

COSTELLAGERINA, A NEW LATE CRETACEOUS GLOBIGERINE FORAMINIFERAL GENUS

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ABSTRACT

The new Late Cretaceous genus *Costellagerina*, with *Rugoglobigerina bulbosa* Belford as type species, includes cosmopolitan Cenomanian-early Campanian meridionally costellate forms which are morphologically distinct from *Rugoglobigerina* and *Hedbergella*. Meridionally aligned costellation, one of the unique textural ornamentations restricted to Cretaceous planktonic foraminifera, probably developed from the fusion of pustulose projections (spine bases) which, with increased calcification in later ontogeny, assumed an overgrown beaded appearance.

INTRODUCTION

Late Cretaceous globigerine foraminifera are a large and variable group which have only recently gained prominence in Cretaceous biostratigraphic and taxonomic work. Originally included in the "catch-all" taxon *Globigerina cretacea* d'Orbigny, the initial attempt to distinguish simple Cretaceous globigerine-shaped species from the true *Globigerina* d'Orbigny was made by Brönnimann and Brown (1958) who erected the genus *Hedbergella* (emended Banner and Blow, 1959) to accommodate this group. The first comprehensive systematic study of Cretaceous globigerines was done by Pessagno (1967) who introduced the genera *Archaeoglobigerina*, *Loeblichella* and *Whiteinella* which, together with *Hedbergella* and *Globigerinelloides*, constitute the Cretaceous globigerine-shaped taxa (Douglas and Rankin, 1969). Michael (1972) added the genus *Favusella* which includes all species with "cancellate" wall ornamentation which were previously referred to as *Globigerina washitensis* Carsey. Masters (1977), however, retrogressively reintroduced the genus *Globigerina* into the Cretaceous. The Cretaceous forms are globigerine only in the sense that they possess uniformly subglobular and subspherical chambers, are mostly trochospiral, and have interiomarginal, umbilical to extraumbilical primary aperture. Although they constitute the basic stock of planktonic foraminifera in the Cretaceous and Cenozoic, the Cretaceous globigerines differ in several respects, most notably wall texture, from their subsequent morphotypic counterparts. In the Cretaceous, the globigerines assumed a peculiar ornamental pattern that was discontinued before the beginning of the Tertiary and was never repeated.

While textural features of the wall surfaces have become increasingly important in the classification and phylogenetic interpretation of Cenozoic planktonic foraminifera, they have received relatively little notice among the Cretaceous forms, probably because of limited investigation. The only Cretaceous genera erected primarily on a textural basis are *Rugoglobigerina* Brönnimann (1952) for Campanian-Maastrichtian species with meridionally arranged costellae and the already mentioned *Favusella*. We do not, by any means advocate an hierarchical arrangement based on single characters, but do suggest that there is room for expansion in the use of textural features in the classification of Cretaceous forms.

Most commonly, the Cretaceous globigerine wall is ornamented with isolated pustules (we use the term pustule loosely, to include any projection from the wall surface) interspersed among pores. The pustules vary in sharpness and density, and commonly there is a tendency for them to decrease in size and density towards the final chamber. Therefore, the ultimate chamber and quite often most of the last whorl may have a smooth appearance which is accentuated if the pores are minute. This type of texture with varying degrees of pustule density occurs in *Hedbergella*, *Archaeoglobigerina*, *Globigerinelloides*, *Whiteinella*, and *Loeblichella*.

On other Cretaceous globigerines there is a pronounced tendency for the pustules to fuse into short or elongate ridges called costellae and for the pustules and costellae to become aligned in a preferred orientation. They are arranged either parallel to the periphery (Banner and Blow, 1959; Caron, 1978; McNulty and Barr, 1979) or they are meridionally aligned.

Pustules and costellae that are distributed randomly over the surface or aligned parallel to the equatorial periphery occur among diverse pre-Campanian globigerines and appear to have no taxonomic value. However, meridionally aligned costellae are unique and occur among a restricted group. The view that development of these costellae is subject to ecologic controls (e.g., Blow, 1979) is not supported by recent evidence. A most unique textural form occurs in the Early Cretaceous-early Cenomanian genus *Favusella*, where a smooth string-like, webbed network is superimposed on an equally smooth wall and numerous minute pores are contained within the polygonally framed ridges of the web. This textural ornamentation mimics the cancellate texture seen in the Tertiary globigerines but the stringy nature of the network is totally unique. As shown by Grigelis and Gorbachik (1980) this wall ornamentation occurs on Jurassic globigerine planktonic foraminifera.

Since these types of textural ornamentation of the

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Cretaceous globigerines do not ever recur in the Cenozoic, it is reasonable to assume that this characteristic of the test is genetically controlled and taxonomically significant. Brönnimann (1952) used the meridionally arranged costellae to define *Rugoglobigerina* and most subsequent workers have referred Cretaceous meridionally costellate species to that genus (Belford, 1960; Bolli, 1959; Douglas, 1969; Frerichs 1979; Frerichs and Dring, 1981; Hanzlikova, 1972). However, Barr (1972), Douglas (1969), McNulty and Barr (1979), and Saint-Marc (1973) placed pre-Campanian meridionally costellate globigerine species under *Hedbergella*. Since unique ornamentation is a generic character among Cretaceous planktonic foraminifera (Belford, personal communication; Pessagno, 1967), and was used to distinguish *Favusella* from *Hedbergella* (Michael, 1972), the new genus *Costellagerina* is erected here to accommodate Late Cretaceous forms that have meridionally aligned costellae and pustules but lack an umbilical cover plate.

SYSTEMATICS

Superfamily GLOBIGERINACEA Carpenter,
Parker and Jones, 1862

Family ROTALIPORIDAE Sigal, 1958

Subfamily HEDBERGELLINAE Loeblich
and Tappan, 1961

Genus **COSTELLAGERINA**, new genus

Type species. Rugoglobigerina bulbosa Belford, 1960, p. 94, pl. 26, figs. 1–3, 4–5, 6–8, 9–10; text-fig. 7.

Definition. Test low to medium trochospiral; outline sub-circular, ovate, or quadrate; equatorial periphery strongly lobulate; axial periphery broadly rounded; chambers globose; aperture an interior marginal, low arch, umbilical to slightly extraumbilical, bordered by a porticus; umbilicus open, small to moderate in size. Wall hyaline, ornamented with pustules and costellae which are meridionally arranged.

Remarks. *Costellagerina* differs from *Hedbergella* in the meridionally aligned pustules and costellae. According to Banner and Blow (1959) *Hedbergella* has no costellae. The types of *Hedbergella libyca* Barr, 1972 in the collection of the U.S. National Museum (holotype U.S.N.M. 67903; paratypes U.S.N.M. 186370) are here placed under *Costellagerina* because they display distinct and meridionally arranged costellae. The middle Cenomanian form *H. costellata* Saint-Marc

(1973) which was described from Lebanon was considered a synonym of *H. libyca* by McNulty and Barr (1979).

Costellagerina is distinguished from the Campanian-Maastrichtian genus *Rugoglobigerina* by the absence of umbilical cover plates (tegillae) and imperforate peripheral bands. Because of the absence of tegillae Belford (personal communication) recently removed from *Rugoglobigerina* western Australian Santonian forms which he previously (Belford, 1960) referred to as *R. bulbosa*, and *R. pilula*, while *R. plana* which lacks a well defined meridional ornamentation was placed under *Hedbergella*. The occurrence of *Costellagerina bulbosa* (Belford) and *C. pilula* (Belford) in the Santonian-early Campanian of California (Douglas, 1969; Douglas and Sitter, 1966), the U.S. Western Interior (Frerichs, 1979; Frerichs and Dring, 1981), the Carpathians (Hanzlikova, 1972), and in Nigeria and Tunisia (this study) attests to the cosmopolitan distribution of this genus. The wide latitudinal range of these species, which display a persistent pattern of meridionally aligned costellae, lends no credence to Blow's (1979) argument that this type of ornamentation is ecophenotypic and confined to the low latitudes. Since *Rugoglobigerina* has a Campanian-Maastrichtian range (Belford, personal communication; Hofker, 1961; Pessagno, 1967), and evolved from rugose globotruncanids (Olsson, 1964), meridionally costellate hedbergellid forms in older strata (Bolli, 1959) are here referred to *Costellagerina*.

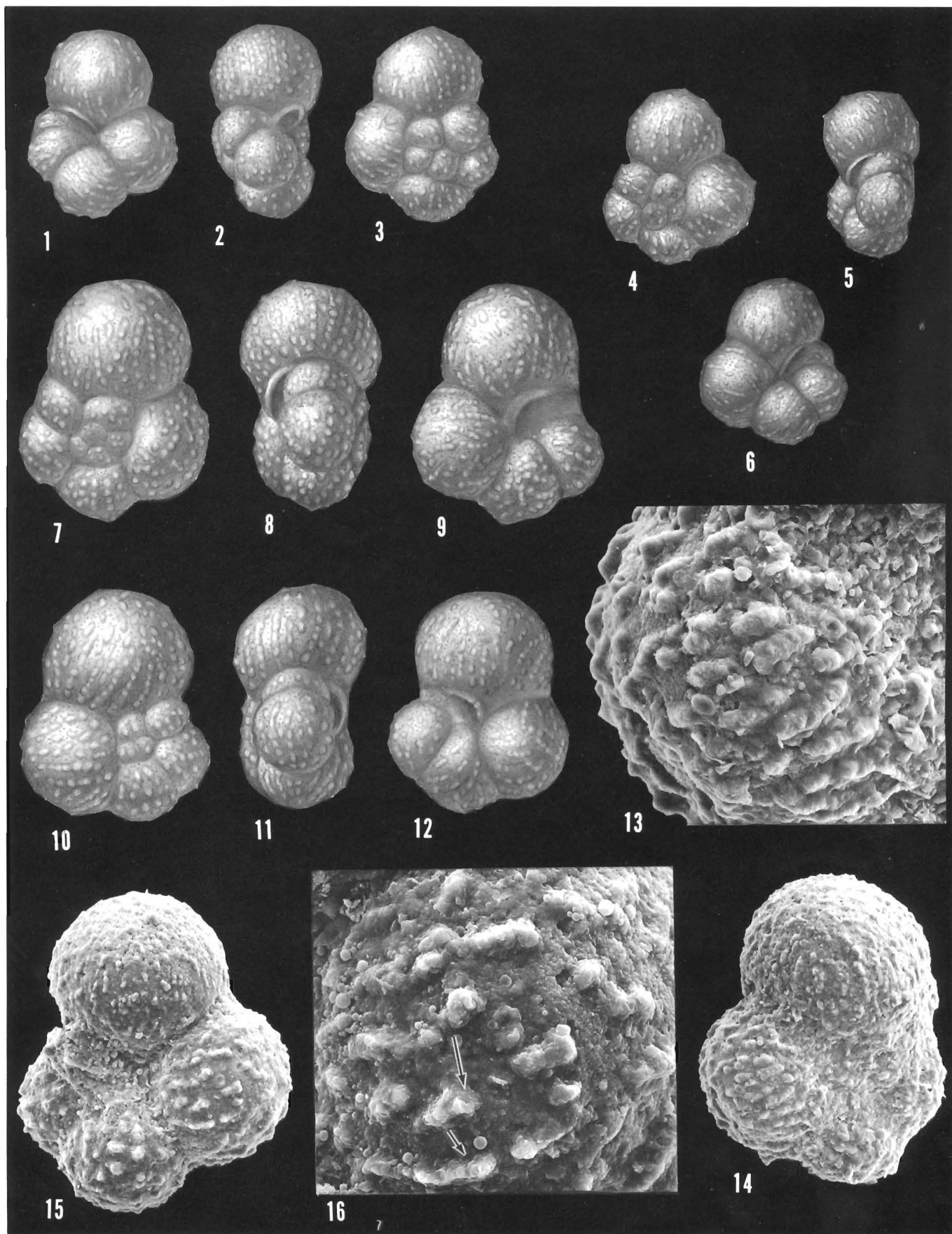
Whiteinella Pessagno, 1967, by definition includes sub-globotruncanid forms with a very shallow umbilicus but does not include meridionally costellate forms, hence the New Jersey Coniacian-early Campanian forms which exhibit this characteristic feature and were placed in *Whiteinella* by Petters (1977) are here included in *Costellagerina*. Although *Archaeoglobigerina* Pessagno, 1967 may exhibit weakly aligned pustules (Douglas and Rankin, 1969), the presence of tegillae separates this genus from *Costellagerina*. *Loeblichella* Pessagno, 1967 is distinguished from *Costellagerina* by its spiral sutural supplementary apertures and the absence of meridionally aligned costellae.

Costellagerina is placed in the family Rotaliporidae (emended Pessagno, 1967) because this family includes globigerine forms with an extraumbilical-umbilical aperture, and portici which extend over the aperture. Pessagno (1967) considered the Rotaliporidae the basic

PLATE I

Magnifications for Figs. 1–12 are all $\times 230$.

1–3 *Costellagerina bulbosa* (Belford). Hypotype, USNM (United States National Museum) 337540. 1, umbilical view; 2, edge view; 3, spiral view. Top of Nkalagu Formation at Ogugu near Awgu, SE Nigeria, about 8 m from top of stream section. 4–6 *Costellagerina bulbosa* (Belford). Hypotype, USNM 337541. 4, spiral view; 5, edge view; 6, umbilical view. Top of Nkalagu Formation at Ogugu near Awgu, SE Nigeria, about 8 m from top of stream section. 7–9 *Costellagerina bulbosa* (Belford). Hypotype, USNM 337542. 7, spiral view; 8, edge view; 9, umbilical view. Lower part of El Bagra Formation, Oued Bahloul anticline, Tunisia. 10–12 *Costellagerina bulbosa* (Belford). Hypotype USNM 337543. 10, spiral view; 11, edge view; 12, umbilical view. Lower part of El Bagra Formation, Oued Bahloul anticline, Tunisia. 13–14 *Costellagerina bulbosa* (Belford). 13, penultimate chamber showing overgrown and beaded costellae, $\times 284$. 14, umbilical view, $\times 108$. Lower part of El Bagra Formation, Oued Bahloul anticline, Tunisia. 15–16 *Costellagerina bulbosa* (Belford). 15, umbilical view, $\times 145$. 16, penultimate chambers with arrows pointing to fused pustules which have a spine base type of structure, $\times 284$. Top of Nkalagu Formation at Ogugu, SE Nigeria.



stock from which most Late Cretaceous planktonic foraminifera evolved. *Costellagerina* most likely evolved from *Hedbergella*.

The name *Costellagerina* is derived from "costellae" which Banner and Blow (1959) defined as "ridge-like thickenings . . . typically running in a meridional direction to converge at a 'pole' at the mid-point of the chamber periphery." *Costellagerina* probably acquired its distinctive ornamentation among the Rotaliporidae by a fusion of the pustules, as previously noted by Blow (1979, p. 1366). The wall surface of *Costellagerina*, like that of *Hedbergella* has minute, widely spaced pores which are reminiscent of the Early Cretaceous genus *Favusella*. The narrow, stringy costellae also invite a comparison with the Early Cretaceous form, but there is no tendency whatsoever in *Costellagerina* for the costellae to form a web-like or cancellate pattern. That the costellae are formed by a fusion of pustules can be seen in Pl. 1, Fig. 15 where short ridge segments are composed of joined pustules.

What are these topographic expressions that we, following precedent, have loosely referred to as pustules? Almost certainly they are not true pustules as defined by Hemleben (1975) because they do not appear to be extensions of the primary laminated wall. For the same reason, and because they are neither hollowed nor pyramidal in shape, they cannot be referred to the muricae of Blow (1979, p. 400). The pustulose projections of *Costellagerina* compare most favorably with the spine bases of spinose species. They are composed of thin, tiered crystallites with angular, acicular caps that appear to be essentially the same as the remnants of broken, elongate spines of modern spinose species (Pl. 1, Figs. 15, 16; Cifelli, 1982). The costellae, formed by the fusion of these pustulose projections or spine bases, are in good agreement with the ridges of Cenozoic spiny species. The principal difference is that costellae are oriented meridionally, a peculiarly Cretaceous tendency, while ridges of Cenozoic forms are either dispersed irregularly among the pores or are arranged in a geometric honeycomb or cancellate pattern with each honeycomb surrounding a single pore (Cifelli, 1982). Costellae also tend to be thinner and stringier than ridges; in late stages of calcification the costellae may be overgrown and have a beaded appearance (Pl. 1, Figs. 13, 16).

Costellagerina bulbosa (Belford)

Pl. 1, Figs. 1-14.

Rugoglobigerina (*Rugoglobigerina*) *bulbosa* Belford, 1960, p. 94, pl. 26, Figs. 1-3, 4-5, 6-8, 9-10; text-fig. 7.

Rugoglobigerina bulbosa Belford. Frerichs, 1979, p. 180, Pl. 9, Figs. 7-9.

Rugoglobigerina bulbosa Belford. Frerichs and Dring, 1981, p. 19, pl. 4, figs. 4-6.

Whiteinella baltica Douglas and Rankin, Petters, 1980, Pl. 2, Figs. 11-14.

Whiteinella sp. 1. Petters, 1977, p. 184, Pl. 4, Figs. 15-17.

Description. Test small to medium in size; low to moderately high trochospiral coil; two to two and one-half whorls; outline ovate and sometimes quadrate;

equatorial periphery strongly lobulate, axial periphery broadly rounded. Chambers globose, sub-rounded, four to four and one-half, rarely 5 chambers in the outer whorl; chamber expansion in the last whorl moderately rapid; sutures depressed, narrow to fairly wide, radially arranged on both spiral and umbilical sides; umbilicus small and shallow or moderately high; aperture a low interiomarginal arch, umbilical to slightly extraumbilical, bordered by a porticus; wall heavily or sparingly ornamented with costellae and pustules meridionally aligned, especially on the last two chambers.

Remarks. Most Tunisian specimens are similar to those western Australian forms (Belford, 1960) which have a low spiral side, shallow umbilicus, and rapid chamber expansion. Due to better preservation, the Australian forms have larger portici than the Tunisian and Nigerian specimens. In test shape the Tunisian forms are similar to those from the U.S. Western Interior (Frerichs, 1979; Frerichs and Dring, 1981), but the pustules on the forms from Wyoming (Frerichs, 1979) are more crowded and exhibit weaker alignment. The quadrate outline, globose chambers, and ornamentation of the Tunisian and Nigerian specimens ally them with the New Jersey forms (Petters, 1977), but the New Jersey specimens have a deeper umbilicus. The Nigerian forms are very small in size, and in spite of their low latitudinal occurrence they are as sparsely ornamented as the forms from Kansas (Frerichs and Dring, 1981). Although small in size, the sparse pustules and costellae on the Nigerian specimens are meridionally arranged.

Occurrence. This species is common in the late Santonian El Bagra Formation in the Oued Bahloul anticline in Tunisia. It is abundant and sometimes occurs monospecifically at the top of the Nkalagu Formation near Awgu in the Benue Trough (SE Nigeria). *Costellagerina bulbosa* has been reported from the Santonian of western Australia, New Jersey, Kansas and Wyoming.

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REFERENCES

- BANNER, F. T., and BLOW, W. H., 1959, The classification and stratigraphical distribution of the Globigerinacea: *Palaeontology*, v. 2, no. 1, p. 1-27.
- BARR, F. T., 1972, Cretaceous biostratigraphy and planktonic foraminifera of Libya: *Micropaleontology*, v. 18, p. 1-46.
- BELFORD, D. J., 1960, Upper Cretaceous foraminifera from the Toolonga Calcilutite and Gingin Chalk, western Australia: *Australia Bureau of Mineral Resources, Geology and Geophysics Bulletin*, no. 57, p. 1-198.
- BLOW, W. H., 1979, The Cainozoic Globigerinida: E. J. Brill, Leiden, 1413 p.

- BOLLI, H. M., 1959, Planktonic foraminifera from the Cretaceous of Trinidad, B.W.I.: *Bulletins of American Paleontology*, v. 39, no. 179, p. 257-277.
- BRÖNNIMANN, P., 1952, Globigerinidae from the Upper Cretaceous (Cenomanian-Maastrichtian) of Trinidad, B.W.I.: *Bulletins of American Paleontology*, v. 34, no. 140, p. 1-70.
- , and BROWN, N. K., 1958, *Hedbergella*, a new name for a Cretaceous planktonic foraminiferal genus: *Journal of the Washington Academy of Science*, v. 48, p. 15-17.
- CARON, M., 1978, Cretaceous planktonic foraminifera from DSDP Leg 40, southeastern Atlantic Ocean: Initial Reports of the Deep Sea Drilling Project, v. 40, p. 651-678.
- CIFELLI, R., 1982, Early occurrences and some phylogenetic implications of spiny honeycomb wall textured planktonic foraminifera: *Journal of Foraminiferal Research*, v. 12, no. 2, p. 105-115.
- DOUGLAS, R. G., 1969, Upper Cretaceous planktonic foraminifera in northern California, Part I—Systematics: *Micropaleontology*, v. 15, p. 151-209.
- , and RANKIN, C., 1969, Cretaceous planktonic foraminifera from Borgholm and their zoogeographic significance: *Lethaia*, v. 2, p. 185-217.
- , and SLITER, W. V., 1966, Regional distribution of some Cretaceous Rotaliporidae and Globotruncanidae (Foraminifera) within North America: *Tulane Studies in Geology*, v. 4, no. 3, p. 89-131.
- FRERICHS, W. E., 1979, Planktonic foraminifera from the Sage Breaks Shale, Centennial Valley, Wyoming: *Journal of Foraminiferal Research*, v. 9, p. 159-184.
- , and DRING, N. B., 1981, Planktonic foraminifera from the Smoky Hill Shale of west central Kansas: *Journal of Foraminiferal Research*, v. 11, p. 47-69.
- GRIGELIS, A., and GORBATCHIK, T., 1980, Morphology and taxonomy of Jurassic and Early Cretaceous representatives of the Superfamily Globigerinacea (Favosellidae): *Journal of Foraminiferal Research*, v. 10, p. 180-190.
- HANZLIKOVÁ, E., 1972, Carpathian Upper Cretaceous Foraminiferida of Moravia (Turonian-Maastrichtian): *Rozprawy Ustredniho Ustavu Geologickeho Svazek* 39, 160 p.
- HEMLEBEN, C., 1975, Spine and pustulose relationships in some Recent planktonic foraminifera: *Micropaleontology*, v. 21, no. 3, p. 334-341.
- HOFKER, J., 1961, The genus *Globigerina cretacea* in northwestern Europe: *Micropaleontology*, v. 7, p. 95-100.
- MASTERS, B. A., 1977, Mesozoic planktonic foraminifera, in Ramsay, A. T. S. (ed.), *Oceanic Micropaleontology*: New York, Academic Press, p. 301-731.
- MCMULTY, C. L., and BARR, F. T., 1979, Meridionally costellate hebergellid foraminifera from the western Atlantic, Deep Sea Drilling Project, Leg 43, Site 386: Gulf Coast Association of Geological Societies, Transactions of the 29th Annual Meeting, p. 302-305.
- MICHAEL, F. Y., 1972, Planktonic foraminifera from the Comanchean Series (Cretaceous) of Texas: *Journal of Foraminiferal Research*, v. 2, p. 200-220.
- OLSSON, R. K., 1964, Late Cretaceous planktonic foraminifera from New Jersey and Delaware: *Micropaleontology*, v. 10, p. 157-188.
- PESAGNO, E. A., JR., 1967, Upper Cretaceous planktonic foraminifera from the western Gulf Coastal Plain: *Paleontographica Americana*, v. 5, no. 37, p. 245-445.
- PETTERS, S. W., 1977, Upper Cretaceous planktonic foraminifera from the subsurface of the Atlantic Coastal Plain of New Jersey: *Journal of Foraminiferal Research*, v. 7, p. 165-187.
- , 1980, Biostratigraphy of Upper Cretaceous foraminifera of the Benue Trough, Nigeria: *Journal of Foraminiferal Research*, v. 10, p. 191-204.
- SAINT-MARC, P., 1973, Presence de *Hedbergella* a "costellae" dans le Cenomanien moyen du Liban: *Journal of Foraminiferal Research*, v. 3, p. 7-12.

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