41. UPPER JURASSIC CALCISPHAERULIDAE FROM DSDP LEG 44, HOLE 391C, BLAKE-BAHAMA BASIN, WESTERN NORTH ATLANTIC

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INTRODUCTION

Three species of isolated Upper Jurassic Calcisphaerulidae have previously been described from the Indian Ocean DSDP Leg 27, Site 261, situated in the northeastern Argo Abyssal Plain (Bolli, 1974): *Pithonella carteri, P. mcnightii,* and *P. thayeri; P. carteri* is a spherical form from the Tithonian whose single-layered test consists of fairly tightly packed, mostly elongate, very small calcite crystals. *P. mcnightii* is also a single layered Tithonian spherical form but has distinctly larger, loosely packed irregularly arranged tabular and angular crystals separated by interspaces. The single-layered test of the third species, *P. thayeri,* consists of very large, irregularly shaped crystals. *P. thayeri* has been found in upper Oxfordian to Tithonian sediments.

The two species here described as *Bonetocardiella paulaworstellae* n. sp. and *B.* *williambensonii* n. sp. are about the same age and come from the Upper Jurassic sediments of Hole 391C. They bear some resemblance to *P. carteri* and *P. mcnightii* from Site 361. *B. paulaworstellae* has a similarly fine-grained outer layer similar to that of *P. carteri*. *B. williambensonii* is characterized by large tabular crystals loosely and irregularly arranged, similar to those of *P. mcnightii* (see Figure 1).

A number of features present in these newly described species from Hole 391C, however, clearly distinguish them from the Indian Ocean forms. The test shape in particular is not fully spherical, but is distinctly flattened and depressed around the apertural area forming a slightly cupped sphere. The aperture consequently lies in a depression, like that characterizing the genus *Bonetocardiella*. Because of this feature the two new species are here tentatively included in the genus *Bonetocardiella,* even though the test outline does not resemble the heart-shaped peripheral outline typical for the genus. An alternative would be to place the species on the basis of its nearly spherical shape in the genus *Pithonella*. Representatives of *Bonetocardiella* have not previously been found in sediments older than Albian. A link would still have to be found to establish that the forms described here are generically related to the Albian and Late Cretaceous *Bonetocardiella*.

The test of the smooth-walled *Bonetocardiella paulaworstellae* n. sp. from Hole 391C consists of two layers. The outer wall is much thicker than that of *Pithonella carteri* and has, in addition, a number of large pits. The other species from Hole 391C, *B. williambensonii* n.sp., with the large tabular crystals similar to the test surface of *P. mcnightii* may also possess a thinner inner layer. This, however, could not yet be established with certainty on the examined specimens.

Whereas the Upper Jurassic specimens from the Indian Ocean, thus far studied, are all hollow, those from the Blake-Bahama Basin are all filled with a calcite core. Cores 50 and 52 of Hole 391C, where the two new species of *Bonetocardiella* occur, contain common to abundant, moderately well preserved calcareous nannofossils. Schmidt (this volume) places the cores in the lower Tithonian or upper Kimmeridgian *Parhabdolithus embergeri* Zone. Wind (this volume) dates the nannoflora of these cores as lower Tithonian.

Cores 50 and 52 contain a benthic foraminifer fauna that includes, among other species, *Lenticulina quenstedti, Epistomina uhligi,* and *Dorothia doneziani* (see Site 391 report, this volume). The interval is correlated to the Oxfordian-Kimmeridgian *Epistomina mosquensis* Zone, on the Grand Banks of Newfoundland (Gradstein, in press).

The discussion of Fütterer (1976) on the relation between Thoracosphaeroidea and Calcisphaerulidae further supports earlier assumptions that Calcisphaerulidae are cysts of planktonic algae. For this reason the International Code of Botanical Nomenclature is applied to the Calcisphaerulidae taxa described or listed herein instead of the International Code of Zoological Nomenclature applied in the author's 1974 and 1978 papers.

The specimens illustrated on Plates 1-3 are deposited in the Museum of Natural History, Basel, Switzerland, under the numbers C34552 to C34570. The number for each specimen appears with the species explanations for the plates.

RECENT LITERATURE

See Bolli (1974) for reference to publications dealing with Calcisphaerulidae published up to 1972. The only isolated Upper Jurassic Calcisphaerulidae published until that date are also described and figured in the same paper. Bolli (1978) contains references published between 1973 and 1976. The following three publications on Calcisphaerulidae on the basis of SEM investigations are new or were not included in the reference list of Bolli (1978).

Fütterer (1976) discusses the taxonomic position of the Thoracosphaeroideae and the possible relation between its genus *Thoracosphaera* and the genus *Pithonella* of the Calcisphaerulidae.

Keupp (1977) describes and figures *Pithonella gustafsonii* (?upper Aptian-upper Albian from DSDP Leg 27), *P.* cf. *thayeri* (upper Oxfordian-Tithonian from DSDP Leg 27), and the new species *P. piriformis* from the Solnhofener Plattenkalke (south of Nuernberg, West Germany) from Upper Jurassic, upper Malm sediments.

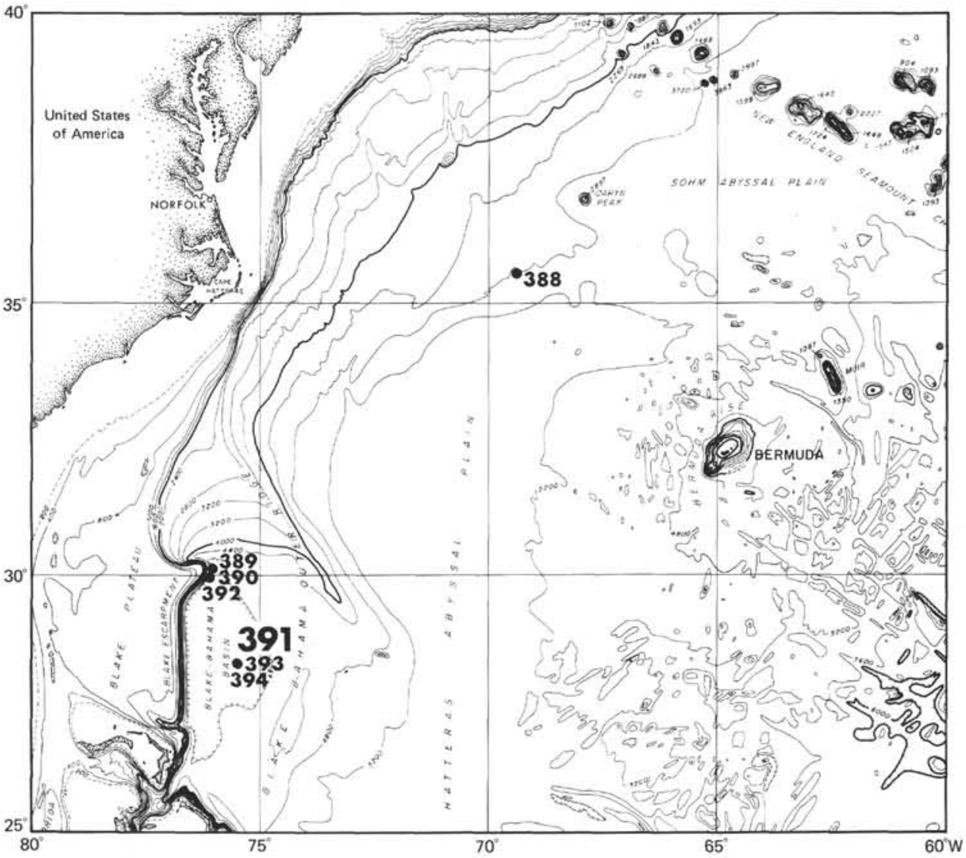

Figure 1. *Location of Leg 44, Hole 391C.*

Note that the *Pithonella* specimens described by Keupp are from 20 to 35 microns in diameter, which is only about half of that of the specimens described from Leg 27.

Marszalek (1975) describes calcisphaeres produced by the Recent shallow-water benthic alga *Acetabularia antillana*. Although the spherical cysts of the calcispheres produced by this species are considerably larger (125-250 micron) than those of the Cretaceous and lower Paleocene *Pithonella* species — which we may also presume to be cysts of planktonic algae — their function may be closely related.

Pflaumann and Krasheninnikov (1978) describe and figure Cretaceous Calcisphaerulidae from DSDP Leg 41, eastern North Atlantic, off the African coast.

SYSTEMATIC DESCRIPTION

Family CALCISPHAERULIDAE Bonet, 1956

Genus BONETOCARDIELLA Dufour, 1968

Bonetocardiella paulaworstellae Bolli, n. sp.
(Plate 1, Figures 1-12)

Description of species: Test a slightly cupped sphere, flattened and moderately depressed around the apertural area, and can be somewhat irregularly shaped. Wall consists of two layers. Surface of outer layer may show large pits of up to 20 μm largest diameter, circular to irregular in outline, up to 8-10 in number. The pits are absent from the flat depressed area around the aperture. Whether these pits are an original feature or caused by subsequent corrosion could not be determined. The outer layer of the test is thick, about 20 μm. It consists of very small, irregularly shaped calcite crystals, which are somewhat loosely arranged to give the surface a fine, granular appearance. The second, inner layer protrudes in some of the specimens in a collar-like manner from the aperture (Plate 1, Figures 4, 5, 7, 8, 9) and measures only about 2 μm in thickness. On its outer surface the collar consists of very densely packed, small, rhombohedral calcite crystals (Plate 1, Figure 9). The entire inner space surrounded by the two layered test wall is filled with coarse, irregularly shaped calcite crystals in all examined specimens (Plate 1, Figures 9, 11, 12). The circular aperture of about 10 μm diameter lies in the center of a wide and gentle depression which gives the test the appearance of a bevelled sphere (Figures 1, 3, 4, 5, 7, 8).

Largest diameter of holotype: 60 μm (Plate 1, Figures 7-9).

Stratigraphic range of species: Upper Jurassic, lower Tithonian or upper Kimmeridgian, *Parhabdolithus embergeri* Zone (on basis of calcareous nannofossils); Oxfordian-Kimmeridgian (on basis of benthic foraminifers).

Lithology of type sample: Calcareous claystone with calcareous silt and clay stringers.

Differential diagnosis: *Bonetocardiella paulaworstellae* n. sp. shows some resemblance to *Pithonella carteri* Bolli (1974) in the fine-grained outer layer. *P. carteri* was recovered from the Tithonian of the Argo Abyssal Plain in the Indian Ocean during drilling at DSDP Site 261, Leg 27. *B. paulaworstellae* differs from this species by the greater thickness of its outer layer, the presence of a thin second inner layer, a distinct flattening or depression of the apertural area, and the presence of large circular to irregular pits on the outer layer.

Locality of figured specimens: DSDP Leg 44, Sample 391C-50-1, 47-62 cm. Blake-Bahama Basin, western North Atlantic; 28°13.61'N, 75°37.00'W. Water depth 4964 meters, 1371-1380.5 meters sub-bottom. Specimens are rare.

Name: The species is named for Paula J. Worstell, Sedimentologist, DSDP Leg 44 and Science Editor, Volume 44, Scripps Institution of Oceanography, La Jolla, California.

Bonetocardiella williambensonii Bolli, n. sp.
(Plate 2, Figures 1-12; Plate 3, Figures 1-12)

Description of species: Test a slightly cupped sphere, flattened to moderately depressed around the apertural area. The wall consists of an outer layer and possibly an inner, thinner layer, which, because of extensive recrystallization in the studied specimens could not be recognized with certainty. The outer layer, which is about 10 μm thick, consists of large tabular calcite crystals positioned with their large facies perpendicular to the test surface. The arrangement and pattern of the individual crystals is irregular and rather loose, leaving large interspaces (Plate 2, Figures 2, 8). The presence of a possible inner layer, considerably thinner (approximately 2 μm) than the outer one is indicated in some broken specimens by a layer of much smaller tabular crystals below the outer wall (Plate 3, Figures 6, 12). The entire inner space surrounded by the test wall is filled in the examined specimens with a calcite core. The surface of this spherical core is variable and may range from coarse, irregularly shaped crystals (Plate 3, Figures 4, 5, 6) to small but distinct rhombohedral crystals (Plate 3, Figure 10) to a smooth, very finely granular dense surface (Plate 3, Figures 8, 9, 11, 12). The aperture is circular, about 10-12 μm, and is positioned in a depression of the test (Plate 2, Figures 1, 10; Plate 3, Figures 1, 3, 4).

Largest diameter of holotype: 60 μm (Plate 2, Figures 1-3).

Stratigraphic range of species: Upper Jurassic, lower Tithonian or upper Kimmeridgian, *Parhabdolithus embergeri* Zone (on basis of calcareous nannofossils); Oxfordian-Kimmeridgian (on basis of benthic foraminifers).

Lithology of type sample: Calcareous claystone with calcareous silt and clay stringers.

Differential diagnosis: Although the crystals which form the test surface of *Bonetocardiella williambensonii* are slightly larger and more slender, their tabular shape and irregular arrangement resembles those of *Pithonella mcnightii* from the Tithonian of DSDP Site 261 of Leg 27, of the Argo Abyssal Plain in the Indian Ocean. The new species, however, differs from the Indian Ocean forms particularly in the depression of the test around the apertural area which causes the characteristic slightly cupped sphere instead of a full sphere as in *P. mcnightii*. The test wall of *P. mcnightii* also consists of one layer only, whereas *B. williambensonii* appears to have in addition to a thick outer layer, a much thinner inner one.

Locality of figured specimens: DSDP Leg 44, Hole 391C, Blake-Bahama Basin, western North Atlantic; 28°13.61′N, 75°37.00′W. Water depth 4964 meters. Specimens Plate 2, Figures 5, 8, 10, 11; Plate 3, Figures 1-6 from Sample 391C-50-1, 47-62 cm, 1371-1380.5 meters sub-bottom. Specimens Plate 2, Figures 1-3 (holotype), 4, 6, 7, 9, 12; Plate 3, Figures 7-12 from Sample 391C-52-2, 56-62 cm, 1390.0-1399.5 meters sub-bottom. Specimens are abundant in both samples.

Name: The species is named for William E. Benson, Co-Chief Scientist DSDP Leg 44; National Science Foundation, Washington, D.C.

ACKNOWLEDGMENTS

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PLATE 1

Bonetocardiella paulaworstellae Bolli, n. sp.

All figured specimens are from Sample 391C-50-1, 47-62 cm.

Figures 1, 2	1. Oblique apertural view of paratype. ×750, C34552. 2. Close-up view of outer surface shown in Figure 1, showing the small irregular shaped crystals that form the outer wall. ×3000.
Figure 3	Side view of paratype, with several pits visible along the right and lower periphery. ×750, C34553.
Figures 4, 5	4. Apertural view of paratype, showing the inner layer exposed as collar around the aperture. ×750, C34554. 5. Close-up view of apertural area shown in Figure 4, showing the dense inner layer surrounding the aperture, and the outer layer which is more loose and granular. ×1800.
Figure 6	View of side opposite to the apertural area of a paratype with numerous pits. ×750, C34555.
Figures 7-9	7. Oblique apertural view of holotype, a somewhat irregular slightly cupped sphere with several pits on the outer surface. The apertural area forms a slight depression in the sphere. ×750, C34556. 8. Oblique close-up view of apertural area shown in Figure 7. ×1800. 9. Close-up view of dense inner layer protruding in a collar-like manner from the aperture shown in Figure 7. Its surface is formed by small rhombohedral crystals. Irregularly shaped large calcite crystals fill the inner space of the specimen, seen here slightly protruding from the circular aperture (also visible on Figure 8). ×3000.
Figures 10, 11, 12	10. Apertural view of paratype, with some pits around the peripheral area. ×750, C34557. 11. Close-up view of apertural area shown in Figure 10. Inner layer here not exposed. Irregularly shaped platy large calcite crystals fill the inner space of the test and are here visible within the circular apertural opening. ×1800. 12. Broken specimen showing the thick finely granular outer wall (about 20 μm) and some pits on the outer surface. The inner space is filled with large irregular calcite crystals. The thin inner layer is not visible. ×750, C34558.

PLATE 1

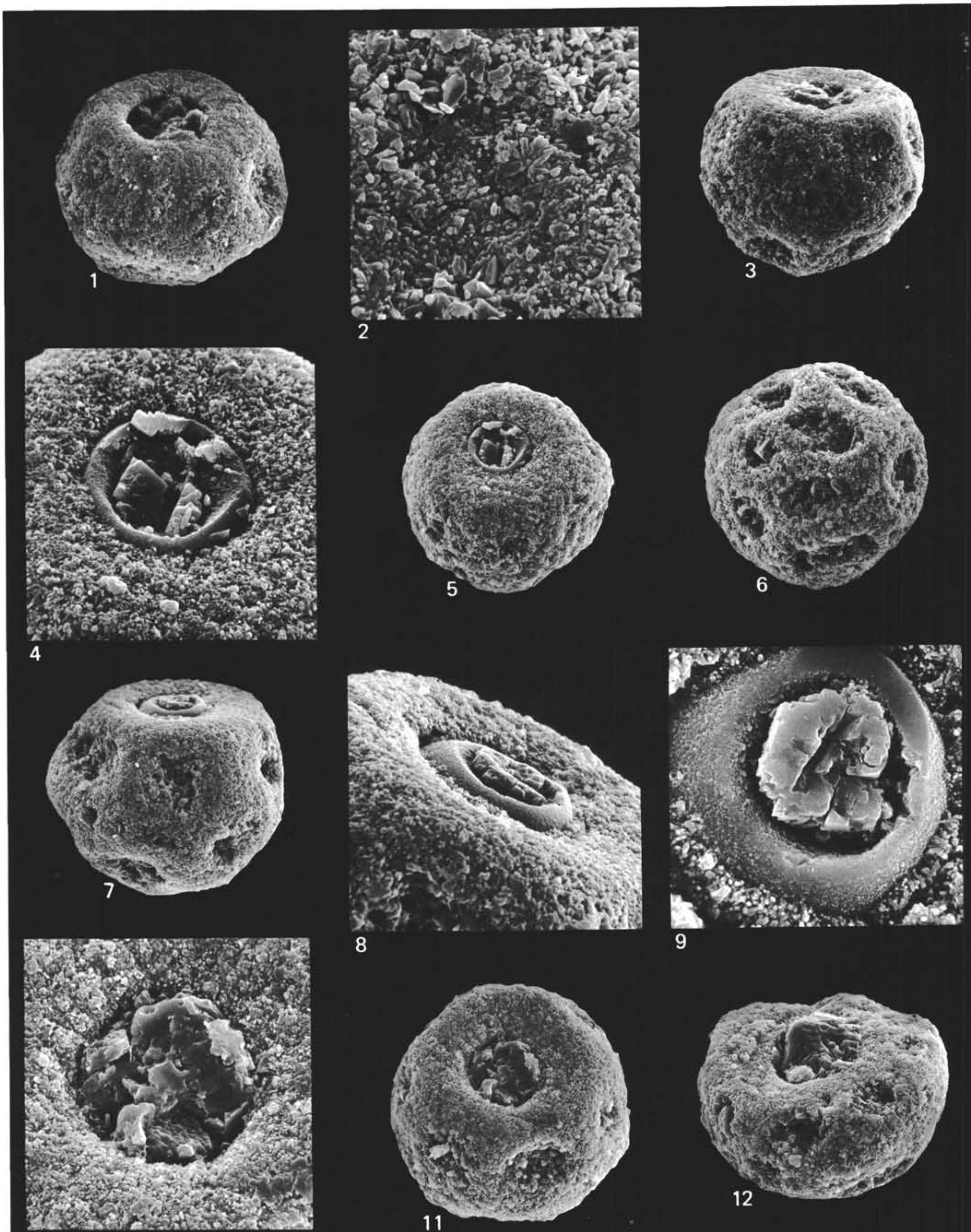

PLATE 2

Bonetocardiella williambensonii Bolli, n. sp.
Figures 1-3, 5, 8, 10-11 from Sample 391C-50-1, 47-62 cm.
Figures 4, 6, 7, 9, 12 from Sample 391C-52-2, 56-62 cm.

Figures 1-3

1. Oblique apertural view of holotype. ×750, C34559.
2. Close-up view of outer surface of Figure 1, showing the perpendicular arrangement of large, tabular calcite crystals in an irregular and loose pattern with distinct interspaces. ×3000.
3. Apertural area shown in Figure 1. ×1800.

Figures 4, 7

4. Oblique apertural view of paratype, clearly showing the slightly cupped sphere. ×750, C34560.
7. Close-up view of the flattened-concave apertural area of Figure 4. ×1800.

Figures 5, 8

5. View of side opposite to apertural area, paratype. ×750, C3456.
8. Surface detail of Figure 5, showing the perpendicular arrangement of large tabular calcite crystals in an irregular and loose pattern leaving distinct interspaces. The crystals show distinct corrosion when compared with those of Figure 2. ×3000.

Figures 6, 9

6. Paratype with strongly worn or corroded outer surface. ×750, C34562.
9. Surface detail of Figure 6. ×3000.

Figures 10, 11

10. Oblique apertural view of paratype with worn surface. ×750, C34563.
11. Close-up view of specimen shown in Figure 10 with a coccolith (distal view of *Cyclagelosphaera margelii* Noël, 1965) either implanted within the wall or stuck in a crevasse. ×3000.

Figure 12

Broken paratype, showing the thick outer wall and the calcite core that fills the inner space. ×1200, C34564.

PLATE 2

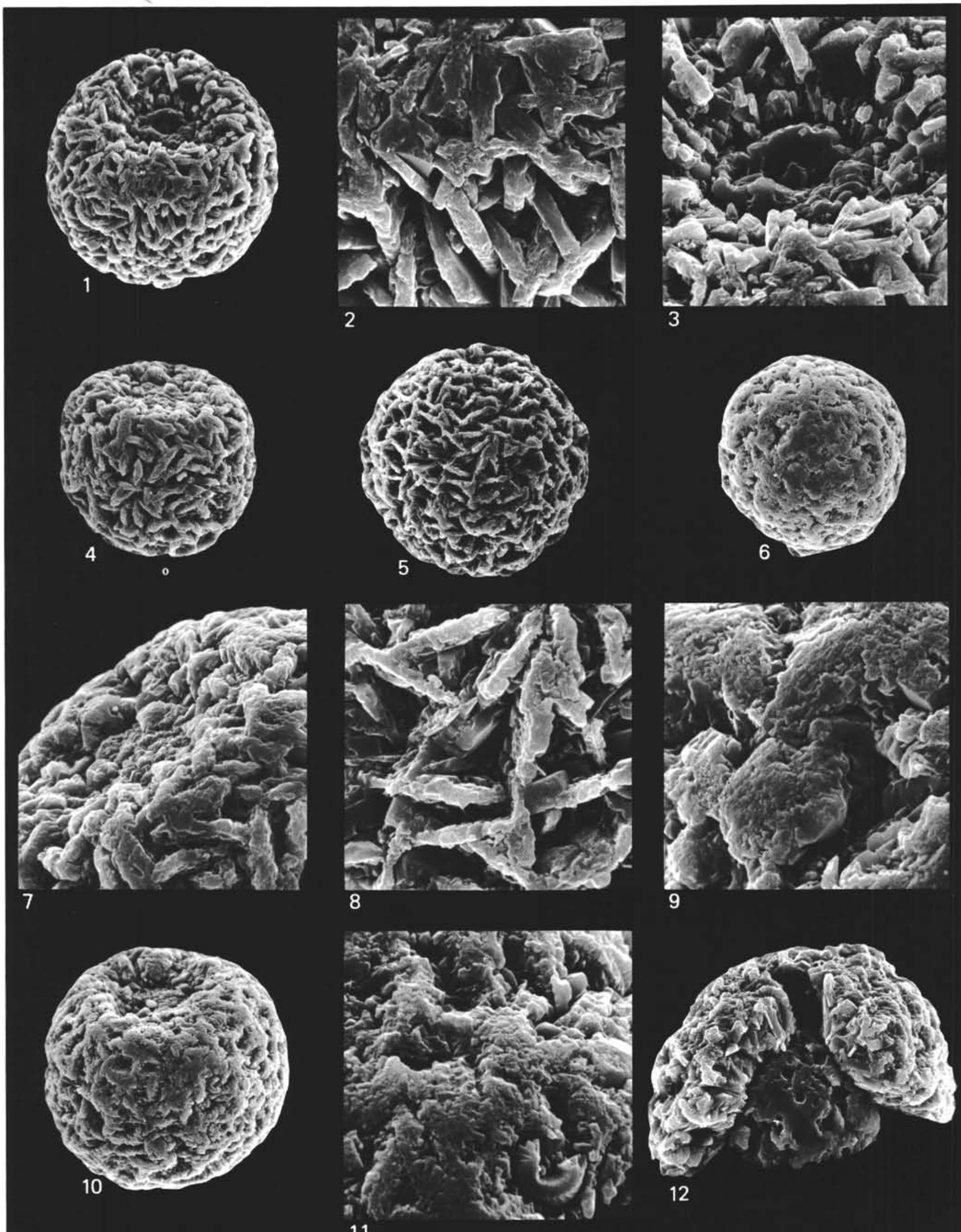

PLATE 3

Bonetocardiella williambensonii Bolli, n. sp.
Figures 1-6 from Sample 391C-50-1, 47-62 cm.
Figures 7-12 from Sample 391C-52-2, 56-62 cm.

Figures 1, 4

1. Apertural view of paratype. ×750, C34565.
4. Close-up view of apertural area shown in Figure 1. Irregularly shaped large platy calcite crystals fill the inner space of the test and are visible within the circular apertural opening. ×1800.

Figures 2, 5

2. Oblique view of paratype. The wall around the apertural area is partly removed which makes the core (filling of the inner space) clearly visible. ×750, C34566.
5. Close-up view of portion of broken apertural area, showing the radially arranged platy calcite crystals of the outer test wall and the coarsely crystalline core that completely fills the inner space of the test. ×3000.

Figures 3, 6

3. Oblique apertural view of paratype with distinctly concave apertural area. ×750, C34567.
6. Close-up view of apertural area shown on Figure 3. Note the layer of radially arranged smaller crystals between the large crystals of the outer layer and those of the filling core, possibly representing a thinner inner layer of the test. ×3000.

Figures 7, 10

7. Side view of paratype with strongly flattened apertural area. ×750, C34568.
10. Close-up view of apertural area shown on Figure 7, showing the small rhombohedral calcite crystals forming the surface of the dense inner core. ×1800.

Figures 8, 11

8. Side view of broken paratype, with part of the surface of the dense inner core visible. ×750, C34569.
11. Detail of specimen shown in Figure 8, showing outer layer below, and surface of fine-grained inner core above. ×3000.

Figures 9, 12

9. Oblique view of broken paratype, with part of the outer wall removed, showing the dense inner core. ×750, C34570.
12. Close-up view of upper part of specimen shown in Figure 9. The radially arranged platy, large calcite crystals forming the test wall shown in cross section. A layer of much smaller crystals of the same type and arrangement is discernible at the base of the large crystals, just above the inner core filling. It may represent a thin, second inner layer. ×3000.

PLATE 3