South Africa as well as in Europe.

Occurrence: So far found in Madagascar and South Africa (Algoa Basin: unpublished) indicating that they represent a regionally limited local form, apparently restricted to the deeper Lower Cretaceous, Upper Valanginian to Lower Hauterivian, of the southern Temperate Realm.

As the material so far available from outcrops and drillings in South Africa is not sufficient for an exact stratigraphic determination, it is not known, whether the subspecies also occurs in the Lower Valanginian and in the Upper Hauterivian (Textfig. 1).

As mentioned when the occurrences of *L.* (*L.*) *nodosa nodosa* were described (footnote[11]), *L.* (*A.*) *nodosa gibber* has now also been found in drilling cores from the southern tip of South America (Tierra del Fuego). This was to be expected according to the publication of SIGAL et al. (1970: 24–27), because during the time of deposition of the deeper Lower Cretaceous, according to the Continental Drift Theory (Textfig. 6) of Alfred Wegener, the southern tips of America and Africa, and therefore the above mentioned localities, were located relatively close to each other and belonged to the same facies region: i.e. the southern Temperate Realm. In their newest publication MALUMIAN & MASIUK (1973: 437) determine the age of the Argentinian material as Valanginian to Hauterivian which corresponds to the age determination in the Algoa Basin (South Africa).

In a recent communication (letter of February 1974), Dr. Malumian announced a forthcoming publication concerning the proof of the Continental Drift between South America and Africa which includes new data on 22 foraminifera species which were formerly described only by ESPITALIÉ & SIGAL 1963 from the Uppermost Jurassic and Lowermost Cretaceous in Madagascar.

Remarks on the worldwide distribution of *Lenticulina (Lenticulina) nodosa* (REUSS) and its subspecies

(Textfig. 6)

With the knowledge of the occurrences of *L.* (*L.*) *nodosa* (REUSS) in the Boreal (northern and southern Temperate Realm) and in the Tethyan facies of the Lower Cretaceous, as shown in this publication, it is now possible to trace a paleogeographic world map of the distribution of this species and its subspecies. At the same time it becomes possible to predict, where else in the Lower Cretaceous occurrences of the world we can expect to discover *L.* (*L.*) *nodosa*, that is if it has not already been described – under a different species name or in literature, not known to us.

ROEMER (1852) was the first to recognize a different northern and southern development of the Upper Cretaceous in North America, which was later extended to the lower Cretaceous throughout the world as well as to other formations.

ROEMER (see BARTENSTEIN 1966: 602) found the northern development of the Upper Cretaceous in the states of New Jersey, Tennessee, Kansas, Dakota and California, the southern development in Texas, Alabama, Mexico, West Indies and Colombia. In Europa this corresponded to the northern (Boreal) facies of England, Denmark, South Scandinavia, Russia and the outeralpine Germany, and to the southern (Tethyan) facies of South Europe including the Alpine and Carpathian regions.

This facies division of ROEMER can also be applied roughly to the Lower Cretaceous and can be found (Textfig. 6) now throughout the entire globe.

Along the northern edge of the Tethys, the deeper Lower Cretaceous in the Boreal and Tethyan facies with *L.* (*L.*) *nodosa* has been proven only in the Euroasiatic region (localities 1–4, 6–7).

In Canada and Alaska the Boreal of the deeper Lower Cretaceous has been found with a microfauna related to that of the European facies region. However, here *L.* (*L.*)

nodosa has not yet been recorded. In the south of North America, the marine Lower Cretaceous only commences with the (Barremian ?) Aptian and Albian, which is relatively too young to contain *L.* (*L.*) *nodosa.*

The same applies to the east of the Asiatic continent, in Japan and the neighbouring regions, where deeper Lower Cretaceous in a boreal facies has not yet been found. An important exception represents the discovery of *L.* (*L.*) *nodosa* in the Neocomian of deep sea drilling cores of Leg 6, Site 49 (locality 14), in the Western Pacific east of Japan, which is the easternmost proof of it that has been found in the European–Asiatic region.

Along the southern edge of the Tethys a considerable increase in Tethyan discoveries in South America (Trinidad: locality 8) and Africa (Morocco: locality 5) can be expected, as here a good marine Lower Cretaceous succession is present, either complete or in parts, from the Berriasian to the Albian. Also discoveries of *L.* (*L.*) *nodosa*

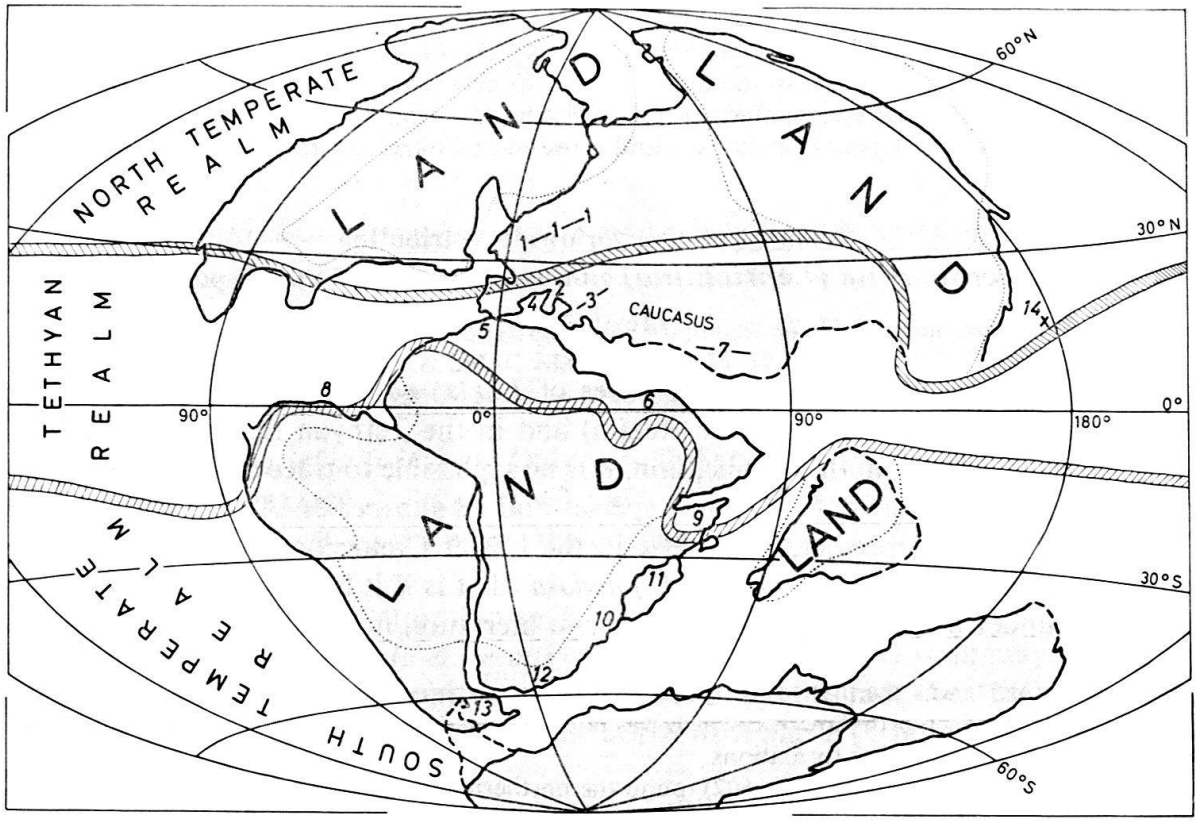

Fig. 6. Important worldwide localities of *Lenticulina* (*Lenticulina*) *nodosa* (REUSS 1863) and its subspecies in the Lower Cretaceous.

- Paleogeographic map of the continents and oceans at the boundary Upper Jurassic to Lower Cretaceous according to DIETZ & HOLDEN 1970 and SCHROEDER 1971.
- Time: approx. 137 million years before present at the initiation of the rift between Africa and South America.
- The numbers of the localities 1–14 correspond to the same numbers in Textfig. 3, left column.
- The exact position of some localities (6, 7, 14) on the paleogeographic map might be open for further discussion.
- Locality 9 is the only one belonging to *Upper Jurassic* (Kimmeridgian to Portlandian). It is possible therefore that in the lowermost Lower Cretaceous this extension of the Tethys towards south was no more present and that a West–East striking boundary dominated.

should be expected from the southern part of North America (California, Gulf Coast), which represents the Tethyan counterpart to Trinidad–Venezuela.

In the southern Temperate Realm, corresponding to the northern Temperate Realm in the Boreal facies of the northern hemisphere, the most interesting discoveries have been made so far along the eastern edge of the Gondwana continent: Madagascar (locality 11) and Mozambique (locality 10)[13]). The occurrence of *L.* (*L.*) *nodosa* in South Africa (locality 12) and in South America (Tierra del Fuego: locality 13) is a further indication of the validity of Alfred Wegener's Continental Drift Theory 1912 (BARTENSTEIN 1974*a*).

So far in the Australian region marine deeper Lower Cretaceous has not been found. However it has been found for the first time in the Indian Ocean in connection with the Deep Sea Drilling Project in Leg 27, Sites 259 (location: 29°37′ S, 112°42′ E) and 261 (12°57′ S, 117°54′ E). The core material spans the boundary zone between Upper Jurassic and Lower Cretaceous, and has been put at the disposal of the author for investigation (BARTENSTEIN 1974; in print); however so far the calcareous foraminifera have not yet been analysed for the presence of *L.* (*L.*) *nodosa* and its subspecies.

In the Pacific region between Australia and the American continent new discoveries of *L.* (*L.*) *nodosa* can be hoped for the future as the latest publication by DOUGLAS (1973: 683–684) reports, from Leg 17, Site 166 (approximate coordinates: 4° N, 175° W) in the Pacific benthonic foraminifera from the Late Hauterivian. The discovery of Lower Hauterivian, Valanginian and Berriasian in shaly facies is probably only a question of time.

Only the occurrence in Somalia (locality 9) differs essentially from the other occurrences and remains under further investigation [see also the remarks on *L.* (*L.*) *nodosa nodosa*, p. 547, occurrence]. Because of its stratigraphic age, Kimmeridgian to Portlandian, which according to Dr. F. Plumhoff is reliable, it is about 18–21 million years earlier than the so far oldest occurrence in the Upper Berriasian, for example in Poland and in Southern France.

According to this the location of the Tethys boundary at this time between N.E. Africa and India (Textfig. 6) together with the striking extension towards the south is definite only for the Upper Jurassic and this has been known for a long time (i.a. BUBNOFF 1956: 409, 482–488); but so far only with doubt for the Lower Cretaceous (BUBNOFF 1956: 547–549). For the Lower Cretaceous therefore the possibility exists that this boundary runs West–East and the continental parts mentioned above already belong to the transition zone of the southern Temperate Realm.

Remarks on Russian occurrences

Lists of microfaunas and species descriptions, corresponding to West European systematics and taxonomy, are rare from the Russian Lower Cretaceous. Also, the publications are available either with difficulty or not at all.

Thus it was only after finishing this investigation that N. Malumian (Buenos Aires) and A.S. Masumov (Taschkent) kindly drew our attention to the important publication by ANTONOVA 1969, which describes the distribution of *L.* (*L.*) *nodosa* and their subspecies in Eastern Europe. In it "*Robulus*" *nodosus* REUSS 1863 is described from the Hauterivian to Aptian of Germany and with single specimens also from West Caucasus (op. cit.: 44; Pl. 5, Fig. 4). Furthermore, a new subspecies, "*Robulus*" *nodosus*

[13]) With the possibility of Mozambique belonging to the southern Temperate Realm, some special stratigraphic problems still pose themselves (see also p. 547, remarks on occurrence), because this Lower Aptian discovery is so much younger than the occurrences in the (Lower) Hauterivian of both temperate realms.

posterioris is created (op. cit.: 45; Pl. 5, Fig. 5–6), which is supposed to occur as successor in the "Albian and Cenomanian" of Trinidad [according to BARTENSTEIN, BETTENSTAEDT & BOLLI 1957: *non* Albian and Cenomanian], in the Albian of Britain and also only in single specimens in the Albian of the North West Caucasus.

The sizes of tests of the Russian material

L. (L.) nodosa nodosa: Diameter 0.35–0.65 mm, thickness 0.3–0.37 mm, number of chambers 10.5
L. (L.) nodosa posterioris: Diameter 0.35–0.7 mm, thickness 0.3–0.4 mm, number of chambers 10–11

correspond with our European and also worldwide *L. (L.) nodosa* material.

The area of the Caucasus was located in the Lower Cretaceous in the transition realm between the Tethyan and Boreal sea. In the South (in the Transcaucasus) the Lower Cretaceous shows Tethyan facies, whereas in the North Western Foreland (in the Ciscaucasus) it is of Boreal facies.

The erroneous stratigraphic interpretations for the occurrences in Germany [*non* Aptian] and Trinidad [*non* Albian and Cenomanian] can be revised relatively easily: see the remarks on p. 542 and p. 551 concerning *L. (L.) nodosa nodosa* and its world-wide distribution. Whether the selection of a new subspecies in the Albian of the North West Caucasus is justified, however, could only be verified by examining the original material: as ANTONOVA, however, always only speaks of single specimens this may not be possible.

For the British Albian, the priority of the name *L. (L.) angulosa* (CHAPMAN 1896) must be pointed out. This is important, if, in ANTONOVA (1969: 45) the identity of the two occurrences – Britain and North West Caucasus – is valid.

Other species related to *Lenticulina (Lenticulina) nodosa* (REUSS)

Form of tests, sculpture and stratigraphic occurrences draw our attention to several other species in the lower Cretaceous, which, though not necessarily directly related to *L. (L.) nodosa*, at least should belong to a common evolutionary sequence.

Lenticulina (Astacolus) humilis (REUSS 1863)

Pl. II, Fig. 19–20; Textfig. 7

* 1863 *Cr. humilis* m. – REUSS, Hils u. Gault: 65; Tf. 6, Fig. 16–17.

Neotype: Specimen Pl. II, Fig. 19. Basal Lower Hauterivian, so-called "Hilskonglomerat", former quarry N.W. Berklingen (Asse), topographic sheet Schöppenstedt No. 3830. Gauss-Krüger coordinates R: 4413080, H: 5777760. Length: 0.57 mm, width: 0.33 mm, thickness: 0.21 mm, number of chambers: 8.

Further material from the type locality: Specimen Pl. II, Fig. 20. Length: 0.55 mm, width: 0.37 mm, thickness: 0.25 mm, number of chambers: 8.

Most important features of the test: Test elongate, oval, relatively large, strongly compressed laterally, with incomplete spire. Oldest chambers very small, simply adjacent to the younger ones, youngest chambers much more wide than high. Sutures distinct, on the peripheral margin often with knot-like thickenings.

Remarks: REUSS' type species was very small (0.56 mm) and thus corresponded nearly to our neotype with 0.57 mm.

Type locality and type horizon are the same as for *L.* (*L.*) *nodosa* N.W. Berklingen (Asse). The close relationship between the two species can be seen where the *marked knots on the dorsal edges* represent the common main characteristics. REUSS (1863: 65) does not stress this specially, but it is confirmed from the material of the N.W. German Lower Cretaceous (see BARTENSTEIN & BETTENSTAEDT 1962: Pl. 28, Fig. 10). This last figure, from the Lower Hauterivian, at the same time corresponds with the second form of REUSS (1863: Pl. 6, Fig. 17), which deviates from the type species by a greater number of chambers (12–13) as well as by the higher and narrower test. This second form does not come from the type locality at Berklingen. Unfortunately REUSS does not give any information on its size. The test in BARTENSTEIN & BETTENSTAEDT (1972) is 1.18 mm long.

Cr. dilecta m. in REUSS (1863: 71; Pl. 7, Fig. 12 – see also ZEDLER 1961: 38) is described as very similar to *L.* (*A.*) *humilis*. With only one specimen of 0.56 mm length, supposed to come from the "oberer Hilsthon", we cannot decide, whether perhaps there has been a confusion of locality and horizon, because if the test comes from the (Lower) Hauterivian (= "mittlerer Hilsthon") then it should fall within the variation band of *L.* (*A.*) *humilis*.

Occurrence: Lower Hauterivian. Whether the species transgresses the boundary from Lower to Upper Hauterivian and locally occurs in the Upper Hauterivian, can not yet be proven definitely. Perhaps *L.* (*A.*) *humilis* changes when reaching the Upper Hauterivian and is replaced by *L.* (*A.*) *neopachynota*.

Lenticulina (*Astacolus*) *humilis humilis* (REUSS 1863)

Pl. II, Fig. 21; Textfig. 7

Derivation of name, holotype, type locality and type horizon as above-mentioned by *L.* (*A.*) *humilis* (REUSS).

· 1938 *Cristellaria* D 93 – HECHT, Unterkreide: Tf. 19 a, Fig. 35–36 a; Tf. 19 b, Fig. 22–30.
v· 1951 *Lenticulina* (*Vaginulinopsis*) *humilis humilis* (REUSS) – BARTENSTEIN & BRAND, Valendis: 287.
v· 1952 *Lenticulina* (*Vaginulinopsis*) *humilis humilis* (REUSS) – BARTENSTEIN, Hauterive-Nomenkl.: 177, 178 [*Cristellaria* D 93].
v· 1961 *Lenticulina* (*Vaginulinopsis*) *humilis humilis* (REUSS) – ZEDLER, Oberhauterive: 38.
v· 1962 *Lenticulina* (*Vaginulinopsis*) *humilis humilis* (REUSS) – BARTENSTEIN & BETTENSTAEDT, Boreal u. Tethys: 267; Tf. 38, Fig. 10; Tab. 17.
v· 1965 *Lenticulina* (*Vaginulinopsis*) *humilis humilis* (REUSS) – BARTENSTEIN, Alb-Nomenkl.: 357 [*Cristellaria* D 93].

Remarks and variability of tests: Very little has to be added to the description of REUSS (1863: 65). The characteristic "saw"-like protrusion of the sutures at the dorsal edge, less so on the ventral edge, can be recognized clearly especially in the older part of the test, and represents the most important characteristic of the subspecies.

Inspite ot the common stratigraphic occurrence with *L. (L.) nodosa nodosa* the independence of *L. (A.) humilis humilis* is preserved always by the presence of an *Astacolus* stage[14]) and furthermore by a different sequence of the chambers. The incomplete spire also distinguishes it from *L. (L.) nodosa nodosa*.

[14]) We do not want to take a stand in the question whether our subspecies still possesses an *Astacolus* stage, or, especially with the very elongated forms, has to be attributed to the *Vaginulinopsis* stage.

A relationship with *L. (A.) nodosa gibber* in the southern Temperate Realm (South Africa, South America) does not exist, as this almost always possesses a well developed spire and shows clear transitions to *L. (L.) nodosa nodosa*.

Occurrence: In the Valanginian it still has not been found, in the Lower Hauterivian it is widely distributed, especially in the *bivirgatus* zone. An occurrence in the Upper Hauterivian is doubtful.

Lenticulina (Astacolus) humilis praecursoria BARTENSTEIN & BRAND 1951

Pl. II, Fig. 18; Textfig. 7

v· 1938 *Cristellaria* D 102 – HECHT, Unterkreide: Tf. 20 b, Fig. 28.
v* 1951 *Lenticulina (Vaginulinopsis) humilis praecursoria* n. subsp. – BARTENSTEIN & BRAND, Valendis: 287; Tf. 5, Fig. 126–127.
v· 1952 *Lenticulina (Vaginulinopsis) humilis praecursoria* BARTENSTEIN & BRAND – BARTENSTEIN, Hauterive-Nomenkl.: 179 [*Cristellaria* D 102 (pars)].
v· 1954 *Lenticulina humilis praecursoria* – BARTENSTEIN & BURRI, schweizer. Faltenjura: Tf. 28.
* 1963 *Astacolus explicatus* n. sp. – ESPITALIÉ & SIGAL, Majunga: 41; Pl. 17, Fig. 6–7.
v· 1965 *Lenticulina (Vaginulinopsis) humilis praecursoria* BARTENSTEIN & BRAND – BARTENSTEIN, Alb.-Nomenkl.: 358 [*Cristellaria* D 102 (pars)].
1973 *Lenticulina (V.) humilis praecursoria* BARTENSTEIN & BRAND – FLETCHER, Speeton Clay: 164; Fig. 1 [*non* Fig. 2–3].
1973 *Lenticulina (A.)* cf. *pachynota* (DAM) – FLETCHER, Speeton Clay: 164; Figs. 1–2 [non *pachynota* DAM].
1973 *Lenticulina (A.) pachynota* (DAM) – FLETCHER, Speeton Clay: Fig. 1 [non Fig. 2–3; non *pachynota* (DAM)].

Remarks and variability of tests: The subspecies is a predecessor of *L. (A.) humilis humilis* and possesses neither the conspicuous limbate sutures nor the dorsal knots. Only occasionally are the dorsal chamberwalls separated somewhat angularly.

During the Lower Hauterivian *L. (A.) humilis praecursoria* could have changed into *L. (A.) humilis humilis* and into *L. (A.) neopachynota* BARTENSTEIN & KAEVER (1973), of which the latter species again develops clear sutures. All three mentioned *Astacolus* forms are distinguished by a spire, mostly incomplete.

The tests of *L. (A.)* cf. *pachynota* (DAM) and of *L. (A.) pachynota* (DAM) from the Middle Valanginian to the Lower Hauterivian of Britain (FLETCHER 1973) belong almost certainly to *L. (A.) humilis praecursoria.*

The occurrences in Madagascar (so far *Astacolus explicatus* ESPITALIÉ & SIGAL) are the first observations outside Europe and the northern Temperate Realm.

Occurrence: Higher Middle Valanginian to Lower Hauterivian. In the Uppermost Hauterivian and Barremian (FLETCHER 1973: *non* Fig. 3) *L. (A.) humilis praecursoria* does not occur any more.

Lenticulina (Astacolus) neopachynota BARTENSTEIN & KAEVER 1973

Pl. II, Fig. 22–25; Textfig. 7

v· 1938 *Cristelleria* D 115 – HECHT, Unterkreide: Tf. 12, Fig. 70–71; Tf. 14a, Fig. 5–6.
* 1946 *Vaginulinopsis pachynota* n. sp. – DAM, Neocom.: 575; Pl. 88, Fig. 5–6.
v· 1952 *Lenticulina (Vaginulinopsis) pachynota* (DAM) – BARTENSTEIN, Barrême-Nomenkl.: 302, 303 [*Cristellaria* D 115].

v· 1956 *Lenticulina* (*Vaginulinopsis*) *pachynota* (DAM) – BARTENSTEIN, engl. Hauterive: 516; Tf. 2, Fig. 55.
· 1959 *Lenticulina* (*Astacolus*) *pachynota* (DAM) – ZEDLER, Moorberg u. Stöcken: 33–34.
· 1961 *Lenticulina* (*Astacolus*) *pachynota* (DAM) – ZEDLER, Oberhauterive: 37; Tf. 8, Fig. 7; Abb. 8.
v· 1967 *Lenticulina* (*Astacolus*) *pachynota* (DAM) – MICHAEL, Barrême I: 43; Tf. 3, Fig. 15; Tf. 4, Fig. 13 [*non* Fig. 38].
v· 1965 *Lenticulina* (*Vaginulinopsis*) *pachynota* (DAM) – BARTENSTEIN, Alb-Nomenkl.: 358 [*Cristellaria* D 115].
* 1973 *Lenticulina* (*Vaginulinopsis*) *neopachynota* nom. nov. – BARTENSTEIN & KAEVER, Helgoland: 223; Tf. 2, Fig. 25–27.
1973 *Lenticulina* (*A.*) *pachynota* (DAM) – FLETCHER, Speeton Clay: Fig. 2–3 [*non* Fig. 1].
1973 *Lenticulina* (*A.*) cf. *pachynota* (DAM)? – FLETCHER, Speeton Clay: 164; Fig. 1–2 [?BARTENSTEIN].
1973 *Lenticulina* (*V.*) *humilis praecursoria* BARTENSTEIN & BRAND – FLETCHER, Speeton Clay: 164; Fig. 2–3 [non Fig. 1: non *humilis praecursoria* BARTENSTEIN & BRAND].

Remarks and variability of tests: "The species is distinguished from congeneric forms by its thickened sutures especially in the media zone of the test and its initial chambers which make up an incomplete coil" (DAM 1946: 575).

It cannot be excluded that confusions are possible in the deeper Middle Barremian between *L.* (*A.*) *neopachynota* and *L.* (*A.*) *nodosa barremiana*, especially if juvenile forms of the latter subspecies are present and the knot-like thickenings on the keel edge are developed only incompletely.

Similar confusions can happen with *L.* (*A.*) *humilis praecursoria* (see the remarks there) in the common stratigraphic range of the higher Lower Hauterivian.

It is probable that the tests of *L.* (*A.*) *pachynota* from the Middle Valanginian to Lower Hauterivian of Britain (FLETCHER 1973: Fig. 1) belong to the range of variation of *L.* (*A.*) *humilis praecursoria* (see the remarks on page 556). *L.* (*V.*) *humilis praecursoria*, however, in the Upper Hauterivian to Lower Barremian (FLETCHER 1973: Fig. 2–3) belongs certainly to *L.* (*A.*) *neopachynota*.

Occurrence: Uppermost Lower Hauterivian and Upper Hauterivian through Barremian, but here probably not until the upper boundary.

Remarks on the regional distribution of *Lenticulina (Lenticulina) nodosa* (REUSS), its subspecies and some related species in the Lower Cretaceous of Germany

The fact that *L.* (*L.*) *nodosa nodosa* has been found in Germany so far only from Middle Valanginian[15]) to Lower Hauterivian is stratigraphically surprising. This is in clear contrast to the world occurrences, where there is a stratigraphic continuity from Upper Berriasian to Aptian.

The occurrences of *L.* (*L.*) *nodosa hilseana* and *L.* (*A.*) *nodosa barremiana* in the Middle Barremian, so far only found in Germany, already represent modified subspecies.

As relatively rich material for comparisons from the German Lower Cretaceous is available, it is not difficult to make systematic as well as stratigraphic analyses of *L.* (*L.*) *nodosa*, and *L.* (*A.*) *humilis* and their subspecies, and with *L.* (*A.*) *neopachynota*.

[15]) In Germany the marine Lower Cretaceous only begins with the Middle Valanginian (= Lower Valanginian of some authors).

It cannot be denied that repeated iterative new developments are also possible within the *Lenticulinae* in the Lower Cretaceous. However, for the group of foraminifera investigated here in the stratigraphically and geographically clearly defined area of Germany, such iterative new developments can be excluded. The same should also be valid for the worldwide occurrences of *L. (L.) nodosa nodosa*, for which we could not find any iterative new developments from other *Lenticulina* species from Berriasian to Aptian (Exceptions: see last paragraph of this chapter).

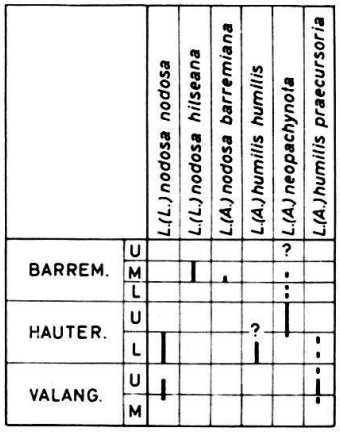

Fig. 7. Distribution of *Lenticulina (Lenticulina) nodosa*, its subspecies and some related species in the Lower Cretaceous of Germany.

Heavy black line = abundant
Dots = rare
Question mark = Occurrence of the species uncertain.

Therefore we regard the new occurrence of *L. (L.) nodosa hilseana* and *L. (A.) nodosa barremiana* in the German Middle Barremian more as a return of *L. (L.) nodosa* from the southern or southeastern Tethyan Sea into the Boreal Sea and as a limited modification of the two mentioned subspecies, limited in time and area.

The delineation of *L. (L.) nodosa nodosa* from *L. (A.) humilis humilis* is always possible without difficulty. Both subspecies in addition complement each other in their stratigraphic importance. This, unfortunately, cannot yet be said of the two other subspecies and species, *L. (A.) humilis praecursoria* and *L. (A.) neopachynota*. Their systematic connection appears to be clear by their stratigraphically relatively distinct separation, that is:

predecessor: *L. (A.) humilis praecursoria*
successor: *L. (A.) neopachynota*.

But here we could also think of an iterative new development of *L. (A.) neopachynota* in the Hauterivian from another species, close to *L. strombecki* (REUSS 1863) or to *L. grata* (REUSS 1863), especially as both species come from the "oberer Hilsthon". Therefore we also deem as justified the retention of *L. (A.) neopachynota* as an independent species.

According to the latest publication by FLETCHER 1973 which includes the distribution of the mentioned species and subspecies in *Britain* (East Coast of Yorkshire: Speeton Clay) it appears important, to contribute a few remarks on the common German–English occurrences with attempts at a stratigraphic correlation.

By applying the German Lower Cretaceous sequence of foraminifera and ostracoda (BARTENSTEIN & KAEVER 1973), the species discussed in this paper are distributed in *Britain* as follows:

L. (*V.*) *humilis praecursoria* from Middle Valanginian 1 to Lowest Hauterivian (*noricum* zone) [and from Uppermost Hauterivian (*seeleyi* zone) to Lower Barremian (*rarocinctum* zone)].[16])

L. (*A.*) cf. *neopachynota* [for cf. *pachynota*: in the Upper Valanginian 1 and] at the boundary Lower to Upper Hauterivian (*bivirgatus* to *capricornu* zone).

L. (*A.*) *neopachynota* [for *pachynota:* from Middle Valanginian 1 to Lowest Hauterivian (*noricum* zone) and] from Upper Hauterivian (*seeleyi* zone) to Lower Barremian (*fissicostatum* zone).

If our suggestions can be proven – descriptions and pictures of the species and subspecies were not published – then the German and British occurrences coincide very well and the connection of the Lower Cretaceous (Valanginian to Barremian) from Britain (FLETCHER, NEALE 1973) via the island of Helgoland (BARTENSTEIN & KAEVER 1973) to the Continent (BARTENSTEIN & BETTENSTAEDT and others) no longer presents systematic and stratigraphic problems.

KEMPER 1963: 473 (see also p. 546) and F. Bettenstaedt (unpublished communication) can be thanked for the discovery of stratigraphically differing, but none the less interesting occurrences of "*L. nodosa*" in the N.W. German Lower Cretaceous (Emsland area).

E. Kemper found the tests, designated as *L.* (*L.*) aff. *nodosa*, in the Lower Aptian (*bodei* zone), whilst F. Bettenstaedt found his material in the lowermost Upper Aptian (Pl. 1, Fig. 20–21).

Similar to the iterative new developments from the foraminifera grouped around *L.* (*L.*) *gaultina* in the British Upper Albian (Pl. II, Fig. 3–4), there separated as an independent species *L.* (*L.*) *angulosa* (CHAPMAN 1896) (see p. 546), we believe also that there is an iterative new development from forms near to *L. muensteri*, especially as this species is still widely distributed in the Aptian.

We do not however regard the material from the N.W. German Aptian as sufficient yet for the nomination of a new species.

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[16]) Brackets [. . .] mean: other species or subspecies; see our comments in the text.

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Plate I

All figures about × 50. – Scanning electron micrographs.
All specimens in lateral views.

Fig. 1–2 *Lenticulina* (*Lenticulina*) *nodosa* (REUSS 1863). Basal Lower Hauterivian, N.W. Berklingen (Asse), type locality of REUSS.

1 = Neotype. – Length: 0.5 mm, width: 0.41 mm, thickness: 0.25 mm, chambers: 11. – C 30169.

2 = Specimen. – Length: 0.6 mm, width: 0.45 mm, chambers: 10. – C 30177.

Fig. 3–17 *Lenticulina* (*Lenticulina*) *nodosa nodosa* (REUSS 1863).

3 = Upper Valanginian 1 (Lower *Dichotomites* zone), well Düste 1, core 536.2–541.3 m (see also BARTENSTEN & BRAND 1951). – Length: 0.55 mm, width: 0.47 mm, thickness: 0,26 mm, chambers: 10. – C 30172.

4 = Upper Valanginian 1, well Siedenburg 2, core 698.6–704.9 m. – Length: 0.85 mm, width: 0.69 mm, thickness: 0.39 mm chambers: 9. – C 30171.

5 = Lower Hauterivian (*noricum* zone), well Siegfried 76. – Length: 0.8 mm, width: 0.65 mm, thickness: 0.5 mm, chambers: 9. – C 30170.

6 = Lower Hauterivian (*noricum* zone), well Gross-Ilsede 3, core 700 m. – Diameter: 0.87 mm, thickness: 0.4 mm, chambers: 10. – C 30184.

7 = Upper Valanginian 1 (Lower *Dichotomites* zone), well Düste 1, core 536.2–541.3 m. Last chamber free from the spire. – Length: 0.82 mm, width: 0.55 mm, thickness: 0.28 mm, chambers: 10. – C 30199.

8–9 = Lower Aptian, Dîmbovicioara zone, Flysch of the Central Carpathians, Rumania, sample No. 142 and 145.

8 = Length: 1.13 mm, width: 1.0 mm, thickness: 0.58 mm, chambers: 10. – C 30189.

9 = Length: 0.62 mm, width: 0.5 mm, thickness: 0.37 mm, chambers: 9. – C 30188.

10 = Lower Hauterivian, Rkoukna (geol. sheet: Talmest), Morocco. – Length: 0.4 mm, width: 0.35 mm, thickness: 0,23 mm, chambers: 8. – C 30178.

11 = Lower Hauterivian, Schweizer Jura, Switzerland, sample No. 24 in BARTENSTEIN & BURRI 1954. – Length: 0.83 mm, width: 0.63 mm, thickness: 0,35 mm, chambers: 10. – C 30186.

12 = Upper Valanginian, well Deby Janisz 2, Central Poland. – Length: 0.57 mm, width: 0.45 mm, thickness: 0.25 mm, chambers: 10. – C 30185.

13–15 = Upper Lower Aptian, Catuane, South Mozambique.

13 = Length: 0.47 mm, width: 0.43 mm, chambers: 9. – C 30 180.

14 = Length: 0.72 mm, width: 0.62 mm, chambers: 10. – C 30179.

15 = Length: 0.49 mm, width: 0.4 mm, chambers: 6.5 – C 30181.

16 = Lower Hauterivian, Coupe du Bois de Carnas (Gard), South France. – Length: 0.55 mm, width: 0.44 mm, thickness: 0.3 mm, chambers: 8.5. – C 30187.

17 = Middle Barremian, Station Road, Trinidad W.I. (see BARTENSTEIN, BETTENSTAEDT & BOLLI 1957). – Length: 0.65 mm, width: 0.58 mm, thickness: 0.3 mm, chambers: 8.5. – C 30190.

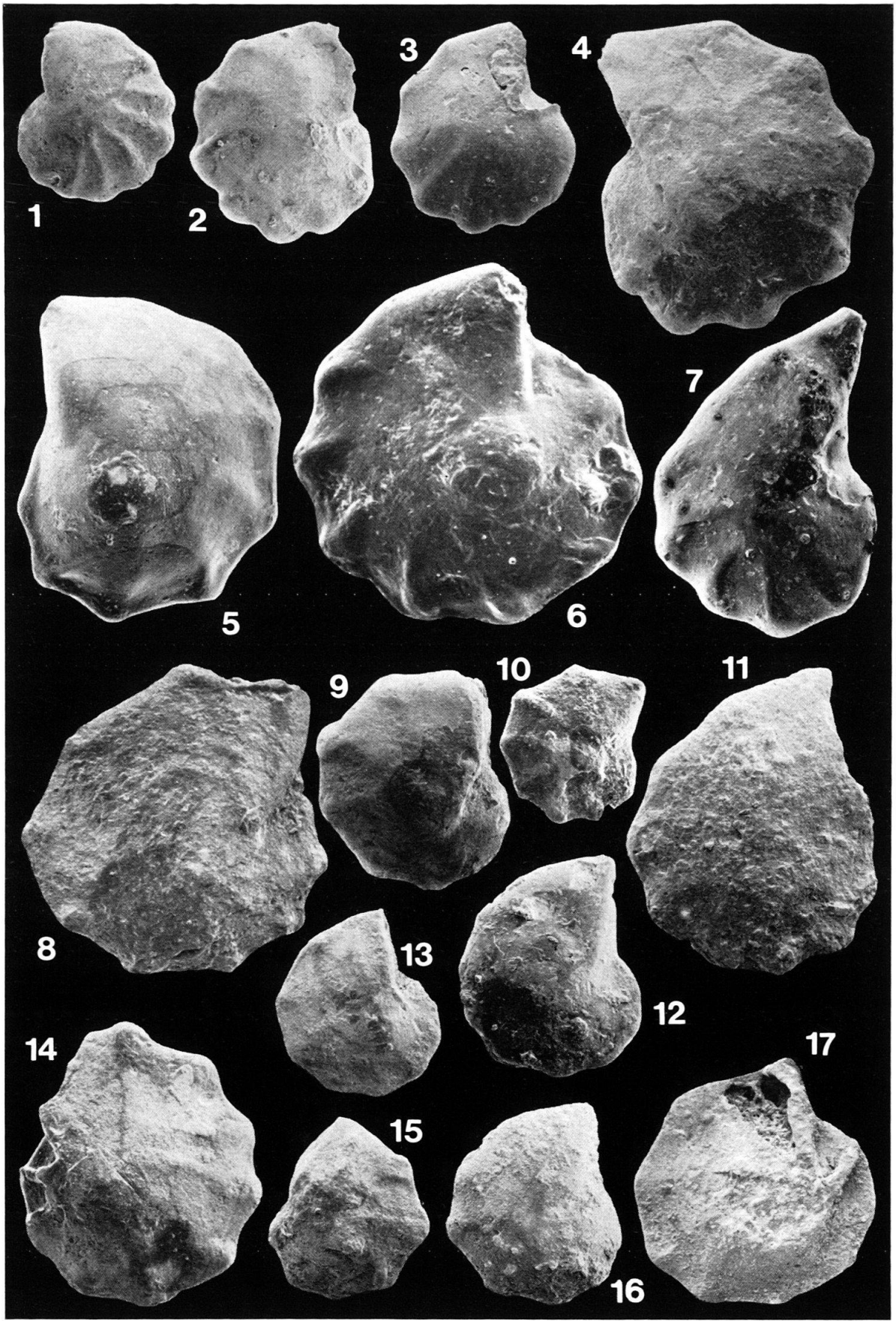
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Plate II

All figures about × 50 (with the exception of fig. 26–29 = × 25). – Scanning electron micrographs. All specimens in lateral view (with the exception of Fig 11 and 12 = front view; Fig. 25 = dorsal view).

Fig. 1–2 *Lenticulina* (*Lenticulina*) species. Lower Upper Aptian, well Georgsdorf 31, Emsland area, core 196 m.
1 = Length: 0.87 mm, width: 0.6 mm, thickness: 0.3 mm, chambers: 8. – C 30182.
2 = Length: 0.7 mm, width: 0.52 mm, thickness: 0.3 mm, chambers: 9. – C 30183.

Fig. 3–4 *Lenticulina* (*Lenticulina*) *angulosa* (CHAPMAN 1896). Lower Gault, Cambridge, England, East Corner of Storey's way.
3 = Diameter: 0.68 mm, thickness: 0.35 mm, chambers: 10. – C 30175.
4 = Diameter: 0.63 mm, chambers: 10. – C 30176.

Fig. 5–6 *Lenticulina* (*Lenticulina*) *nodosa nodosa* (REUSS 1863). Upper Valanginian to Lower Hauterivian, Sundays River formation, well KE 1/71, core 90–100 m, Algoa Basin South Africa.
5 = Length: 0.5 mm, width: 0.4 mm, thickness: 0.25 mm, chambers: 9. – C 30192.
6 = Length: 0.4 mm, width: 0.3 mm, thickness: 0.18 mm, chambers: 9. – C 30193.

Fig. 7–8 *Lenticulina* (*Astacolus*) *nodosa gibber* ESPITALIÉ & SIGAL 1963. Upper Valanginian to Lower Hauterivian, Sundays River formation, Algoa Basin, South Africa.
7 = Unrolled stage. – Length: 0.85 mm, width: 0.42 mm, thickness: 0,2 mm, chambers: 12. – C 30195.
8 = Evolute spire. – Length: 0.6 mm, width: 0.4 mm, thickness: 0.2 mm, chambers: 9.5. – C 30194.

Fig. 9–12 *Lenticulina* (*Lenticulina*) *nodosa nodosa* (REUSS 1863). Upper Valanginian to Lower Hauterivian, Pampa Rincón formation, well Pampa Rincón X-2, core 1679–1689 m, Tierra del Fuego, Argentina, South America. Association of different types of test in the same sample (see also Fig. 13–15)
9–10 = *Lenticulina* test, 11–12 = *Darbyella* test.
9 = Diameter: 0.55 mm, chambers: 10. – C 30210.
10 = Length: 0.5 mm, width: 0.37 mm, chambers: 8. – C 30212.
11 = Apertural view. – Length: 0.65 mm, thickness: 0.32 mm. – C 30214.
12 = Apertural view. – Length: 0.63 mm, thickness: 0.29 mm. – C 30209.

Fig. 13–15 *Lenticulina* (*Astacolus*) *nodosa gibber* ESPITALIÉ & SIGAL 1963. Upper Valanginian to Lower Hauterivian, Pampa Rincón formation, well Pampa Rincón X-2, core 1679–1689 m, Tierra del Fuego, Argentina, South America.
13 = Length: 0.74 mm, width: 0.49 mm, chambers: 9. – C 30208.
14 = Length: 0.77 mm, width: 0.37 mm, chambers: 10. – C 30211.
15 = Length: 0.72 mm, width: 0.4 mm, chambers: 11. – C 30213.

Fig. 16–17 *Lenticulina* (*Lenticulina*) *nodosa nodosa* (REUSS 1863). Kimmeridgian, well in Somalia, East Africa.
16 = Length: 0.5 mm, width: 0.43 mm, thickness: 0.3 mm, chambers: 8. – C 30207.
17 = Length: 0.6 mm, width: 0.48 mm, thickness: 0.35 mm, chambers: 9. – C 30206.

Fig. 18 *Lenticulina* (*Astacolus*) *humilis praecursoria* BARTENSTEIN & BRAND 1951. Upper Valanginian 1 (Lower *Dichotomites* zone), well Düste 1, core 541.3–543.6 m (see also BARTENSTEIN & BRAND 1951). – Length: 0.57 mm, width: 0.32 mm, thickness: 0.21 mm, chambers: 8. – C 30196.

Fig. 19–20 *Lenticulina* (*Astacolus*) *humilis* (REUSS 1863). Basal Lower Hauterivian, N.W. Berklingen (Asse), type locality of REUSS.
19 = Neotype. – Length: 0.57 mm, width 0.33 mm, thickness: 0.21 mm, chambers: 8. – C 30173.
20 = Specimen. – Length: 0.55 mm, width: 0.37 mm, thickness: 0.25 mm, chambers: 8. – C 30174.

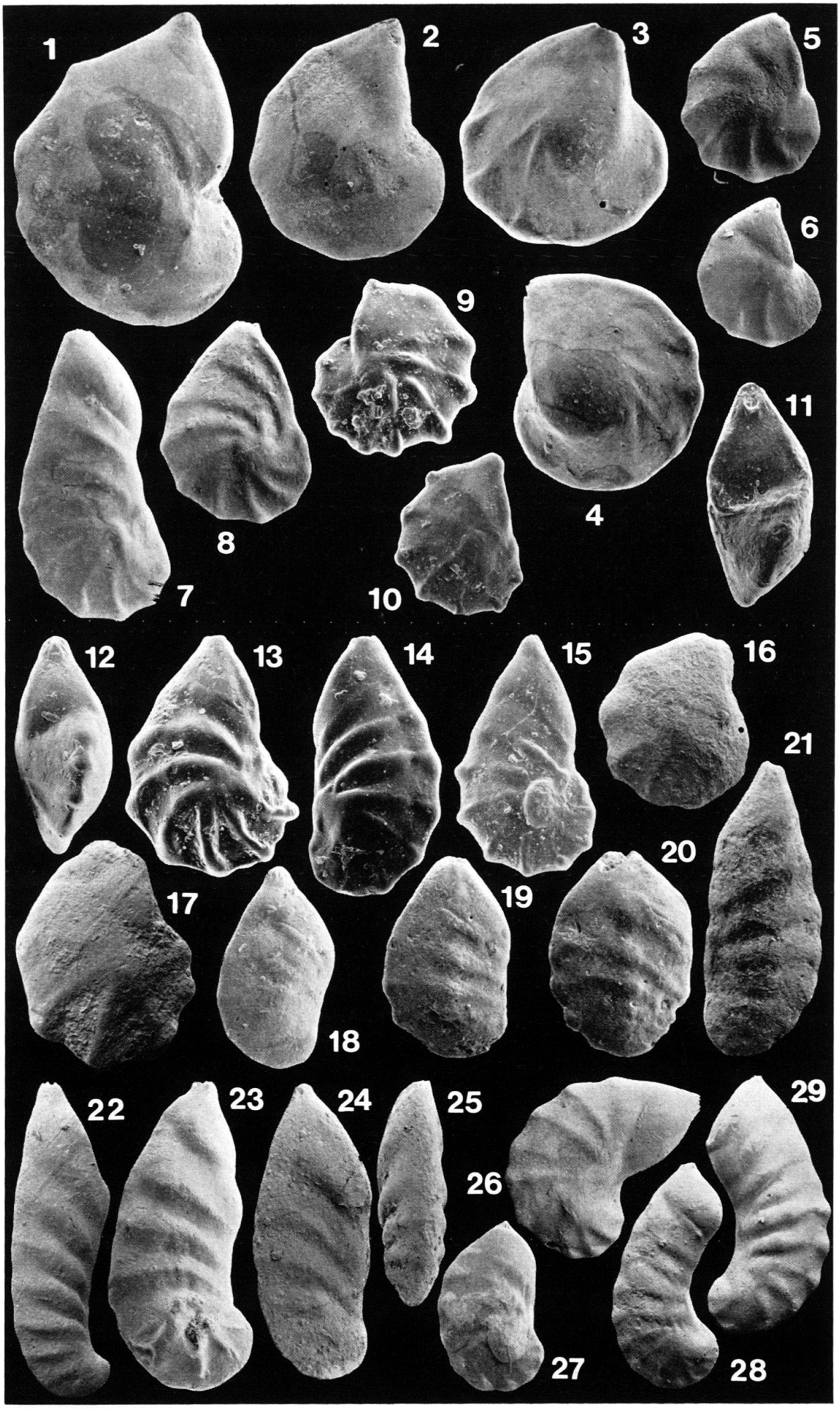
Fig. 21 *Lenticulina* (*Astacolus*) *humilis humilis* (REUSS 1863). Lower Hauterivian (*noricum* zone), well Harsebruch 1, core 830.8–837.7 m. – Length: 0.83 mm, width: 0.32 mm, thickness: 0.22 mm, chambers: 12. – C 30191.

Fig. 22–23 *Lenticulina* (*Astacolus*) *neopachynota* BARTENSTEIN & KAEVER 1973. Upper Hauterivian (boundary *hildesiense/seeleyi* zone), Helgoland, sample No. 22 (see BARTENSTEIN & KAEVER 1973). Two different types of generation.
22 = Length: 0.88 mm, width: 0.28 mm (in the upper portion of the test), thickness: 0.18 mm, chambers: 10. – C 30198.
23 = Length: 0.88 mm, width: 0.37 mm, thickness: 0.26 mm, chambers: 10. – C 30197.

Fig. 24–25 *Lenticulina* (*Astacolus*) *neopachynota* BARTENSTEIN & KAEVER 1973. Upper Hauterivian, well Georgsdorf 5, core 400–402.7 m.
24 = Length: 0.83 mm, width: 0.42 mm, thickness: 0.21 mm, chambers: 9. – C 30203.
25 = Dorsal view. – Length: 0.64 mm, width: 0.3 mm, thickness: 0.22 mm, chambers: 7. – C 30204.

Fig. 26–27 Transitional forms from *Lenticulina* (*Lenticulina*) *nodosa hilseana* n.subsp. to *Lenticulina* (*Astacolus*) *nodosa barremiana* MICHAEL 1967.
26 = Lower Barremian (*elegans* zone), Helgoland, sample No. 56 (see BARTENSTEIN & KAEVER 1973). – Length: 1.25 mm, width: 0.65 mm, thickness: 0.41 mm (lower part), 0.31 mm (upper part), chambers: 12. – C 30200.
27 = Lower Middle Barremian, Brickyard Roklum. – The test shows two ribs on the last but one chamber. – Length: 0.97 mm, width: 0.52 mm, chambers: 12. – C 30205.

Fig. 28–29 *Lenticulina* (*Astacolus*) *nodosa barremiana* MICHAEL 1967.
28 = Lower Middle Barremian, Brickyard Roklum. – Length: 1.3 mm, width: 0.43 mm, thickness: 0.47 mm (spire), 0.31 mm (upper part), chambers: 16. – C 30202.
29 = Lower Middle Barremian (*elegans* zone), Helgoland, sample No. 56 (see BARTENSTEIN & KAEVER 1973). – Length: 1.45 mm, width: 0.5 mm, thickness: 0.37 mm, chambers: 13. – C 30201.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