ART. II. SOME LARGE STRAIGHT ORDOVICIAN CEPHALOPODS FROM MINNESOTA

By A. K. Miller and Bernhard Kummel
The State University of Iowa

(Plates I-IV)

It has been known for a long time that during the Ordovician period, cephalopods, as a class, were most probably the largest animals extant, and some of the straight forms are estimated to have attained a length of as much as fifteen feet. At many localities large specimens are abundant, and almost all natural history museums display well preserved individuals. Therefore it is somewhat of a surprise to find that the literature contains very few good illustrations and detailed descriptions of these large forms. Perhaps it is because "familiarity breeds contempt" and particularly because of the excessive amount of work involved in dealing with heavy and more or less fragmentary specimens. That is, it is difficult indeed to collect these large specimens without breaking them, and few reasonably complete individuals have been obtained.

Moderately large orthocones were recorded long ago from the European Ordovician, and almost one hundred years ago Hall described comparable forms from contemporaneous beds in New York. Also, as early as 1856, Woodward studied a Chinese specimen 29 inches long, and it is now known to be Ordovician in age. Perhaps the major contribution to our knowledge of these Early Paleozoic giants is contained in Clarke's report on "The Lower Silurian Cephalopoda of Minnesota," published in 1897. During the preparation of that study, Clarke examined a number of large specimens and for reasons not entirely clear referred most of them to *Endoceras* ["*Cameroceras*"] *proteiforme* Hall, the holotype of which is of relatively modest proportions. Clarke of course emphasized the "enormous size" of the specimens he had under consideration, and he observed that the dimensions attained were indicated by an incomplete internal mold of a siphuncle "measuring 3 feet 3 inches in length." Also, he stated that "entire shells referable to this species have been found with a length of ten to fifteen feet," though all of the material available to him was of a smaller size.

In 1932 Miller described as *Endoceras giganteum* a large incomplete

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crushed specimen from the Ordovician Bighorn formation of Wyoming and concluded that originally it "must have been somewhat comparable in length" to the largest of the Minnesota specimens mentioned by Clarke. Miller also pointed out that "for the most part, the descriptions and illustrations of the large specimens (probably representing more than one form) that have been referred to *Endoceras proteiforme* are not adequate for comparisons." For example, Clarke unfortunately included in his report only an outline sketch of his large specimen.

Through the courtesy of the Carnegie Museum, we have been permitted to study an extensive collection of exceptionally fine large nautiloids from the Ordovician of Minnesota. The labels which accompany this collection indicate that the specimens were obtained long ago from "Trenton limestone" in the Lindersmith quarry near Owatonna, Steele County, Minnesota. In a report on the geology of Steele County, published in 1876, Harrington mentions the Lindersmith quarry, states that the rock exposed there is "Trenton limestone," and adds that the quarry is located in sec. 28, T. 108 N., R. 20 W., north of Owatonna and just south of Clinton Falls. Stauffer and Thiel (1941, p. 198), in their recent report on the Paleozoics of Minnesota, state that a present-day quarry, the Klemmer Rock Quarry, in the southeast corner of Section 28 about one mile south of Clinton Falls, exposes eight feet of Stewartville shale and limestone and 27 feet of Dubuque limestone with some shale—they regard the Dubuque as a member of the Maquoketa formation. In a personal communication dated December 4, 1942, Stauffer writes:

"There are several old quarries in Section 28 and also in Section 33, T. 108 N., R. 20 W., to the south of Clinton Falls, Steele County, Minnesota. They lie along both sides of Straight River and are not very far distant from it. None of them ever amounted to much and none extend much below the water level in the adjacent river. The beds exposed in these old pits are entirely in the Maquoketa [which is here interpreted as including the Dubuque]. Mr. W. R. Lindersmith owns the land (164 acres), but I do not know that he ever operated the quarries. They were old abandoned quarries the first time I saw them some twenty years ago. None of the old pits were more than from eight to ten feet deep. The section we give on page 198 is of the new quarry opened a few years ago by the Klemmer Construction Company. It is on the public road along the west side of the river farther upstream and about three or four times as deep as the old pits. It is the only large scale quarrying ever done on the section.

"No complete collection of the fauna at the new locality was made when we were working in that region. It was an extremely active place and geologists were a bit of a nuisance at the time. I do not recall *Endoceras* as an especially abundant fossil in the lower beds of the [Dubuque "member" of the] Maquoketa [which are some 7 feet thick], but I am of the opinion that Dr. Tolmachoff's [the Carnegie Museum] collection came from the more fossiliferous upper beds in one of the old quarries where Endoceratoid cephalopods are common."

It therefore seems clear that the specimens we have under consideration came from well up in the Dubuque limestone, the age of which is a moot question. Kay regards it as belonging in the upper Middle Ordovician, whereas Stauffer and Thiel place it as basal Upper Ordovician. Perhaps, it should be stated here that in this general area large straight cephalopods occur in the Ordovician beds that underlie the Dubuque, that is, in the Platteville, Decorah, and Galena formations, as well as in the overlying Maquoketa.

The photographs which accompany this report were retouched by Mr. John Carrier. Also, we wish to acknowledge our indebtedness to the Graduate College of the State University of Iowa, which made the work financially possible.

SYSTEMATIC PALEONTOLOGY

Genus ENDOCERAS Hall, 1847

Genotype: *Endoceras proteiforme* Hall

In the first volume of the *Palaeontology of New York*, Hall established this genus for orthoceraconic nautiloids with large excentric siphuncles in which there are endocones. Throughout the volume, he referred numerous species from the Ordovician of New York to the genus, but he did not designate a genotype. In 1915, Bassler, probably following Clarke (1897, p. 775), listed as the "accepted genotype," *Endoceras proteiforme* Hall, a species described in the same volume in which the generic name *Endoceras* was proposed. There is, to be sure, some question as to whether or not Bassler can be said to have established the genotype, particularly since the International Rules of Zoological Nomenclature emphasize that in selecting a genotype an author must be quite definite. Throughout most of his studies of Paleozoic cephalopods, Foerste seems to have been uncertain as to whether or not *E. proteiforme* should be regarded as the

valid genotype. However, in 1930, Teichert (and in 1932, Foerste) definitely listed it as such and thereby established its validity, if it had not been established previously. Insofar as we have been able to ascertain, in the meantime no other species has been designated as genotype, though Foerste pointed out several times that *E. subcentrale* Hall was the first species to be described by Hall under the generic name.

Endoceras proteiforme Hall is now well known, for Foerste has restudied the type specimens and designated one of them as the holotype. This specimen came from the Trenton limestone at Middleville, New York. As pointed out by Bassler in 1915, this "species has been identified from almost all of the Mohawkian and Cincinnatian formations of the United States and Canada" but "undoubtedly" a "variety of forms" has been included.

From a study of Foerste's illustrations and descriptions of the geno-holotype, and numerous similar forms, we have drawn up the following generic diagnosis of *Endoceras:*

Conch long, slender, straight, and rather gradually expanded orad, that is, orthoceraconic. Cross section circular or slightly depressed dorsoventrally. Aperture apparently unmodified. Surface of test smooth or bearing small transverse annulations that are surficial (so that internal mold is essentially smooth). Sutures straight and directly transverse or in depressed conchs forming shallow dorsal and more prominent ventral lobes (due to a ventral flattening of the conch). Siphuncle large, ventral and in some cases marginal in position, and holochoanitic in structure. Adapical portion of siphuncle contains numerous closely invaginated endocones which are long and slender.

Perhaps the most significant character of this genus is the large holochoanitic siphuncle, which in many cases has a diameter equal to almost half that of the conch. Each septal neck is long enough to invaginate into the infundibular adoral end of the next neck apicad. The siphuncle is therefore composed entirely of septal necks, for no connecting rings are present. As in most holochoanitic forms, the siphuncular segments are distinctly concave exteriorly.

Presumably the closely invaginated endocones in the adapical portion of the siphuncle of mature individuals served as ballast. As shown by text figure 1, Hyatt observed an endosiphotube extending through the apices of these endocones. Kobayashi also has indicated the presence of an endosiphotube here, but none of the specimens studied by us has this portion of the conch well preserved. We have, however, found an

endosiphotube to be present in a related holochoanite, *Cassinoceras amplum* (Dawson), of the Lower Ordovician of southern Quebec. In that form, at irregular intervals there are partitions across the endosiphotube.

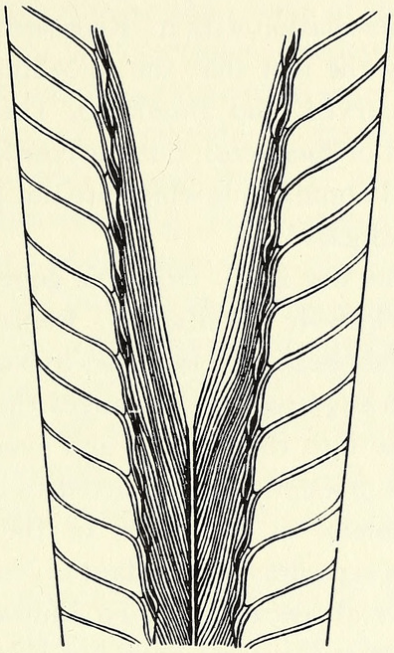

FIG. 1. Diagrammatic median longitudinal section of *Endoceras proteiforme* Hall(?), from the Ordovician of New York, showing endocones and an endosiphotube. After Hyatt.

Such are not shown by Hyatt's figure, but he may possibly have overlooked them.

In many specimens belonging in the genus *Endoceras*, the siphuncle contains an internal mold of the adoral endocone and this has been termed a spiculum. Not infrequently the spiculum has been preserved whereas the endocones have not. It seems likely that the endocones were composed entirely of aragonite and were therefore not likely to be preserved.

Both Bassler and Teichert indicate that the genus *Endoceras* was established by Hall in 1844. It is true that in the *Abstract of the proceedings of the fifth session of the Association of American Geologists and Naturalists*, published in the American Journal of Science and Arts in that year, Hall (p. 109) discussed orthoceratoids that contained endocones and concluded that the structures they exhibited "may serve as the foundation of generic distinction." However, insofar as we have been able to ascertain, no name was published for the genus until 1847.

The genotype of *Vaginoceras* (*Endoceras multitubulatum* of the Black

River limestone of New York) is poorly known, but it appears to be congeneric with the genotype of *Endoceras*. *Vaginoceras* should therefore be suppressed as a synonym of *Endoceras*, which has priority.

Endoceras resembles rather closely *Cameroceras* and *Cyclendoceras*, both of which occur in association with it. Representatives of *Cameroceras* can be distinguished by the fact that the spiculum is short, rapidly expanded orad, slightly curved, and annulated. The spiculum in *Cyclendoceras* is similar to that of *Endoceras*, but the conch and also the internal mold bear large rounded annulations which are not parallel to the sutures and which are quite distinctive.

Endoceras is one of the few Early Paleozoic genera that are known to have an essentially world-wide distribution. Representatives of it have been found at many widely separated localities in North America, Europe, Asia, and Australia. Stratigraphically it ranges throughout most of the Ordovician, and possibly into the Silurian and even the Devonian. The oldest forms that can be unequivocally referred to it are from the Lower Ordovician Powell dolomite of Arkansas. In the Middle and Upper Ordovician, *Endoceras* is exceedingly abundant in North America, Europe, and Asia. Although several species from the Silurian have been referred to the genus by different authors, we have not been able to satisfy ourselves that valid representatives occur in that system. Also, although we have not seen the specimen, we are inclined to doubt that the Devonian form mentioned by Foerste (1925, p. 15) belongs in this genus.

Endoceras clarkei, sp. nov.

(Plate I, figures 1-3; Plate II, figures 1, 2;
Plate III, figure 2; Plate IV, figure 2)

1897. *Cameroceras proteiforme* [part] Clarke, Minnesota Geol. and Nat. Hist. Survey, vol. 3, pt. 2, pp. 777-779, pl. 48, figs. 1, 2; pl. 49, fig. 2; pl. 50, figs. 1, 2; pl. 51, figs. 1-3; pl. 53, figs. 4, 5. [Not *Endoceras proteiforme* Hall, 1847.]

Conch large, rather gradually expanded orad, and circular or (due to dorsoventral depression) broadly elliptical in cross section. Surface of test bears small rounded annulations that are essentially straight and directly transverse. Internal mold smooth and marked only by sutures. Camerae short and sutures, like annulations, are essentially straight and directly transverse. Siphuncle large, subcircular, and ventral but not quite marginal.

Of the numerous specimens available to us for study, that represented by figures 1 and 2 on Plate I seems to be the best from several points of view. We are therefore designating it as the holotype of the new species, even though it is much smaller than some of the specimens that we are including in the species. This specimen is septate throughout. It is about 165 mm. long, and its width increases from some 50 mm. near its adapical end to about 64 mm. near its adoral end. Its maximum height, which is attained at its adoral end, is only about 47 mm., but clearly the conch has been crushed dorsoventrally. This specimen retains a considerable portion of the test (or a replacement of it), and this shows that the surface of the test (but not the internal mold) bears small rounded annulations which are of about the same size as the intermediate grooves and are essentially straight and directly transverse. On the adoral portion of the holotype, the crests of these annulations are on the average about 5¾ mm. apart and they rise almost 1 mm. above the bottoms of the adjacent grooves. Also, on what appears to be an inner layer of the test, there are fine vertical lirae.

The surface of the internal mold is essentially smooth, and for the most part no trace of the annulations of the test can be discerned on the internal mold. In the adoral third of the holotype, the camerae average about 8.5 mm. in length. The sutures of this specimen are somewhat sinuous, presumably as a result of distortion during preservation, and it is believed that originally they were essentially straight and directly transverse. At the adoral end of the holotype, the siphuncle is about 27 mm. wide and 24.5 mm. high, and it is located about 1 mm. from the ventral wall of the conch.

Most of the numerous specimens that we are referring to this species are considerably larger than the holotype. The largest of them (Pl. II, fig. 1) is about 750 mm. long and it is septate throughout and is not complete adapically or adorally. The large specimen represented by figure 2 on Plate IV is crushed, but at a transverse break near its mid-length the width of its conch measures about 200 mm. and that of its siphuncle about 97 mm. The specimen represented by figure 2 on Plate III seems to be part of a large conch of the same general magnitude as the two mentioned last, and it shows that the test of large specimens is annulated as is that of the holotype. The annulations on this large specimen are somewhat irregularly spaced, but on the average they are about 7 mm. apart and they rise some 2 mm. above the bottoms of the adjacent troughs. These annulations appear to be directly transverse to the long axis of the conch

and to be very slightly sinuous—their sinuosity may, however, be a result of distortion.

The extreme adapical part of the specimen represented by figure 3 on Plate I is a spiculum; that is, this portion of the specimen is an internal mold of the adoral endocone in the siphuncle. Only the adoral 35 mm. of the spiculum are retained, but it appears to be contracted apicad very gradually and therefore to have been long and slender.

Remarks: At least part of the Minnesota specimens that Clarke figured in 1897 as *Cameroceras proteiforme* probably belong in this species. However, Clarke regarded as conspecific some "fragments" from Decorah, Iowa, and although we have not seen them, we are inclined to believe that they are specifically distinct. Possibly, they represent *Endoceras decorahense.*

One of the most distinctive characters of this species seems to be the annulated surface of its test, which, to say the least, is unusual and presumably differentiates it from such similar forms as *Endoceras decorahense,* described below. There is no good reason to believe that *Endoceras proteiforme* ever attained the gigantic proportions achieved by mature representatives of this species. *E. hennepini,* which occurs in the same general area in Minnesota, has a subcentral rather than a marginal siphuncle.

Occurrence: The holotype of this species came from the Dubuque limestone near Walcott, Rice County, Minnesota. All of the paratypes are from the same formation in sec. 28, T. 108 N., R. 20 W., south of Clinton Falls, Steele County, Minnesota. Clarke states that the "majority" of the specimens that he referred to *Cameroceras proteiforme* came from Cannon Falls, Goodhue County, Minnesota, where the Prosser, Decorah, and Platteville are exposed; insofar as can be told from the published illustrations, at least superficially these Cannon Falls specimens seem to resemble those that we have under consideration, but without seeing them we hesitate to express a definite opinion in regard to their specific affinities. The very large siphuncle which Clarke illustrated and described came from Wykoff, Fillmore County, Minnesota, where the Maquoketa, Dubuque, Stewartville, Prosser, Decorah, and Platteville outcrop; it is of course not possible to determine with certainty the relationship between this siphuncle and the specimens we are studying.

Types: Carnegie Museum, 7651, 7652, 7653, 7654, 7656 and 7657 (holotype and 24 paratypes).

Endoceras gracillimum, sp. nov.

(Plate III, figure 1)

This species is being based on a single internal mold of a phragmacone, which is about 670 mm. long but is not complete adorally or adapically. The cross section of this specimen is broadly elliptical due to dorsoventral depression, at least part of which is not original. It is expanded orad very gradually, and its width increases from about 90 mm. near its adapical end to about 125 mm. near its adoral end. The angle between its lateral zones measures only about 3 degrees.

No trace of surface markings is discernible on this holotype, which is marked only by the sutures. These have been somewhat distorted, but apparently they were essentially straight and directly transverse. The camerae are rather short. In the adapical and central portions of the specimen under consideration they average about 20 mm. in length. In the adoral portion of the same specimen they become considerably shorter, and the length of the adoral five camerae averages only about 14 mm. No trace of the siphuncle is preserved in the only known representative of the species.

Remarks: The above-described specimen is rather poorly preserved to serve as a holotype, and since its siphuncle is not preserved it cannot be oriented satisfactorily. However, it differs markedly from the comparable forms with which it is associated in that it is expanded orad much more gradually, and it does not seem to be referable to any previously described species.

Occurrence: The single known representative of this species came from well up in the Dubuque limestone in sec. 28, T. 108, N., R. 20 W., south of Clinton Falls, Steele County, Minnesota.

Holotype: Carnegie Museum, 7655.

Endoceras decorahense, sp. nov.

(Plate IV, figure 1)

Two portions of the internal mold of a large phragmacone serve as a basis for this species. The larger is about 625 mm. long, and the length of the smaller measures about 320 mm. The interval between the two pieces is estimated to have been some 115 mm., so the total length of the portion of the phragmacone represented by the holotype was some 1060 mm. The specimen is not complete adapically or adorally. However, its adoral camerae are considerably shorter than the preceding ones, which

indicates that it is a mature individual and that the adoral end of the specimen represents essentially the adoral end of the phragmacone. The lateral zones of the holotype converge apicad rather gradually, and the angle between them measures only about 5½ degrees. If this pleural angle was constant throughout the length of the conch, the phragmacone must have been some 2500 mm. (or 8 feet) long. No data are available in regard to the length of the living chamber, and therefore the total length of the conch cannot be estimated.

The dorsal portion of the conch is not preserved, but the holotype is depressed dorsoventrally, probably in part, at least, as a result of distortion during preservation. At the adapical end of the specimen the conch is about 130 mm. wide, and its corresponding height is estimated to be about 125 mm. The maximum width, which is attained at the adoral end of this specimen, is about 230 mm.

The surface of the holotype, an internal mold, is devoid of markings other than the sutures. These are somewhat irregular, presumably due to a slight amount of distortion that the specimen appears to have undergone, but originally they seem to have been essentially straight and directly transverse. The camerae are rather short. Their length averages about 11 mm. in the adapical part of the holotype, reaches a maximum of some 14 mm. in the adapical portion of the larger piece of the specimen, and measures only about 7 mm. in the extreme adoral part of it.

The siphuncle is large and is ventral and marginal in position. Like the conch, it is somewhat depressed dorsoventrally, which may, of course, be a result of distortion. At the adapical end of the holotype, the siphuncle is about 55 mm. wide and about 43 mm. high. At a transverse break near the mid-length of the adoral piece of the holotype, where the conch is about 210 mm. wide, the width and height of the siphuncle measure about 95 mm. and 80 mm., respectively.

Remarks: The above-described holotype is the most nearly complete of the large straight Ordovician cephalopods available to us. The more distinctive characters of the species are the large, rather gradually expanded conch, short camerae, essentially straight transverse sutures, and large marginal siphuncle. So little precise information is available in regard to comparable forms described in this report and elsewhere, that detailed comparisons are not possible.

Occurrence: Decorah formation north of Decorah, Winneshiek County, Iowa—Winneshiek County is just south of the Iowa-Minnesota boundary.

Holotype: State University of Iowa, 2,143.

ADDENDUM

The Chicago Natural History Museum has on display a large endoceratoid, numbered P 17148, from the "Trenton" [Pecatonica member of the Platteville] limestone near Troy Grove, La Salle County, Illinois. This specimen is not complete adorally or adapically and it is slightly crushed. The preserved portion of it is some six feet long and within that length its diameter increases from some four inches to some eight inches. With the possible exception of its adoral four or five inches, this specimen is septate throughout, and the length of the camerae increases adorally. The surface of the test bears low annulations but the internal mold is almost smooth. At least in the adoral part of this specimen, the annulations are not as far apart as are the septa.

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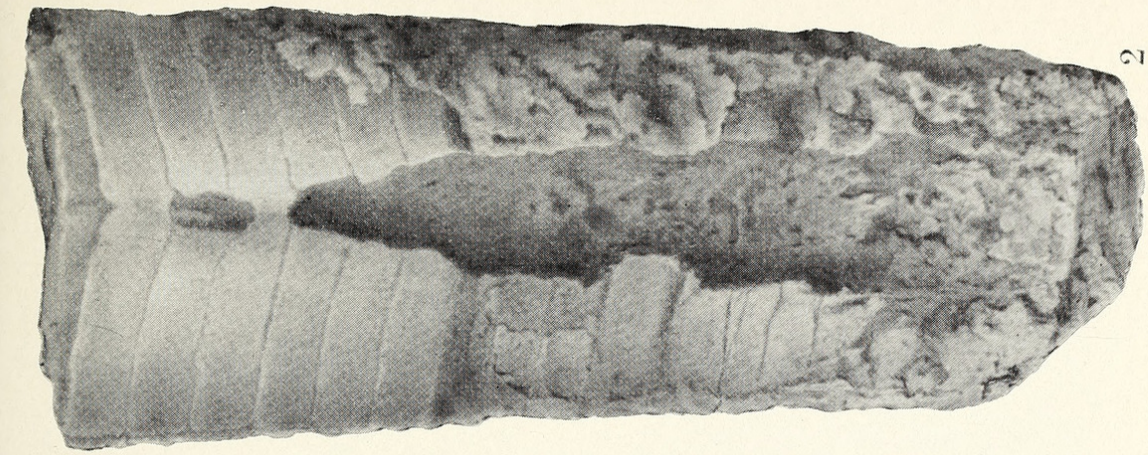
EXPLANATION OF PLATE I

FIGS. 1-3. *Endoceras clarkei*, sp. nov.

Two views of the holotype (figs. 1, 2—C. M. 7653) and one view of a paratype (fig. 3—C. M. 7654), all x ⅔. Both specimens are from the Dubuque formation of southeastern Minnesota—the holotype is from near Walcott and the paratype from south of Clinton Falls.



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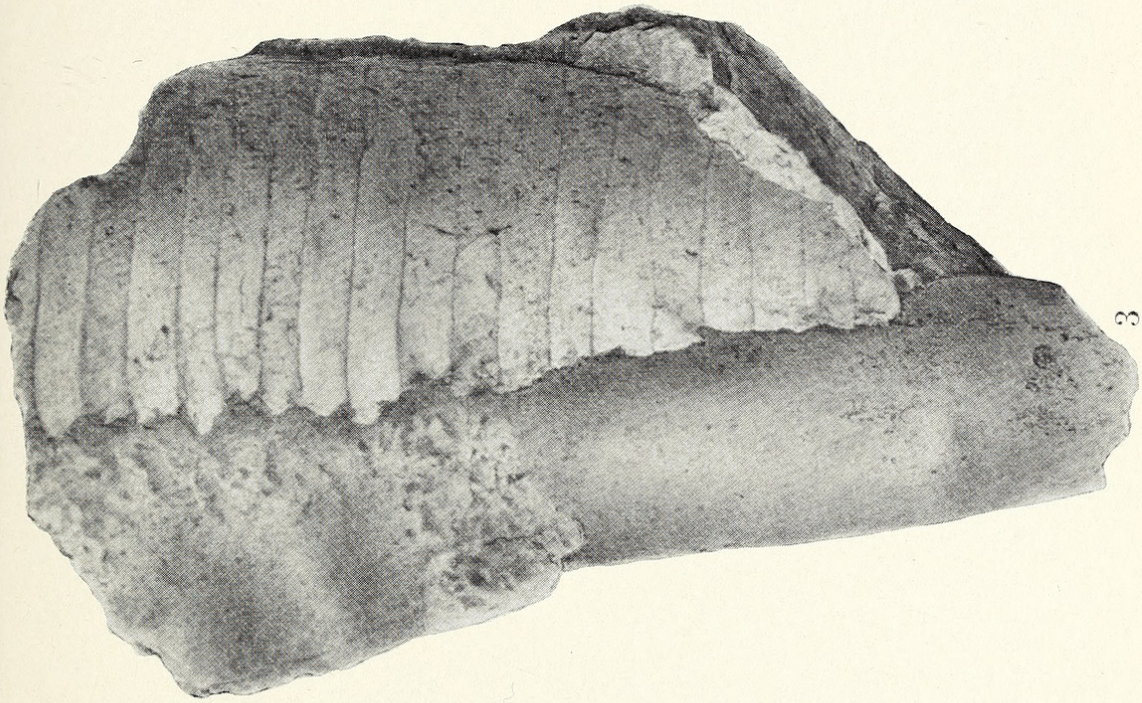

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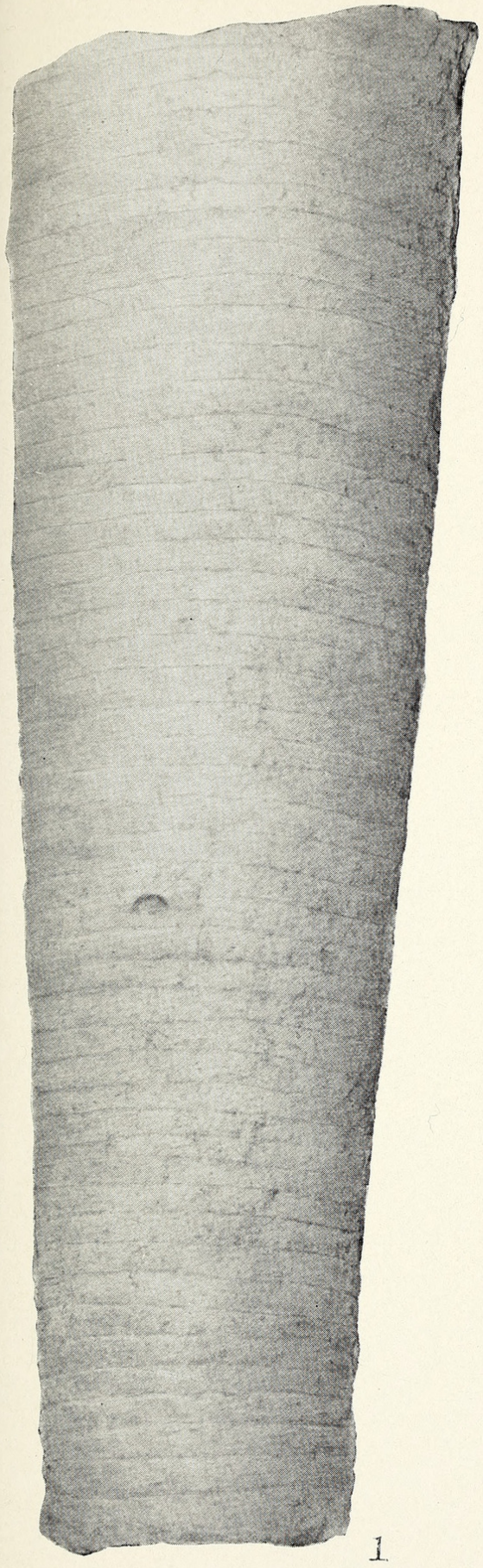
1

EXPLANATION OF PLATE II

FIGS. 1, 2. *Endoceras clarkei*, sp. nov.

Two large paratypes, x ¼, from the Dubuque formation south of Clinton Falls, Minnesota (C. M. 7651, 7652).



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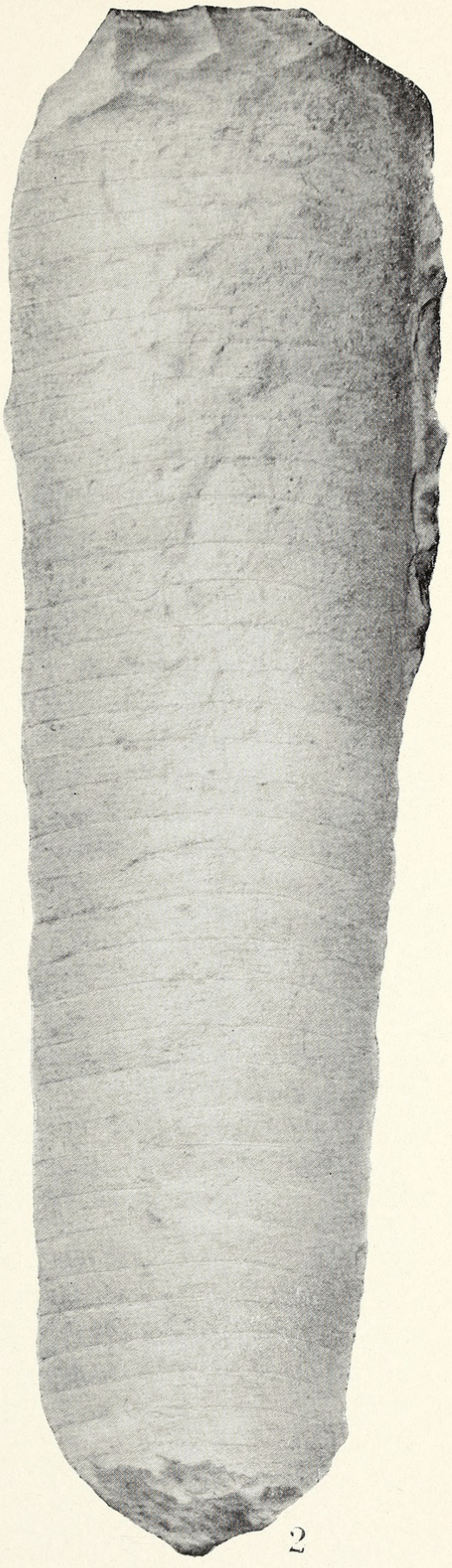

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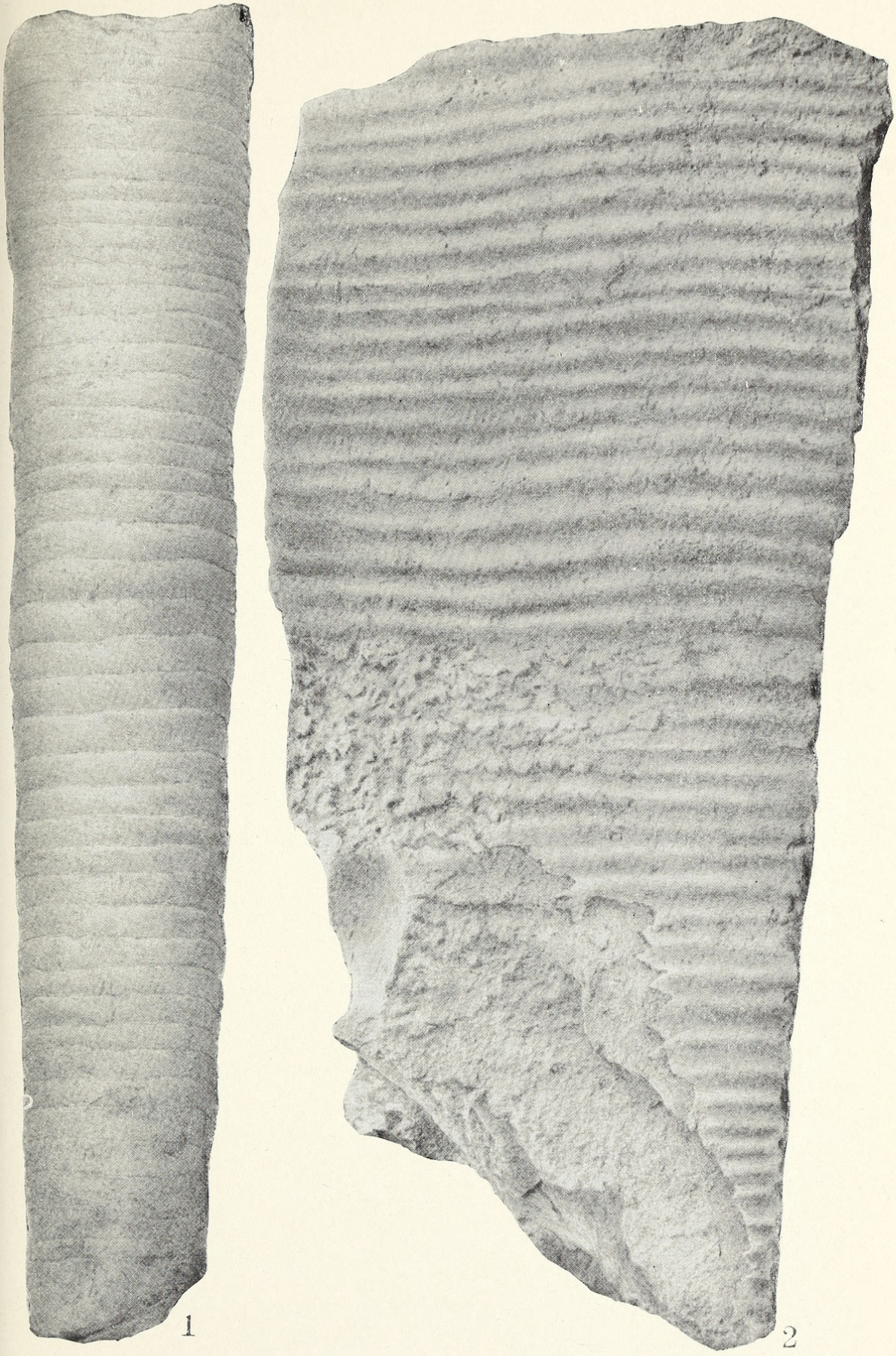
EXPLANATION OF PLATE III

FIG. 1. *Endoceras gracillimum*, sp. nov.

The holotype, x ¼, from the Dubuque formation south of Clinton Falls, Minnesota (C. M. 7655).

FIG. 2. *Endoceras clarkei*, sp. nov.

A paratype, x ⅗, from the same horizon and locality as the preceding (C. M. 7656).



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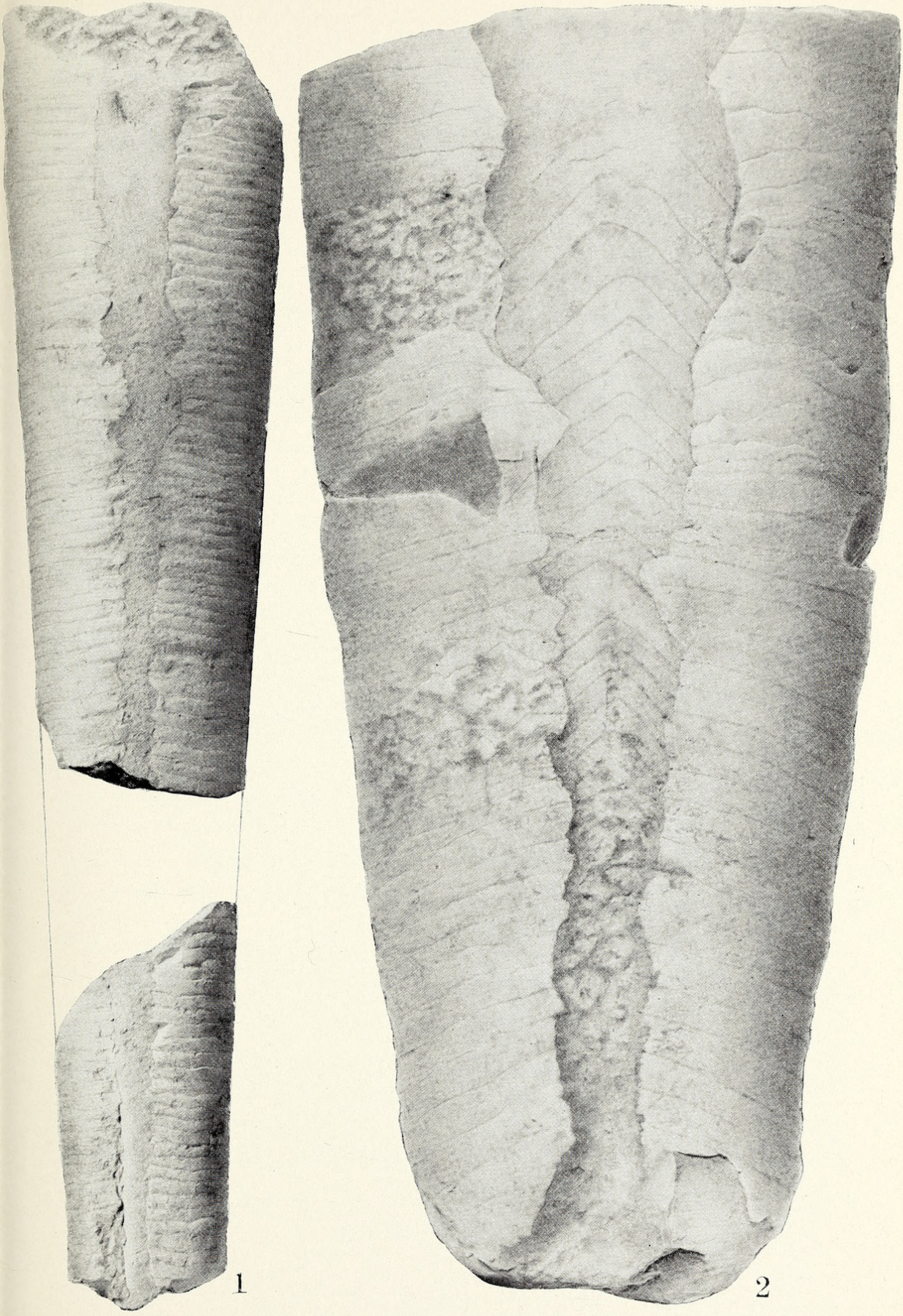
EXPLANATION OF PLATE IV

FIG. 1. *Endoceras decorahense*, sp. nov.

The holotype, x 1/6, from the Decorah formation north of Decorah, Iowa (S. U. I. 2,143).

FIG. 2. *Endoceras clarkei*, sp. nov.

A paratype, x 2/5, from the Dubuque formation south of Clinton Falls, Minnesota (C. M. 7657).



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