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REPORT OF INVESTIGATIONS 186

NORTH AMERICAN PALEOZOIC CHITINOZOA

BY

CHARLES COLLINSON AND HOWARD SCHWALB

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

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ILLUSTRATIONS

NORTH AMERICAN PALEOZOIC CHITINOZOA

BY

CHARLES COLLINSON AND HOWARD SCHWALB

ABSTRACT

Chitinozoans have received little study by American paleontologists but newly reported occurrences from Ordovician, Silurian, and Devonian strata in North America suggest that they may become important stratigraphic indices. A rapid reconnaissance of wells, outcrops, field notes, etc., has yielded eighteen geographic occurrences and leads us to believe that these microfossils are widely distributed and abundant in the Paleozoic. More than 500 specimens have been examined. Study of a complete Silurian-Devonian core sequence in White Co., Ill., has shown chitinozoans occur in three separate zones and represent two faunules.

The taxonomic position of the Chitinozoa is discussed, and it is concluded that these microfossils represent an extinct order of rhizopod protozoans. The common association of chitinozoans and glauconite in the Clear Creek chert suggests that these microorganisms lived in relatively shallow marine waters in a moderately anaerobic environment.

All previously recorded genera are briefly described, and two new genera, *Ampullachitina* and *Illichitina,* are proposed. All known species are listed and eleven new species from Illinois are described and illustrated.

INTRODUCTION

In recent years the existence of the Chitinozoa has been virtually forgotten by paleontologists and stratigraphers. In Europe, where they were first described, there has been little progress in knowledge of these fossils for more than a decade. In the United States they have never received significant attention from paleontologists, although some subsurface stratigraphers have used zones in which chitinozoans are abundant as stratigraphic markers without knowing the nature of the fossils. Oil geologists in the Eastern Interior Basin and Illinois Geological Survey stratigraphers have used abundance of these "black spore-like bodies" as a criterion for recognizing the Clear Creek chert for a number of years. In some areas abundance of the "black spores" has been used to define the limits of the formation.

Because of the abundance of chitinozoans and their importance to the oil industry as stratigraphic markers, the authors in 1953 began to collect and study these microfossils. The Superior Oil Company–H. C. Ford et al. C-17 core from White Co., Ill., then became available for study and, as the entire Silurian-Devonian section was cored in that test, we initiated a study to determine the precise range and abundance of chitinozoans in the core. Although more than 500 specimens from the Superior core provide the nucleus for this study, a number of other occurrences of chitinozoa in the Midwest were found as study progressed. So much material has been obtained that this paper should be considered a progress report and a basis for further study.

We believe that Chitinozoa are so widely distributed in the lower Paleozoic of North America that they offer promise of becoming an important tool for outcrop and subsurface correlation. Several characteristics favor their use as stratigraphic indices: 1) they are of widespread geographic occurrence, 2) they consist of material that is virtually indestructible, so they are abundantly preserved and may be recovered from concentrated hydrofluoric, sulfuric, hydrochloric, or other acid residues, 3) they are easily recognizable in outcrop and well samples, and 4) they are small and have enough distinguishing features to be identified even in finely crushed well samples. Determination of their value as index fossils now depends upon detailed study by micropaleontologists and stratigraphers, and we hope that this study will serve as a basis for renewed interest in the microfossils.

It is a pleasure to acknowledge help from several colleagues of the Illinois Geological Survey. H. B. Willman and D. H. Swann

read and criticized the manuscript and gave information and encouragement throughout the study. R. M. Kosanke gave information that greatly aided our work, especially during the early stages of the project. We are also indebted to W. F. Bradley, who made our X-ray photographs, to James Baxter, who discovered chitinozoans in the Silurian of Illinois, and to Alan Scott, who made most of the text figures.

STRATIGRAPHIC AND GEOGRAPHIC OCCURRENCE

Eisenack coined the name *Chitinozoa* in 1931 for a previously undescribed group of "chitinous" microfossils that he obtained from Ordovician and Silurian rocks of the East Prussia Baltic region of Europe. In subsequent publications, he, DeFlandre, and Lewis extended the known range and occurrence of the Chitinozoa in Europe to the Silurian of the Montagne Noire of southern France, the Ordovician of northern Wales, the Ordovician of western Germany, and the Ordovician of western Czechoslovakia.

Stauffer (1933) reported the first chitinozoan species from the western hemisphere when he described *Rhabdochitina ? minnesotensis* from the Middle Ordovician Decorah formation of Minnesota. Cooper (1942) reported that chitinozoans range from the Ordovician to the Devonian in North America, and Lange (1949) described a single species from the Devonian of Brazil.

Our study leads us to believe that the Chitinozoa are abundant and widespread in Midwestern United States and that they will be found to be abundant elsewhere. We have learned from L. E. Workman, Canadian Stratigraphic Service, Ltd., Calgary (personal communication), that chitinozoans are common in the Devonian rocks of Alberta. While this report was being completed, an occurrence of chitinozoans in the Upper Ordovician Maquoketa shale in a well in Lake County, Ill., was discovered. All occurrences of chitinozoans in North America known to us, other than the abovementioned two, are shown in figure 2, and the occurrence of all known species are listed under the discussion of each respective genus. It is emphasized that the known occurrences listed are the results of a reconnaissance examination of wells and outcrops and probably represent only a small fraction of the total occurrences in Illinois and adjacent states.

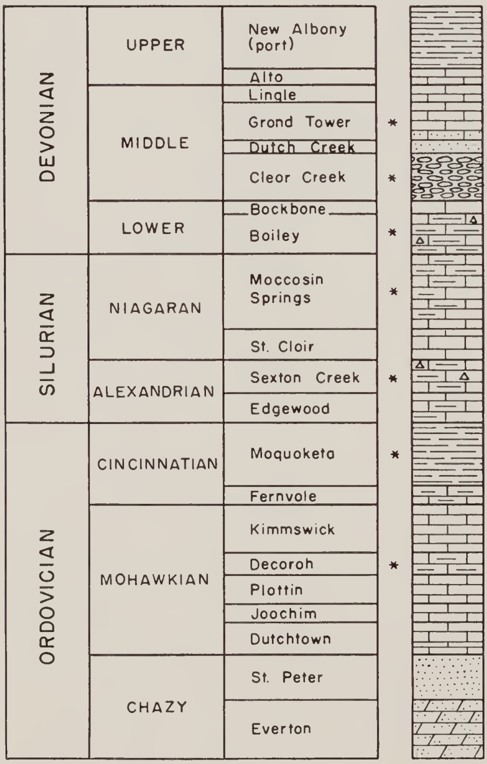

FIG. 1.—Generalized section for southern Illinois showing* all reported stratigraphic occurrences of chitinozoans. The Maquoketa occurrence is in northern Illinois, the Moccasin Springs in the Racine of northern Illinois, and the Decorah in southern Minnesota.

Chitinozoans in Superior-Ford C-17 core.—The results of a detailed study of the lithology, chert percentages, insoluble residues, and occurrence of chitinozoans in the Superior Oil Co.–Ford C-17 core are illustrated in figure 3. Examination of the chitinozoans was undertaken as part of a general study of the core. The lithologies of the whole core were described, the amount of chert present was estimated visually, and the core was sampled every foot. Half of each sample was retained as a hand specimen and the other half was crushed for insoluble-residue and other analyses. Ten to 20 grams of crushed material from each sam-

Fig. 2.—Map showing locations of wells and outcrops from which chitinozoans have been collected. (In Illinois, unless otherwise noted.)

1. Mulford Engineering Service–Thornton well, sec. 34, T. 36 N., R. 14 E., Cook Co., depths 145–150 feet, Racine formation.
2. Allen and Sherritt–Biggs well 1, sec. 9, T. 11 N., R. 14 W., Clark Co., depths 1425–1445 feet, Clear Creek chert.
3. National Assoc. Petroleum Co.–Handley well 1, sec. 26, T. 10 N., R. 7 E., Cumberland Co., depths 3736–3743 feet, Grand Tower formation.
4. Northern Ordinance, Inc.–Sapp well 1, sec. 5, T. 2 N., R. 5 E., Clay Co., depths 4650–4670 feet, Clear Creek chert.
5. Magnolia Petroleum Co.–Youngs well 28, sec. 20, T. 2 N., R. 2 E., Marion Co., depths 3406–3440 feet, Clear Creek chert.
6. Superior Oil Co.–Williams et al. well 1, sec. 22, T. 2 N., R. 1 E., Marion Co., depth 3480 feet, Clear Creek chert.
7. Shell Oil Co.–Ragan well 1, sec. 25, T. 2 S., R. 1 E., Jefferson Co., depths 3900–3935 feet, Bailey formation.
8. Shell Oil Co.–Schubert well A1, sec. 23, T. 4 S., R. 2 W., Perry Co., depths 2974–3014 feet, Clear Creek chert.
9. Superior Oil Co.–H. C. Ford et al. well C–17, sec. 27, T. 4 S., R. 14 W., White Co.; see figure 2 for distribution.
10. Phillips Oil Co.–Garr well 1, sec. 31, T. 4 S., R. 11 E., White Co., depths 5120–5130 and 5150–5155 feet, Clear Creek chert.
11. Burr Lambert Co.–Hagler well 1, sec. 28, T. 10 S., R. 2 W., Jackson Co., depths 2400–2565 feet, Clear Creek chert.
12. F. Lyrler–Baysinger well 1, sec. 32, T. 10 S., R. 3 W., Jackson Co., depths 270–295 feet, Bailey formation.
13. Little Egypt Oil Co.–Bassler well 1, sec. 35, T. 11 S., R. 1 W., Union Co., depths 2425–2824 feet, Clear Creek chert.
14. Hobson and Holman–J. T. West well 1, 1–F–26, Christian Co., Ky., depths 2285–2330 feet, Clear Creek chert.
15. Gerre Jordan well 1, Hardin Co., Tenn., depth 80 feet, questionable Devonian.
16. Blocks of rock believed to be Grand Tower limestone excavated for foundation of an aerial pipeline crossing tower near Devils Bakeoven, sec. 23, T. 10 S., R. 4 W., Jackson Co.
17. Outcrop in lower part of Decorah shale, 5 feet above the base of the formation, Ford Bridge, Minneapolis, Minn.
18. Outcrop in the shale just above the "marble layer," 4½ feet above the base of the Decorah shale, Lieb Quarry, Faribault, Minn.

ple was dissolved in 10 percent hydrochloric acid, and the resulting residue was weighed and examined for microfossils. Many free chitinozoans were found in the residues, and the total abundance was visually estimated and plotted.

The location of the core in the central and deepest part of the Eastern Interior Basin (fig. 2, well 9) makes it of key importance, for it is about equidistant from the relatively complete outcrop-sections of Silurian-Devonian strata in the southwestern Illinois Grand Tower area, the central Tennessee Wells Creek area, and the Louisville area of Kentucky and Indiana. So far, outcrops containing chitinozoans have been reported only from the Grand Tower area but as far as we know they have not been sought in the other outcrop areas.

The chitinozoans occur in three zones in the core—two thick zones in the Middle Devonian Clear Creek chert and one thin zone in the lower part of the Lower Silurian Sexton Creek formation. In the Clear Creek, which is generally defined as a cherty limestone or calcareous chert unit, the zones extend from 4990 to 5100 feet and from 5205 to 5456 feet, respectively. They coincide closely in each case with siliceous, dolomitic portions of the core and are separated by about a hundred feet of relatively pure limestone without chitinozoans. Such coincidence of the chitinozoans

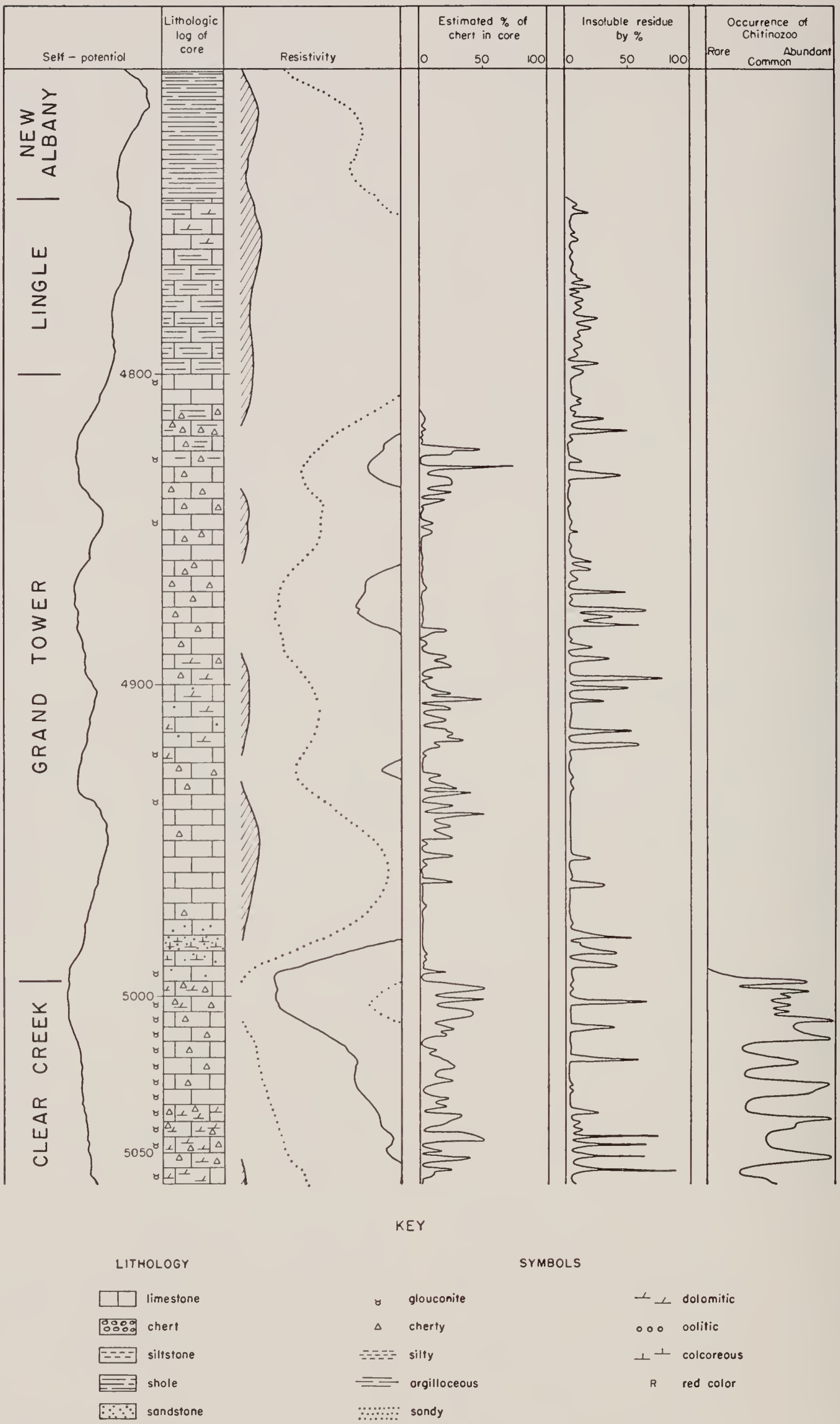
Self – potential
Lithologic log of core
Resistivity
Estimated % of chert in core
0 50 100
Insoluble residue by %
0 50 100
Occurrence of Chitinozoa
Rare Common Abundant
NEW ALBANY
LINGLE
GRAND TOWER
CLEAR CREEK
4800
4900
5000
5050
KEY
LITHOLOGY
limestone
chert
siltstone
shale
sandstone
SYMBOLS
glauconite
cherty
silty
argillaceous
sandy
dolomitic
oolitic
calcareous
R red color

Fig. 3.

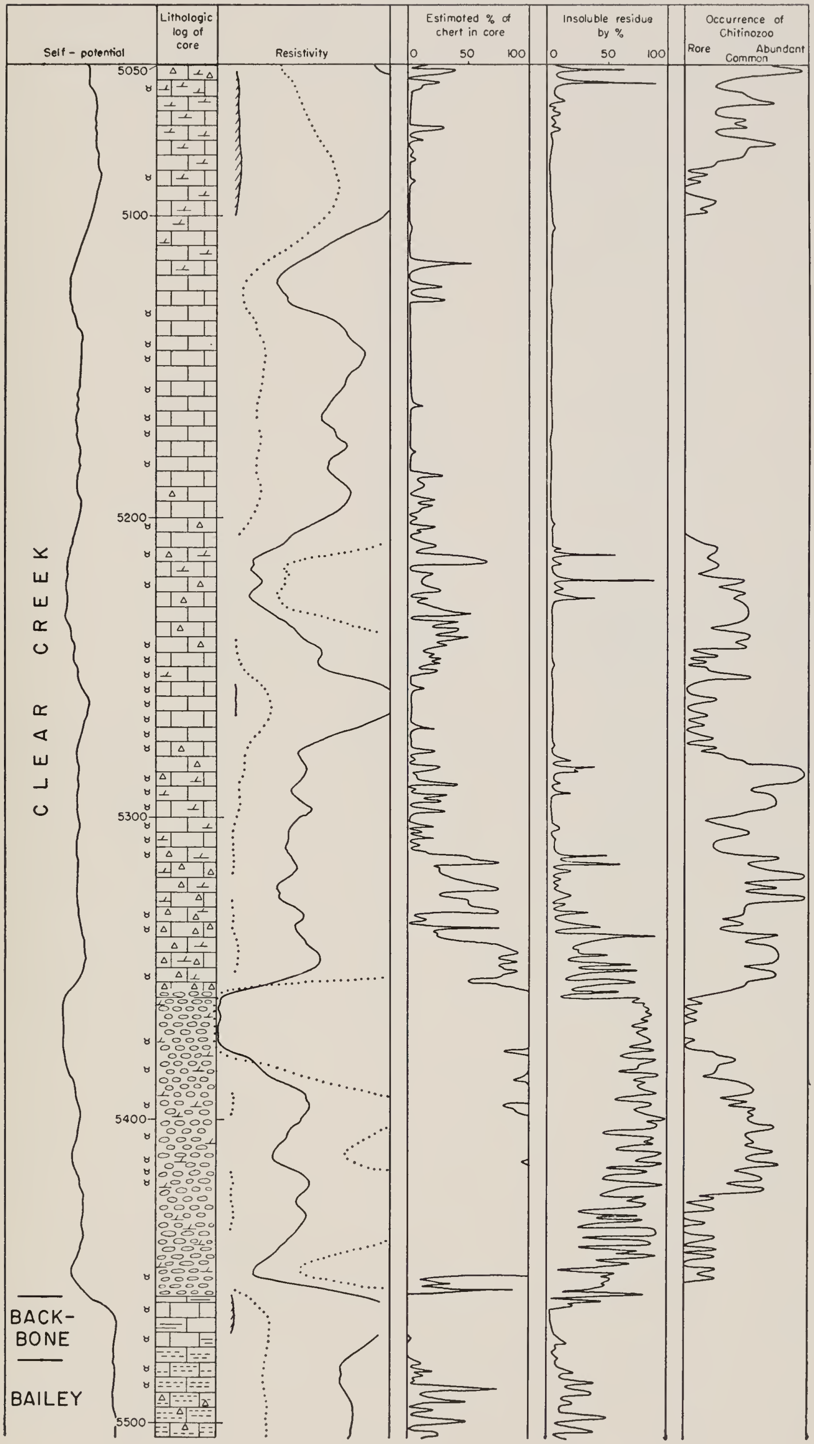

FIG. 3.—(Continued)

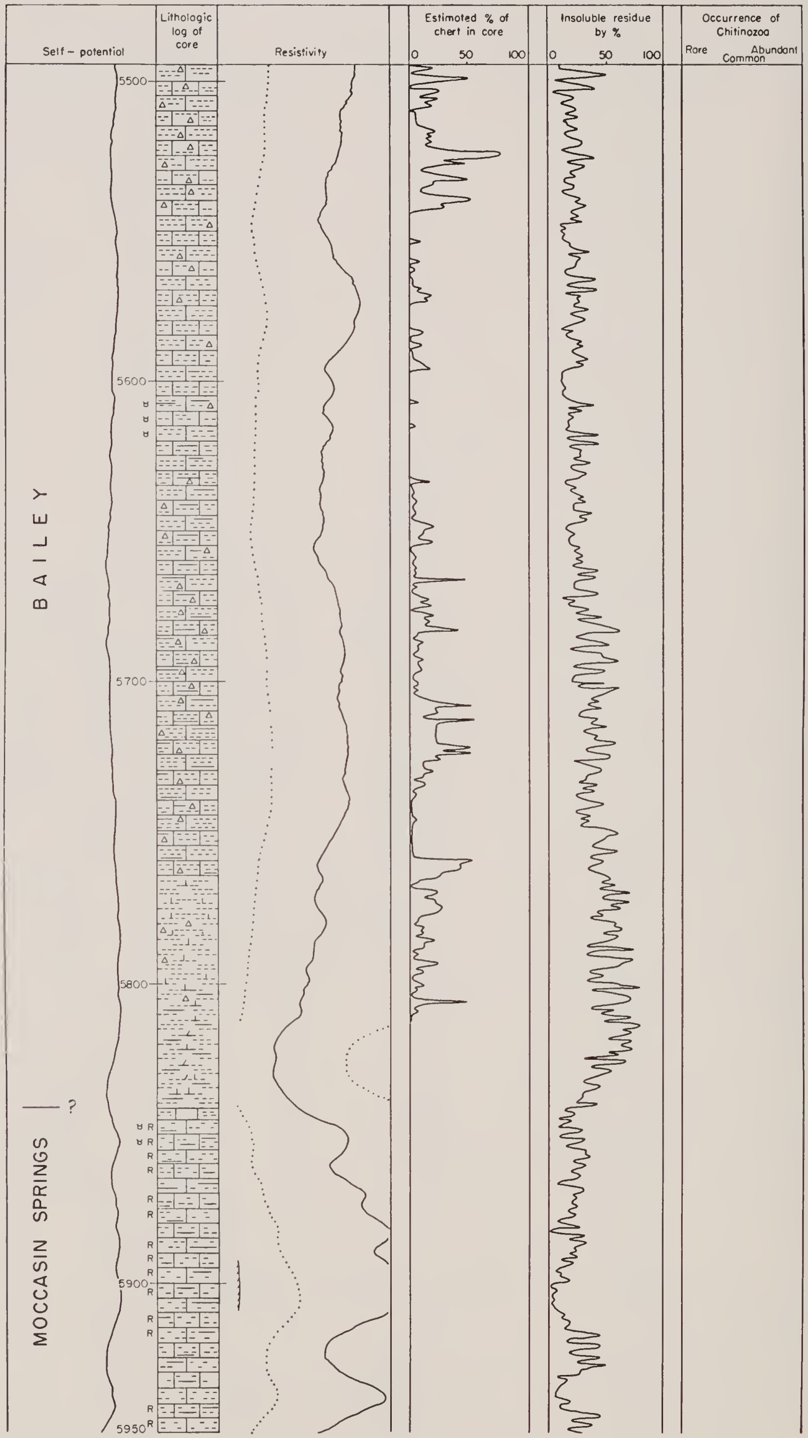

FIG. 3.—(Continued)

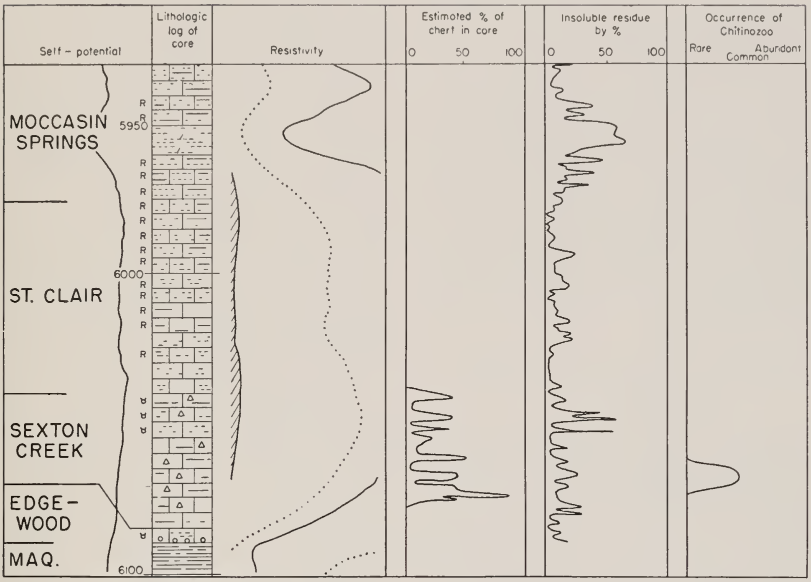

Fig. 3.—(Continued)—Graphic section of a portion of the 6-inch Superior-Ford C–17 core, sec. 27, T. 4 S., R. 14 W., White Co. The core was completed in 1952 and the portion shown is continuous. Oil-base mud was used in drilling and the electric log should be interpreted accordingly.

with the siliceous strata might lead to the conclusion that the chitinozoans owe their preservation to the silicification of the beds. However, as mentioned above, many of the Chitinozoa were dissolved from the calcareous portions of the core. This points to the possibility that chitinozoans may have flourished in environments favorable to the deposition of chert whether that be governed by the depth, pH of the water, or some other factor. The following species occur in both zones of the Clear Creek.

Lagenochitina brevicervicata n. sp.
L. elongata n. sp.
Angochitina flasca n. sp.
A. pusilla n. sp.

L. brevicervicata and *A. flasca* are very common to abundant; the other two species are rare to common. A number of *Bairdia*-like ostracodes were found associated with Chitinozoa between depths of 5267 and 5395 feet. Sponge spicules were noted at a 5385-foot depth, and a single occurrence of bryozoa was recorded at a depth of 5489 feet.

Glauconite, which is characteristic of the Clear Creek, occurs throughout the formation, but it is most common in the two chitinozoan zones. Cloud (1955, p. 490) gives physical limits for glauconite formation. The limits that appear to be significant in indicating the environment of the Clear Creek and its chitinozoan fauna are: 1) It occurs off most oceanic coasts and mainly on the continental shelves away from large streams; 2) It is known to originate only in marine waters of normal salinity; 3) Its formation requires at least slightly reducing conditions, at sites of origin within the enclosing sediments; 4) Its formation is facilitated by the presence of decaying organic matter, which results in reducing conditions. The bottom habitat is favorable to sediment-ingesting organisms with low oxygen requirements; 5) Its formation is favored in the upper part of the 10 to 400 fathom interval. It is rare to uncommon at other depths; 6) It has a wide range of temperature tolerance; and 7) It is commonly associated with remains and fecal pellets of sediment-ingesting organisms. It is rare in beds that are rich in algae, corals, or bryozoans. The presence of ostracode shells is not out of keeping with such an environment as outlined by Cloud, and the conditions are favorable to protozoans, such as we believe the Chitinozoa to be.

The third chitinozoan zone was found in the lower part of the Sexton Creek formation between depths of 6065 and 6075 feet, where the rock is a cherty argillaceous limestone. Two species were common, *Ampullachitina laguncula* and *Illichitina crotalum*. Some glauconite is present in the upper part of the formation, but it immediately overlies the zone of Chitinozoa.

THE SYSTEMATIC POSITION OF THE CHITINOZOA

There has been considerable doubt about the precise zoological affinities of the Chitinozoa. Eisenack (1931), in the first report on the fossils, stated that he believed them to be related to the rhizopod order Thecamoebaea (Testacea), which contains genera with structureless chitin-like tests. Such recent Thecamoebaea genera as *Diplophrys* Barker, *Micrometes* Cienkowski, *Lieberkühnia* Claparède and Lachmann, *Microgromia* Hertwig and Lesser, and *Gromia* Dujardin contain species that not only have structureless chitin-like tests but compare in size, shape, and color to the fossil Chitinozoa *Lagenochitina* and *Desmochitina*. Eisenack stated, however, that living members of the Thecamoebaea live mainly in fresh water and he noted that their shells are soluble in potash lye whereas those of the Chitinozoa are not.

In 1932 Eisenack called attention to the similarity between the flagellate protozoan genus *Trachelomonas* Ehrenberg and some chitinozoans. Some species of *Trachelomonas* float about in a brittle covering which extends away from the body and is generally colored brown by iron oxide. The tests are thick and possess necks and collars much like *Lagenochitina, Angochitina,* and *Desmochitina*. Some are smooth, others covered with short spines. The material of the tests is apparently different in comparable species of the two groups, however, as the *Trachelomonas* test is composed of cellulose. Furthermore, the genus is only known to occur in fresh water. These factors, Eisenack wrote, seem to oppose any connection between the flagellates and the Chitinozoa. He did, however, indicate a strong belief that the Chitinozoa are protozoans.

Jepps (1926) published a detailed study of the Thecamoebaea species *Gromia oviformis* Dujardin, which occurs in great quantity along the seashore of Great Britain. The similarity of this form to such chitinozoan genera as *Lagenochitina* and *Angochitina* is certainly close. *G. oviformis* is almost spherical, being either slightly depressed or ellipsoidal in general shape with a small mouth at one end of the long axis. The shape of the animal is constant because of the rigid pseudochitinous test. The mouth is bordered by a neck, such as is found in *Lagenochitina brevicervicata,* and the neck carries a soft collar through which the pseudopodia are extruded. The collar may be extended or retracted as the pseudopodia are extended or retracted. The oral diaphragm of some chitinozoans may have been flexible enough to have performed a similar function. The test or chamber of *G. oviformis* is composed of an outer perforate layer and a thinner structureless inner layer. The two layers appear to correspond to the tegmen and chamber wall found in *Lagenochitina* (fig. 6).

The composition of the chitinozoan test.—One of the most important factors to be considered in determining the affinities of Chitinozoa is the nature of the material that composes the test. Jepps in 1926 reported the results of analyses in which she subjected the shells of the Recent Thecamoeba *Gromia oviformis* to several analyses. They indicated that the inner layer of the test is insoluble in acetic acid, hydrochloric acid, or cold 50 percent caustic potash. In boiling caustic potash the basal membrane broke up, presumably as the result of the violent boiling. The outer layer of the shell resisted solution in all the solvents except caustic potash, which dissolved the layer in one week. The collar dissolved in both the hydrochloric acid and the caustic potash but was insoluble in dilute acetic acid. Jepps came to the conclusion that the outer layer is composed of pseudochitin but gave no opinion concerning the structureless inner

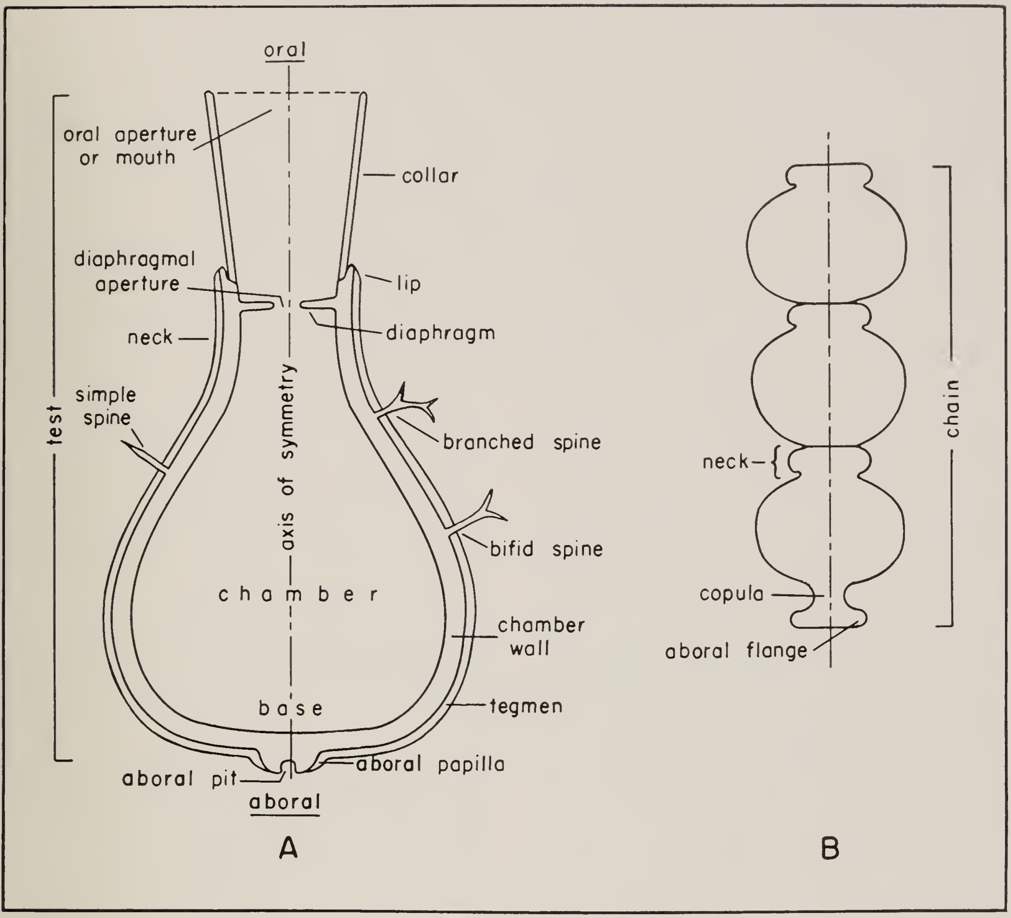

FIG. 4.—Diagrams of hypothetical chitinozoan individual (A) and chain (B) illustrating the terminology used in this report. The terms *proximal* and *distal* used in previous chitinozoan studies are abandoned because they have been applied in a sense contrary to general usage of the terms.

layer, although her analyses seem to show that it is of a pseudochitinous nature also.

Eisenack (1931) conducted a number of experiments in an attempt to determine the chemical composition of the chitinozoan test. He found the tests completely resistant to heating with concentrated hydrochloric acid, concentrated hydrofluoric acid (40 percent), or concentrated potash lye (20 and 50 percent), even when the specimens are heated in these solutions for long periods at 100° C. The Chitinozoa were heated up to 200° C. in 90 percent sulfuric acid and did not dissolve. Eisenack noted that chitin from modern animals is affected by caustic soda if the chitin has already been hydrolized by heating with hydrochloric acid or sulfuric acid. As the result of these tests, he recognized that there seems to be a distinct difference in composition between modern chitin and the tests of the Chitinozoa, but he concluded that the chitinozoan test is probably stabilized by an anhydrous structure that resists hydrolyzation.

Clark and Smith (1936) performed a series of experiments on chitin from the carapace of the lobster *Homarus americanus,* and they noted the following characteristics: 1) The chitin occurs in long fibrils that can be teased apart after treatment with absolute alcohol; 2) The chitin is soluble in hot saturated sodium hydroxide; 3) The chitin is soluble in concentrated mineral acids such as HCl but is unattacked by others. Even at room temperature, chitin is hydrolyzed in hydrochloric acid.

Kesling (1951, p. 70-71) took an X-ray powder photograph of dried *Daphnia longispina,* which are said to be made entirely of chitin. The film showed only very diffuse halos of high d values (approximate values of 4.5 and 11.7Å at the center of the diffuse bands). Clark and Smith published powder patterns of lobster chitin that were very diffuse, indicating an almost amorphous structure.

W. F. Bradley made X-ray photographs for us of the test wall of several broken representatives of *Angochitina flasca.* The results were comparable with those quoted by Kesling for *Daphnia.* However, as also noted by Kesling, the halos are too diffuse to be used as proof that the material X-rayed was or was not chitin.

The experiments by Jepps, from which she concluded that *Gromia* is pseudochitinous, the analyses made by Clark and Smith on chitin from the lobster *Homarus,* and the work by Eisenack on chitinozoans lead to the conclusion that the composition of the Chitinozoa is close to that of *Gromia* and not very close to true chitin. If allowance is made for any changes in composition of the chitinozoan tests during preservation, then an original composition of pseudochitin seems probable.

In general shape, such choanoflagellates as the marine protomonad genera *Salpingoeca* James-Clark and *Conodoeca* James-Clark closely resemble the chitinozoan species *Angochitina bifurcata,* and *Lagenochitina sacculus.* Furthermore, these flagellate genera contain species that possess chitin-like tests and soft oral collars and are either attached by a stalk or are free-swimmers. These characteristics speak strongly for classification of the Chitinozoa with the flagellates. However, very few pseudochitinous or marine flagellate genera are known, and forms with relatively thick tests, such as are characteristic of the Chitinozoa, are very rare.

Among the rhizopods, thick pseudochitinous tests are very common, and there are many more marine genera than among the flagellates. Oral collars and flagella are known but are uncommon; attachment organelles, whose presence is reflected in the shape of the test, are rare. Nevertheless, there are many species of sessile rhizopods. Thus the Chitinozoa have characteristics in common with both flagellates and rhizopods but do not fit perfectly into either class. Furthermore, neither class possesses such chitinozoan features as bifurcate and branched spines or thick oral diaphragms. Therefore it seems best to consider the Chitinozoa as an extinct order of marine protozoans which, because of their thick pseudochitinous tests and marine habitat, we are referring to the class Rhizopoda (Sarcodina). *Chitinozoa* may be a misnomer in that the microfossils seem to be composed of pseudochitin.* The term is retained, however, because of its previous usage and because many paleontologists use the word *chitin* in a broad sense for any horny organic substance.

PALEOBIOLOGY

Any attempt to describe the biology of the Chitinozoa is partly based upon their identification as rhizopods and the assumption that they lived much as modern forms do. There are, however, several characteristics of the Chitinozoa that give clues to their mode of life. For example, the aboral pit, which is present on many chitinozoan species, may have served as a receptacle for a stalk or other kind of holdfast organelle. Forms with pits therefore may have been benthonic, whereas such forms as *Angochitina bifurcata* and *Ampullachitina laguncula,* which possess spines and no aboral pit, were probably floaters. The collared chitinozoans are much like living flagellates. It seems reasonable to presume their collar functioned like the flagellate collar and was a food-gathering device that may have paralyzed algae or other microscopic organisms that came in contact with it.

From comparison with modern forms, we infer that most of the Chitinozoa gathered

* Hyman (1940, p. 55) states "pseudochitin is a glycoprotein, a combination of protein and carbohydrate, similar chemically to mucin (slime). Chitin is non-protein and consists of acetic acid united to glucosamine (the sugar glucose with one OH group replaced by NH_2)."

food and moved by use of pseudopodia or flagella extended from the oral aperture. Reproduction among living rhizopods is chiefly by binary fission but also by multiple fission and budding. In many cases the life cycle includes production of flagellate swarmers, and some forms are flagellate at times in the adult state. In some genera reproduction involves an alternation of sexual and asexual generations, and the adult is commonly dimorphic. In simple species, however, the two forms cannot be distinguished. Such may also be the case with some chitinozoans. In the chitinozoan genus *Desmochitina* two to six individuals are commonly found in chains that may be similar to the chains of the dinoflagellate *Ceratium* that are formed by repeated binary fission.

PALEOECOLOGY

So far, chitinozoans have been found mainly in limestone but great numbers have also been recovered from chert, dolomite, and shale. Where found, the fossils are very abundant and occur in a considerable range of sizes. Often such delicate features as bifurcate spines and translucent collars are preserved. These facts seem to indicate that the faunas have not been transported any significant distance and that in most cases they represent a life assemblage. In each assemblage one or two species predominate. Other species are very rare and may merely represent specific variants or mutations of the predominant species.

In one southern Illinois occurrence, Devonian chitinozoans were found associated with scolecodonts. In the Superior-Ford C-17 core, ostracodes were commonly found with chitinozoans throughout a 128-foot zone; some sponge spicules and one bryozoan were also found associated with chitinozoans. With the exception of the bryozoan, all these associated forms could have lived and flourished in an oxygen-poor environment, such as Cloud has stated (see p. 13) is required for the formation of glauconite. These conditions along with the other requirements for glauconite formation listed by Cloud may very well outline the environment of the Chitinozoa.

SYSTEMATIC PALEONTOLOGY

The Chitinozoa were established by Eisenack in 1931 and revised by the later work of Eisenack and DeFlandre. For the reasons outlined above, we are recognizing Chitinozoa as an order and placing it in the class Rhizopoda. Revision of existing classification has been held to a minimum in anticipation of more extensive studies. However, a few changes have been made in order to effect a more natural and useful classification. The polymorphic genus *Conochitina* is restricted to slightly tapered forms, and the genera *Ampullachitina* n. gen. and *Illichitina* n. gen. are erected for ampulla-shaped forms with long necks and bell-shaped forms, respectively. In addition, two species, *Conochitina lagenomorpha* Eisenack and *C. filifera* Eisenack, are referred to *Angochitina*.

Phylum Protozoa Goldfuss, 1818
Class Rhizopoda Dujardin, 1841
Order Chitinozoa Eisenack, 1931

Axially symmetrical marine organisms with simple but varied rod-, club-, flask-, or trumpet-shaped tests. Individuals range from about .03 mm. to .5 mm. in length. The test, which we believe to be pseudochitinous, is generally black, structureless, and opaque. In some species the test is brown or amber and is translucent. The test is open at one end, the oral, and closed at the other end, the aboral. The surface of the test may be very smooth, tuberculate, or hispid. In combination with any of these surface textures, the test may possess either simple or branched spines.

The organisms occur either singly or in chains of several individuals. The most individuals found in a chain is six. Stratigraphically they are known to occur from the Middle Ordovician to the Middle Devonian. They have been found in the United States, Canada, Brazil, Wales, Germany, France, and Czechoslovakia.

Family Lagenochitinidae Eisenack, 1931

As defined by Eisenack, this family consists of flask-shaped individuals that have their greatest diameter near the midlength.

Fig. 5.—Representatives of all genera of Chitinozoa, with omission of the genus *Ampullachitina* (fig. 9). All except figure A are holotypes upon which the genotypes of genera published prior to this report are based. (A) *Illichitina cervicornis* (Eisenack); (B) *Angochitina echinata* Eisenack; (C) *Lagenochitina baltica* Eisenack; (D) *Mirachitina quadrupedis* Eisenack; (E) *Acanthochitina barbata* Eisenack; (F) *Desmochitina nodosa* Eisenack; (G) *Parachitina curvata* Eisenack; (H) *Conochitina claviformis* Eisenack; (I) *Rhabdochitina magna* Eisenack. All after Eisenack.

The chamber tapers gradually to a tubular neck which is terminated by a smooth mouth.

Genus Lagenochitina Eisenack, 1931
Genotype: *Lagenochitina baltica* Eisenack

The genus contains flask-shaped forms without spines. The genotype was originally described from the Ordovician Ostseekalk of the East Prussia Baltic region. The genus now contains the following species:

L. cylindrica Eisenack—Ordovician limestone, East Prussia Baltic region.

L. prussica Eisenack—Ordovician Ostseekalk, East Prussia Baltic region.

L. sphaerocephala Eisenack—Silurian Beyrichienkalk, East Prussia Baltic region, Ordovician (E_2) of Kozel, western Czechoslovakia (Bohemia); Silurian of Combe d'Izarne in the Montagne Noire of southern France.

L. bohemica Eisenack—Ordovician $D_{\psi 1}$ of Šarka, western Czechoslovakia (Bohemia).

L. brevicervicata n. sp.—Middle Devonian Clear Creek chert of southern Illinois and southern Tennessee.

L. elongata n. sp.—Middle Devonian Clear Creek chert of southern Illinois.

L. sphaerica n. sp.—Middle Devonian Clear Creek chert of southern Illinois.

L. sacculus n. sp.—Lower Devonian Bailey formation of southern Illinois.

Lagenochitina brevicervicata Collinson and Schwalb, n. sp.

Plate 1, figures 16-19; plate 2, figures 11-13

Diagnosis.—Chamber subspherical, slightly elongate; terminated orally by simple mouth at end of very short rather indistinct neck; terminated aborally by small obscure papilla with external pit; chamber wall thin and opaque; exterior surface finely tuberculate.

Remarks.—This species is known from the Clear Creek chert of southern Illinois, where it is very common in some zones, and from beds of questionable Middle Devonian age in southern Tennessee.

The holotype of this species (pl. 2, fig. 13) is a large individual .21 mm. in maximum diameter and .25 mm. long. The oral end of the holotype has been compressed laterally during preservation, but before deformation must have been about 1/3 the diameter of the chamber. The lip appears to have been simple and smooth. The chamber walls of the species are thin and there is a thin oral diaphragm at the base of the neck. The diaphragm has a single oral aperture about 1/3 the diameter of the neck.

Nearly all representatives of this species have been deformed to some extent during preservation. Flattened specimens, such as those shown in plate 1, figures 18 and 19, make up a large percentage of the individuals observed. The thin chamber walls probably account for the large proportion of crushed specimens.

L. brevicervicata is related to *L. sphaerica,* but the latter has a long neck and the aboral papilla is large and distinct. The specific name *brevicervicata* is chosen because the short neck is characteristic of the species.

Occurrence.—Middle Devonian Clear Creek chert in the following wells: 1) Magnolia Petroleum Co.–Youngs well 28, sec. 20, T. 2 N., R. 2 E., Marion Co., Ill., where this species is abundant in the top 10 or 20 feet of the chert. The small paratype illustrated in plate 1, figure 16, came from a depth of 3407 feet; 2) Superior-Ford well C-17, sec. 27, T. 4 S., R. 14 W., White Co., Ill., where this species occurs at depths of 5310 to 5380 feet. The holotype shown in plate 2, figure 13, and the paratypes illustrated in plate 1, figures 17-19, and plate 2, figures 11 and 12, came from a depth of 5376 feet; and 3) Burr Lambert Co.–Hagler well 1, sec. 28, T. 10 S., R. 2 W., Jackson Co., Ill., where the species is common at depths of 2560 to 2565 feet.

Several representatives of the species have been found in Gerre Jordan well 1 in Hardin Co., Tenn., where the specimens were found in rocks of questionable age. As all other occurrences of this species are in rocks of Middle Devonian age, the same age seems indicated for the Tennessee specimens.

Repository.—Illinois Geological Survey.

LAGENOCHITINA ELONGATA Collinson and Schwalb, n. sp.

Plate 2, figure 10

Diagnosis.—Chamber subovoid, elongate, flattened basally; terminated orally by thin collar at end of short neck; terminated aborally by prominent papilla; chamber wall moderately thick and opaque; exterior surface smooth.

Remarks.—This species is based on a single distorted but well-preserved specimen .16 mm. in maximum diameter and .30 mm. long. As shown by plate 2, figure 10, the chamber of the holotype has a large rupture, which appears to have been made during or shortly after the life of the specimen, while the test was still relatively flexible. A remnant of a thin translucent oral collar is preserved.

The holotype was found in subsurface Clear Creek chert in southern Illinois. The specimen is clearly referable to *Lagenochitina* because its maximum diameter is near the midlength. However, its general shape approaches that of the genotype of *Conochitina, C. claviformis* Eisenack. *L. elongata* is not closely similar to any other species.

Occurrence.—Superior-Ford well C-17, sec. 27, T. 4 S., R. 14 W., White Co., Ill., from a depth of 5303 feet.

Repository.—Illinois Geological Survey.

LAGENOCHITINA SACCULUS Collinson and Schwalb, n. sp.

Figure 6

Diagnosis.—Chamber pyriform; terminated orally by long thin translucent cylindrical collar; mouth simple; neck indis-

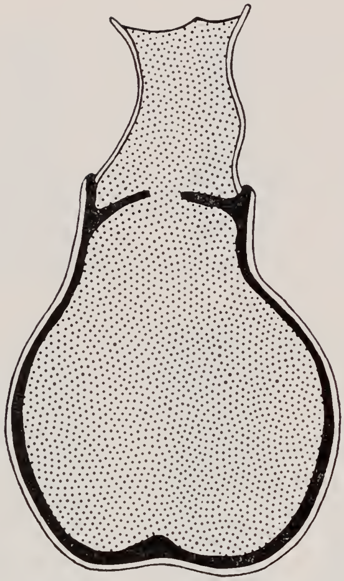

FIG. 6.—The holotype of *Lagenochitina sacculus* n. sp., a natural section in white chert, ×370. Note the presence of a tegmen.

tinct; very broadly rounded aborally; chamber wall thin and opaque; external surface appears smooth.

Remarks.—This species is known from the holotype and three paratypes found in the Lower Devonian Bailey formation of southern Illinois. The holotype is well preserved in chert and is .12 mm. in maximum diameter and .20 mm. in over-all length. The collar is .07 mm. long, and the diameter of the mouth is about 1/5 that of the chamber. Although the chamber wall is opaque, it is covered by a thin brown translucent tegmen. The collar is joined to the chamber in such a fashion that the lip of the mouth serves as a flange for attachment (fig. 4).

L. sacculus is reminiscent of *Angochitina flasca* from the Clear Creek chert but is smaller and apparently possesses neither spines nor aboral papilla. In general shape, *L. sacculus* is much like *Angochitina bifurcata,* with which it was found associated, but *L. sacculus* is larger, possesses no spines, and has an opaque rather than translucent chamber wall.

The specific name *sacculus* (Latin) means "little bag," and describes the general shape of the species.

Occurrence.—Lower Devonian Bailey formation in the F. Lyrler–Baysinger well 1, sec. 32, T. 10 S., R. 3 W., Jackson Co., Ill., from depths of 270 to 275 feet.

Repository.—Illinois Geological Survey.

LAGENOCHITINA SPHAERICA Collinson and Schwalb, n. sp.

Plate 1, figures 7-15

Diagnosis.—Chamber spherical to subspherical; terminated orally by flared collar at end of short neck; terminated aborally by prominent papilla with pit; chamber wall thick and opaque; exterior surface finely tuberculate.

Remarks.—This species is known from the Middle Devonian Clear Creek chert and possibly from the Bailey formation of the subsurface of southern Illinois. The holotype (pl. 1, figs. 7, 9, and 10) is a large, very well preserved specimen .22 mm. in maximum diameter and .27 mm. long. It is incomplete orally, as were all representatives of the species observed. The diameter of the neck is equal to about one-third that of the chamber. In most specimens there is little doubt that a collar was once present. The collar of the holotype is translucent and only partially preserved (pl. 1, fig. 9). Its wall is much thinner than that of either the neck or the chamber. Although the presence of an oral diaphragm could not be determined in the holotype, a natural section of a paratype (plate 1, fig. 8) clearly shows a thick diaphragm which has at least one small aperture. The exterior tuberculate surface of the holotype is shown on plate 1, fig. 7. The paratypes (pl. 1, figs. 8 and 11-15) illustrate the common state of preservation of this species as well as the variation in basal flattening and size of the aboral papilla.

This species is very similar in size and general shape to *L. brevicervicata,* with which it is associated, although the latter is distinguished by its very short indistinct neck. *L. sphaerocephala* Eisenack from the Silurian of the East Prussia Baltic region is the European species most like *L. sphaerica* but Eisenack's species has a very long neck.

In general shape *Desmochitina*? *urna* Eisenack resembles the species under consideration but *D.*? *urna* possesses a basal flange.

Occurrence.—Middle Devonian Clear Creek chert at depths of 2500 to 2565 feet in Burr Lambert Co.–Hagler well 1, sec. 28, T. 10 S., R. 2 W., Jackson Co., Ill., and Hobson and Holman–J. T. West well 1, 1-F-26, Christian Co., Ky., at depths of 2285 to 2330 feet. The holotype and paratypes illustrated on plate 1, figures 7-10 and 13-15, came from between 2500 to 2505 feet depths in the Illinois well. The paratype figured on plate 1, figures 11 and 12, came from between 2560 and 2565 feet in the same well.

Repository.—Illinois Geological Survey.

Genus ANGOCHITINA Eisenack, 1931

Genotype: *Angochitina echinata* Eisenack

Figure 5B

Angochitina differs from *Lagenochitina* in that the former possesses surface spines. The genotype is from the Silurian Beyrichienkalk of the East Prussia Baltic region. Two other species were assigned to the genus by Eisenack, *A. capillata* and *A. elongata,* both from the Ordovician or Silurian of the Baltic region. We have assigned three additional species to the genus, *A. pusilla* and *A. flasca* from the Middle Devonian Clear Creek chert and *A. bifurcata* from the Lower Devonian Bailey formation, all from the subsurface of southern Illinois. Also, we believe that two species assigned to *Conochitina* by Eisenack should be referred to *Angochitina* – *C. lagenomorpha* Eisenack, from the Silurian of the East Prussia Baltic region and questionably from the Silurian of the Montagne Noire in southern France, and *C. filifera* Eisenack, from the Silurian of the East Prussia Baltic region and probably the Ordovician (E_2 zone) Bohemian Kalk of Karlstein in western Czechoslovakia.

ANGOCHITINA BIFURCATA Collinson and Schwalb, n. sp.

Figure 7; plate 2, figures 1-3

Diagnosis.—Chamber pyriform; terminated orally by long thin translucent subcylindrical collar at the end of a short flared neck; broadly rounded aborally; mouth simple; chamber wall thin and translucent; external surface of chamber covered with numerous fine bifid spines.

Remarks.—This species is known from numerous individuals in the Lower Devonian Bailey formation in wells of southern Illinois. The holotype and the two figured paratypes are preserved in white chert as natural cross sections. The holotype (pl. 2, fig. 3) is .12 mm. long and .05 mm. wide if the spines are disregarded. The spines average about .025 mm. long in the holotype, and it is estimated that there are about 50 spines per individual in the species. A few short spines occur on the collar of the holotype and one paratype. The collar of the holotype is .037 mm. long and the aperture of the chamber .025 mm. in diameter. The collar is very slightly expanded orally and in outline appears to be an extension of the neck.

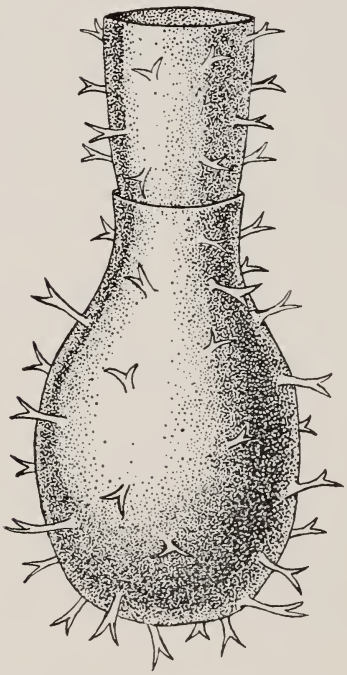

FIG. 7.—Diagrammatic representation of *Angochitina bifurcata* n. sp., illustrating the shape of the spines and attachment of the collar, ×665.

Angochitina bifurcata more closely resembles *A. capillata* Eisenack from the Ordovician Ostseekalk than any other species. The European species differs, however, in that it has no distinct collar and its spines are simple and short. *Lagenochitina sacculus* is much like *A. bifurcata* but it is larger and possesses no spines. Likewise *Lagenochitina baltica* Eisenack is shaped like *A. bifurcata* but has no spines.

The species name *bifurcata* (Latin) means "forked" and refers to the bifurcate nature of the spines.

Occurrence.—Very abundant in the Lower Devonian Bailey formation in Shell Oil Co.–Ragan well 1, sec. 25, T. 2 S., R. 1 E., Jefferson Co., Ill., between the depths of 3907 and 3910 feet; and in the F. Lyrler–Baysinger well 1, sec. 32, T. 10 S., R. 3 W., Jackson Co., Ill., between the depths of 270 and 335 feet. All figured specimens came from the latter well; the holotype (pl. 2, fig. 3) from between the depths of 315 and 320 feet and the figured paratypes from between 330 and 335 feet.

The species also occurs abundantly in loose blocks of rock believed to be Grand Tower limestone excavated for the foundation of an aerial pipeline crossing tower near the Devils Bakeoven in sec. 23, T. 10 S., R. 4 W., Jackson Co., Ill.

Repository.—Illinois Geological Survey.

ANGOCHITINA FLASCA Collinson and Schwalb, n. sp.

Figure 8; plate 1, figures 1-6; plate 2, figures 14 and 15

Diagnosis.—Chamber pyriform to subpyriform; terminated orally by simple mouth at end of short neck; terminated aborally by broad slightly concave base, which has distinct papilla with external pit; chamber walls moderately thick; exterior surface of chamber relatively smooth except for scattered short spines.

Remarks.—*Angochitina flasca* is found in great numbers in the Middle Devonian Clear Creek chert throughout the subsurface of southern Illinois. The holotype (pl. 1, figs. 5 and 6) is a well-preserved moderate-size individual .15 mm. in maximum diameter and .17 mm. long. The size range of the species is from about .10 mm. to .30 mm. in length. The diameter of the mouth of the holotype is about 1/3 the diameter of the chamber. Although it could not be demonstrated with certainty, the mouth appears to have an oral diaphragm. The paratype illustrated in plate 1, figure 1, does not possess such a structure, but it does show that the lip is much thinner than the chamber wall and that the chamber wall is only moderately thick (about .01 mm.). Details of the aboral papilla are shown in figure 8. There is some variation in the general shape of *A. flasca*. Some individuals, such as the paratype shown on plate 1, figures 2-4, are more depressed than the holotype, and others, such as the one shown on plate 2, figure 15, are more elongate. Perhaps species should be erected for these variants, but we are reluctant to do so until we have studied a greater number of individuals.

FIG. 8—*Angochitina flasca* n. sp. Diagrammatic cross section showing details of the lip and the aboral papilla, approx. ×335.

In general size and shape *A. flasca* is similar to *L. elongatus*, which is known from the Clear Creek chert in a single well in White County, Ill. However, *L. elongatus* is only slightly flattened basally. The European species that most closely resembles *A. flasca* is the one from the Ordovician of Czechoslovakia that Eisenack (1934, p. 68) referred to *Conochitina*? cf. *filifera*. The European species probably belongs in

Angochitina, but it differs from *A. flasca* in that it has a flared neck and a large number of spines.

The specific name *flasca* is Low Latin for "wine bottle" or "flask."

Occurrence.—Middle Devonian Clear Creek chert in the following wells: 1) Magnolia Petroleum Co.–Youngs well 28, sec. 20, T. 2 N., R. 2 E., Marion Co., Ill., at depths between 2485 and 2490 feet; 2) Superior-Ford well C-17, sec. 27, T. 4 S., R. 14 W., White Co., Ill., where the species is common to abundant at depths of 4995 to 5456 feet (fig. 3). The holotype shown on plate 1, figures 5 and 6, is from a depth of 5020 feet. The paratypes illustrated on plate 1, figures 1-4, and plate 2, figures 14 and 15, are from a depth of 5051 feet; 3) Burr Lambert Co.–Hagler well 1, sec. 28, T. 10 S., R. 2 W., Jackson Co., Ill., where the species occurs at depths between 2485 and 2590 feet; and 4) National Assoc. Petroleum Co.–Handley well 1, sec. 26, T. 10 N., R. 7 E., Cumberland Co., Ill., where a questionable occurrence of the species was noted at a depth of 3736 feet.

Repository.—Illinois Geological Survey.

ANGOCHITINA PUSILLA Collinson and Schwalb, n. sp.

Plate 1, figures 20 and 21

Diagnosis.—Chamber pyriform; terminated orally by simple mouth, no distinct neck; rounded aborally; chamber wall moderately thick and opaque; exterior surface covered with scattered coarse spines.

Remarks.—All known representatives of this species are from the Clear Creek chert in the subsurface of White Co. in southern Illinois. The holotype (pl. 1, fig. 21) measures only .08 mm. in diameter and .12 mm. in length, and the two paratypes are of the same size. In general shape and size *A. pusilla* closely resembles *Angochitina bifurcata* although that species possesses a thin translucent chamber wall and numerous bifid spines. *A. pusilla* also closely resembles *A. capillata* Eisenack from the Ordovician Ostseekalk of the Baltic region but the American species has fewer and much coarser spines.

The specific name *pusilla* (Latin) means "small and insignificant."

Occurrence.—Middle Devonian Clear Creek chert in the Superior-Ford well C-17, sec. 27, T. 4 S., R. 14 W., White Co., Ill., between depths of 5020 and 5030 feet.

Repository.—Illinois Geological Survey.

Genus ACANTHOCHITINA Eisenack, 1931

Genotype: *Acanthochitina barbata* Eisenack

Figure 5E

Only the genotype is referred to this group of bluntly terminated spiny forms. The genus is known only from the Ordovician Ostseekalk of the Baltic region.

Family CONOCHITINIDAE Eisenack, 1931

Chitinozoans of a general tapered or conical shape are referred to this family. The greatest thickness is always near the aboral end. The family contains a number of forms that resemble the preceding Lagenochitinidae but also contains forms similar to some of the Desmochitinidae.

Genus CONOCHITINA Eisenack, 1931

Genotype: *Conochitina claviformis* Eisenack

Eisenack gave the Conochitina the same characteristics as the family, and to date 26 species have been assigned to the genus. Among these species there is great variation in size and shape, and we feel that the genus has become polymorphic to such an extent that it is of little taxonomic value. Accordingly, we are emending Conochitina to include only slightly tapered, club-shaped chitinozoans. As thus defined, the following species are referable to the genus:

C. cactacea Eisenack—Ordovician of East Prussia Baltic region.

C. claviformis Eisenack—Silurian Graptolithengestein of Baltic region, Silurian of Montagne Noire in southern France, and Ordovician (E_2) of Lodenitz in western Czechoslovakia (Bohemia).

C. micracantha Eisenack—Ordovician Ostseekalk of the East Prussia Baltic region, the Ordovician Schiefergebirges of western Germany (Rheinland), and the Middle Silurian Racine formation of northeastern Illinois.

C. primitiva Eisenack—Ordovician Schiefergebirges of western Germany.

C. proboscifera Eisenack—Silurian of the Baltic region.

C.? simplex Eisenack—Ordovician (?) of the East Prussia Baltic region.

C. stentor Eisenack—Ordovician of the East Prussia Baltic region and the Ordovician Schiefergebirges of western Germany.

C. tuba Eisenack—Silurian of the East Prussia Baltic region.

?*C. biconstricta* Lange—Devonian of Paraná, southern Brazil.

C. dactylus n. sp.—Middle Silurian of northern Illinois.

Conochitina dactylus Collinson and Schwalb, n. sp.

Plate 2, figures 16-19

Diagnosis.—Chamber club-shaped with greatest diameter about one-third total length from aboral end, tapers slightly from greatest diameter both aborally and orally; oral one-third of chamber nearly cylindrical; aboral end broadly rounded; terminated orally by very short thin translucent collar; mouth simple; terminated aborally by relatively large papilla; chamber wall moderately thick; external surface smooth.

Remarks.—This species occurs abundantly in the Middle Silurian Racine formation in one well in northeastern Illinois. The holotype (pl. 2, fig. 17) is a well-preserved, though distorted specimen .17 mm. in maximum diameter and .47 mm. long. The mouth is estimated to have been about .06 mm. in diameter before distortion. The holotype retains remnants of a very short thin translucent collar, as do several of the paratypes.

C. dactylus is very closely related to the genotype *C. claviformis,* which is known from the Silurian of the Baltic region and southern France and questionably from the Ordovician of western Czechoslovakia. The only differences between the two species are that the genotype is slightly flared orally and possesses short fine processes about the mouth. *C. dactylus* is found associated in Illinois with *C. micracantha* Eisenack, but the latter species is differentiated by its flat base.

The name *dactylus* (Latin) means "growing like a finger."

Occurrence.—Interreef facies of the Middle Silurian Racine formation in the Mulford Engineering Service–Thornton well, sec. 34, T. 36 N., R 14 E., Cook Co., Ill., between depths of 120 and 160 feet.

Repository.—Illinois Geological Survey.

Explanation of Plate 1

All magnifications ×135 except where otherwise noted.

Figs. 1–6 —*Angochitina flasca* Collinson and Schwalb, n. sp. 1, natural section of a paratype showing interior of chamber, wall thickness, and oral lip; 2–4, three views of a depressed paratype showing oral aperture, aboral papilla, and general shape, respectively.

7–15—*Lagenochitina sphaerica* Collinson and Schwalb, n. sp. 7, detail of the holotype showing finely tuberculate exterior surface, ×205; 8, natural section of a paratype illustrating the oral diaphragm and aperture; 9, lateral view of the holotype showing the distinct neckand remnants of an oral collar; 10, oblique aboral view of the holotype showing the aboral papilla and pit; 11, 12, oral and lateral views of a paratype; 13–15, lateral, oral, and opposite lateral views of an incomplete distorted paratype illustrating specific variation.

16–19—*Lagenochitina brevicervicata* Collinson and Schwalb, n. sp. 16, 17, lateral view of a small incomplete paratype and oblique oral view of a small complete paratype; 18, 19, lateral views of two crushed paratypes showing a common state of preservation for this species.

20, 21—*Angochitina pusilla* Collinson and Schwalb, n. sp. 20, lateral view of the single paratype; lateral view of the holotype showing the incomplete neck and a few coarse spines.

Collinson and Schwalb. Paleozoic Chitinozoa

Collinson and Schwalb, Paleozoic Chitinozoa

Conochitina micracantha Eisenack

Plate 2, figures 20-22

Conochitina micracantha Eisenack, 1931, Palaeontologische Zeitschrift, bd. 12, p. 84-85, pl. 1, figs. 19-21; pl. 2, figs. 20-22; pl. 4, fig. 16. *Conochitina micracantha* Eisenack, 1939, Senckenbergiana, bd. 21, p. 142, pl. A, fig. 114.

Diagnosis.—Chamber shaped like tapered rod or club with maximum diameter at aboral end and tapering slightly toward mouth; terminated orally by thin translucent collar; terminated aborally by flat base in middle of which is a small papilla; chamber wall moderately thick; external surface smooth with exception of fine basal spines.

Remarks.—This species is very abundant in one well in northeastern Illinois, where it was found in the Middle Silurian Racine formation. The species was first described from Ordovician strata of the East Prussia Baltic region by Eisenack, who gave the size range of the species as from .23 mm. to .36 mm. in length. Our specimens fall within that range. Eisenack did not describe the type specimens as possessing collars, but he stated that they had appendages about the mouth. As many of our specimens have what we interpret to be irregular remnants of thin collars, we feel that these "appendages" may be the structures Eisenack described.

The basal spines on our Illinois specimens are very fine and short and are seen only with magnifications of 100× or more. Most of our specimens are well preserved but somewhat distorted.

In addition to the Illinois and Baltic occurrences of *C. micracantha,* the species is also known from the Ordovician Schiefergebirges of western Germany (Rheinland). The species is perhaps closest to *C. primitiva,* also from the Schiefergebirges, but the latter does not possess spines. The basal flattening of *C. micracantha* differentiates it from *C. dactylus.*

Occurrence.—Interreef facies of the Middle Silurian Racine formation in the Mulford Engineering Service–Thornton well, sec. 34, T. 36 N., R. 14 E., Cook Co., Ill., between depths of 120 and 160 feet.

Repository.—Illinois Geological Survey.

Explanation of Plate 2

All magnifications ×135 except where otherwise noted.

Figs. *1–3* —*Angochitina bifurcata* Collinson and Schwalb, n. sp. 1, natural longitudinal section of a paratype with an incomplete collar; 2, natural transverse section of a paratype; 3, natural longitudinal section of the holotype showing collar, neck, and spines. All ×205.

4–6 —*Ampullachitina laguncula* Collinson and Schwalb, n. sp. 4, lateral view of a distorted paratype; 5, lateral view of the holotype showing neck, collar, and several spines; 6, lateral view of a distorted paratype. All ×205.

7–9 —*Illichitina crotalum* Collinson and Schwalb, n. sp. 7, slightly oblique lateral view of incomplete holotype showing bell-shaped chamber and cylindrical neck; 8, 9, lateral views of distorted and incomplete paratypes, ×205.

10—*Lagenochitina elongata* Collinson and Schwalb, n. sp. Lateral view of the holotype showing large open rupture in the chamber wall.

11–13—*Lagenochitina brevicervicata* Collinson and Schwalb, n. sp. 11, 12, lateral views of two small paratypes illustrating kinds of specific variation; 13, lateral view of the holotype which is slightly distorted.

14, 15—*Angochitina flasca* Collinson and Schwalb, n. sp. 14, lateral view of a relatively long paratype; 15, aboral oblique view of a paratype showing relatively small papilla.

16–19—*Conochitina dactylus* Collinson and Schwalb, n. sp. 16, lateral view of a crushed paratype showing undistorted aboral papilla; 17, lateral view of slightly crushed holotype with remnants of a collar at the oral end; 18, lateral view of small paratype; 19, lateral view of largest paratype.

20–22—*Conochitina micracantha* Eisenack. 20, lateral view of specimen showing remnant of oral collar and aboral papilla; 21, lateral view of relatively complete undistorted specimen with remnants of oral collar; 22, lateral view of crushed specimen.

Genus AMPULLACHITINA Collinson and Schwalb, n. gen.

Genotype: *Ampullachitina laguncula* Collinson and Schwalb, n. sp.

One group of chitinozoan species, which Eisenack referred to the genus *Conochitina,* have certain common characteristics. They have a maximum diameter near the aboral end. From there they taper rapidly for less than half their total length, and the remaining length consists of a long cylindrical or subcylindrical neck. For this group of species, we are proposing the generic name *Ampullachitina. Ampullachitina laguncula,* n. sp. from the Lower Silurian in the Superior-Ford C-17 well in southern Illinois is the genotype. Like the genotype, species referred to this genus commonly possess spines on the aboral part of the chamber. The following species should be referred to *Ampullachitina.*

A. ancyrea (Eisenack)—Silurian Choneteskalk of the East Prussia Baltic region.

A. diabolo (Eisenack)—Silurian of Baltic region, Ordovician (E_2) at Kozel and Lodenitz in western Czechoslovakia, and Middle Silurian of the Montagne Noire in southern France.

A. fungiformis (Eisenack)—Ordovician of the East Prussia Baltic region and Silurian e_β zone of Dlouha hora in western Czechoslovakia.

A. kuckersiana (Eisenack)—Ordovician Kuckers'schen Stufe of the East Prussia Baltic region and the Middle Silurian of the Montagne Noire in southern France.

A. metancyrea (Eisenack)—Silurian Beyrichienkalk of the East Prussia Baltic region.

A. pistilliformis (Eisenack)—Silurian Choneteskalk of the East Prussia Baltic region.

A. protancyrea (Eisenack)—Ordovician Ostseekalk of the East Prussia Baltic region.

A. spinosa (Eisenack)—Silurian Crinoidenkalk of the East Prussia Baltic region.

AMPULLACHITINA LAGUNCULA Collinson and Schwalb, n. gen., n. sp.

Figure 9; plate 2, figures 4-6

Diagnosis.—Chamber subconical; terminated orally by slightly expanded thin translucent collar at end of long cylindrical neck; terminated aborally by flat base fringed with few fine spines; chamber wall thin and translucent; external surface generally smooth.

Remarks.—Four rather poorly preserved individuals were recovered from hydrochloric-acid-insoluble residues of Lower Silurian dolomite from the Superior-Ford C-17 core (fig. 3). The least distorted and most complete specimen (plate 2, fig. 5) is designated the holotype; it is .075 mm. in maximum diameter and .12 mm. long. The diameter of the neck is about 1/3 that of the chamber, and the diameter of the collar is ½ that of the chamber. The neck and collar are .025 and .037 mm. long, respectively. Although most of the basal spines of the holotype were broken during study of the specimen (see fig. 9 for restoration), two are still preserved; they are short, fine, and slightly curved.

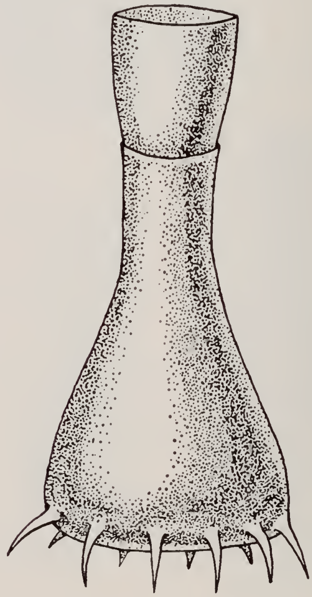

FIG. 9.—Diagrammatic representation of *Ampullachitina laguncula* n. gen., n. sp. showing the general shape of the genus, attachment of the collar, and basal spines, ×580.

Ampullachitina laguncula closely resembles *A. diabolo* (Eisenack), which is known from the Silurian of the East Prussia Baltic region, the Ordovician of western Czechoslovakia, and the Middle Silurian of southern France. The European species has very coarse hollow spines which form extensions of the chamber. Also, *A. diabolo* is broadly rounded aborally rather than flattened. The specific name *laguncula* (Latin) means "little flask."

Occurrence.—Lower part of the Lower Silurian Sexton Creek formation in the Superior-Ford well C-17, sec. 27, T. 4 S., R. 14 W., White Co., Ill., between depths of 6065 and 6070 feet.

Repository.—Illinois Geological Survey.

Genus ILLICHITINA Collinson and Schwalb, n. gen.

Genotype: *Illichitina crotalum* Collinson and Schwalb, n. sp.

Like *Ampullachitina, Illichitina* is proposed for a number of species assigned to *Conochitina* by Eisenack but which do not belong to that genus as emended in this report. *Illichitina* includes all species that possess a shape reminiscent of a bell with the large end closed and the small end open, that is, with the maximum diameter at the aboral end, tapering rapidly from that diameter for a very short distance to form a slight basal flare, then tapering gradually to a cylindrical neck, but with a slight inflation near the midlength. The species vary greatly in their proportions, some being very elongate, others short. A few species have a fringe of basal spines. *I. crotalum* n. sp. from the Lower Silurian Sexton Creek formation in the Superior-Ford well C-17 is the genotype.

The genus *Illichitina* is named for the State of Illinois.

The following species are referable to *Illichitina.*

I. calix (Eisenack)—Ordovician Ostseekalk and Ordovician (B_2 and B_3 or C zones) of East Prussia Baltic region; Ordovician Schiefergebirges of western Germany (Rheinland).

I. campanulaeformis (Eisenack)—Silurian Choneteskalk of the East Prussia Baltic region; the Ordovician Schiefergebirges of western Germany (Rheinland); the Ordovician at Šarka-Vokovice (D_{ψ_1} and D_{ψ_2} zones) and Prag along the Wilson-Bahnhof (D_{ψ_2} zone) in western Czechoslovakia (Bohemia).

I. cervicornis (Eisenack) — Silurian? sandstone of East Prussia Baltic region.

I. coronata (Eisenack)—Ordovician Ostseekalk of East Prussia Baltic region.

I. elegans (Eisenack)—Silurian? sandstone of East Prussia Baltic region.

ILLICHITINA CROTALUM Collinson and Schwalb, n. gen., n. sp.

Plate 2, figures 7-9

Diagnosis.—Chamber subconical with maximum diameter at base, tapers rapidly toward the oral end, very slightly flared at aboral end; terminated orally by short thin translucent collar at end of short cylindrical neck; terminated aborally by flat base; chamber wall rather thin, brown, and translucent; external surface very finely tuberculate.

Remarks.—The four known representatives of this species were found in hydrochloric-acid-insoluble residues from the Lower Silurian Sexton Creek formation of southern Illinois. The holotype (plate 2, fig. 7) is well preserved, although both the collar and base are incomplete. The specimen is .15 mm. in maximum diameter and .18 mm. long, and the neck is about .012 mm. long and .047 mm. in diameter. The mouth of the chamber appears to be simple and smooth. The collar appears to have been about .015 mm. long. There is no evidence of a diaphragm.

Each of the three paratypes is distorted, incomplete, and smaller than the holotype, averaging about .12 mm. in length. The species was found associated with *Ampullachitina laguncula* and numerous scolecodonts. The species closely resembles *I. campanulaeformis* (Eisenack) from the Silurian of the East Prussia Baltic region and the Ordovician of Germany and Czechoslovakia. However, the European species has a relatively long neck and a distinct basal flare.

The specific name *crotalum* (Latin) means "bell."

Occurrence.—Common in the lower part of the Lower Silurian Sexton Creek formation in the Superior-Ford well C-17, sec. 27, T. 4 S., R. 14 W., White Co., Ill., between depths of 6065 and 6070 feet.

Repository.—Illinois Geological Survey.

Genus RHABDOCHITINA Eisenack, 1931

Genotype: *Rhabdochitina magna* Eisenack

Figure 51

This genus was given wide limits by Eisenack. It includes species that are very long, tubular, and terminated in almost any manner. Some species included in the genus by Eisenack have basal bulbs, others are broadly rounded or flat, and some have a basal flare. In addition to the genotype, which is from the Ordovician Ostseekalk of the East Prussia Baltic region, the following species have been assigned to the genus.

R. canna DeFlandre—Middle Silurian limestone of the Montagne Noire in southern France.

R. conocephala Eisenack—Silurian Kuckers'schen Stufe of the East Prussia Baltic region.

R.? minnesotensis Stauffer—Middle Ordovician Decorah formation of southern Minnesota.

R. cf. *pistilliformis* Eisenack—Ordivician (D_{ψ_1} zone) of western Czechoslovakia (Bohemia).

R. pistillifrons Eisenack — Ordovician Schiefergebirges of western Germany (Rheinland).

R.? taenia Eisenack—Silurian? of East Prussia Baltic region.

RHABDOCHITINA ? MINNESOTENSIS Stauffer

Figure 10

Diagnosis.—Of this species Stauffer wrote (1933, p. 1209) "Body elongate, subcylindrical in outline, although it tapers slightly towards the proximal end, suggesting the outline of a baseball bat. Terminal, or distal, end is smooth and rounded, but some specimens show a small elevation with a flattened apex. Proximal end is slightly smaller and probably had some means of attachment. Surface of the test is smooth, shiny, and black."

FIG. 10.—The holotype of *Rhabdochitina ? minnesotensis* Stauffer from the Middle Ordovician Decorah formation of southern Minnesota. Adapted from Stauffer (1933), ×82.

Remarks.—Although we have not seen the types of this species, we are including the description for the sake of completeness.

Occurrence.—"Lower part of the Decorah (Middle Ordovician) shale, 5 feet above the base of the formations, Ford Bridge, Minneapolis, Minnesota. In the shale just above the 'marble layer,' 4½ feet above the base of the Decorah shale. Lieb Quarry, Faribault, Minnesota."

Holotype.—Geological Museum, University of Minnesota, B4233.

Family DESMOCHITINIDAE Eisenack (1931)

This family includes bubble- or flask-shaped individuals commonly united to form chains. The most-aboral chamber was suggested by Eisenack to be the parent of the succeeding individuals that arose by budding from the parent. Since little is actually known of the Desmochitinidae, we are using the term *chain* to designate two or more individuals that are united. Individuals of most species are interconnected by a basal disc to which we are applying the term *flange.* The flange is attached to the chamber by a rod-like process which Eisenack designated the *copula.* Some species, however, possess only a thick copula and no flange. Others have neither flange nor copula.

Genus DESMOCHITINA Eisenack, 1931

Genotype: *Desmochitina nodosa* Eisenack

Figure 5F

Eisenack described this genus as having the same characteristics as the family. It and *Conochitina* are the two most common genera known. In addition to the genotype which is known from the Silurian of the East Prussia Baltic region the following species have been referred to *Desmochitina:*

D. amphorea Eisenack—Silurian? of East Prussia Baltic region.

D.? bohemica Eisenack—Upper Silurian of western Czechoslovakia (Bohemia).

D. cingulata Eisenack—Silurian? of the East Prussia Baltic region.

D.? cocca Eisenack—Ordovician Ostseekalk? of East Prussia Baltic region.

D.? complanata Eisenack—Ordovician? of East Prussia Baltic region.

D.? erinacea Eisenack—Ordovician (B_3 or C zone) of East Prussia Baltic region.

D. erratica Eisenack—Silurian Graptolithengestein of the East Prussia Baltic region.

D.? gigantea Eisenack — Ordovician ($D_{\psi 1}$ zone) of Šarka in western Czechoslovakia (Bohemia).

D. margaritana Eisenack—From the Silurian? of the East Prussia Baltic region.

D.? minor Eisenack—Ordovician Ostseekalk of East Prussia Baltic region; Ordovician (D_{ψ_1} and D_{ψ_2} zones) at Šarka and Svota Dobrotina in western Czechoslovakia (Bohemia); Ordovician Schiefergebirges of western Germany (Rheinland).

D. ex. aff. *minor* Eisenack—Ordovician Schiefergebirges of western Germany (Rheinland).

D. poculum n. sp.—Lower Devonian Bailey formation of southern Illinois.

D. rhenana Eisenack—Ordovician Schiefergebirges of western Germany (Rheinland).

D.? urna Eisenack—Silurian? of East Prussia Baltic region; Silurian (E_β or E_α zone) of western Czechoslovakia (Bohemia); Silurian of the Montagne Noire of southern France.

D.? sp. A. Eisenack—Ordovician (D_{ψ_1} zone) of Šarka in western Czechoslovakia (Bohemia).

D.? sp. B. Eisenack—Ordovician (D_{ψ_2} zone) of Svota Dobrotina, western Czechoslovakia (Bohemia).

DESMOCHITINA POCULUM Collinson and Schwalb, n. sp.

Figure 11

Diagnosis.—Chamber subspherical, depressed; terminated orally by simple mouth; terminated aborally by flange at end of short copula; chamber wall thin and opaque; external surface smooth (fig. 11C).

Remarks.—Only three representatives of this species are known, and all are preserved as natural cross sections in white chert. All came from the Lower Devonian Bailey formation in a well in southern Illinois. Two of the specimens are single individuals and the third is a somewhat distorted chain of two complete chambers and a portion of a third (fig. 11A). The larger of the two single individuals is designated the holotype (fig. 11B) and it is .07 mm. in maximum

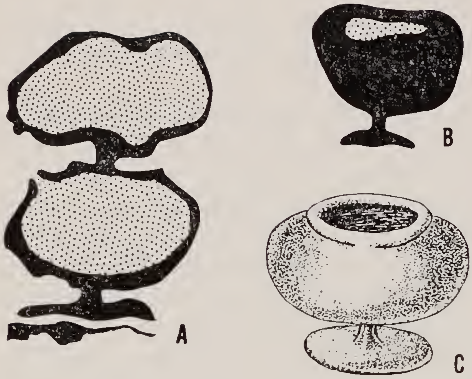

Fig. 11.—*Desmochitina poculum* n. sp. (A) represents a natural longitudinal section of an incomplete chain showing two complete chambers and part of a third, ×305; (B) represents a natural longitudinal section of the holotype, ×390; (C) is a diagrammatic reconstruction based on the holotype and two paratypes, approx. ×300.

diameter and .07 mm. long. The copula is .012 mm. long and the flange is .025 mm. in diameter. The diameter of the mouth is about 1/3 that of the chamber. Several chains of distorted and unidentifiable representatives of *Desmochitina* are associated with *D. poculum* along with great numbers of *Angochitina bifurcata*. *D. poculum* is similar to *D. margaritana* Eisenack from the Silurian? of the East Prussia Baltic region in that neither species possesses a neck. However, the chamber of the European species is not depressed and its copula is relatively long.

The specific name *poculum* (Latin) means "goblet" or "bowl."

Occurrence.—Lower Devonian Bailey formation in F. Lyrler–Baysinger well 1, sec. 32, T. 10 S., R. 3 W., Jackson Co., Ill., between depths of 270 and 275 feet.

Repository.—Illinois Geological Survey.

Desmochitina sp.

Figure 12

Several representatives of *Desmochitina* have been identified although none are sufficiently well preserved to be diagnosed specifically. All are preserved in white chert from the Lower Devonian Bailey formation in the following wells: 1) Shell Oil Co.–Ragan well 1, sec. 28, T. 2 S., R. 1 E., Jefferson Co., Ill., between depths of 3907 and 3910 feet; 2) F. Lyrler–Baysinger well 1, sec. 32, T. 10 S., R. 3 W., Jackson Co., Ill., between depths of 270 and 275 feet.

Repository.—Illinois Geological Survey.

Genus Mirachitina Eisenack, 1931

Genotype: *Mirachitina quadrupedis* Eisenack

Figure 5D

This genus deviates from normal chitinozoan symmetry and therefore is included here with some doubt. The genus is monospecific and, as interpreted by us, the genotype *M. quadrupedis* Eisenack consists of a main cylindrical chamber which is rounded aborally and possesses a small papilla. At the oral end of the main chamber, four subsidiary chambers are attached at about 120° to the axis of the main chamber and at 90° to each other. The genotype is from Silurian? limestone of the East Prussia Baltic area.

Genus Parachitina Eisenack, 1937

Genotype: *Parachitina curvata* Eisenack

Figure 5G

This genus, like *Mirachitina,* departs from normal chitinozoan symmetry and is included here with uncertainty. The genus is monospecific and includes U-shaped specimens which have an inflated abdomen and two tapering shanks which end bluntly. The genotype is from the Silurian? of the East Prussia Baltic region.

Fig. 12.—Natural longitudinal section of *Desmochitina* sp. from the Lower Devonian Bailey formation of southern Illinois, ×320.

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