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Artikel: Keramosphaera allobrogensis, n. sp., from the Upper Berriasian of the Jura Mountains and the Subalpine Region

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KERAMOSPHAERA ALLOBROGENSIS, N. SP., FROM THE UPPER BERRIASIAN OF THE JURA MOUNTAINS AND THE SUBALPINE REGION [1]

BY

Norbert STEINHAUSER, Paul BRÖNNIMANN and Louisette KOEHN-ZANINETTI

The comparative stratigraphic study of the Berriasian and Valanginian series in the area defined by the towns of Albertville, Seyssel and Les Echelles (Southern Jura Mountains and Subalpine Region, Massif des Bauges, France) has shown the existence of a datum horizon in the upper Berriasian, defined by *Pseudotextulariella courtionensis* BRÖNNIMANN and by a large, globular porcelaneous foraminifer describes in the paleontological chapter as *Keramosphaera allobrogensis* STEINHAUSER, BRÖNNIMANN and KOEHN-ZANINETTI, n. sp.

In order to establish the stratigraphic significance of this interesting and in the field easily recognizable datum horizon of 1 to 4 m thickness, we have extended our investigations toward the N of the above defined area up to Neuchâtel. We were able to show that *Keramosphaera allobrogensis*, n. sp., occurs also in the stratotype of the Valanginian, about 4 km NW of Neuchâtel. At the present, we are actively engaged in a study of the geographic extension of this datum horizon in the Jura Mountains and in the Subalpine Region. The results of this work will be published as part of the doctoral thesis of N. STEINHAUSER.

STRATIGRAPHY

A. LIST OF OUTCROPS WITH *Keramosphaera allobrogensis*, n. sp.

a) The following localities in Savoie, France, refer to outcrops examined by N. STEINHAUSER.

[1] This study is part of a continuing research program supported by the Fonds National Suisse de la Recherche Scientifique.

1. *Cluse de Pierre-Châtel*

(Coordinates Lambert 865,50/84,04 — sheet IGN La Tour-du-Pin 4.)
On Route Nationale 521B, 1 km W of Yenne, Savoie. STEINHAUSER samples 466 to 468.

2. *Molard de Vions*

(Coordinates Lambert 869,43/98,58 — sheet IGN Rumilly 1.)
On the road from railroad bridge to Molard-dessus. STEINHAUSER samples 834 and 839.

3. *La Chambotte*

(Coordinates Lambert 874,30/93,58 — sheet IGN Rumilly 6.)
On Route Nationale 491 B, 3 km S of Chindrieux, Savoie. STEINHAUSER samples 1611, 1616 and 1624.

4. *Cluse de Banges*

(Coordinates Lambert 892,05/90,50 — sheet IGN Rumilly 8.)
On the road from Allèves to La Filia. STEINHAUSER samples 1516 and 1517.

b) In the course of fieldwork in the Jura Mountains of the Cantons of Neuchâtel and Vaud, Switzerland, STEINHAUSER and CHAROLLAIS found *Keramosphaera allobrogensis*, n. sp., in the following localities:

5. *Crêt-de-l'Anneau*

(Coordinates 543,1/199,25 — Carte nat. Suisse — sheet 241 Val de Travers.)
In a quarry, 1.5 km NE of Travers. STEINHAUSER sample 1256.

6. *Combe de Peu*

(Coordinates 552,0/201,45 — Carte nat. Suisse — sheet 242 Avenches.)
W of Trois Rods, in the railroad cut at km 10/9. STEINHAUSER Sample 1399 is from the base of bed 12 of the section measured by FREI (1925).

7. *Valangin*

(Coordinates 559,43/206,98 — Carte nat. Suisse — sheet 242 Avenches.)
At northern end of the Seyon gorge; SSW of Valangin (stratotype of Valanginian). STEINHAUSER samples 1780 and 1781 are from beds 26 and 25 respectively of the section measured by HAEFELI (1966).

8. *La Cure*

(Coordinates 495,25/146,08 — Carte nat. Suisse — sheet 1240 Les Rousses.)
On the Route Nationale 5, 800 m S of La Cure. STEINHAUSER samples 1252,

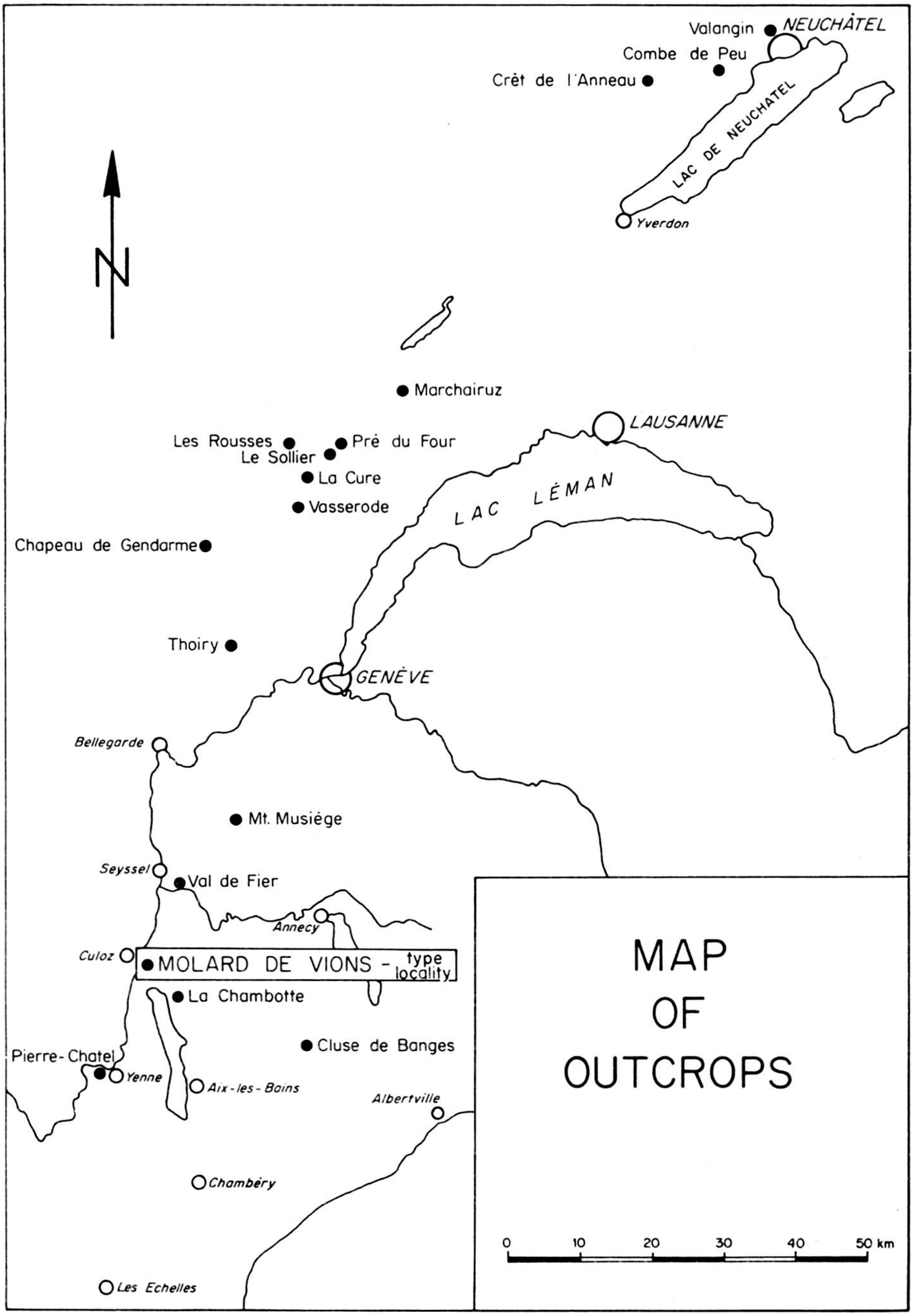

Valangin
NEUCHÂTEL
Combe de Peu
Crêt de l'Anneau
LAC DE NEUCHATEL
Yverdon
N
Marchairuz
LAUSANNE
Les Rousses
Pré du Four
Le Sollier
La Cure
Vasserode
LAC LÉMAN
Chapeau de Gendarme
Thoiry
GENÈVE
Bellegarde
Mt. Musiège
Seyssel
Val de Fier
Annecy
Culoz
MOLARD DE VIONS - type locality
La Chambotte
Cluse de Banges
Pierre-Chatel
Yenne
Aix-les-Bains
Albertville
Chambéry
Les Echelles
MAP OF OUTCROPS
0 10 20 30 40 50 km

FIG. 1.

1253 and 1254 are from the beds 29, 30 and 31 of the section measured by MOUTY (1966).

9. *Le Sollier*

(Coordinates 497,0/146,48 — Carte nat. Suisse — sheet 1240 Les Rousses.) 400 m S of the chalet " Le Sollier ". STEINHAUSER sample 1355.

10. *Pré du Four*

(Coordinates 498,27/147,65 — Carte nat. Suisse — sheet 1241 Marchairuz.) 200 m S of the chalet " Pré du Four ". STEINHAUSER sample 1354.

11. *Col du Marchairuz*

(Coordinates 509,0/156,9 — Carte nat. Suisse — sheet 1241 Marchairuz.) 500 m N of the Col du Marchairuz. STEINHAUSER sample 1255 is from bed 47 of the section measured by MOUTY (1966).

c) The following samples with *Keramosphaera allobrogensis*, n. sp., are from the collections of MOUTY, JAQUET, YAZGAN and SARMAN, deposited in the Institut de Géologie et de Paléontologie, Université de Genève.

12. *Val de Fier*

(Coordinates Lambert 875,17/169,70 — sheet IGN Seyssel 5.) In a quarry on the left side of the Fier river. MOUTY sample 45.

13. *Mont de Musiège*

(Coordinates Lambert 880,77/120,44 — sheet IGN Seyssel 3.) On the Route départementale 197, 0.5 km S of Malpas. MOUTY samples 25 and 26.

14. *Thoiry*

(Coordinates 486,90/124,68 — Carte nat. Suisse — sheet 1280 Gex.) On forest road, 870 m altitude. Sample JAQUET 121 A is from bed 41 of the section measured by MOUTY (1966).

15. *Les Rousses*

(Coordinates 493,00/148,85 — Carte nat. Suisse — sheet 1240 Les Rousses.) On Route Nationale 5,1 km SW of Les Rousses. MOUTY samples 29 and 31.

16. *Chapeau de Gendarme*

(Coordinates 482,00/135,35 — Carte nat. Suisse — sheet 1260 Col de la Faucille.) On Route Nationale 436, 1.5 km S of Septmoncel. Samples MOUTY 39 and SARMAN 17.

17. *La Vasserode*

(Coordinates 493,75/140,65 — Carte nat. Suisse — sheet 1260 Col de la Faucille.) On Route Nationale 5 between the farmhouse of Malcombe and La Vasserode. Sample YAZGAN 27.

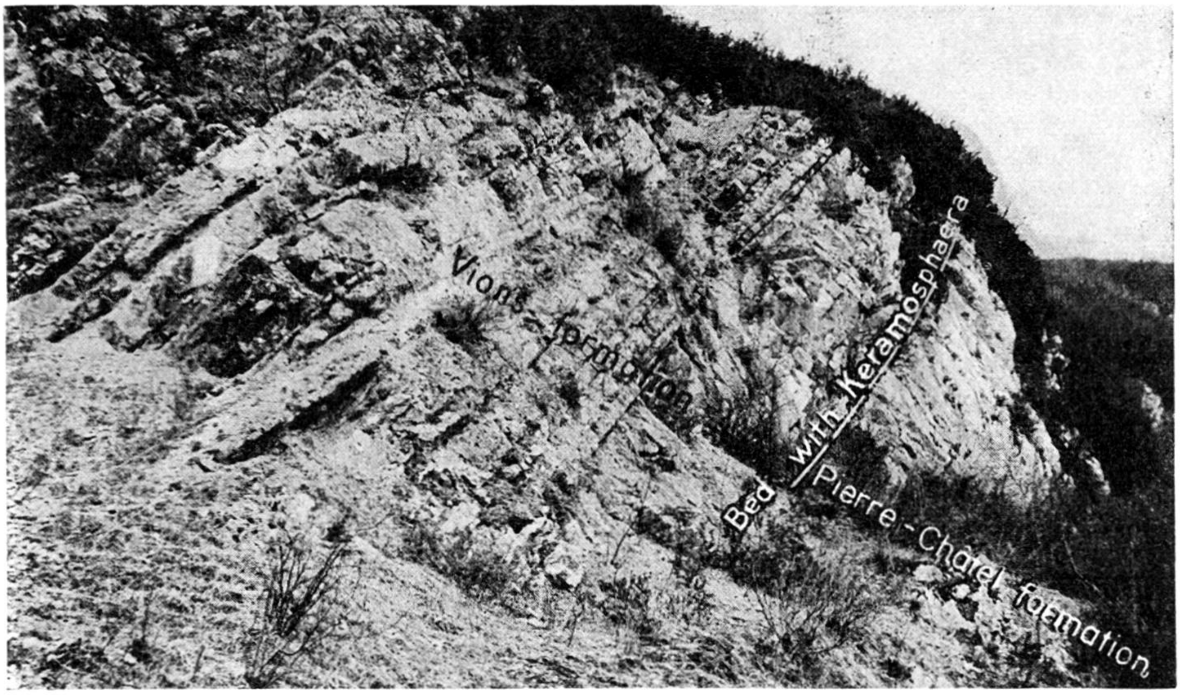


FIG. 2. — Type-locality of *Keramosphaera allobrogensis*, n. sp. Molard de Vions. Photo STEINHAUSER.

B. REMARKS ON THE LITHOLOGY OF THE BEDS CONTAINING *Keramosphaera allobrogensis*, n. sp.

The lithology of the beds with *Keramosphaera allobrogensis*, n. sp., changes considerably from locality to locality. It seems that this foraminifer is rather independant of depositional conditions. It occurs in clays and marls, in fine sublithographic limestones and in pseudo-oölithic limestones.

At Molard de Vions, the limestones of the Pierre-Châtel formation are clearly of marine origin whereas the overlying beds with *Keramosphaera allobrogensis*, n. sp. (STEINHAUSER locality 839) show a distinct brackish water to lacustrine influence as witnessed by abundant plant debris, oogonia of Characeae, and brackish water and fresh water ostracods.

C. AGE OF THE *Keramosphaera allobrogensis* - DATUM HORIZON

At the Cluse de Banges, Subalpine Region Savoie, France, the *Keramosphaera allobrogensis* - horizon is underlain by a lower Berriasian cephalopod occurrence

(G. LE HEGARAT, personal communication) and overlain by a cephalopod bed of uppermost Valanginian to basal Hauterivian age (J. P. THIEULOY, personal communication). The ostracods from the Vions formation (STEINHAUSER locality 839) are according to OERTLI and STEINHAUSER (1969) of upper Berriasian age.

The *Keramosphaera*-datum horizon is normally about 1 m thick. Greater thickness have been only exceptionally measured, such as about 4 m at the section of La Chambotte, Savoie, France.

PALEONTOLOGY

Order Foraminiferida

Suborder Miliolina, DELAGE and HEROUARD, 1896
Superfamily Miliolacea, EHRENBERG, 1839
Family Soritidae, EHRENBERG, 1839
Subfamily Keramosphaerinae, BRADY, 1884
Genus *Keramosphaera* BRADY, 1882

Keramosphaera allobrogensis, STEINHAUSER, BRÖNNIMANN and KOEHN-ZANINETTI, n. sp.
Pl. III and IV; Text-fig. 3-5, 6 *a*, *b*, *c*, 7, 8, 9 *c*, 10.

Holotype: The holotype of *Keramosphaera allobrogensis*, n. sp., is the centered section of an isolated specimen from thin section B, STEINHAUSER locality 839, illustrated by Pl. IV, Fig. 1, 2 and by Text-fig. 7 *a*, *b*. The maximum diameter of test is 1330μ.

Type Locality: STEINHAUSER locality 839, Molard de Vions, Département de la Savoie, about 2.5 km from Culoz, Département de l'Ain, France. Coordinates: 869.43/98.58, sheet IGN Rumilly.

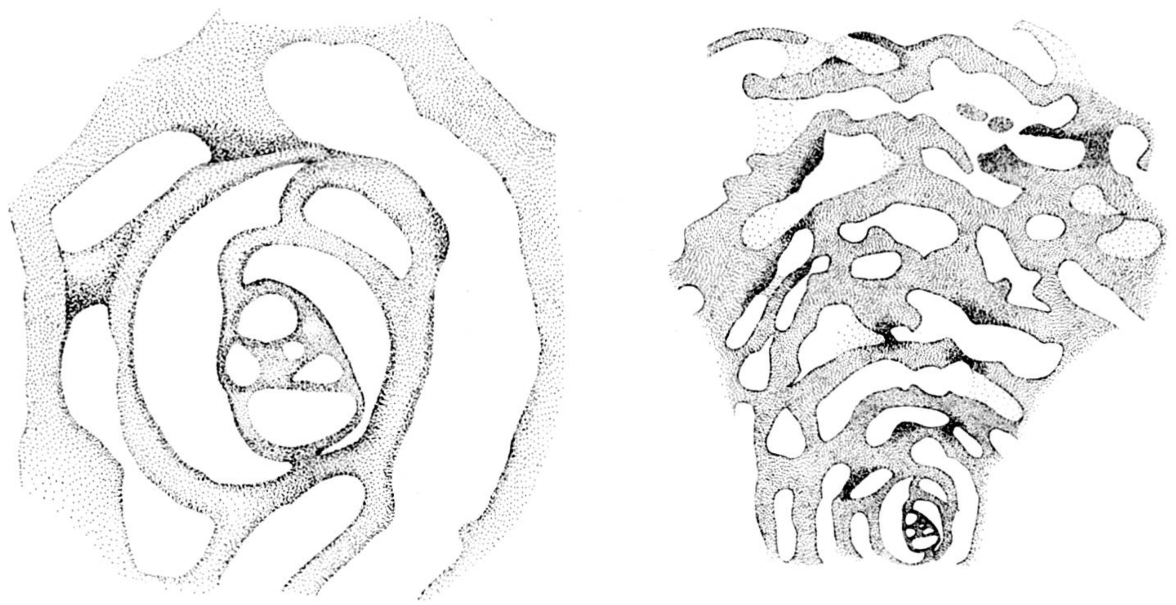
Type Level: Upper Berriasian.

Material: The here described material consists of numerous isolated specimens from the type locality, of oblique cuts encountered in thin sections and polished sections of rock pieces from different localities of the Jura Mountains and the Alps. Centered cuts were made from isolated specimens. The material will be deposited in the Museum d'Histoire naturelle, Geneva.

Morphological description:

Exterior: Isolated specimens from marly beds outcropping at Molard de Vions (STEINHAUSER locality 839) are of irregularly globular shape with diameters ranging from about 750 to 1830 μ. The maximum diameter of specimens from other localities may go up to 3,6 mm.

The small tests are possibly megalospheric and the larger ones microspheric specimens. However, as all the sectioned small forms are recrystallized in the central portion of the test, nothing definite can be said about the possible grouping into small-sized, megalospheric, and large-sized, microspheric forms. In thin sections of rock pieces, some small-sized forms seem to have megalospheric centers (Pl. III, fig. 4; Text-fig. 5 *a*, *b*). The surfaces of the globular tests are irregular and in many cases apparently damaged through transport. In places, the outlines of post-embryonic chambers, which form the mass of the globular body, can be detected. Surfaces



a b

FIG. 3. — *Keramosphaera allobrogensis*, n. sp.

a) microspheric embryo showing quinqueloculine enrollment. STEINHAUSER locality 467, Pierre-Châtel, thin section 3. 280 ×.

b) Same specimen showing irregular post-embryonic chambers. 72 ×.

etched with diluted acid show an unorganized meshwork of branching chambers whose cavities communicate through large openings. In some of the isolated specimens from the type level, the walls of the chambers are of porcelaneous aspect, whitish, but chalky, without the lustre typical of the walls of Recent Miliolacea. In other specimens, the original porcelaneous walls have been completely altered and show a yellowish to light brownish tint. In polished sections from the limestones directly underlying the marly beds at STEINHAUSER locality 839, the tests of the keramosphaeras as well as of the accompanying Miliolacea are invariably of whitish porcelaneous aspect.

Interior: As in other large Miliolacea, such as in alveolinids, also in *Keramosphaera allobrogensis*, n. sp., a short embryonic and a much longer post-embryonic ontogenetic stage can be distinguished. In order to establish the relationship of this species with the Miliolacea, special care was taken to cut the centers of isolated microspheric forms which show distintly quinqueloculine features and in the holotype a prolocular flexostyle (Text-fig. 3, 7; Pl. IV). Arrangement, form and size of the chambers do not seem to change much during growth, hence no further subdivisions into post-embryonic substages seem to be applicable.

A. *Embryonic stage*

Microspheric embryo. Details of the microspheric embryos are illustrated by Pl. IV and Text-fig. 3, 7. The illustrations are from centered sections of two specimens of about 1200μ (STEINHAUSER locality 839, thin section B) and of about 1440μ dia-

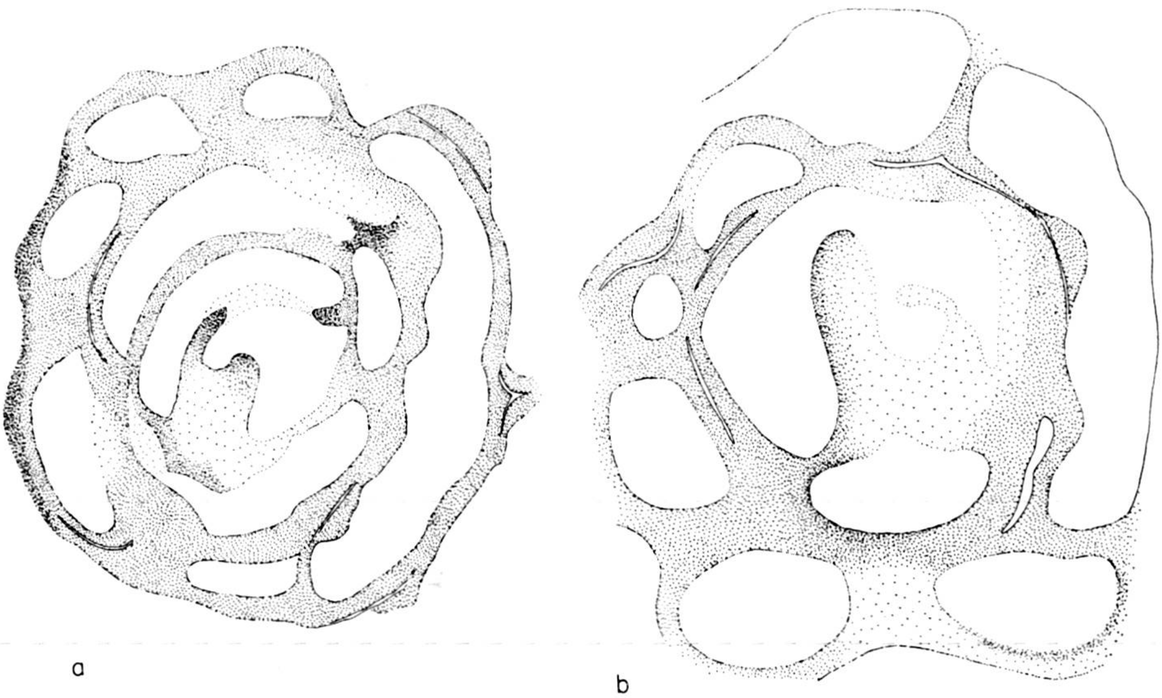


FIG. 4. — *Keramosphaera allobrogensis*, n. sp.

a) Almost centered section showing initial portion. STEINHAUSER locality 467, Pierre-Châtel, thin section 1. 220 ×.

b) Almost centered section showing initial portion. Thin section MOUTY 29, Les Rousses. 185 ×

meter (STEINHAUSER locality 467, thin section 3). The microspheric embryo shows a quinqueloculine enrollment which is immediately followed by chambers of the post-embryonic stage. The globular proloculus of the holotype (Pl. IV, Fig. 1, 2 and Text-fig. 7 *a*, *b*) of about 25μ maximum diameter opens through a flexostyle into the first chamber of the quinqueloculine stage. The maximum diameter of the quinqueloculine embryonic stage is about 120μ in the holotype and about 72μ in specimen 467 (3), in which proloculus and flexostyle are not cut. There is a distinct change in the thickness of the walls from the quinqueloculine stage to the first post-embryonic chambers. In the holotype, the walls of the final quinqueloculine chambers are about 6.5μ thick against 14μ + for the walls of the first *Keramosphaera* chambers. This change in the thickness of the walls occurs also in specimen 467 (3), where the quinqueloculine wall is about 8μ thick and that of the first *Keramosphaera* chamber about 16μ +.

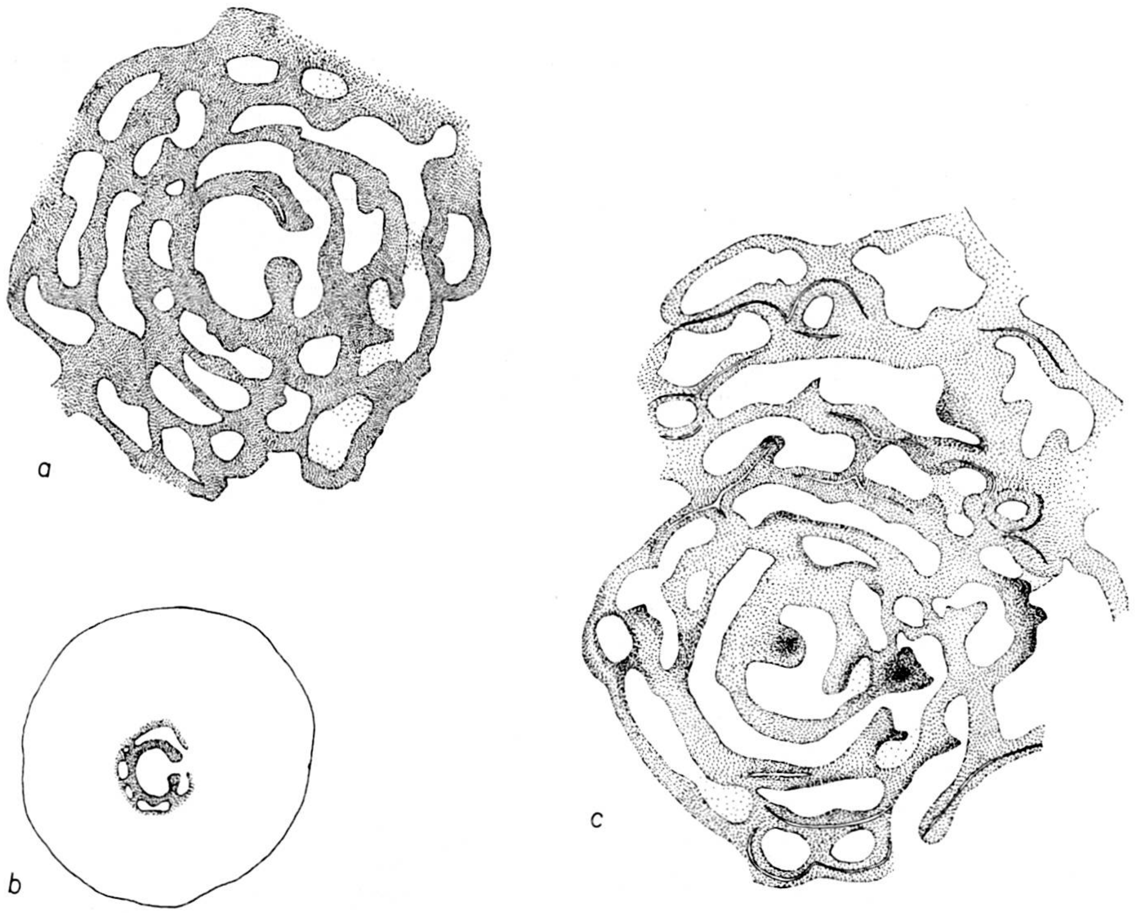


FIG. 5. — *Keramosphaera allobrogensis*, n. sp.

a), b) Centered section of megalospheric (?) specimen. Thin section MOUTY 623, locality unknown. *a)* 80 ×, *b)* 30 ×.

c) Almost centered section showing initial portion. STEINHAUSER locality 467, Pierre-Châtel, thin section 2. 80 ×.

Megalospheric embryo. The presence of a megalospheric embryo is difficult to establish, because it can never be known whether a large, apparently central chamber is the result of obliteration through recrystallization of a quinqueloculine embryo or whether it represents truely the beginning of a megalospheric form. Details of an embryo, here tentatively regarded as a megalospheric embryo, are illustrated by Pl. III, fig. 4 and Text-fig. 5 *a, b*. The centered cut is from a specimen of about 1040μ maximum diameter (thin section MOUTY 632, locality unknown). The embryo shows an oblong central chamber of about 166μ larger and about 95μ smaller inner diameter. In a lumen of this size a microspheric quinqueloculine embryo of 72 to 120μ maximum diameter could very well have been existed and then replaced through recrystallization. The wall of this central lumen is about 40μ thick. It represents the " prolocular " wall and basal layers of immediately adjoining *Keramosphaera* chambers. The thickness of the " prolocular " wall alone is of the order of 15 to 20μ, and therefore comparable to the thickness of the wall of a normal, innermost *Keramosphaera* chamber in the microspheric form. The " proloculus " communicates through a large opening of about 30μ diameter with the first chamber of post-embryonic stage.

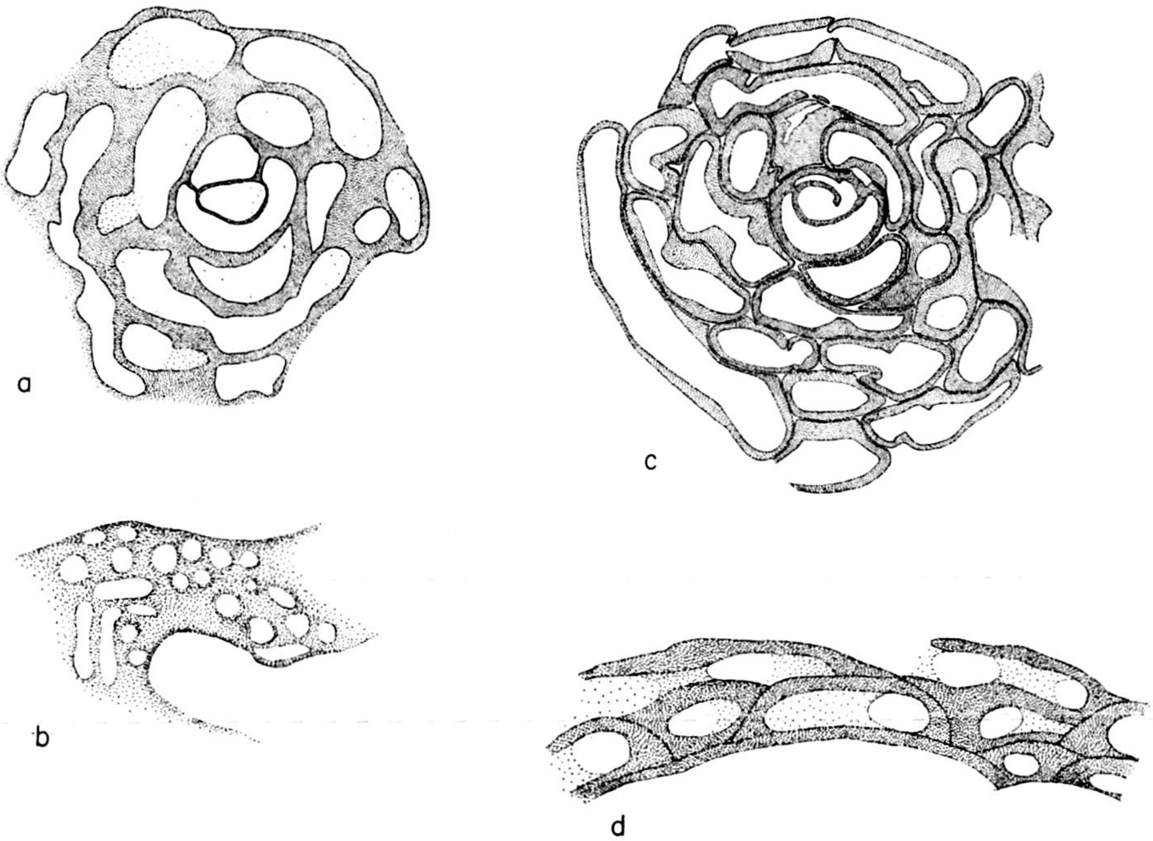


FIG. 6 *a, b, c.* — *Keramosphaera allobrogensis*, n. sp.

a) Almost centered section showing initial portion. STEINHAUSER locality 1780, Valangin, thin section 2. 80 ×.

b) Detail of perforated wall. STEINHAUSER locality 467, Pierre-Châtel, thin section 3. 310 ×.

c) Almost centered section showing initial portion. STEINHAUSER locality 468, Pierre-Châtel, thin section 1. 80 ×.

d) *Keramosphaera murrayi* BRADY. Detail of peripheral portion of axial section. 220 ×.

B. *Post-embryonic stage*

The post-embryonic stage consists of numerous small chambers apparently without any definite arrangement, which develop in such a way as to form at any time a more or less globular body. An axial section across the post-embryonic stage

(Pl. III, fig. 3; Pl. IV, fig. 4) gives the impression of an unorganized mass of *Keramosphaera* chambers cut in all possible transversal ways. If the surface of the virtually globular *Keramosphaera* body is considered at a given moment in growth, then we would find numerous irregularly shaped, branching, flattered chambers distributed in a random pattern (Text-fig. 8). Indications of such a random pattern can be seen on the surfaces of some of the larger and better preserved isolated specimens from STEINHAUSER locality 839. The emplacement of the new chambers changes during growth all over the surface of the test thus ensuring its more or less globular form. Growth of the test is radial and each chamber at the surface of the sphere has the potential to produce new chambers at random. The post-embryonic chambers are relatively small cavities in respect to volume and surface of the test.

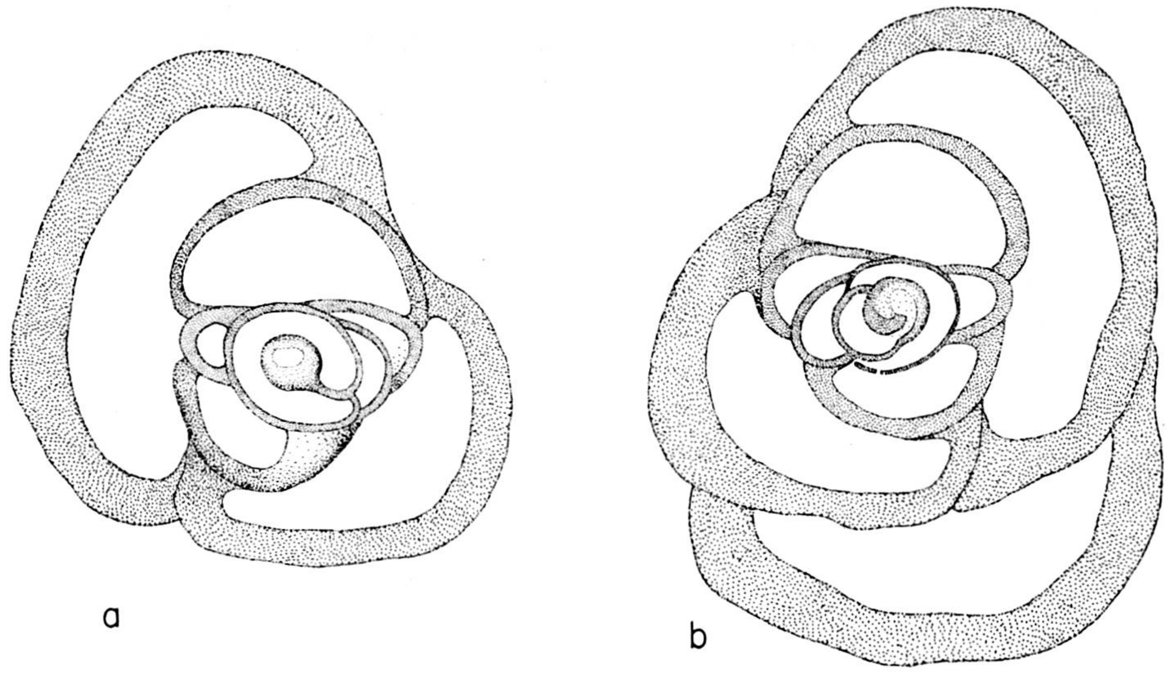


FIG. 7. — *Keramosphaera allobrogensis*, n. sp.

a) b) Holotype, embryonic portion showing proloculus and flexostyle *b)* and quinqueloculine enrollment. *a)* lower view, *b)* upper view of thin section. 280 ×.

About 14 poorly defined post-embryonic " layers " occur in the specimen illustrated by Pl. III, fig. 3, which has a maximum diameter of abour 2160μ, and about 11 " layers " in the microspheric specimen illustrated by Pl. IV, fig. 4, with a maximum diameter of about 1680μ. As shown by Text-fig. 6 *c*, each *Keramosphaera* chamber is a minute flattened tubular cavity completely surrounded by its own wall. In a specimen of about 1200μ maximum diameter, from STEINHAUSER locality 839, thin section D, the lumina of the peripheral chambers measure about 40μ in height. As the chambers are branching, their lengths are difficult to measure in transverse sections and their maximum extension may range from about 160 to 240μ. Near the center, the lumina are about 30μ in height and about 160μ in length. The thickness of the walls between lumina, which in fact are double walls, one layer belonging to the underlying and one layer to the overlying tubular chamber, increases gradually from the center to the periphery.

In the microspheric specimen from locality STEINHAUSER 467, thin section 3, illustrated by Pl. IV, fig. 4, the thickness of the composite wall is about 5 to 10μ near the center, about 15μ in a distance of 160μ from the center, about 25μ in a distance of 400μ from the center and about 25 to 35μ near the periphery of the test. The outermost walls of the peripheral chambers are much thinner than the walls between older chambers because they are single-layered. In the microspheric specimen illustrated by Pl. IV, fig. 4, they are about 5 to 8μ thick.

In tangential sections and on etched surfaces, the irregular branching chambers completely exposed (Text-fig. 8). It is evident from such sections that the chambers are interconnected throughout the test. Axial sections, on the other hand, exhibit

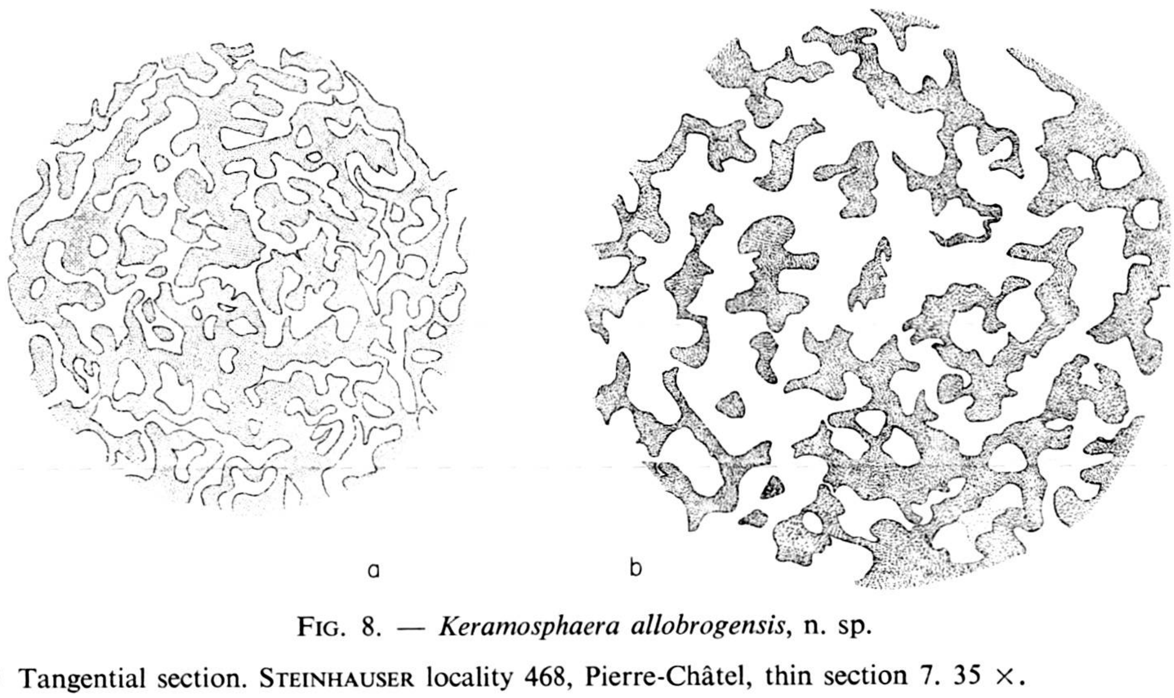


FIG. 8. — *Keramosphaera allobrogensis*, n. sp.

a) Tangential section. STEINHAUSER locality 468, Pierre-Châtel, thin section 7. 35 ×.
b) Tangential section. Same locality, thin section 4. 35 ×.

only transverse cuts of the chambers and do not permit conclusions as to their general outlines. They inform, however, on the height, and sometimes even on the length, of the chambers and on wall thickness. The walls are finely microgranular, dark, and show occasionally the brownish tint typical of representatives of the Miliolacea. The walls of the peripheral portions of the tests may be perforated by an unknown micro-organism (Text-fig. 6 *b*). The maximum diameter of these perforations, which are cut transversely or obliquely, are about 4 to 6μ.

Each chamber has at least one, with increasing size most probably several simple more or less rounded apertures which may be at the ends of the branches. It is possible that also lateral openings are developed. This could not be established in our material.

Table of dimensions

Average diameter of the test: 1 to 2 mm. Minimum diameter: 0.75 mm.
Maximum diameter: 3.6 mm.
Diameter of the holotype: 1.2 mm.
Average diameter of the quinqueloculine embryonic stage: 100μ.
Diameter of the microspheric proloculus: 25μ.
Maximum diameter of the megalospheric " proloculus ": 166μ.
Thickness of the wall of the proloculus: 15 to 20μ.
Length of the post-embryonic chambers: about 16 to 24μ.
Height of the post-embryonic chambers: about 30 to 40μ.
Thickness of the wall of the post-embryonic chambers near the center of the test: 5 to 15μ.
Thickness of the wall of the post-embryonic chambers near the periphery of the test: 25 to 35μ.

Remarks on *Keramosphaera murrayi* BRADY, 1882, and *Keramosphaera tergestina* (STACHE), 1889

Keramosphaera tergestina (STACHE) from the Upper Cretaceous of the Mediterranean region and *Keramosphaera allobrogensis*, n. sp., from the upper Berriasian of the Jura Mountains and the Subalpine Region are the only fossil species known to belong with certainty to the genus *Keramosphaera* BRADY, type species *Keramosphaera murrayi* BRADY, a Recent form. Morphologically, the three species are clearly related. *Keramosphaera irregularis* GRZYBOWSKI and *Keramosphaera densa* MILLETT, Tertiary forms referred to *Keramosphaera* BRADY, need to be re-examined before a decision concerning their generic position can be made. According to LOEBLICH and TAPPAN (1964, p. C 501) also the species of *Orbulinaria* RHUMBLER should be placed in the genus *Keramosphaera*. The only species of *Orbulinaria* assigned by LOEBLICH and TAPPAN directly to *Keramosphaera* is the Recent *Orbulinaria fallax* RHUMBLER, which, has repeately been cited also from Upper Cretaceous beds. However, on the strength of illustrations and descriptions (EGGER, 1909; FRANKE, 1928; GALLOWAY, 1933, etc.) most of the spheric forms referred to *Orbulinaria* RHUMBLER are certainly not representatives of *Keramosphaera* BRADY. Their hollow and agglutinated tests suggest more a primitive group of arenaceous foraminifera, such as perhaps the Saccaminidae, and not the Miliolacea EHRENBERG. Also these forms need to be re-examined before a definitive decision regarding their generic position can be made. It seems to be rather difficult to obtain type specimens of the various species of *Orbulinaria*

RHUMBLER and of the Tertiary keramosphaeras, hence *Keramosphaera allobrogensis*, n. sp., was compared only with *Keramosphaera murrayi* and *Keramosphaera tergestina*. Of both of these species which are well described, type material is in our possession.

A complete revision of the *Keramosphaera* group, however, still remains to be made.

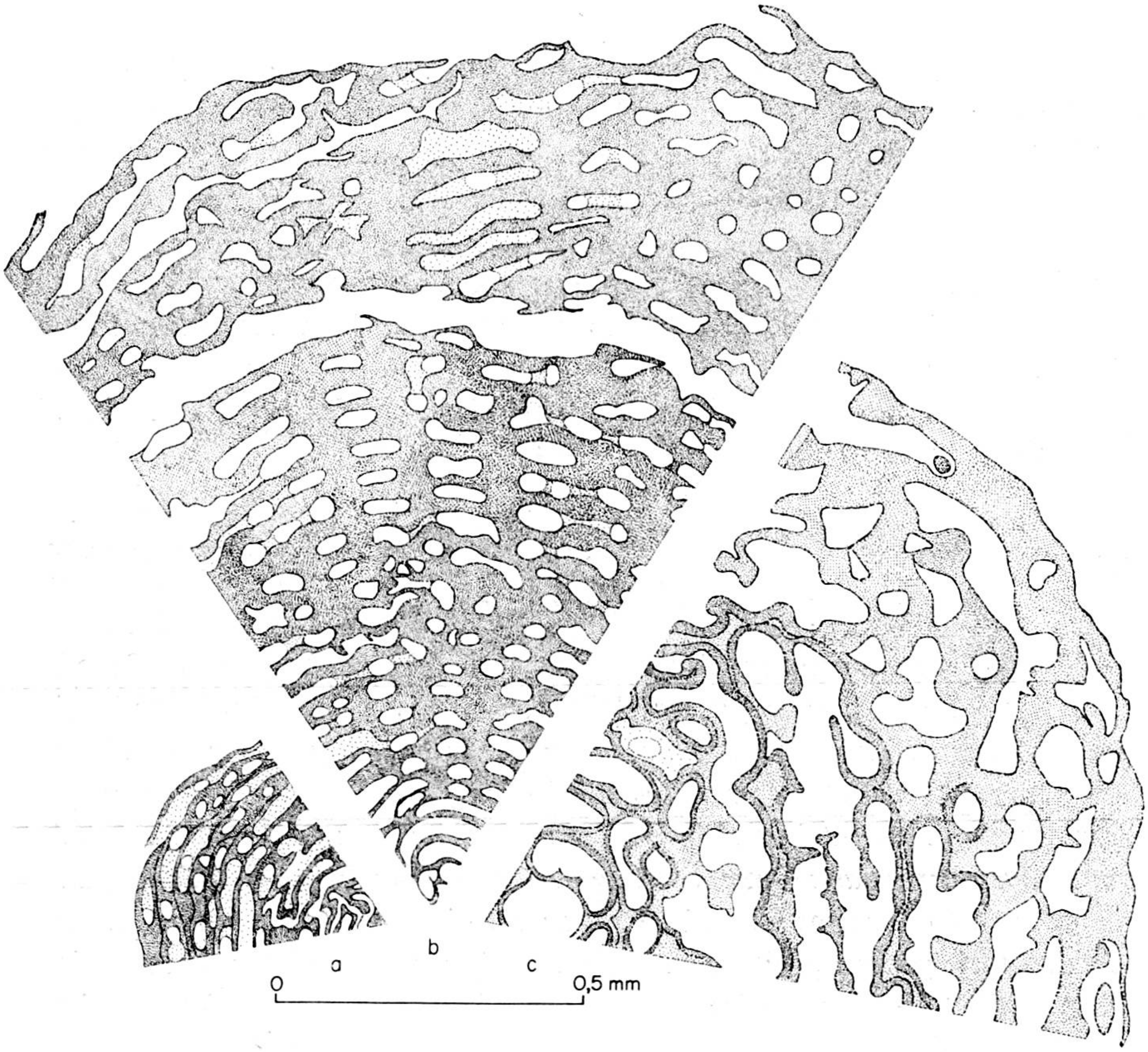


FIG. 9. — Illustration of subaxial sections of *Keramosphaera murrayi* BRADY *a)*, *Keramosphaera tergestina* (STACHE) *b)* and *Keramosphaera allobrogensis*, n. sp., *c)*.

a) *Keramosphaera tergestina* (STACHE) and *Keramosphaera allobrogensis*, n. sp.

Dr. G. DEVOTO, Geological and Paleontological Institute, University of Rome, Italy, kindly sent us a rock thin section with a good subaxial cut of *Keramosphaera tergestina* from the Upper Cretaceous of Costa San Antonio (Vallecorse), Monti Lepini, Italy. The embryonic portion is tangentially cut and the post-embryonic stage exhibits the characteristic concentric and radial organization of this species.

The thin section has been illustrated by DEVOTO (1964, pl. II, fig. 3) and it is reproduced in the present paper by Text-fig. 9 *b*. The here presented morphologic analysis of *Keramosphaera tergestina* (STACHE) is based on the descriptions by STACHE (1889, 1905) and DEVOTO (1964), and on the examination of this thin section. The large globular test of *Keramosphaera tergestina* with a diameter from 5 to 7 mm, according to DEVOTO (1964, p. 51), up to 9.5 mm, and according to DE WITT PUYT (1941, p. 64)

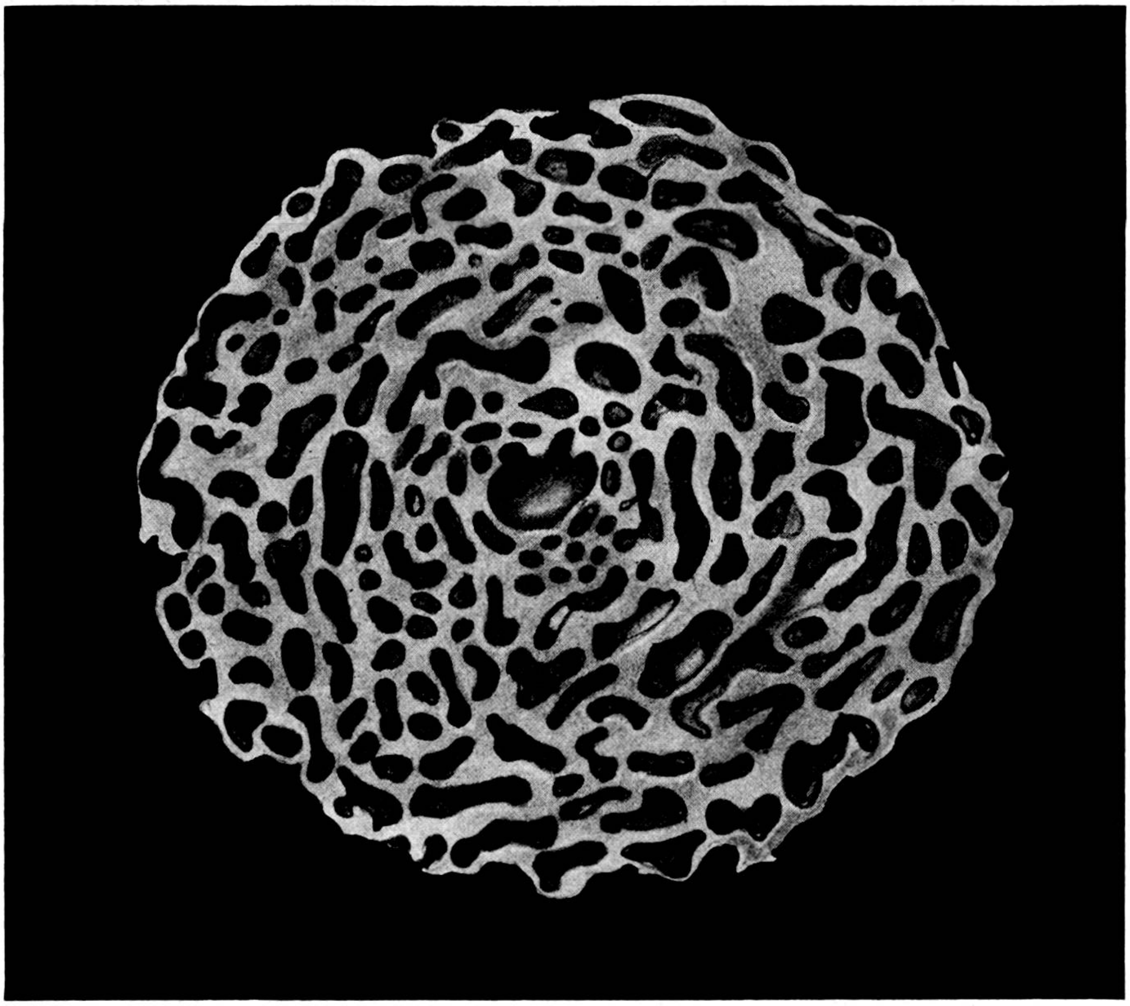


FIG. 10. — Polished section of *Keramosphaera allobrogensis*, n. sp., drawn by L. B. ISHAM, Washington, U.S.A. 46 ×

up to 12 mm, shows in axial section a rather regular, concentric and radial organization, which differs strongly from the unorganized structure of *Keramosphaera allobrogensis*, n. sp. The numerous post-embryonic chambers are small and arranged in well-defined concentric layers. In transverse section, the chambers appear as more or less circular to oblong, to elongate cavities, often slightly convex or sinuous. Their bases are normally plane, and the chambers do not develop irregular radial extensions as in *Keramosphaera allobrogensis*, n. sp. The other characteristic feature of the axial section of *Keramosphaera tergestina* is the alignment of the post-embryonic chambers in radial series, separated from each other by pseudo-pillars formed by simple thickenings of the lateral walls. These pseudo-pillars are here interpreted as elements of support, a necessary structural element of a globular test with the dimensions of *Keramosphaera tergestina*. They occur already in the early post-embryonic stage and their number increases with growth of the test. These pseudo-pillars lack completely in the relatively unorganized globular test of *Keramosphaera allobrogensis*, n. sp. In this stratigraphically older species, which is considerably smaller than its Upper Cretaceous congener, the post-embryonic chambers are not radially aligned nor are they arranged in any clearly concentric layers. On the other hand, the tangential sections of the Berriasian and the Upper Cretaceous species are morphologically similar. In fact, the comparison of the tangential sections of *Keramosphaera tergestina* illustrated by DEVOTO (1964, pl. I, fig. 5, 6) with that of *Keramosphaera allobrogensis*, n. sp., here illustrated by Fig. 1 of Pl. III, shows that the structures are very much alike. The chambers develop in both species more or less complex lateral ramifications. They are, however, much finer and more regular in *Keramosphaera tergestina* than in *Keramosphaera allobrogensis*, n. sp. *Keramosphaera allobrogensis*, n. sp., is here interpreted as a possible ancestor of *Keramosphaera tergestina*. The primitive characters of *Keramosphaera allobrogensis*, n. sp., are represented by the large and strongly irregular chambers and their poorly organized arrangement. The evolutionary changes which lead to *Keramosphaera tergestina* affect the following features:

1. Increase of the size of the test.
2. Increase of the number of the chambers and decrease of the dimension of the chambers.
3. Simplification of the shape of the chambers.
4. Arrangement of the chambers in concentric layers and in radial series.
5. Development with the increase in size of the test of radial pillar-like structures (system of support).

b) *Keramosphaera murrayi* BRADY and *Keramosphaera allobrogensis*, n. sp.

The morphologic comparison of *Keramosphaera allobrogensis*, n. sp., with *Keramosphaera murrayi* BRADY is based on an isolated specimen and on a subaxial thin section of the Recent form. Both specimens are from Challenger Station 15, 53° 55′ S and 108° 35′ E, E of Kerguelen, at 1950 fathoms. We are much obliged to Dr. C. G. ADAMS, British Museum (Natural History), London, for having put this specimen at our disposal and for having authorized preparation of scanning electron micrographs by Dr. W. H. BLOW, BP-Research Centre, Sunbury-on-Thames, Middlesex, England. We are most grateful to Dr. BLOW for his collaboration.

The surfaces of the tests of *Keramosphaera murrayi* and of *Keramosphaera allobrogensis*, n. sp., are similarly structured. Both exhibit irregularly branching chambers. However, those of *Keramosphaera murrayi* are not as finely branching as those of *Keramosphaera allobrogensis*, n. sp. As demonstrated by the micrographs of Pl. I, the chambers of the Recent species are rather flattened and provided with multiple apertures in form of simple, rounded lateral openings. We strongly suspect that also *Keramosphaera allobrogensis*, n. sp., develops, at least in the later ontogenetic stages, multiple apertures. However, the surfaces of the isolated specimens from STEINHAUSER locality 839 are not well-enough preserved as to permit observation of these openings. Further, the more regular, concentric layers of *Keramosphaera murrayi*, as illustrated by Pl. II, distinguish the Recent species from *Keramosphaera allobrogensis*, n. sp. The chambers are, in transverse sections, more or less elongate, with convex distal and more or less plane proximal walls, without any of the irregularities typical of *Keramosphaera allobrogensis*, n. sp. The large openings which can be seen in the subaxial section illustrated by Pl. II are here interpreted as transverse cuts of branching extensions of the chambers and not as openings between chambers as suggested by BRADY (1882, p. 245, explanation to Fig. 4, Pl. XIII). It should be emphasized that the Recent species does not develop the high degree of organization with radial series of chambers, separated by pseudo-pillars and regular concentric layers characteristic of *Keramosphaera tergestina*, hence the morphologic differences are smaller between *Keramosphaera murrayi* and *Keramosphaera allobrogensis*, n. sp., than between *Keramosphaera murrayi* and *Keramosphaera tergestina*. From a phylogenetic point of view, it seems therefore plausible to accept a direct linkage between Berriasian and the Recent species than between the former and the Upper Cretaceous species. Perhaps, *Keramosphaera tergestina* should be interpreted as a highly organized lateral off-shoot, without much possibilities of further modifications, from the evolutionary series defined by *Keramosphaera allobrogensis*, n. sp. - *Keramosphaera murrayi*.

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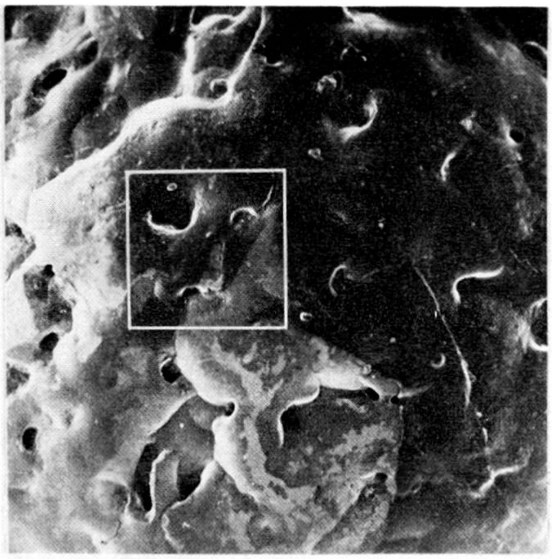

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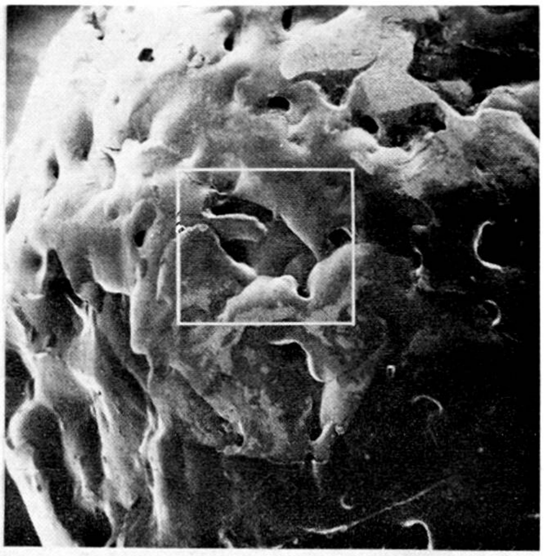

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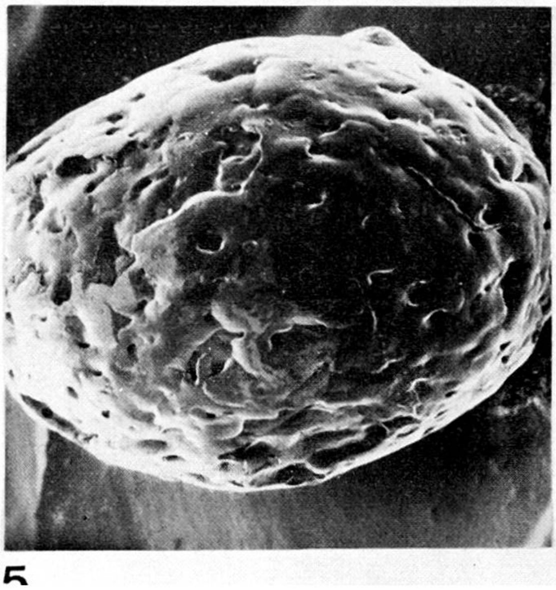

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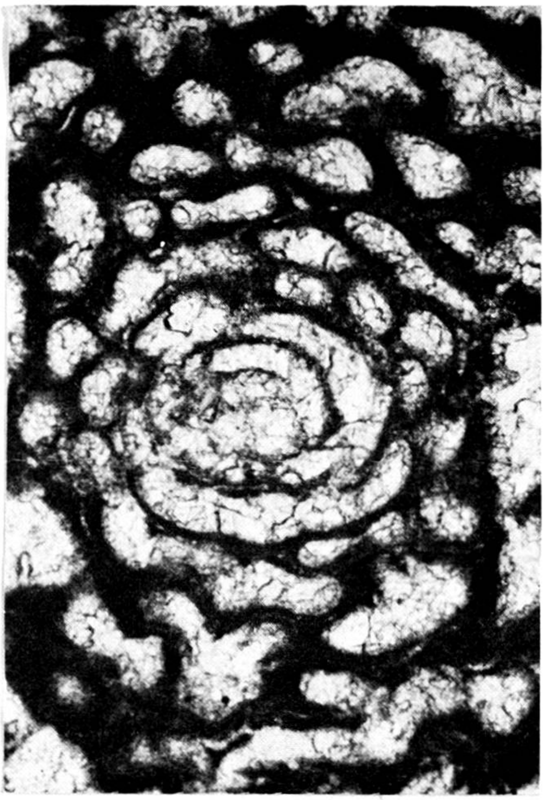

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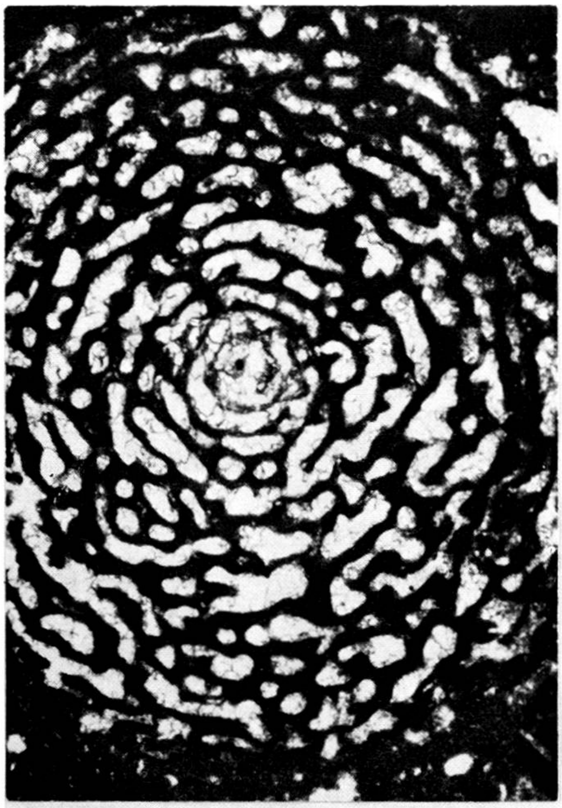

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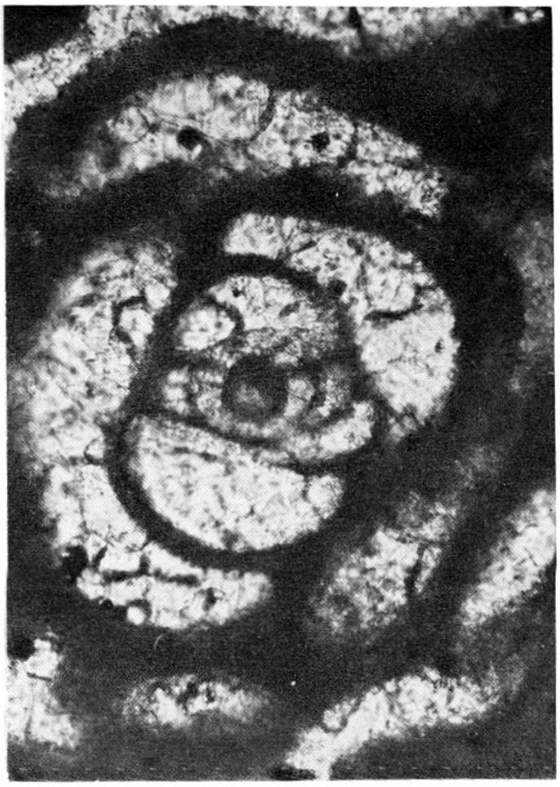

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PLATE I

Keramosphaera murrayi Brady

Syntype.

Recent. Challenger Station 157, 53° 55′ S and 108° 35′ E, at 1950 fathoms, east of Kerguelen. Deposited in the Collections of the British Museum (Natural History), London.

Scanning micrographs of the surface showing flattened and irregularly outlined chambers with multiple apertures. Fig. 1, 87 ×; fig. 2, 74 ×; fig. 3, 255 ×, detail of fig. 1; fig. 4, 218 ×, detail of fig. 2; fig. 5, 37 ×.

PLATE II

Keramosphaera murrayi Brady

Syntype.

Recent. Challenger Station 157, 53° 55′ S and 108° 35′ E, at 1950 fathoms, east of Kerguelen. Deposited in the Collections of the British Museum (Natural History), London.

Almost centered axial section. The innermost portion is tangentially cut. Large rounded openings are interpreted as sections across branching extensions of the chambers 380 ×.

This specimen is rather small for the genus with a maximum diameter of about 840 μ. The walls are brownish and show the preservation of typical Recent Miliolacea.

PLATE III

Keramosphaera allobrogensis, n. sp.

Fig. 1. Tangential section. Steinhauser locality 468, Pierre-Châtel, thin section 4.33 ×.

Fig. 2. Almost centered section showing the irregular arrangement of early post-embryonic chambers. Innermost portion is tangentially cut. Steinhauser locality 467, Pierre-Châtel, thin section 1. 100 ×.

Fig. 3. Almost centered section showing the irregular arrangement of post-embryonic chambers from center to periphery. Steinhauser locality 467, Pierre-Châtel, thin section 2. 40 ×.

Fig. 4. Centered section of a megalospheric (?) specimen. Thin section Mouty 623, locality unknown. 115 ×.

PLATE IV

Keramosphaera allobrogensis, n. sp.

Fig. 1. Microspheric embryo showing quinqueloculine enrollment and globular proloculus. Holotype. Steinhauser locality 839, Molard de Vions, thin section B. 90 ×.

Fig. 2. Same specimen 240 ×.

Fig. 3. Microspheric embryo showing quinqueloculine enrollment and early post-embryonic chambers. Steinhauser locality 467, Pierre-Châtel, thin section 3. 216 ×.

Fig. 4. Same specimen as Fig. 3 with strongly irregular post-embryonic chambers. On the right with branching extensions cut transversely. Below *Keramosphaera allobrogensis*, n. sp., an oblique axial cut of *Pseudotextulariella courtionensis* Brönnimann. 36 ×.