

ABSTRACT

Additional evidence to support the numerous observations that the exterior chamber wall of all "calcareous perforate" foraminifera thickens by one lamella for each new chamber is advanced. Hofker's contrary opinions are refuted. Double septa are also discussed.

Comments on wall structure of foraminifera

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In one of his recent papers Hofker (1962) discusses the wall structure of some planktonic and benthonic foraminifera. Several of Hofker's statements appear to be in conflict with well-established facts and call for a brief comment.

Hofker states that: a) "secondary thickening" occurs only in a few benthonic foraminifera and then always on the surface of the test of the fully mature individual, once and not "per instar"; obliquely cut walls may give the appearance of thickened walls; b) double septa occur only in some "rotalid" foraminifera, viz. *Gavelinella*, *Gavelinopsis*, *Gavelinonion*, *Stensioina*, and *Rotalia* s.s., while the septa of such genera as *Valvulineria*, *Cancris*, *Globorotalia*, *Globigerina*, *Globorotalites*, *Cibicides* s.s. and *Globotruncana* are always simple; c) in his opinion, Smout's and the present writer's alleged findings that each chamber receives the "second lamella" when the next-following chamber is formed do not correspond to the facts; d) the "canals" in the keels of *Globotruncana* are formed by spaces between "loosely adhering" chamber walls. Finally, Hofker states that Smout's (1954) schematic drawings of lamellar structure – reproduced and partly modified by the present writer – are "fantastic" and the photomicrographs given by Smout (op. cit.) and by the present writer (1957, 1958) are "illusory pictures", as demonstrated by Hofker's drawings. As a result of these considerations, Hofker rejects this writer's "theory" on bilamellid foraminifera.

In stating that the "secondary thickening" occurs only in a few benthonic foraminifera, whenever conditions permit, always on the surface of the test of fully mature individuals, and only once, not per instar (as the drawings of Smout (op. cit.) tend to show) Hofker ignores the large number of excellent photomicrographs published by various authors. These photos show beyond any doubt the lamellar structure in the early chambers, per instar, as fully explained by Smout, both in benthonic and planktonic foraminifera, in fact in all truly "perforate" ones, no matter whether oblique or centered sections are viewed. A large number of these

photos show the *individual lamellae* added one per instar, *not just simple thickening* of the walls which could be interpreted as an appearance produced by oblique sections. No matter how oblique the sections, no lamellae would be seen so clearly that they can often be counted if they did not exist. Furthermore, Hofker seems also to ignore the fact that, even if the individual lamellae can not be seen clearly (a matter elaborated upon elsewhere; Reiss, in press; Smout, op. cit.), the thickness of the outer walls of spiral forms is not greater in the last coil, but increases gradually and decreases again in successive coils, a fact which would be impossible if the "secondary thickening" were added only "on the surface of the test of fully mature individuals." The laws according to which the thickness of the walls changes in successive coils of lamellar spiral foraminifera have been clearly explained by Smout (1954) and need no repetition here. An attentive study of some of the published photos will convince the reader of the correctness of Smout's explanations (see references).

One is at a loss trying to explain on the basis of Hofker's statements such sections as those presented by Glaessner and Wade (1959, pl. 2, figs. 4, 8; pl. 3, figs. 5–7) (cf. also text-figs. 1–2), by Smout (1954, on numerous plates), by Nyholm (1961, pl. 3, fig. 1), by Reiss and Merling (1958, pl. 1, figs. 1–6) or by the present writer in the publications cited at the end of this note. It is equally difficult to dismiss outright the lamellar structure of planktonic foraminifera without ignoring completely the structural features shown by the sectioned specimens figured, e. g., by Banner and Blow (1959), Hagn and Zeil (1954) (see especially fig. 11 on pl. 7), by Pessagno (1960) (particularly pl. 1, figs. 1, 5 and pl. 2, fig. 1) or by the present writer (1957, pl. 20, figs. 6, 8).

In accepting Hofker's statements concerning the "illusion" of lamellar addition per instar one is also compelled to disregard all findings of many authors (among them Smout and the present writer) concerning ornamentation, lateral chamberlets, umbilical cavities and pores on the one hand, and lamellar superposition

on the other, as well as the observations on living individuals pertaining to the addition of lamellae and pore plugs as described by Arnold (1954), LeCalvez (1947), Myers (1943) and Nyholm (1961).

In the present writer's opinion the evidence given by Hofker is insufficient to label hundreds of observations as fantastic and large numbers of reliable, unretouched photomicrographs as illusory. The lamellar structure of all perforate foraminifera by addition of lamellae per instar remains a demonstrable fact.

As far as the double septa of foraminifera are concerned, Hofker's statements again ignore demonstrable facts. To disprove Hofker's claims that such genera as *Globorotalites*, *Cibicides*, *Globorotalia*, *Globigerina* and *Globotruncana* have always simple septa (and that Hofker has never seen anything which would suggest double septa in *Globotruncana*) one can only refer to the descriptions and especially to the photomicrographs given by Belford (1960), Bronnimann and Brown (1956), Kaever (1958), Ksiazkiewicz (1954), Reichel (1950), Reiss (1958, 1959 and especially 1960). However, photomicrographs are not accepted by Hofker as convincing evidence. Incidentally, Nyholm's suggestion (1961) that the "controversy" between Hofker and the present writer concerning the number of lamellae forming the septa of *Cibicides* may stem from the stage in the life cycle in which a specimen is examined is not supported by the examination of large numbers of thin sections of various species of *Cibicides*, including *C. lobatulus*. All have double septa and this is shown even in the photos (unsatisfactory as far as wall structure is concerned) given by Nyholm (op. cit., pl. 3, fig. 2). It is noteworthy that a study of large suites of well-preserved specimens of *Planorbulina* and *Planorbulinella* from many localities has shown these genera also to have primary double septa (Reiss, in press, but cf. Reiss, 1958).

Hofker's statement pertaining to Smout's and the present writer's finding that the "second lamella" is deposited when the next-following chamber is formed is unintelligible in the context of Hofker's discussion of planktonic foraminifera (Hofker, op. cit.). The present writer suspects that Hofker refers both to Smout's (1954, 1955) description of the doubling of the septa by a septal flap in the Rotaliidea, s. s., which is *secondary*, as the septal flap is part of the toothplate of the next-following chamber (Reiss and Merling, 1958); and to the description of the *primarily* double chamber walls (hence septa) of the Bilamellidea as given by the present writer (op. cit.) (cf. also Belford, Bronnimann and Brown, Glaessner and Wade, Reichel, op. cit.). Hofker disregards most obviously the fundamental differences between the rotaliid (s.s.) and the bilamellid groups - i. e., the differences between the septal flap and the inner lining - and for this reason includes, e. g., *Gavelinella* and *Rotalia* in the same group of "rotalid" (sic!, Hofker's sense) foraminifera. On the basis of the resulting confusion, Hofker also postulates relation-

ships (e. g., between *Pararotalia* and *Globorotalia*) which are entirely unwarranted.

An examination of photomicrographs in the publications referred to in this note shows that the "canals" (or "passages" as this writer now prefers to call them) in the keels of *Globotruncana* and *Globorotalia* are situated - like the "dark lines" and "dots" within the septa of these genera - between the outer lamella and the inner lining, and not between consecutive outer lamellae, as would follow from Hofker's statements (Hofker also denies, however, the existence of double walls in the planktonic foraminifera; see above). To this the present writer can only add that the spaces ("passages") filled with brownish substance as they occur in the septa of bilamellid foraminifera (cf. Bronnimann and Brown, Glaessner and Wade, Reiss, op. cit.) continue into peripheral extensions not only in the Globotruncanidae and Globorotaliinae (cf. Bronnimann and Brown, Pessagno, Reichel, Reiss, op. cit.), but also as thin, incipient passages in various Gavelinellidae. This feature can be clearly seen in exactly equatorial sections (cf. Reiss, 1957, pl. 18, figs. 1-3; 1958, pl. 3, figs. 13-15).

Finally, the present writer is not aware of having offered any "theory" concerning the bilamellid foraminifera, as suggested by Hofker. He has merely suggested a reclassification of the foraminifera based on observations on many thousands of oriented thin-sections and dissected specimens, as well as on a careful study of the pertinent literature. A richly illustrated, more comprehensive paper dealing with these observations is in press.

BIBLIOGRAPHY

- ARNOLD, Z. M.
1954 - *Discorinopsis aguayoi* (Bermúdez) and *Discorinopsis vadesens* Cushman and Bronnimann: A study of variation in cultures of living foraminifera. Cushman Found. Foram. Res., Contr., vol. 5, pt. 1, pp. 4-13, pls. 1-2, tf. 1.
- BANNER, F. T. and BLOW, W. H.
1959 - *The classification and stratigraphical distribution of the Globigerinaceae*. Palaeontology, vol. 2, pt. 1, pp. 1-27, pls. 1-3, tfs. 1-5.
- BELFORD, D. J.
1960 - *Upper Cretaceous foraminifera from the Toolonga calcilutite and Gingin chalk, Western Australia*. Australia, Bur. Min. Res. Geol. Geophys., Bull. no. 57, pp. 1-198, pls. 1-35, tfs. 1-14.
- BRONNIMANN, P. and BROWN, N. K.
1956 - *Taxonomy of Globotruncanidae*. Eclogae Geol. Helv., vol. 48, no. 2, pp. 503-561, pls. 20-24, tfs. 1-24.
- GLAESSNER, M. F. and WADE, MARY
1959 - *Revision of the foraminiferal family Victoriellidae*. Micropalaeontology, vol. 5, no. 2, pp. 193-212, pls. 1-3, tfs. 1-6.
- HAGN, H. and ZEIL, W.
1954 - *Globotruncanen aus dem Ober-Cenoman und Unter-Turon der bayerischen Alpen*. Eclogae Geol. Helv., vol. 47, no. 1, pp. 1-60, pls. 1-7, tfs. 1-3.

- HOFKER, J.
1962 - *Studien an planktonischen Foraminiferen*. Neues Geol. Jahrb. Pal., Abh., vol. 114, no. 1, pp. 81-134, tfs. 1-85.
- KAEVER, M.
1959 - *Über Globorotalites Brotzen, 1942 und Conorotalites nov. gen.* Geol. Jahrb., vol. 75, pp. 433-436, tfs. 1-2.
- KSIĄZKIEWICZ, M.
1956 - *Jura i Kreda Bachowic*. Polsk. Towarz. Geol., Rocznik (Soc. Géol. Pologne, Ann.), vol. 24, nos. 2-3, pp. 121-405, pls. 11-23, tfs. 1-61.
- LE CALVEZ, J.
1947 - *Les perforations du test de Discorbis erecta (foraminifères)*. Lab. Mar. Dinard, Bull., vol. 29, pp. i-4, tf. 1.
- MYERS, E. H.
1943 - *Biology, ecology and morphogenesis of a pelagic foraminifer*. Stanford Univ., Publ., Biol. Ser., vol. 9, no. 1, pp. 1-30, pls. 1-4.
- NYHOLM, K.-G.
1961 - *Morphogenesis and biology of the foraminifer Cibicides lobatulus*. Uppsala, Zool. Bidrag, vol. 33, pp. 157-196, pls. 3-5, tfs. 1-21.
- PESAGNO, E. A.
1960 - *Thin-sectioning and photographing smaller foraminifera*. Micropaleontology, vol. 6, no. 4, pp. 419-423, pls. 1-2, tfs. 1-3.
- REICHEL, M.
1950 - *Observations sur les Globotruncana du gisement de la Breggia (Tessin)*. Eclogae Geol. Helv., vol. 42, no. 2, pp. 596-617, pls. 16-17, tfs. 1-7.
- REISS, Z.
1957 - *The Bilamellidea, nov. superfam. and remarks on Cretaceous globorotaliids*. Cushman Found. Foram. Res., Contr., vol. 8, pt. 4, pp. 127-145, pls. 18-20, tfs. 1-7.
1958 - *Classification of lamellar foraminifera*. Micropaleontology, vol. 4, no. 1, pp. 51-70, pls. 1-5.
1959 - *The wall-structure of Cibicides, Planulina, Gyroidinoides and Globorotalites*. Micropaleontology, vol. 5, no. 3, pp. 355-357, pl. 1.
1960 - *Structure of so-called Eponides and some other rotaliiform foraminifera*. Israel, Geol. Survey, Bull., no. 29, pp. 1-28, pls. 1-3, tfs. 1-2.
- REISS, Z. and MERLING, P.
1958 - *Structure of some Rotaliidea*. Israel, Geol. Survey, Bull., no. 21, pp. 1-19, pls. 1-5.
- SMOUT, A. H.
1954 - *Lower Tertiary Foraminifera of the Qatar Peninsula*. Brit. Mus. (Nat. Hist.), Monogr., pp. iii-ix, 1-96, pls. 1-15, tfs. 1-44.
1955 - *Reclassification of the Rotaliidea (Foraminifera) and two Cretaceous forms resembling Elphidium*. Washington Acad. Sci., Jour., vol. 45, no. 7, pp. 201-210, tfs. 1-10.