Ammonites from the Navesink Formation at Atlantic Highlands, New Jersey

By WILLIAM A. COBBAN

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Species of the genera Baculites, Nostoceras, Axonoceras, Exiteloceras, Didymoceras, Hoploscaphites, *and* Pachydiscus *are described and illustrated*

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AMMONITES FROM THE NAVESINK FORMATION AT ATLANTIC HIGHLANDS, NEW JERSEY

By WILLIAM A. COBBAN

ABSTRACT

Only a few species of ammonites have been recorded from the Upper Cretaceous Navesink Formation. An active group of amateur collectors has recently obtained many ammonite specimens from the basal part of this formation at Atlantic Highlands. The following forms can now be recognized: *Baculites ovatus* Say, *B. claviformis* Stephenson, *Nostoceras helicinum* (Shumard), *N. hyatti* Stephenson, *N.* cf. *N. stantoni* Hyatt, *N. pauper* (Whitfield), *N. mendryki* Cobban, n. sp., *Axonoceras* cf. *A. angolanum Haas, Exiteloceras oronense* (Lewy), *Didymoceras navarroense* (Shumard), *Hoploscaphites pumilus* (Stephenson), *H.* sp., and *Pachydiscus* sp. Most specimens represent the genera *Baculites* and *Nostoceras;* representatives of other genera are extremely scarce.

The ammonites occur as uncrushed internal molds within 3 feet of the base of the Navesink Formation, which is dominantly a greensand unit about 25 feet thick. Body chambers and septate chambers are filled with soft dark-greenish-gray glauconitic sandstone.

The fossils can be assigned either to the very late Campanian or to the very early Maestrichtian. A late Campanian assignment is slightly favored from the molluscan evidence, although a Maestrichtian age is suggested by planktonic Foraminifera.

INTRODUCTION

Ammonites have been known from the Navesink Formation at Atlantic Highlands since 1820, when Say (p. 41) described *Baculites ovatus*. Very few species, however, have been recorded from this locality. Whitfield (1892, p. 268–271) described a new ammonite, *Turrilites pauper*, and illustrated another species as *Heteroceras conradi* (Morton). Prather (1905, p. 171) listed *Baculites compressus* Say, *B. ovatus* Say, *B. asper* Morton, *Turrilites pauper* Whitfield, and *Heteroceras conradi* (Morton) from the Navesink at Atlantic Highlands. The *B. compressus* and *B. asper* of Prather are herein interpreted as variants of *B. ovatus*, and the *H. conradi* of Prather and Whitfield is *Nostoceras hyatti* Stephenson. Whitfield's *T. pauper* is more correctly assigned to *Nostoceras*, and the list of ammonites from Atlantic Highlands is then reduced to *Baculites ovatus, Nostoceras hyatti*, and *N. pauper*.

In recent years an active group of amateur collectors has obtained many ammonites from the basal part of the Navesink Formation at Atlantic Highlands. Several genera and species not previously known from the Navesink were discovered. The largest collection was made by Mr. Harold Mendryk, Harrison, N.J., who kindly made his splendid collection available to me for study and later donated it to the Smithsonian Institution. Mr. Mendryk also borrowed important specimens from other private collections as an aid to my study. Some of these specimens have since been donated to the Smithsonian Institution. These loans and donations were made by Messrs. Christopher Laskowich, West Paterson, N.J., Richard Heintz and John Brzostoski, River Plaza, N.J., Kenneth Rose, West Orange, N.J., and Ralph Johnson, West Long Branch, N.J. Dr. Karl M. Waagé, Yale University, New Haven, Conn., arranged the loan of several ammonites from the Peabody Museum of Natural History. I am grateful to all these persons for their generosity in furnishing me these interesting and important specimens that made this study possible.

The photographs were made by Robert E. Burkholder of the U.S. Geological Survey. All specimens that have USNM numbers are stored in the National Museum of Natural History in Washington, D.C. Plaster casts of many of the specimens are kept in the U.S. Geological Survey's Mesozoic invertebrate fossil collections at the Federal Center at Denver, Colo.

For a detailed map (geologic, topographic, and cultural) of the Atlantic Highlands area, the reader is referred to plate 1 in the recent work of Minard (1969). The fossils were collected along the bluff facing Sandy Hook Bay from ½ to 1 mile east of the pier at Atlantic Highlands yacht harbor. According to Mr. Mendryk (written commun., April 30, 1972), at least 90 percent of the fossils came from two localities about 8/10 and 9/10 mile east of the pier.

NAVESINK FORMATION AND AMMONITE OCCURRENCE

The Navesink Formation, dominantly a greensand unit about 25 feet thick in the Atlantic Highlands area, consists of about 30 percent clay and silt and 70 percent very fine to coarse glauconite sand (Minard, 1969, p. 14). Unweathered outcrops are dark greenish gray and massive to thick bedded (Owens and Sohl, 1969, fig. 10*D*). An outer shelf environment has been interpreted by Owens and Sohl (1969, p. 254, 257, 258), and water depths of 180–350 feet have been suggested by R. K. Olsson (1963, p. 651). The contact with the underlying Mount Laurel Sand is sharp and unconformable (Minard, 1969, p. 14; Owens and Sohl, 1969, fig. 10*A*). According to Minard (1969, p. 14), fossils occur at the base and near the middle of the formation in the Atlantic Highlands area. Minard noted that the basal foot or two contained reworked phosphatized fossils.

Mendryk (written commun., Dec. 28, 1970) observed that at the locality of his collection the fossils occurred in two

layers — a lower layer 6–8 inches thick, 27 inches above the base of the Navesink, and an upper layer 5 inches thick, 8 inches above the lower layer. Nearly all specimens came from the lower layer. All are uncrushed internal molds, a few of which display mother-of-pearl colors. Body chambers and septate chambers are filled with silt and glauconite sand and, rarely, fecal pellets. Sutures are usually corroded a little. Epizoa, such as worm tubes (pl. 6, figs. 9, 10; pl. 7, figs. 4, 5) and membraniporoid bryozoans (pl. 8, figs. 17, 18), are present on a few specimens. The bryozoans are of interest in that none was recorded from the Cretaceous outcrops in New Jersey in the summary of parts of the faunas by Richards (1962, p. 197).

AGE OF NAVESINK FORMATION

A Maestrichtian age was assigned to the Navesink Formation by Stephenson in several papers dating back to 1928 (Stephenson, 1928, p. 494, fig. 1). Stephenson recognized an *Exogyra costata* zone that included the ammonite *Sphenodiscus* and the belemnite *Belemnitella americana* (Morton). *Sphenodiscus* was well accepted as an index fossil to rocks of Maestrichtian age, and the *Exogyra costata* zone was assigned that age. *Exogyra costata* Say and *Belemnitella americana* had been recorded as common fossils in the Navesink (Weller, 1907, p. 105–128). *Exogyra costata* was also recorded from the Mount Laurel Sand underlying the Navesink, as well as from the overlying Red Bank Sand and Tinton Sand (Weller, 1907, p. 128, 458). A subzone of *E. cancellata* Stephenson was recognized in the lower part (Mount Laurel Sand) of the *E. costata* zone (Stephenson, 1923, pl. 8; 1933).

The age of the *E. cancellata* subzone has been controversial. Stephenson (1923, pl. 8) first assigned a Campanian age, later he (1933, p. 1359) indicated a late Campanian or early Maestrichtian age, and, finally, Stephenson, King, Monroe, and Imlay (1942, chart) assigned a Maestrichtian age. However, they (Stephenson and others, 1942, p. 438–439) noted that in the gulf coastal area some micropaleontologists considered the microfauna of the *E. cancellata* subzone, represented in the Neylandville Marl, to be more closely related to that of the underlying Taylor Marl than to that of the overlying Nacatoch Sand (approximate Navesink equivalent). The molluscan fauna of the *E. cancellata* subzone, in contrast, was considered more closely related to that of the Nacatoch Sand.

R. K. Olsson (1963, p. 647; 1964, p. 158), on the basis of the planktonic foraminiferal fauna, regarded the Mount Laurel Sand in New Jersey as early Maestrichtian. Jeletzky (1962, p. 160), on the other hand, considered the Mount Laurel, as well as the overlying Navesink Formation, to be of late Campanian age. Recently, Sohl and Mello (Owens and others, 1970, p. 28–55) made a critical analysis of the invertebrate faunas of the Upper Cretaceous formations of New Jersey and Delaware. On the basis of the megafossils, Sohl concluded that the Mount Laurel was late Campanian and that the Campanian-Maestrichtian boundary was within the Navesink Formation. Mello analyzed the foraminiferal content of the Mount Laurel Sand and underlying Marshalltown Formation along the Chesapeake and Delaware Canal and concluded that these formations were of late Campanian to earliest Maestrichtian age. From the above review, it is apparent that the Mendryk collection of ammonities lies near the Campanian-Maestrichtian boundary.

The Mendryk collection of ammonites from the basal part of the Navesink Formation at Atlantic Highlands consists of the following species:

Baculites ovatus Say
claviformis Stephenson
Nostoceras helicinum (Shumard)
hyatti Stephenson
pauper (Whitfield)
cf. *stantoni* Hyatt
mendryki, n. sp.
Axonoceras cf. *A. angolanum* Haas
Exiteloceras oronense (Lewy)
Didymoceras navarroense (Shumard)
Hoploscaphites pumilus (Stephenson)
Hoploscaphites sp.
Pachydiscus sp.

Nostoceras helicinum and *N. hyatti* have been found at Barra do Dande, Angola, in strata that had been assigned to the Campanian by some authors and to the Maestrichtian by others. Howarth (1965) studied a large collection from this locality that had been briefly reported on earlier by Spath (1951, p. 127–128), who had considered it as Maestrichtian. Howarth (1965, p. 404) concluded that these heteromorphs could be either late Campanian or early Maestrichtian and that most evidence favored a late Campanian age. Antunes and Sornay (1969, p. 71–82), who later summarized the stratigraphy of the fossiliferous beds at Barra do Dande, also believed that the heteromorphs were probably of late Campanian age.

Nostoceras helicinum, N. hyatti, Exiteloceras oronense, and *Didymoceras navarroense* have been found in the uppermost part of the Mishash Formation in southern Israel (Lewy, 1967, p. 169; 1969, p. 117, 120). Although the Mishash contains the ammonite *Libycoceras*, which is usually considered to be a Maestrichtian fossil (for example, Wright, in Arkell, Kummel, and Wright, 1957, p. *L*437), Reiss (1962, p. 3–14) has presented convincing evidence for a late Campanian age based on foraminiferal and molluscan data. *Nostoceras hyatti* has also been recorded with *Libycoceras chargense* Blanckenhorn in the calcareous phosphorite bed at the top of the Sayyarim Formation in southern Israel (Bartov and others, 1972, p. 88).

Błaszkiewicz (1966) presented a very good summary of the Campanian and Maestrichtian stratigraphy and ammonite record of the middle Vistula River valley in Poland. Four ammonite zones were recognized in the upper Campanian and two in the lower Maestrichtian. The youngest

Campanian zone is characterized by a heteromorph listed as "*Nostoceras vistulae* (Pożaryski in sched.)." Photographs of this ammonite, kindly sent to me by Dr. Błaszkiewicz, reveal a form that closely resembles *N. hyatti*. The Polish species has the rows of ventrolateral tubercles a little farther apart but not as far apart as those on the slightly older *N. dracone* Stephenson of the Neylandville Marl of Texas.

The new species, *Nostoceras mendryki*, from the upper of the two ammonite beds near the base of the Navesink, closely resembles the European *N. schloenbachi* (Favre, 1869, p. 30, pl. 7, figs. 5*a*–*c*) which has been recorded from the upper Campanian (Wiedmann, 1962, p. 204), uppermost Campanian and lowermost Maestrichtian (Najdin, 1969, p. 181), and lower Maestrichtian (Pożaryska, 1954, table 1; Błaszkiewicz, 1966, table 1; Cieśliński and Pożaryski, 1970, p. 212). Pachydiscids from the basal part of the Navesink consist of two small fragments resembling *Pachydiscus neubergicus* (von Hauer) of early Maestrichtian age. The smaller (pl. 11, figs. 5, 6) of these specimens from the Navesink came from the upper of the two ammonite beds; the larger specimen is from one of these beds. The occurrence of this type of a pachydiscid together with a *schloenbachi*-type of *Nostoceras* suggests an early Maestrichtian age for the upper ammonite bed, whereas the *hyatti-helicinum* type of *Nostoceras* in the lower bed argues for a very late Campanian age for that bed.

R. K. Olsson (1963, p. 647, 649; 1964, p. 158) assigned an early Maestrichtian age to the Navesink Formation of New Jersey on the basis of its rich planktonic foraminiferal content. Unfortunately, none of Olsson's samples came from the Navesink at Atlantic Highlands, and the two ammonite beds cannot be keyed to the planktonic foraminiferal zonation.

SYSTEMATIC DESCRIPTIONS

Unless stated otherwise, all diameter measurements are intercostal. Rib density is expressed by the rib index, which is the diameter of the whorl divided by the distance between the crests of two adjacent ribs on the middle of the venter. This is close to, but not entirely the same as, the rib index or rib density of most authors. It permits a more accurate expression of low rib density, such as that of many baculites, where the distance between ribs is greater than the diameter of the shell.

Phylum MOLLUSCA

Class CEPHALOPODA

Order AMMONOIDEA

Family BACULITIDAE Meek, 1876

Genus BACULITES Lamarck, 1799

Type species. — *Baculites vertebralis* Defrance, 1830.

Baculites ovatus Say

Plate 1, figures 1–32; plate 2, figures 1–14; plate 3, figures 1–6, 9–11; text-figure 4

1820. *Baculites ovata* Say, Am. Jour. Sci., 1st ser., v. 2, p. 41.

1829. *Baculites ovata* Say (part). Morton, Acad. Nat. Sci. Philadelphia Jour., 1st ser., v. 6, pt. 1, p. 89, pl. 5, figs. 5–6.

1830a. *Baculites ovatus* Say. Morton, Acad. Nat. Sci. Philadelphia Jour., 1st ser., v. 6, pt. 2, pt. 2, p. 196, pl. 8, fig. 8 (not figs. 6–7).

1830b. *Baculites ovatus* Say. Morton, Am. Jour. Sci., 1st ser., v. 17, p. 280.

1830c. *Baculites ovatus* Say. Morton, Am. Jour. Sci., 1st ser., v. 18, pl. 1, fig. 8 (not figs. 6–7).

1834. *Baculites ovatus* Say. Morton, Synopsis of the organic remains of the Cretaceous group of the United States [Philadelphia, Key & Biddle], p. 42 (part), pl. 1, fig. 8 (not figs. 6–7).

1892. *Baculites ovatus* Say. Whitfield, U.S. Geol. Survey Mon. 18, p. 275, pl. 46, figs. 3–9.

1896. *Baculites ovatus* Say. Harris, Bulls. Am. Paleontology, v. 1, no. 5, p. 289 (reprint of Say, 1820).

1905. *Baculites ovatus* Say. Johnson, Acad. Nat. Sci. Philadelphia Proc., v. 57, p. 26.

1907. *Baculites ovatus* Say. Weller, New Jersey Geol. Survey, Paleontology ser., v. 4, p. 821 (part), pl. 109, fig. 5.

1916. *Baculites ovatus* Say (part). Gardner, Maryland Geol. Survey, Upper Cretaceous, p. 375 (not pl. 12, figs. 2–3).

1926. *Baculites ovatus* Say (part). Wade, U.S. Geol. Survey Prof. Paper 137, p. 181 (not pl. 60, fig. 9).

1927. *Baculites ovatus* Say (part). Reeside, U.S. Geol. Survey Prof. Paper 151, p. 9 (not pl. 5, figs. 12–13; pl. 6, figs. 1–4; pl. 7, figs. 1–8).

1962. *Baculites ovatus* Say. Reeside, New Jersey Bur. Geology and Topography Bull. 61, pt. 2, p. 113, pl. 68, fig. 4.

Baculites ovatus was described by Say (1820, p. 41) as follows:

> *B. ovata*, elongated; transverse septa subovate, sixlobed and a smaller one behind; *lobes of the superior faces* of the septa, three on each side, with a minute one between each, dentated at their edges, anterior lobe, (nearest the siphuncle) small not sinuous, second lobe with a single projection each side and sinus at tip, third lobe dilated, with a small sinus each side and more obtuse and profound one at tip, posterior lobe hardly larger than the lateral intermediate ones.
>
> Greatest diameter of the transverse section one inch and one fifth, smaller diameter seven tenths; length of the segment about half an inch.
>
> The specimen is in the collection of Mr. Reuben Haines of this city [Philadelphia], it was found on the Neversink hills, in Monmouth County, New-Jersey, it is a cast of three very entire segments, no vestige of the shell remaining. The dimensions are taken from the largest segment.

Morton (1829, p. 89–90) reworded Say's description and noted the presence of faint lateral undulations on the type specimen. He pointed out that lateral undulations were common on "all the Baculites I have seen from this region [New Jersey and Delaware]." That the lateral ribs could scarcely be discerned on the holotype was attributed to the fact that the "specimen was carried for thirty years in the pocket of the finder; which fact sufficiently accounts for the rings [ribs] having become almost imperceptible." Morton noted that the specimen was from the "marl of Sandy-Hook Bay, New-Jersey, where many other specimens have been obtained." He illustrated a lateral view of Say's specimen as well as a lateral view of a smaller, well-ribbed individual about 11 mm (millimeters) in diameter from a different locality. Morton (1830a, pl. 8, figs. 6–8) later showed a dorsal view of Say's specimen and lateral and end views of a well-preserved internal mold of a very stout baculite that

has a broad elliptical cross section and narrow, widely spaced lateral ribs.

The holotype of *Baculites ovatus* was recorded at the Academy of Natural Sciences, Philadelphia, in 1905 by Johnson (p. 26). According to Reeside (1962, p. 115), the type may now be lost. Reeside (1962, pl. 68, figs. 1–3) illustrated a specimen at the Academy of Natural Sciences that he thought could be interpreted as the remainder of Say's type, although the fragment was unnumbered and in a tray with three other baculites accompanied by a label merely stating "St. Georges, Del." (J. B. Reeside, Jr., written commun., Dec. 20, 1954). This fragment, about 32 mm in diameter and 23.6 mm in width (measurements from a plaster cast), consists of two septal chambers instead of the original three of Say's type. It is composed of reddish-brown fine-grained glauconitic, ferruginous sandstone that closely resembles the material filling ammonites from the Merchantville Formation of New Jersey and Delaware. The specimen has a stouter cross section (ratio of width to diameter 71 percent) than that of Say's type (ratio 58 percent).

The holotype of *B. ovatus* apparently came from the Navesink Formation at the well-known exposures along the bluff on the south side of Sandy Hook Bay at Atlantic Highlands, Monmouth County, N.J. Morton (1829, p. 90; 1830b, p. 280) included in his descriptions of this species baculites from the older (early Campanian) Merchantville Formation, such as from the deep cut of the Chesapeake and Delaware Canal, as well as baculites from the Mississippi embayment area and the western interior region (Morton, 1830a, p. 196).

Following the publication of Morton's papers, most authors continued to define *Baculites ovatus* in a very broad sense, and baculites from the western interior region of the United States and Canada were commonly described and illustrated as examples of this species. The range in age of these western interior specimens is considerable, as indicated by the following examples: late Cenomanian (White, 1877, p. 199, pl. 19, figs. 4*b*, *c*), early Campanian (Reeside, 1927, p. 9, pl. 5, figs. 12, 13; pl. 6, figs. 1–4; pl. 7, figs. 1–8), late Campanian (Landes, 1940, p. 171), and early Maestrichtian (Meek, 1876, p. 394, pl. 20, figs. 1*a*, *b*, 2*a*–*c*). In addition to the great range in age of specimens described as *B. ovatus*, some baculites from other parts of the world were referred to this species; a few examples are Venezuela (Reyment, 1958, p. 7, pl. 1, figs. 1, 2; text-figs. 1, 2), Palestine (Taubenhaus, 1920, p. 11, pl. 6, figs. 1*a*–*d*), and Russia (Bodylevsky and Shulgina, 1958, pl. 44, figs. 5*a*, *b*).

Reeside (1962, p. 114) pointed out that, inasmuch as Say's type specimen was from the Atlantic Highlands area, the type specimen could not be from rocks older than the Mount Laurel Sand, which is the oldest formation exposed there. He believed the name *Baculites ovatus* should be restricted to specimens from the Mount Laurel Sand and overlying Navesink Formation and that the baculites from the older Merchantville Formation and Woodbury Clay represented other species. He excluded from *B. ovatus* the very broad-ventered stout specimen figured by Morton (1830a, pl. 8, figs. 6, 7; 1830b, pl. 1, figs. 6, 7; 1834, pl. 1, figs. 6, 7). He also stated that specimens from the western interior region formerly identified as *B. ovatus* belonged to other species such as *B. haresi* Reeside and *B. grandis* Hall and Meek. The following definition of *B. ovatus* was presented by Reeside (1962, p. 114):

"Shell attaining moderate size, very gradually tapering; cross section broad-ovate, the siphonal side somewhat more narrowly rounded than the antisiphonal side. Surface of shell usually smooth, but sides of living chamber sometimes with ill-defined, broadly curved, obliquely transverse ribs. Suture with rather simple rounded elements, lateral lobes and saddles subequal, subdivisions of lobes small, subequal."

The Mendryk collection from Atlantic Highlands contains 189 baculites, of which 177 are suitable for measurement; all but 2 of the measurable specimens lie within a range in diameter from 8.4 to 48 mm. The exceptions (pl. 3, figs. 7, 8, 12–14) are two septate individuals 50 and 59 mm in diameter that closely resemble the holotype of *Baculites claviformis* Stephenson and are assigned to that species. The rest of the specimens are assigned to *B. ovatus*, although a few could be immature specimens of *B. claviformis*. Most of the 175 measurable specimens assigned to *B. ovatus* have smooth flanks, and only 53 (30 percent) have very weak to moderate broad arcuate lateral ribs. The size distribution of individuals in the total sample of measurable specimens as well as the size distribution of the ribbed specimens is shown in figure 1.

The specimens of *Baculites ovatus* in the Mendryk collection have growth angles of taper of 2–8 degrees; most have angles of 4–6 degrees (fig. 2). The angle decreases slightly after the shells attain a diameter of 35 mm. There seems to be very little difference between the taper of smooth-flanked and rib-flanked shells; the angle of taper of ribbed shells is slightly less — hardly averaging a degree less. Nearly all specimens are straight, but a few juveniles may show some curvature (pl. 1, figs. 2, 6; pl. 2, fig. 2; pl. 3, fig. 2).

Most shells have a cross section that is distinctly ovate. Regarding the degree of stoutness of the cross section, the following table is used in order to have a tangible reference, and the descriptive terms are those used by most authors who have described baculites.

Ratio of width to diameter	*Descriptive term*
0.500–0.624	Slender
.625– .749	Moderately stout
.750– .874	Very stout
.875– .999	Subcircular

According to this scheme, most baculites in the Mendryk

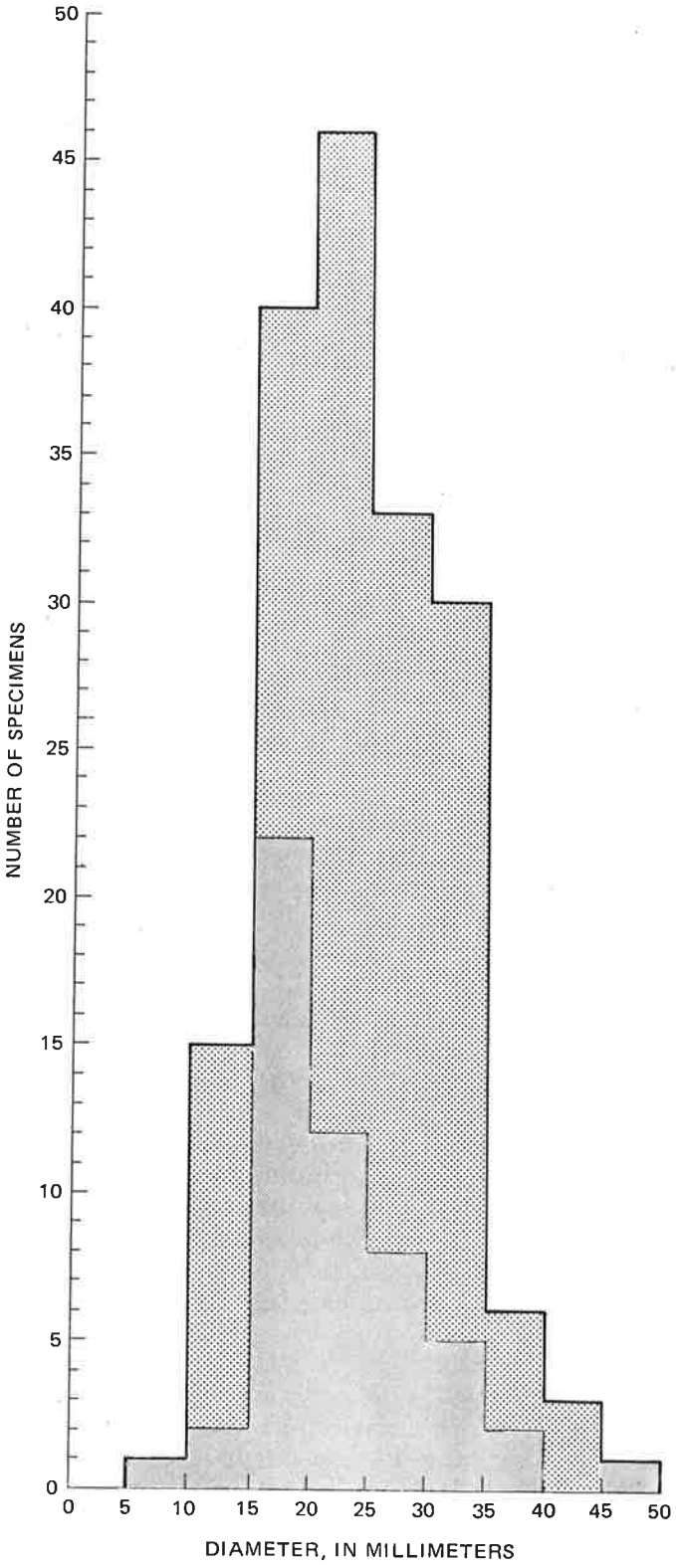

FIGURE 1. — Histogram showing size frequency distribution of samples of *Baculites ovatus* Say from the basal few feet of the Navesink Formation at Atlantic Highlands, N.J. Heavy line shows distribution of the total number of specimens (175) suitable for measurement; light line enclosing the dark-shaded areas shows distribution of the number (53) of specimens that have lateral ribs.

collection have a moderately stout section that tends to be on the slender side (fig. 2). If Say's dimensions (1 1/5 in. by 7/10 in.) of the type specimen are correct, its cross section was unusually narrow (ratio of 0.58) and slightly more so than the most slender specimen in the Mendryk collection.

Two of the 175 baculites have a dorsolateral depression (pl. 2, figs. 7, 12). In the western interior region, dorsolateral depressions are rather common on young adults of *Baculites clinolobatus* Elias, a species younger than *B. ovatus* (Gill and Cobban, 1966, p. A34).

Lateral ribs may appear at diameters as small as 12–14 mm (pl. 1, figs. 22–24) or at diameters as large as 38 mm (pl. 2, fig. 13, 14). They are usually spaced about 1.5 for the shell diameter (pl. 1, figs. 9, 16, 23), but they may be as closely spaced as 3 per shell diameter or as widely spaced as 0.7 per shell diameter (pl. 1, fig. 31). The ribs are located on the dorsal half of the flank and range in shape from well-defined arcuate forms (pl. 1, figs. 9, 16) to poorly defined lateral swelling (pl. 1, fig. 31).

Ventral ribs, which are present on most specimens, vary from barely discernible (pl. 1, figs. 14, 26; pl. 2, figs. 6, 11) to moderately conspicuous (pl. 1, figs. 8, 17; pl. 2, fig. 14; pl. 3, fig. 10). They tend to be irregular in strength and spacing. Specimens that have well-defined lateral and ventral ribs closely resemble *B. undatus* Stephenson (1941, p. 405, pl. 79, figs. 5–10), from which they differ only by having narrower venters. The cross section shown by Stephenson (1941, pl. 79, fig. 8) is incorrect in that the venter is too narrow. The venter of the holotype is about as broad as the dorsum (fig. 3).

The outline of the aperture can be seen on only two specimens, one of which is shown on plate 2, figure 13; it follows the shape of the lateral and ventral ribs.

Sutures, which are visible on 164 specimens, are moderately complex; most resemble those in figure 4 or that of a specimen illustrated by Whitfield (1892, pl. 46, fig. 7). The opposite branches of the lateral lobe (L) are usually well separated. On many specimens the opposing saddles that separate the two main branches on each side of the lobe are a little closer to each other than those shown in figure 4*A*, and on a very few individuals (five) the opposing saddles are near enough to produce a suture (fig. 4*B*) comparable to that of *Baculites compressus* Say or *B. eliasi* Cobban (1958, text-figs. 1*i, j*). Ten specimens have sutures comparable to that of *B. gregoryensis* Cobban (1951, text-figs. 10, 12) and *B. scotti* Cobban (1958, text fig. 1*h*). In this type of suture (fig. 4*C*) the saddles separating the two main lateral branches on each side of the lobe remain far apart, but the lateral lobe is constricted above the upper pair of major branches.

Types. — Hypotypes USNM 182443–182459.

Baculites claviformis Stephenson

Plate 3, figures 7, 8, 12–14

1892. *Baculites asper* Morton. Whitfield, U.S. Geol. Survey Mon. 18, p. 278, pl. 46, figs. 10, 11.

Aside from northeastern Texas and New Jersey, *B. claviformis* is present in U.S. Geological Survey collections from the Nacatoch Sand of southwestern Arkansas and the Ripley Formation of Tennessee, Alabama, and, possibly, Mississippi. It may be present in the western interior region. *Baculites claviformis* is possibly the same as some earlier named European species such as *B. ambiquus* Eichwald (1868, p. 1176, pl. 37, figs. 3*a*–*c*) and *B. gigas* Sintzov (1888, p. 126).

Types. — Holotype USNM 77241; hypotypes USNM 182460, 182461.

Family NOSTOCERATIDAE Hyatt, 1894

Genus NOSTOCERAS Hyatt, 1894

Type species. — *Nostoceras stantoni* Hyatt, 1894.

Hyatt (1894, p. 569) based his genus on a collection of heteromorphs from Chatfield, Navarro County, Tex. He designated *Nostoceras stantoni* Hyatt as the genotype and then described the varieties *retrorsum, prematurum,* and *aberrans,* without describing *N. stantoni stantoni.* None of the specimens was illustrated. An ammonite, described on an earlier date by Shumard (1861, p. 191) as *Turrilites helicinus,* was assigned to *Nostoceras* by Hyatt. Stephenson (1941, p. 407) noted the necessity of designating one of Hyatt's varieties as the genotype; accordingly, he selected the variety *retrorsum.* In addition, he illustrated Hyatt's types of *N. stantoni* [Hyatt's variety *retrorsum*] and the varieties *prematurum* and *aberrans.* Inasmuch as Shumard's types were lost, Stephenson selected and illustrated a neotype for *N. helicinum* (Shumard), and the new varieties *humile* and *crassum* were described. Stephenson also described and illustrated the new species *N. colubriformis, N. hyatti,* and *N.? draconis.*

Reeside (1962, p. 118) presented the following concise definition of *Nostoceras.*

"It has a closely coiled spiral of three to six volutions, either dextral or sinistral, followed by a free down dropping U-shaped retroversal old-age living chamber that brings the aperture back to a position just beneath the base of the last volution of the spire. The shell is ornamented with costae, most of which are single, but some of which may bifurcate. Constrictions are usually present on the spire. Two rows of ventral tubercles are more or less prominently developed, and a contact furrow is present on the whorls of the spire."

Collections of heteromorphs from the Nacatoch Sand of the Corsicana-Chatfield-Kaufman area of northeastern Texas show a natural grouping of the helical shells that are characterized by dense ribbing and the presence of constrictions; these forms can all be conveniently placed in *Nostoceras.* The spire varies from high (*N. colubriformis*) to very low (*N. dracone*), and the retroversal body chamber (hook) ranges from a lengthy U-shaped form at right angles to the spire (*N. dracone*) to a short U-shaped form at an acute angle to the spire (*N. colubriformis*). Unfigured spires of *N. dracone* from the Corsicana area show the presence of constrictions; Stephenson's query for the generic assignment can now be removed. The neotype of *Turrilites splendidus* Shumard (1861, p. 191) selected and illustrated by Stephenson (1941, p. 415, pl. 82, figs. 1, 2) has constrictions, and the end of the last preserved whorl has uncoiled slightly (not visible in Stephenson's illustrations); this species is best assigned to *Nostoceras* (Matsumoto, 1959b, p. 46; 1960, p. 172). *Turrilites saundersorum* Stephenson (1941, p. 416, pl. 83, figs. 6–8), which has dense ribbing and conspicuous constrictions, but is incomplete at both ends, is also probably a *Nostoceras* (Matsumoto, 1967, p. 339).

Outside North America *Nostoceras* has been recorded from Colombia (Petters, 1955, p. 216, 224; Bürgl, 1955, p. 33, 43; Bürgl and Dumit Tobon, 1954, p. 36), Angola (Haughton, 1925, p. 275; Haas, 1943, p. 2–7; Howarth, 1965, p. 378–284; Antunes and Sornay, 1969, p. 86–87), South Africa (Spath, 1921, p. 248–252), Madagascar (Collignon, 1969, p. 46), Australia (Brunnschweiler, 1966, p. 40–43), Israel (Lewy, 1967, p. 165–169; 1969, p. 117–122), England (Wright, in Arkell, Kummel, and Wright, 1957, p. L224), and Poland (Błaszkiewicz, 1966, p. 1063–1065). The fragments of heteromorphs from the Maestrichtian of Peru, identified as *Helicoceras* sp. and *Turrilites peruvianus* by A. A. Olsson (1934, p. 73; 1944, p. 107), are probably *Nostoceras.*

The Mendryk collection of helically coiled ammonites from the basal part of the Navesink Formation at Atlantic Highlands consists of 150 specimens of which 131 represent the *Nostoceras helicinum-hyatti* species group, 5 may be *N. stantoni* Hyatt, 9 are *N. pauper* (Whitfield), 3 are a new species of *Nostoceras,* and 2 are *Didymoceras navarroense* (Shumard). The specimens representing the *helicinum-hyatti* group consist of 34 incomplete spires (17 sinistral, 17 dextral) and 97 complete or partial hooks (43 sinistral, 38 dextral, 16 undetermined). Most of these specimens are not quite typical of either *N. helicinum* or *N. hyatti,* possibly due to the great geographic distance that separates New Jersey from Texas. The differences, however, do not seem great enough to warrant new subspecific names. It is also possible that the specimens represent a single variable species. Likewise, if more specimens were available from Texas, *N. helicinum* and *N. hyatti* might prove to be one variable species. Until more material is available from Texas, the specimens from Atlantic Highlands will be interpreted as representing the two species.

Nostoceras helicinum (Shumard)

Plate 4, figures 1-21; text-figure 6

1861. *Turrilites helicinus* Shumard, Boston Soc. Nat. History Proc., v. 8, p. 191.

1894. *Nostoceras helicinum* (Shumard). Hyatt, Am. Philos. Soc. Proc., v. 32, no. 143, p. 573.

1941. *Nostoceras helicinum* (Shumard). Stephenson, Texas Univ. Bull. 4101, p. 410, pl. 80, figs. 11, 12.

1943. *Nostoceras helicinum* (Shumard). Haas, Am. Mus. Novitates 1222, p. 2, figs. 1*a*, 6, 7.

?1965. *Nostoceras helicinum* (Shumard). Howarth, British Mus. (Nat. History) Bull., Geology, v. 10, no. 10, p. 383, pl. 8, figs. 3*a*, *b*, 5*a*–*c*.

?1969. *Nostoceras* aff. *N. helicinum* (Shumard). Sornay, *in* Antunes and Sornay, Lisboa Univ. Fac Ciênc. Rev., 2d ser. C, v. 16, pt. 1, p. 86, pls. 2–5.

The type specimens described by Shumard (1861, p. 191) are lost; they came from "Chatfield Point and Corsicana, Navarro County." Stephenson (1941, p. 411, pl. 80, figs. 11, 12) selected as the neotype a spire of three complete whorls from the Nacatoch Sand near Chatfield. This specimen has an apical angle of 92° and whorl rib counts of 56 at a diameter of 14 mm, 59 at 15 mm, 61 at 19 mm, and 64 at 23 and 28 mm (fig. 5). The neotype differs from *Nostoceras stantoni* and *N. hyatti* in greater apical angle and in denser ribbing. A body chamber was not illustrated. According to Stephenson, the neotype came from a collection of fossils (USGS Mesozoic loc. 762; Stephenson, 1941, p. 47) that included the type specimens of Stephenson's *Baculites undatus, Scaphites rugosus, S. pumilus,* and *Solenoceras multicostatum,* as well as specimens of *Solenoceras texanum* (Shumard), *Nostoceras stantoni* Hyatt, *Turrilites* [*Nostoceras*] *splendidus* Shumard, *Helicoceras* [*Didymoceras*] *navarroense* Shumard, and *Parapachydiscus* [*Pachydiscus*] *arkansanus* Stephenson.

Nostoceras helicinum is apparently scarce in the Nacatoch Sand in the Chatfield area. The material from Chatfield studied by Stephenson but not described or figured includes but a single fragment referable to *N. helicinum.* Of 45 *Nostoceras* spires at hand, collected from the Chatfield area after the publication of Stephenson's work, 43 represent *N. stantoni* and 2 represent Stephenson's *N. helicinum* var. *crassum.* Specimens of *Nostoceras* from the Nacatoch Sand of the Corsicana area (12 miles south of Chatfield) consist of *N. helicinum* and *N. hyatti* and probably represent a slightly different age level than the fossiliferous beds at Chatfield. The collection from Corsicana (USGS Mesozoic loc. 518; Stephenson, 1941, p. 47) from which Stephenson selected his types of *N. hyatti* include six other *Nostoceras* spires all referable to *N. helicinum.* Other ammonites in this collection are Stephenson's *Baculites undatus* and *Solenoceras multicostatum.*

About 10 specimens in the Mendryk collection seem assignable to *Nostoceras helicinum.* One consists of a body chamber and part of the spire (pl. 4, figs. 1–4), another consists of a nearly complete body chamber (pl. 4, figs. 5–7), and the rest consist of parts of body chambers and (or) the adjoining parts of septate whorls. The specimen consisting of hook and spire is about the size of the neotype and about as densely ribbed (62 ribs at a diameter of 30 mm). (See fig. 5.) Ribs on the hook have a minimum index of 6.

A nearly complete body chamber (pl. 4, figs. 5–7) consists of a hook from a specimen that was a little larger than the neotype. A well-defined contact furrow 31 mm long suggests that the spire was at least 37–38 mm in diameter. The hook is more open than that of either *N. hyatti* or *N. stantoni,* and the aperture does not directly face the spire. The aperture, 24.5 mm wide, is incomplete but apparently bounded by a thin rib. A smooth area 7.5 mm wide separates this rib from a conspicuous constriction bordered by thin high ribs. The rest of the hook is ornamented by sharp ribs that are narrower than the interspaces and strongest on the flanks. Rib indices are 6 to 8, and bifurcated and intercalated ribs are common. The dorsum is nearly smooth. Tubercles of the lower row are conspicuous on the older part of the hook where they rise from every other rib and become bullate. At the point where the hook bends downward, both rows of tubercles weaken abruptly and remain barely discernible on the rest of the hook.

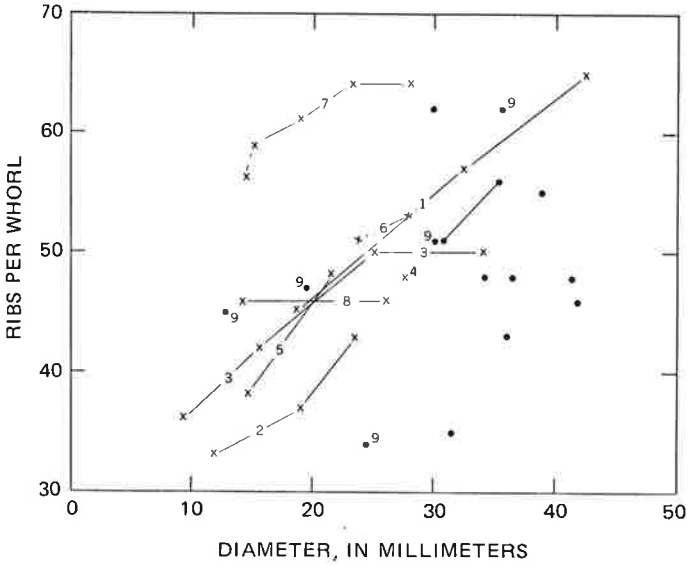

FIGURE 5. — Scatter diagram showing the number of ribs per whorl on the spires of *Nostoceras* of the *helicinum-hyatti* species group from the basal part of the Navesink Formation at Atlantic Highlands, N.J. (dots), and on Stephenson's types from the Nacatoch Sand in northeastern Texas (crosses). Rib counts and diameters of the Nacatoch specimens are based on plaster casts and photographs. 1, *N. hyatti* Stephenson; holotype USNM 77258; 2, *N. hyatti*; paratype USNM 77259; 3, *N. stantoni* Hyatt; cotype USNM 23278a; 4, *N. stantoni*; cotype USNM 23278b; 5, *N. stantoni* var. *prematurum* Hyatt; holotype USNM 23279; 6, *N. stantoni* var. *aberrans* Hyatt; cotype USNM 23280a; 7, *N. helicinum* (Shumard); neotype USNM 21103a; 8, *N. helicinum* var. *crassum* Stephenson; holotype USNM 77261; 9, Figures estimated owing to incomplete whorls.

A large septate fragment (pl. 4, figs. 12–14) has a diameter of 23 mm and a conspicuous contact furrow. Tubercles, which are very weak, are present on every second or third rib. The suture is shown in figure 6.

In addition to the New Jersey and Texas records, *N. helicinum* occurs in the United States in the Coon Creek Tongue of the Ripley Formation in western Tennessee, where it is associated with *N. hyatti* Stephenson,

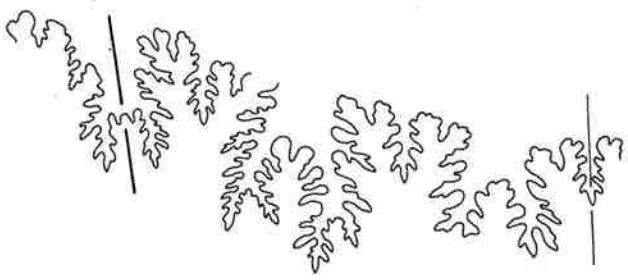

FIGURE 6. — Suture, × 2, of *Nostoceras helicinum* (Shumard) at a diameter of 21.5 mm (pl. 4, figs. 12–14). Heavy line marks the middle of the external lobe; light line marks the middle of the internal lobe. Hypotype USNM 182465.

Solenoceras texanum (Shumard), *S. reesidei* Stephenson, *Didymoceras navarroense* (Shumard), and *Baculites undatus* Stephenson. It has also been recorded questionably from the Saratoga Chalk of southwestern Arkansas (Dane, 1929, p. 111).

Nostoceras helicinum has been recorded from Colombia (Bürgl and Dumit Tobon, 1954, pl. 6), Angola (Haas, 1943, p. 2; Howarth, 1965, p. 383), and Israel (Lewy, 1967, p. 169; 1969, p. 120). The specimens from Angola figured by Howarth (1965, p. 383, pl. 8, figs. 3*a, b*, 5*a–c*) consist of parts of two spires that combine the low whorls of *N. helicinum* with the sparser ribbing of *N. hyatti*. A splendid *Nostoceras* from Angola consisting of a hook and a spire of three whorls has been figured by Sornay (in Antunes and Sornay, 1969, p. 86, pls. 2–5) who referred it to *Nostoceras* aff. *helicinum*. The spire has the dense ribbing of *N. helicinum*, but the whorls are higher. Sornay's specimen has been the subject of a recent postage stamp in Angola.

Types. — Neotype USNM 21103a; hypotypes USNM 182462–182468.

Nostoceras hyatti Stephenson

Plate 5, figures 1–21; plate 6, figures 1–12; plate 7, figures 1–10; plate 8, figures 1–30; text-figure 8

1892. *Heteroceras conradi* (Morton) (part). Whitfield, New Jersey Geol. Survey Paleont. Ser., v. 2, p. 269, pl. 45, figs. 12, 13 (not figs. 9–11, 14).

1892. *Heteroceras conradi* (Morton) (part). Whitfield, U.S. Geol. Survey Mon. 18, p. 269, pl. 45, figs. 12, 13 (not figs. 9–11, 14).

1907. *Heteroceras conradi* (Morton). Weller, New Jersey Geol. Survey Paleont. Ser., v. 4, p. 833, pl. 108, figs. 5–8.

1941. *Nostoceras hyatti* Stephenson, Texas Univ. Bull. 4101, p. 410, pl. 81, figs. 9–12.

1951. *Didymoceras* sp. nov. ind. Sornay, Rev. Zool. et Bot. Africaines, p. 274, pl. 4, fig. 4.

1962. *Nostoceras* sp. Reeside, New Jersey Bur. Geology and Topography Bull. 61, pt. 2, p. 119, pl. 69, figs. 7–12.

1965. *Nostoceras hyatti* Stephenson. Howarth, British Mus. (Nat. History) Bull., Geology, v. 10, no. 10, p. 378, pl. 9, figs. 1*a–d*, 2*a–c*; pl. 10, figs. 1*a, b*; text-fig. 16.

?1969. *Nostoceras* cf. *N. hyatti* Stephenson. Lewy, Israel Jour. Earth-Sci., v. 18, p. 118, pl. 1, figs. 4*a, b*.

1969. *Nostoceras* aff. *N. hyatti* Stephenson. Sornay, *in* Antunes and Sornay, Lisboa Univ. Fac. Ciênc. Rev., 2d ser. C, v. 16, pt. 1, p. 86, pl. 6, fig. 1.

Stephenson (1941, pl. 81, figs. 9–12) illustrated the holotype and two paratypes all from the Nacatoch Sand at Corsicana, Navarro County, Tex. The holotype consists of a spire of three whorls that has an apical angle of 81°. The back third of the specimen is missing, but my estimates of the number of ribs per whorl ranges from 45 at a diameter of 18.5 mm to 65 at a diameter of 42.5 mm (fig. 5). One of the paratypes is a smaller spire of three whorls that has an apical angle of 65° and rib counts per whorl of 33 at 11.8 mm, 37 at 19.0 mm, and 43 at 23.6 mm (fig. 5). The other paratype is a complete body chamber or hook. Rib density on the two spires does not differ greatly from that on the spires of the type specimens of Hyatt's *Nostoceras stantoni* and his varieties *prematurum* and *aberrans* (fig. 5). Stephenson (1941, p. 410) observed that *N. hyatti* differed from *N. stantoni* "in its much greater size, in its coarser, sharper and more irregular ornamentation, and in the somewhat looser and more rapid incoiling of the spiral volutions."

Ninety-four body chambers and fragments of the septate to nonseptate portions of the older parts of hooks in the Mendryk collection are assignable to *Nostoceras hyatti*. Parts of 24 spires can also be considered this species, although none consists of more than 2 whorls. Most of these spires have lower whorls (and, hence, greater spire angles) than those of the types of *N. hyatti*, and most are more sparsely ribbed. Rib counts, which could be made or estimated on 12 of the spiral whorls, range from 34 to 56 per whorl (fig. 5). Inasmuch as the spires are internal molds, the ribs and tubercles are not as sharply defined as those on the types of *N. hyatti* from the Nacatoch Sand that retain their shell material. Some of the ribs are flattened on crossing the venter (pl. 8, figs. 14, 16, 27, 28), and most tubercles are flat topped, indicating the presence once of septate spines. On three spires the flat-topped tubercles abruptly change to pointed tubercles (pl. 8, figs. 11, 12, 17), and at the same place, the ribs become sharper. This change occurs at spire diameters of 25.5, 31.0, and 31.5 mm. No evidence of this change is apparent on other spires, two of which have diameters as great as 41 and 43 mm (pl. 8, figs. 20, 22).

Constrictions are well developed on the spires and number three to five per whorl. One specimen has a moderately high rib bounding one side of a constriction.

The body chamber varies considerably in length; it may include the entire hook (pl. 5, fig. 19) or only part of it (pl. 5, fig. 12). The aperture is normal and not flared.

The 94 hooks or parts of hooks in the Mendryk collection show a great range in size without separation into two clearly defined size groups if sexual dimorphism was apparent. Measurements of the diameter of the older part of the limb of a hook just ahead of the bend reveal that most specimens have limb diameters of 14–20 mm. The size distribution of the 57 specimens that have this part of the limb preserved is shown in figure 7. The smallest specimen has less than one-half the diameter of the largest specimen.

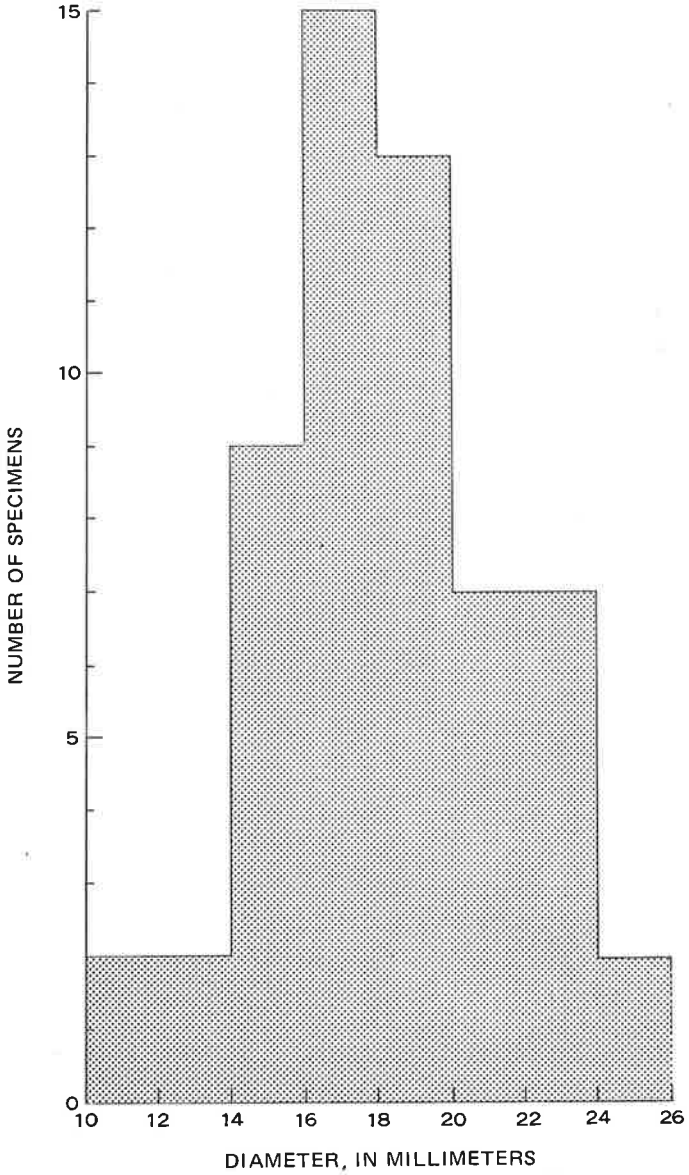

FIGURE 7. — Histogram showing size frequency distribution of 57 body chambers of *Nostoceras hyatti* Stephenson from Atlantic Highlands, N.J., based on the intercostal diameter of the older part of the limb just above the bend.

Ribs on the hooks are strong, sharp, and generally singular. Most are spaced three to four for the limb diameter. They are highest on the middle of the flank and very weak or absent on the middle of the dorsum. The ribs weaken on crossing the venter at the bend of the hook and then become strong again toward the aperture, where they also become more closely spaced. They are prorsiradiate on the older half of the hook and rursiradiate to rectiradiate on the younger half. A few ribs may branch on the flanks.

Tubercles are usually present on each rib around the bend of the hook and on each rib from the bend to the aperture (pl. 5, figs. 17, 18). On the older part of the hook, tubercles may occur on every rib or on alternate ribs. On some individuals, the tubercles of a pair at the bend and older part of the hook are connected across the venter by double ribs (pl. 5, fig. 8), or they are connected by ribs in a zigzag manner. Tubercles are largest at the bend of the hook where they are usually conical and sharp; they become smaller and bullate away from there. On some small specimens tubercles are very weak and are present on only a few ribs (pl. 5, fig. 5) or they may be absent (pl. 5, fig. 1). Tubercles are present on all but one of the larger specimens (pl. 5, figs. 14–16).

A typical suture is shown in figure 8. The only suture that has been illustrated for *N. hyatti* is one by Howarth (1965, text-fig. 16) for a specimen from Angola.

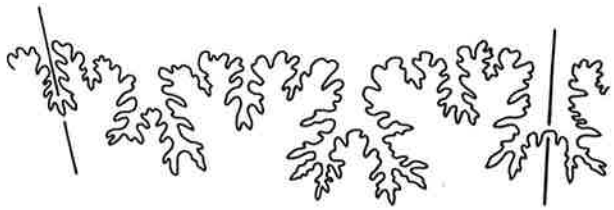

FIGURE 8. — Suture, × 2, of *Nostoceras hyatti* Stephenson at a whorl diameter of 20.5 mm (pl. 7, figs. 4, 5). Heavy line marks the middle of the external lobe; light line marks the middle of the internal lobe. Hypotype USNM 182480.

Aside from New Jersey and northeastern Texas, *Nostoceras hyatti* is known with certainty elsewhere in North America only in the Coon Creek Tongue of the Ripley Formation in western Tennessee, where it is associated with *N. helicinum* (Shumard), *Baculites undatus* Stephenson, *Solenoceras texanum* (Shumard), *S. reesidei* Stephenson, and *Didymoceras navarroense* (Shumard). Parts of two limbs from California, described and illustrated by Anderson and Hanna (1935, p. 23, pl. 7, figs. 2–4; pl. 8, fig. 5) as *"Hamites" vancouverensis* Gabb and later assigned to *Exiteloceras* by Anderson (1958, p. 201), resemble *N. hyatti* in their general appearance as already pointed out by Howarth (1965, p. 380). One of the specimens, consisting of the younger limb of a hook 85 mm long, is nearly twice as large as any known similar limb of *N. hyatti* from Texas, Tennessee, or New Jersey. The other specimen, consisting of the elbow of a hook, is also larger than any example of *N. hyatti* at hand.

Outside the United States *Nostoceras hyatti* has been recorded from Angola (Howarth, 1965, p. 378), Madagascar (Collignon, 1970, p. 17), and Israel (Lewy, 1967, p. 169; 1969, p. 117). Howarth (1965, pl. 9, figs. 1*a–d*, 2*a–c*; pl. 10, figs. 1*a*, *b*) has illustrated several body chambers and the basal whorl of a spire all closely resembling specimens in the Mendryk collection. A nearly complete specimen from Angola recently figured by Sornay (in Antunes and Sornay, 1969, p. 86, pl. 6, fig. 1) as *Nostoceras* aff. *hyatti* seems to me to be a typical *N. hyatti*. A specimen from Angola figured earlier by Sornay (1951, p. 274, pl. 4, fig. 4) as *Didymoceras*, sp. nov., was assigned to *N. hyatti* by Howarth (1965, p. 378). The whorl from the

middle Campanian of Madagascar described by Collignon (1970, p. 17, pl. 614, fig. 2293) as *N. hyatti* var. *mitraikyensis* is too slender and too loosely coiled to belong to *N. hyatti*. The body chamber from Israel illustrated by Lewy (1969, pl. 1, figs. 5*a, b*) as an example of *N. hyatti* has the rows of tubercles too far apart for this species. A nearly complete specimen described by Lewy (1969, p. 118, pl. 1, figs. 4*a, b*) as *Nostoceras* cf. *N. hyatti* seems to me to be a *N. hyatti* transitional to *N. helicinum*, much like the specimen from Atlantic Highlands shown on plate 7, figures 4, 5.

Types. — Holotype USNM 77258; paratypes USNM 72259; hypotypes USNM 182469–182496, 182526.

Nostoceras cf. N. stantoni Hyatt

Plate 9, figures 23–31; text-figure 9

1894. *Nostoceras stantoni* Hyatt, Am. Philos. Soc. Proc., v. 32, no. 143, p. 570.

1941. *Nostoceras stantoni* Hyatt. Stephenson, Texas Univ. Bull. 4101, p. 407, pl. 80, figs. 1–5.

The spires of the cotypes of *Nostoceras stantoni* have higher whorls and smaller apical angles than the types of *N. helicinum* and *N. hyatti*. Rib density of these spires is comparable to that of the holotype of *N. hyatti* (fig. 5). The smaller of the cotype spires has about 48 ribs at a diameter of 27.4 mm, and the larger has 36 ribs at 9.7 mm, 42 ribs at 15.5 mm, and 50 ribs at 24.7 and 34 mm. One of the cotypes includes the body chamber, which is rather densely ribbed with six to eight ribs for the limb diameter. Tubercles on this body chamber and on both spires are very small.

Part of five spires in the Mendryk collection have the high whorls and comparable rib density of *N. stantoni*. One individual (pl. 9, figs. 26–28) consists of a complete whorl, but the others consist of half a whorl or less. The complete whorl has a rib count of 54 at a diameter of 36 mm. Tubercles are absent on four of these internal molds and barely discernible on the fifth. Densely ribbed body chambers like that of the cotype of *N. stantoni* are not present in the Mendryk collection of heteromorphs. Until such body chambers are discovered, it seems best not to definitely assign the five spire fragments to *N. stantoni*. The sutures of two of these specimens are shown in figure 9.

Nostoceras stantoni is known with certainty only from the Nacatoch Sand of northeastern Texas.

Types. — Cotypes USNM 23278a and b; figured specimens USNM 182503–182506.

Nostoceras pauper (Whitfield)

Plate 9, figures 1–22; text-figure 10

1892. *Turrilites pauper* Whitfield, New Jersey Geol. Survey Paleont. Ser., v. 2, p. 268, pl. 45, figs. 1–5; U.S. Geol. Survey Mon. 18, p. 268, pl. 45, figs. 1–5.

1907. *Turrilites pauper* Whitfield. Weller, New Jersey Geol. Survey Paleont. Ser., v. 4, p. 834, pl. 108, figs. 1–4.

1910. *Turrilites pauper* Whitfield. Grabau and Shimer, North American index fossils, v. 2, p. 211, figs. 1484, 1485.

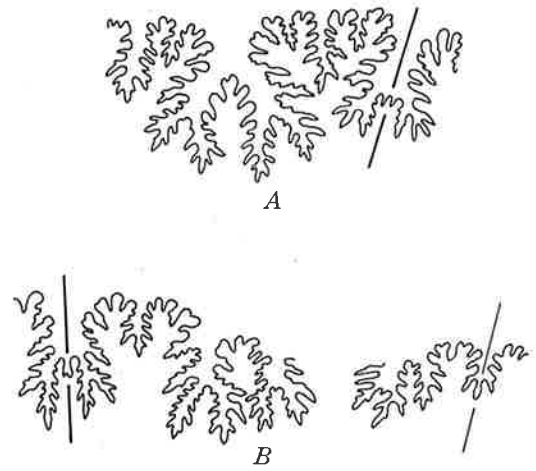

FIGURE 9. — Sutures × 2, of *Nostoceras* cf. *N. stantoni* Hyatt. Heavy line marks the middle of the external lobe; light line marks the middle of the internal lobe. *A*, External and lateral lobes of the specimen shown on plate 9, figures 29–31; USNM 182505. *B*, Most of the suture of a specimen; USNM 182506.

1921. *Didymoceras pauper* (Whitfield). Spath, South African Mus. Annals, v. 12, pt. 7, no. 16, p. 249, 251.

1925. *Turrilites pauper* Whitfield. Diener, Fossilium Catalogus, I, Animalia, Part 29, p. 84.

1962. *Nostoceras pauper* (Whitfield). Reeside, New Jersey Geol. Survey Bull. 61, pt. 2, p. 118, pl. 68, figs. 10–13.

The holotype, and only specimen previously illustrated, consists of one and one-third whorls of a high sinistral spire that may have had an apical angle of as little as 20°. The diameter of the spire at its larger end is 29 mm. A deeply impressed area is present on the upper surface of the whorls, and its contact with the outer side is abrupt and angular. The sides of the whorls are broadly rounded and bear two conspicuous constrictions on the last half whorl. About 44 ribs are present on the side of a whorl of 29 mm diameter. Ribs in the impressed area are strong, singular, and rursiradiate, whereas those on the rest of the whorl are prorsiradiate, singular to branched, and narrower than the interspaces. Ribbing is strongest at the outer margin of the impressed area. Two rows of small pointed bullate tubercles are present, one near the middle of the side and the other lower. Tubercles tend to form on alternate ribs, and those of one row form on different ribs than those of the other row. The specimen is partly septate, and its suture, figured by Whitfield (1892, pl. 45, fig. 5), is about as incised as that of either *Nostoceras helicinum* or *N. hyatti*.

A plaster cast of a worn spire of three complete whorls in the collections at the National Museum of Natural History is of considerable interest even though the whereabouts of the original specimen is unknown (pl. 9, fig. 11). It reveals that the final whorl of *N. pauper* bends down a little at a small angle to the spire so that the last part of the whorl is freed from the penultimate whorl, and the aperture may have been directed at almost a right angle to the spire.

The label for this cast merely states "Turrilites. Cretaceous. New Jersey."

Nine specimens in the Mendryk collection represent *N. pauper*. Six are sinistral and three are dextral. Five consist of less than a whorl, whereas the others consist of one and a fourth to three complete whorls. The specimen of three whorls (pl. 9, fig. 12) has a height of 38 mm, a diameter of 29 mm, and an apical angle of 30 degrees. Rib density is similar to the holotype; 40 ribs are present for a whorl at 18 mm diameter, and 44 ribs are present at 22 mm. Five deep constrictions occur on this spire of three complete whorls. Tubercles are sharp and bullate on the last quarter whorl and are flat-topped on the rest of the whorls. On most of the specimen two ribs rise from each tubercle of the upper row and cross the upper half of the side to the margin of the impressed area where the ribs become accentuated. An intercalated rib may occur between the pairs of ribs.

Tubercles and the constrictions and ribs in the impressed area are well developed on the two smallest specimens at hand which have diameters of 13 and 14 mm (pl. 9, figs. 1–6). On a slightly larger and more densely ribbed half whorl that has a diameter of about 18 mm, tubercles are absent (pl. 9, figs. 15, 16).

The two largest specimens have diameters of 38 and 39 mm. The smaller (pl. 9, figs. 19–22), which consists of one and a fourth nonseptate whorls, has 40 ribs and two constrictions per whorl and an apical angle of about 30–35°. Small slightly bullate pointed tubercles are present on alternate ribs on the older part and on nearly every rib on the younger part. Near the larger end of the specimen, the area between the rows of tubercles flattens and then becomes slightly depressed (pl. 9, fig. 19). The larger specimen (pl. 9, figs. 17, 18) is most unusual by having large tubercles which impart a depressed appearance to the somewhat flattened area between the rows of tubercles. The tubercles are slightly bullate and number 19 per whorl. Two ribs usually rise from each tubercle of the upper row, whereas usually one rib rises from a tubercle in the lower row. The specimen, which has an apical angle of about 42°, is septate at least to a whorl diameter of 38 mm.

Parts of sutures are visible on most specimens, but they are usually poorly preserved. The best suture is shown in figure 10.

Nostoceras pauper is known only from New Jersey. A closely related species has been found in slightly older rocks along the Chesapeake and Delaware Canal in Delaware and in the Mancos Shale (*Didymoceras stevensoni* zone) near Aspen, Colo. (Freeman, 1972, loc. D7028).

Types. — Holotype New Jersey State Mus. 7659; hypotypes USNM 182497–182502.

Nostoceras mendryki Cobban, n. sp.

Plate 10, figures 1–17; text-figure 11

Parts of three spires, two sinistral and one dextral, from Atlantic Highlands differ from other examples of *Nostoceras* by having more tubercles and by having them lower on the sides of the whorls. Aside from these three specimens, the species is represented by only six other specimens, from a locality near Holmdel, N.J.

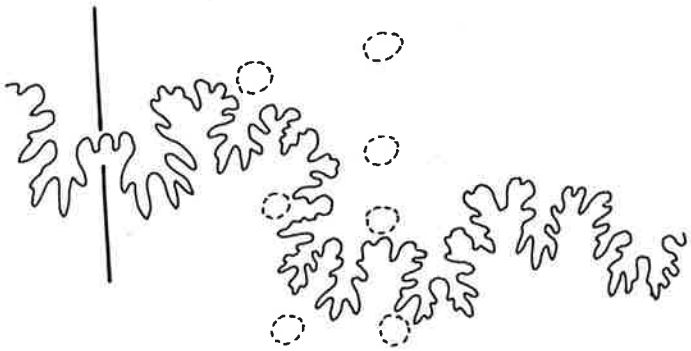

FIGURE 10. — Part of the suture, × 4, of *Nostoceras pauper* (Whitfield) (pl. 9, figs. 7–10). Heavy line marks the middle of the external lobe; dashed circles mark positions of ventral tubercles. Hypotype USNM 182499.

The holotype (pl. 10, figs. 6–8) is a septate dextral whorl 24 mm in diameter that has a moderately small umbilical opening and a well-defined impressed area. A single constriction is present; it is bounded by thin high ribs. Tubercles are flat topped and occur in equal numbers in two closely spaced rows. The upper row is located at the middle of the whorl where it attains its greatest diameter. The tubercles of a row are closely spaced, numbering about 33 per whorl. Each tubercle of the upper row gives rise to two ribs which slant backwards a little on crossing the upper half of the whorl. Some of these ribs may unite again at the margin of the impressed area, where all ribs become slightly accentuated. The ribs then cross the impressed area with a forward slant. Most tubercles of the lower row give rise to single ribs which cross the lower part of the whorl with a forward slant. The ribs weaken and disappear on the dorsum. Ribs per whorl number about 38 on the impressed area and on the lower part of the whorl, whereas they number about 50 on the upper half of the side. The suture is rather simple (fig. 11); lobes and saddles are broad, and their branches are short.

A smaller sinistral whorl of a spire (pl. 10, figs. 4, 5) is much like the holotype except that the ribs and tubercles are sharper. Ribs in the impressed area number about 30 per whorl.

The largest specimen from Atlantic Highlands consists of the older part of a body chamber (pl. 10, figs. 9–11) that is beginning to show its bend downward and away from the spire. Ribs are sharp and narrower than the interspaces except in the area between the rows of tubercles where the ribs are subdued and mostly flattened. Some pairs of tubercles are connected by double or looped ribs.

Specimens from the Holmdel area consist of a whorl or less of two sinistral and three dextral spires and most

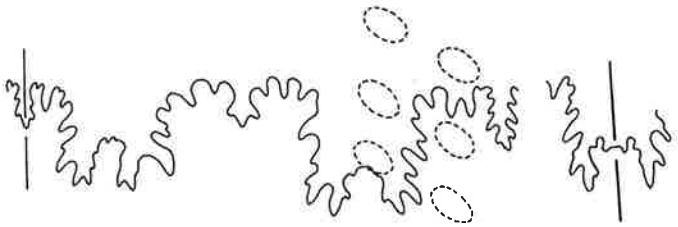

FIGURE 11. — Suture, × 5, of *Nostoceras mendryki* Cobban, n. sp., at a diameter of 19 mm (pl. 10, figs. 6–8). Heavy line marks the middle of the external lobe; light line marks the middle of the internal lobe; dashed circles mark positions of ventral tubercles. Holotype USNM 182507.

of a sinistral body chamber. The smallest specimen (pl. 10, figs. 1–3) shows sharply defined ribs and tubercles at a diameter of 11 mm. The largest specimen (pl. 10, figs. 15–17) is a body chamber lacking the apertural end. Its older end has an impressed area of the spire. The body chamber curved away from the spire at an acute angle, and its aperture may have been directed almost at right angles to the axis of the spire. Ribs are sharp, narrow, singular on the underside of the whorl, and singular to branched on the upper side. Tubercles are sharp and conspicuously bullate.

Nostoceras mendryki is closely related to *N. alternatum* (Tuomey) and *N. schloenbachi* (Favre). *N. alternatum,* originally described but not illustrated by Tuomey (1854, p. 168) as *Ammonites alternatus* from Mississippi, differs by having the tubercles much lower on the whorls. Tuomey's species is slightly younger than *N. mendryki* and occurs in the Ripley Formation of Mississippi, Alabama, and Georgia. *N. schloenbachi,* originally described from France as *Helicoceras schloenbachi* Favre (1869, p. 30, pl. 7, figs. 5*a*–*c*), differs by having lower whorls and a larger umbilical opening.

Types. — Holotype USNM 182507; paratypes USNM 182508–182512.

Genus AXONOCERAS Stephenson, 1941

Type species. — *Axonoceras compressum* Stephenson, 1941.

Stephenson (1941, p. 422) proposed this genus for "long slender shells coiled in one plane, with numerous closely spaced ribs and two rows of ventral nodes. * * *. The shells may be closely coiled, though not involute, but most of them are more or less loosely and irregularly coiled."

Haas (1943, p. 9), in the course of describing a new species of *Axonoceras,* noted that his species deviated a little from Stephenson's generic definition by having a very flat helicoid spire and by having tubercles only at a certain growth stage.

Axonoceras is further characterized by the small size of adult specimens and by the presence of constrictions. Some authors (Matsumoto, 1967, p. 340, 344; Lewy, 1969, p. 123) regard *Axonoceras* as a subjective synonym of *Exiteloceras* Hyatt (1894, p. 576). The genera are easily separated; *Exiteloceras* has much larger adult specimens that have considerably more complex sutures, and the early whorls, which are usually hamitid, lack constrictions.

Axonoceras has been recorded only from Texas (Stephenson, 1941, p. 422–425), Colorado (Izett and others, 1971, p. A7), and Angola (Haas, 1943, p. 7–10; Antunes and Sornay, 1969, p. 88). A helical whorl from Angola figured by Soares (1958, p. 19, pl. 5, figs. 2, 4) as *Axonoceras*? lacks tubercles, is much larger than any known *Axonoceras,* and represents some other genus.

Axonoceras cf A. angolanum Haas

Plate 10, figures 18–21

1943. *Axonoceras angolanum* Haas, Am. Mus. Novitates 1222, p. 8, text-figs. 3, 10–13.

This species is coiled in an extremely low flat spiral in which the limbs are in contact at first and later freed. The whorl section is subcircular with the width slightly exceeding the height; its dorsum is flattened. Ribs are rectiradiate at first and later rursiradiate; they are singular, narrow, sharp, and closely spaced (index of 4 or 5). Very small pointed tubercles are present on every rib on a small part of the shell and absent on the rest.

A single, uniformly curved nonseptate fragment 20 mm long in the Mendryk collection may be *Axonoceras angolanum.* The width of its subcircular whorl section slightly exceeds the height. Ribs are singular, rursiradiate, narrow, and sharp; they have an index of 4. The ribs are strongest at the ventrolateral margin and weakest on the flattened dorsum where they are arched forward. The height of the ribs decreases slightly on the middle part of the venter. Tubercles are absent.

Haas' specimens came from Angola. The specimen from Atlantic Highlands is unique in that no other examples are known from the Navesink Formation. Likewise, representatives of *Axonoceras* have not been found in the time-equivalent Nacatoch Sand of Texas nor in the Coon Creek Tongue of the Ripley Formation of Tennessee.

Type. — Figured specimen USNM 182513.

Genus EXITELOCERAS Hyatt, 1894

Type species. — *Ancyloceras jenneyi* Whitfield, 1877

The species on which this genus is based is loosely coiled in a plane. The early whorls vary from straight limbs connected by semicircular elbows to elliptical or nearly circular loops. Later whorls are elliptical to circular. Contact between whorls is unusual. The ovate whorl section has a broader dorsum than venter. Ribs are mostly rursiradiate, but they may be rectiradiate on parts of some whorls. The ribs may be straight or flexuous; most have indices of 4 to 6. Each rib usually rises into a conspicuous nodate tubercle at the ventrolateral shoulder. Opposite tubercles are generally connected by a single weak rib, but on a few specimens a pair of weak looped ribs connect the tubercles. The suture is deeply incised.

Exiteloceras oronense (Lewy)

Plate 10, figures 22–35; text-figure 12

1969. *Idiohamites? oronensis* Lewy, Israel Jour. Earth-Sci., v. 18, p. 127, pl. 3, figs. 10, 11.

This species differs from the genotype species by having more numerous ribs (indices of 9–12 at midflank) and by having fewer tubercles than ribs. Lewy's figured holotype and paratype are parts of loose elliptically coiled limbs that do not have the suture preserved.

Parts of three elliptically coiled septate limbs in the Mendryk collection seem assignable to *Exiteloceras oronense*. The largest specimen (pl. 10, figs. 29–32), 83 mm long, has a subquadrangular whorl section 37 mm high and 28 mm wide at the larger end. The dorsum is broader than the flattened venter, and the greatest width of the section is at the dorsolateral margin. Ribs are rectiradiate to rursiradiate, rather straight, narrower than the interspaces, and closely spaced (index of 9). About every two ribs rise into a flat-topped ventrolateral tubercle. Opposite tubercles are connected across the venter by a pair of broad weak ribs. The dorsum is smooth.

The other two specimens (pl. 10, figs. 22–28) have similar whorl heights of about 25.5 mm and cross sections in which the dorsum is broader than the venter. Ribbing is a little rursiradiate and, on one specimen, slightly flexuous. The rib index for these specimens is 8, which is a little lower than that of Lewy's two figured specimens. Tubercles are flat topped and rise from each pair of ribs on one specimen and from every third or fourth rib on the other. Sutures of these specimens are shown in figure 12.

An unusual specimen (pl. 10, figs. 33–35) in the Peabody Museum at Yale University has a blunt tubercle on each rib. The specimen is a septate fragment 45 mm long of an elliptically coiled limb. Its midflank rib index is 8.

Types. — Hypotypes USNM 182514–182516, Yale Peabody Mus. 68.

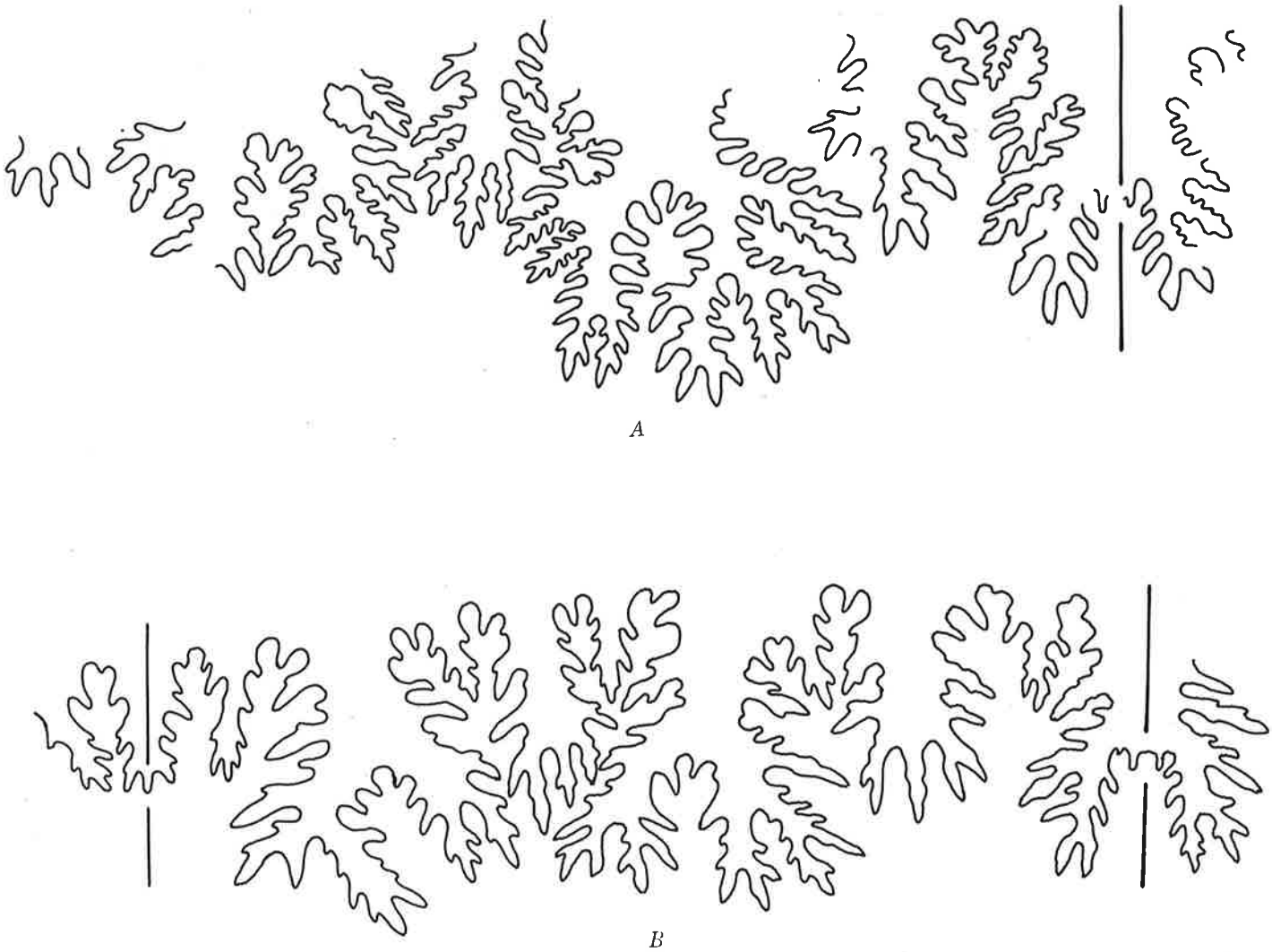

FIGURE 12. — Sutures, × 4, of *Exiteloceras oronense* (Lewy). Heavy line marks the middle of the external lobe; light line marks the middle of the internal lobe. *A*, Hypotype USNM 182514 (pl. 10, figs. 22–24). *B*, Hypotype USNM 182515 (pl. 10, figs. 25–28).

Genus DIDYMOCERAS Hyatt, 1894

Type species. — *Ancyloceras*? *nebrascensis* Meek and Hayden, 1856.

This genus and its type species have been treated recently (Cobban, 1970, p. D71–D72). A closely related form, *Cirroceras* Conrad (1868, p. 730), was based on a crushed helicoid whorl from Arneytown, N.J. The specimen is apparently lost, and plaster casts made of it before its disappearance are either poor or represent a very worn specimen. Howarth (1965, p. 372), Matsumoto (1967, p. 339), and Lewy (1969, p. 110) considered *Cirroceras* an unusable generic name; I am in agreement with them.

Didymoceras navarroense (Shumard)

Plate 11, figures 1–4; text-figure 13

1861. *Helicoceras navarroensis* Shumard, Boston Soc. Nat. Hist. Proc., v. 8, p. 190.
1926. *Helicoceras navarroense* Shumard. Wade, U.S. Geol. Survey Prof. Paper 137, p. 184, pl. 61, figs. 8–11; pl. 62, figs. 1, 2.
1928. *Helicoceras*? *navarroense* Shumard. Adkins, Texas Univ. Bull. 2838, p. 210.
1941. *Helicoceras navarroense* Shumard. Stephenson, Texas Univ. Bull. 4101, p. 417, pl. 83, figs. 9–13.
1959. *Didymoceras* sp. ind. Sornay, in Arambourg and others, Mus. Natl. Histoire Nat. [Paris], Notes et Mém. sur le Moyen-Orient, v. 7, p. 222, pl. 7, figs. 3*a*, *b*.
1965. *Didymoceras navarroense* (Shumard). Howarth, British Mus. (Nat. History) Bull., Geology, v. 10, no. 10, p. 373.
1969. *Didymoceras* cf. *navarroense* (Shumard). Lewy, Israel Jour. Earth-Sci., v. 18, p. 115, pl. 1, fig. 1.

Fragments of two septate sinistral whorls in the Mendryk collection are referred to *Didymoceras navarroense* (Shumard). Each consists of about a quarter of a whorl of a large specimen. Ribs are rounded, narrower than the interspaces, and longest on the upper side of the whorl, where they are rursiradiate. Each pair of ribs on the upper side merge into a strong rounded ventrolateral tubercle. Opposite tubercles are connected across the somewhat flattened venter by a pair of very weak ribs. Ribs tend to be singular on the lower side of the whorl. The suture is complex (fig. 13).

Didymoceras navarroense has not been recorded previously from New Jersey. In the United States the species occurs in Tennessee, Arkansas, Texas, and Colorado. The Tennessee occurrences are in the Coon Creek Tongue of the Ripley Formation where *D. navarroense* is associated with *Baculites undatus* Stephenson, *Nostoceras hyatti* Stephenson, *N. helicinum* (Shumard), *Solenoceras texanum* (Shumard), and *S. reesidei* Stephenson. Arkansas occurrences are in the Saratoga Chalk. In northeastern Texas *D. navarroense* occurs in the Neylandville Marl and overlying Nacatoch Sand. The Colorado occurrences are in the Pierre Shale near Kremmling (Range Zone of *Baculites cuneatus* Cobban) and Fort Collins (Range Zone of *Baculites reesidei* Elias). Outside the United States, *D. navarroense* has been recorded from Israel (Lewy, 1969, p. 115) and Colombia (Petters, 1955, p. 216, 224).

Types. — Hypotypes USNM 182517, 182527.

Family SCAPHITIDAE Meek, 1876

Genus HOPLOSCAPHITES Nowak, 1911

Type species. — *Ammonites constrictus* J. Sowerby, 1817.

Wright (in Arkell, Kummel, and Wright, 1957, p. L229) defined *Hoploscaphites* in a broad sense as follows: "Compressed and flat-sided to inflated with convex sides; venter flat or rounded, bordered with strong ventrolateral clavi, at least on shaft and hook; shaft normally short." To this definition, I would add that tubercles may be sparse or absent on some specimens. *Hoploscaphites* has been considered as a subgenus of *Scaphites* Parkinson (for example, Birkelund, 1965, p. 102; Cobban and Jeletzky, 1965, p. 794).

Hoploscaphites pumilus (Stephenson)

Plate 11, figures 9–12

1941. *Scaphites pumilus* Stephenson, Texas Univ. Bull. 4101, p. 426, pl. 90, figs. 10–12.

Stephenson based his species on a single adult 31 mm long from the Nacatoch Sand near Chatfield, Tex. (USGS Mesozoic loc. 762). The body chamber of the holotype has a squarish trapezoidal cross section in which the greatest width occurs at the umbilical shoulders; its venter is very broadly rounded, and the ventrolateral and umbilical shoulders are sharply defined. On the older or straighter part of the body chamber the flanks are flat, but on the younger or curved part, they are pinched in a little. The phragmocone has a well-defined umbilicus whose ratio is 14 percent. Flanks and venter on the older half of the outer septate whorl are well rounded, but on the younger half, they gradually flatten as they merge with the body chamber. Ribs are strong and rectiradiate on the phragmocone, where they are divisible into primaries and secondaries. Each primary rises into a small nodate tubercle at the middle of the flank; the tubercles disappear near the end of the phragmocone. The body chamber is smooth except for low, widely spaced inconspicuous ventral ribs, a conspicuous row of closely spaced clavate ventrolateral tubercles, and a row of nodate umbilical tubercles. Both rows probably extended to the oral end, although the aperture has been broken off the specimen. The row of lateral tubercles on the phragmocone disappears near the area where the ventrolateral tubercles of the body chamber begin, but the two rows are offset and do not represent continuations of a single row — a feature observed also by Stephenson (1941, p. 427).

Hoploscaphites pumilus is extremely scarce — only one other specimen is at hand from the Nacatoch Sand of Texas. This specimen, an adult 41 mm long, differs from the holotype by having a smaller umbilicus that is partly covered by an umbilical swelling and by having broader flanks. The specimen can be readily interpreted as a female, whereas the smaller holotype can be interpreted as a male (Cobban, 1969, p. 8–10). On the younger part of the larger (female) specimen, closely spaced lateral ribs are present

FIGURE 13. — Most of the suture, × 3, of *Didymoceras navarroense* (Shumard) at a whorl diameter of 30.5 mm (pl. 11, figs. 3, 4). Line marks the middle of the external lobe. Hypotype USNM 182527.

which are strongest a little out from the middle of the flank and tend to disappear before reaching the row of ventrolateral tubercles.

Three specimens from Atlantic Highlands seem best assigned to *Scaphites pumilus*. One is a large complete body chamber of a female, whereas the other two are small body chambers of males. The female (pl. 11, figs. 11, 12), 50 mm in diameter, has a maximum thickness of 20.7 mm at the umbilical shoulder at the end of the straight part. Flanks are broad and flat, the venter is well rounded, and the ventrolateral shoulder is sharply defined. An umbilical swelling imparts a convex outline to the umbilical wall on the straight part of the body chamber. The aperture is complete with constricted mouth border and dorsal lappet. Umbilical and ventrolateral rows of tubercles are conspicuous and persist completely around the body chamber. Umbilical tubercles are nodate to bullate, equal sized, and six in number; they are located on the umbilical shoulder on the curved part, but due to the umbilical swelling, the tubercles move out onto the flank on the straight part. The ventrolateral row consists of 17 nodate to clavate tubercles of nearly the same size and spacing. On the straight part of the body chamber, a low broad rib extends from each ventrolateral tubercle down onto the outer part of the flank, where it weakens and disappears. Likewise, a broad weak rib extends onto the lower part of the flank from each umbilical tubercle. Closely spaced narrow straight ribs occur on the flanks of the curved part of the body chamber; they are strongest on the outer part of the flank and tend to disappear before reaching the row of ventrolateral tubercles. Ventral ribs are conspicuous and evenly spaced on the older half of the body chamber and near the aperture; they are weak on the rest of the venter. Most ribs are rather straight, but those near the aperture are arched slightly forward. On most of the venter, pairs of ribs occur on elevated areas that are separated by low areas containing one or two ribs. Part of the last chamber is attached and reveals the ventral half of the last suture. This suture is poorly preserved but shows a rather simple pattern in which the lateral saddle is asymmetrically bifid and about twice as wide as the lateral lobe.

Both males from Atlantic Highlands are incomplete body chambers. The best specimen consists of the last three-fourths of a body chamber about 34 mm diameter (pl. 11, figs. 9, 10). The flanks are flat, and the venter is broadly rounded. Nodate umbilical tubercles seem to persist to the constricted mouth border, but the clavate ventrolateral ones disappear about 15 mm back from the aperture. Distinct, closely spaced lateral ribs occur on the younger part of the body chamber, whereas a few broad indistinct lateral ribs occur on the older part. Evenly spaced ribs cross the venter, and those near the aperture are arched forward slightly. The venter on the older part is undulated conspicuously so that three or four ribs lie on each elevation and an equal number occupy each intervening low area.

The undulations on the venter recall sparse specimens of *Hoploscaphites constrictus* (J. Sowerby) (Binckhorst, 1873, pl. V*d*, fig. *f*; Mikhailov, 1951, pl. 17, figs. 79, 80; Luppov and Drushchits, 1958, pl. 62, figs. 3*a*, *b*), *H.? pungens* (Binckhorst, 1873, pl. V*a*3, figs. 1*a*–*d*; de Grossouvre, 1908, pl. 11, figs. 2*a*, *b*), *H.? gibbus* (Schlüter, 1872, pl. 26, figs. 6–9), *Acanthoscaphites? tridens* (Kner) var. *quadrispinosa*

(Geinitz) (Mikhailov, 1951, pl. 19, fig. 93), and *Scaphites hippocrepis* (DeKay) (Cobban, 1969, pl. 5, figs. 19–23).

Types. — Hypotypes USNM 182520, 182521.

Hoploscaphites sp.

Plate 11, figures 13–19; text-figure 14

Parts of five septate coils and a fragment of a body chamber are referred to *Hoploscaphites* sp. The septate coils show a great range in stoutness from specimens that have whorls that are higher than wide to those that have whorls that are as wide as high (pl. 11, figs. 13, 14) or wider than high (pl. 11, figs. 15–18). Flanks are flattened to broadly convex, and the venter is well rounded. All specimens have conspicuous ribs and umbilical and ventrolateral tubercles. Tubercles are small, pointed, and somewhat bullate on the septate coils and slightly clavate on the body chamber. The suture (fig. 14) is moderately complex and similar to the examples presented by Meek (1876, pl. 25, figs. 1*c*, 2*c*, 3*c*).

The slender to moderately stout septate whorls are similar to those of *H. nodosus* (Owen, 1852, p. 581, pl. 8, figs. 4, 4*a*) from the western interior region and its equivalent *H. rugosus* (Stephenson, 1941, p. 425, pl. 89, figs. 15–18) from the gulf coastal region. One individual (pl. 11, figs. 13, 14), however, has more closely spaced tubercles than those on any specimens at hand from those regions. Ammonites identified as *Scaphites nodosus* have been listed from rocks recorded as the Navesink Formation (Miller, 1956, p. 734; Dorf and Fox, 1957, p. 5).

Two septate coils (pl. 11, figs. 15–18) are larger and have more depressed sections than any scaphites of comparable age in the United States. A piece of a huge body chamber (pl. 11, fig. 19) is probably from this type of scaphite.

Types. — Figured specimens USNM 182522–182525.

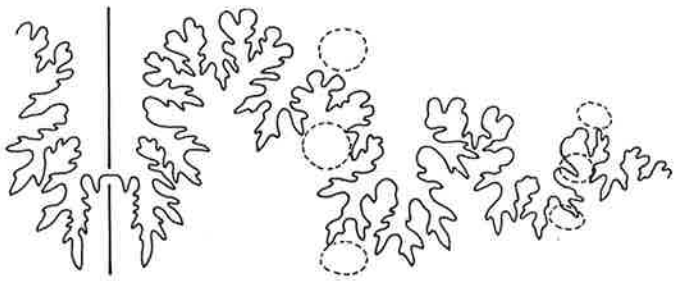

FIGURE 14. — External suture, × 2, of a very stout specimen of *Hoploscaphites* sp. (pl. 11, figs. 15, 16). Line marks the middle of the external lobe; dashed circles mark positions of ventrolateral tubercles. USNM 182523.

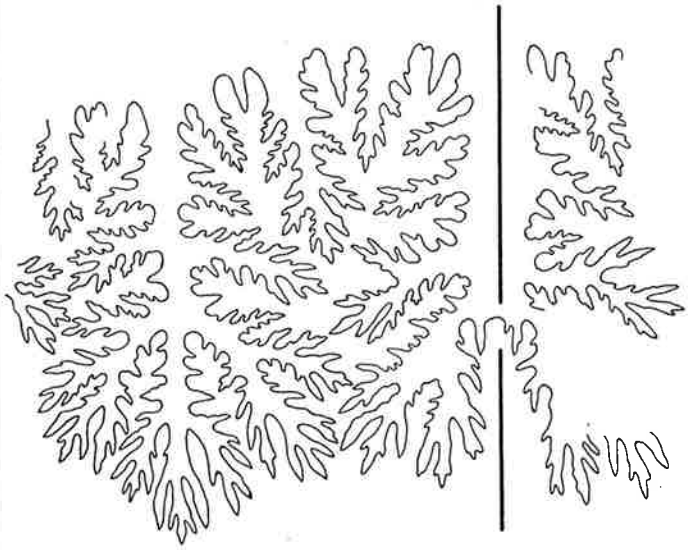

FIGURE 15. — Part of the external suture, × 3, of *Pachydiscus* sp. (pl. 11, figs. 7, 8). Line marks the middle of the external lobe. USNM 182519.

Family PACHYDISCIDAE Spath, 1922

Genus PACHYDISCUS Zittel, 1884

Type species. — *Ammonites neubergicus* von Hauer, 1858.

Fragments of two septate whorls are all that represent the family Pachydiscidae in the Mendryk collection. Pachydiscids are present sparingly in the Wenonah Formation of New Jersey and in the Marshalltown Formation of Delaware.

Pachydiscus sp.

Plate 11, figures 5–8; text-figure 15

The two fragments from Atlantic Highlands are parts of septate whorls. The larger one (pl. 11, figs. 7, 8) is a piece of the ventral part of a whorl whose cross section suggests a slightly compressed pachydiscid. Ribs are closely spaced, accentuated on the venter, and interrupted by a narrow depression along the siphuncle. Enough of the flank is preserved to indicate that ribbing is differentiated as umbilical and ventrolateral. Most of the ventral lobe, lateral lobe, and first lateral saddle are well exposed and highly incised (fig. 15). The smaller specimen (pl. 11, figs. 5, 6) consists of less than half a whorl of a poorly preserved specimen that may have had smooth flanks and venter. Four bullate umbilical tubercles are visible; they probably numbered about six per half whorl. The suture is too poorly preserved to illustrate.

Casts of these specimens were examined by Dr. Andrzej Błaszkiewicz, Institute of Geology, Warsaw, Poland, who believed that they showed the most similarity to *Pachydiscus neubergicus* von Hauer (1858, p. 12, pl. 2, figs. 1–3; not pl. 3, figs. 1, 2) of early Maestrichtian age (written commun., Aug. 1972).

Types. — Figured specimens USNM 182518, 182519.

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Parapachydiscus (Pachydiscus) arkansanus ---- 9
pauper, Didymoceras ---- 12
  Nostoceras ---- 1, 2, *12*; pl. 9
  Turrilites ---- 1, 12
prematurum, Nostoceras ---- 8, 10
pumilus, Hoploscaphites ---- 2, *16*; pl. 11
  Scaphites ---- 9, 16, 17

Q, R

quadrispinosa, Acanthoscaphites tridens ---- 18

reesidei, Solenoceras ---- 10
retrorsum, Nostoceras ---- 8
rugosus, Hoploscaphites ---- 18
  Scaphites ---- 9

S

saundersorum, Turrilites ---- 8
Scaphites ---- 16
  hippocrepis ---- 18
  nodosus ---- 18
  pumilus ---- 9, 16, 17
  rugosus ---- 9
Scaphitidae ---- *16*
schloenbachi, Helicoceras ---- 14
  Nostoceras ---- 3, 14
Sphenodiscus ---- 2
Solenoceras multicostatum ---- 9
  reesidei ---- 10, 16
  texanum ---- 9, 10, 16
splendidus, Turrilites ---- 8
  Turrilites (Nostoceras) ---- 9
stantoni, Nostoceras ---- 2, 8, 9, 10, *12*; pl. 9

T

texanum, Solenoceras ---- 9, 10
tridens quadrispinosa, Acanthoscaphites ---- 18
Turrilites helicinus ---- 8
  pauper ---- 1, 12
  peruvianus ---- 8
  saundersorum ---- 8
  splendidus ---- 8
  (Nostoceras) splendidus ---- 9

U, V

undatus, Baculites ---- 5, 9, 10, 11, 16

vancouverensis, Hamites ---- 11
vertebralis, Baculites ---- 3
vistulae, Nostoceras ---- 3

PLATES 1–11

[Contact photographs of the plates in this report are available, at cost, from the U.S. Geological Survey Photographic Library, Federal Center, Denver, Colorado 80225]

PLATE 1

[All figures natural size]

FIGURES 1–32. *Baculites ovatus* Say (p. 3).

From the basal part of the Navesink Formation at Atlantic Highlands, N.J.

1–3. Ventral, lateral, and end views of part of a juvenile body chamber showing curvature. Hypotype USNM 182443.

4–7. End, dorsal, lateral, and ventral views of a smooth septate juvenile. Hypotype USNM 182444.

8–11. Ventral, lateral, dorsal, and end views of a septate fragment of a juvenile that has unusually strong ribbing. Hypotype USNM 182445.

12–14. End, lateral, and ventral views of a smooth septate fragment showing considerable taper. Hypotype USNM 182446.

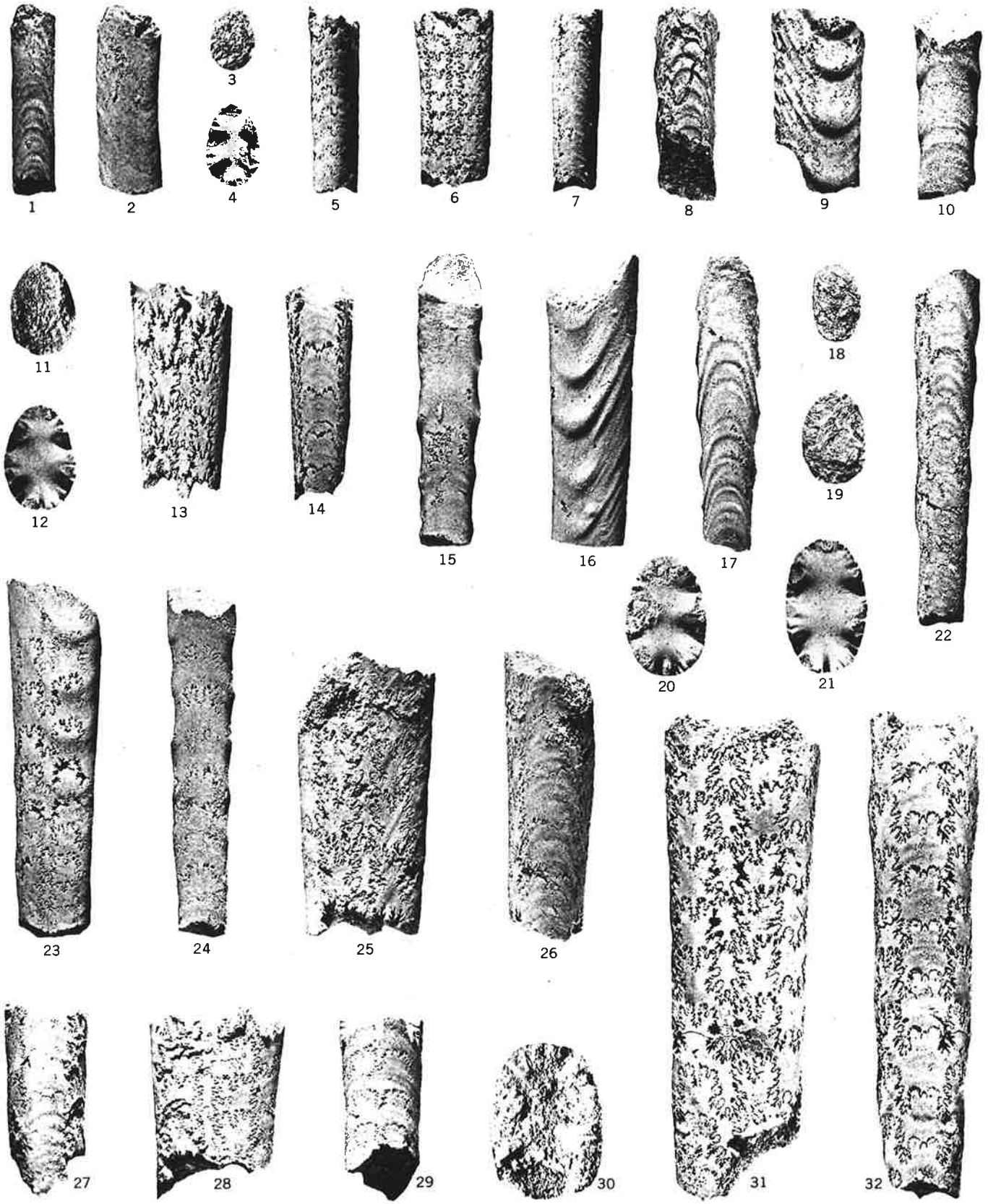
15–18. Dorsal, lateral, ventral, and end views of most of a small body chamber that has unusually strong ribbing. Hypotype USNM 182447.

19, 22–24. End, ventral, lateral, and dorsal views of a young septate specimen showing rise of ribbing. Hypotype USNM 182448.

20, 25, 26. End, lateral, and ventral views of a septate specimen that has a suture characterized by a narrowing at the base of the terminal branches of the lateral lobe. See text-figure 4*B*, for the suture. Hypotype USNM 182449.

21, 27–29. End, ventral, lateral, and dorsal views of a septate fragment that has a slender cross section, smooth flanks, and weak ventral ribs. Hypotype USNM 182450.

30–32. End, lateral, and ventral views of a septate specimen that has unusually wide spaced low flank swellings. Hypotype USNM 182451.



BACULITES OVATUS

PLATE 2

[All figures natural size]

FIGURES 1–14. *Baculites ovatus* Say (p. 3).

From the basal part of the Navesink Formation at Atlantic Highlands, N.J.

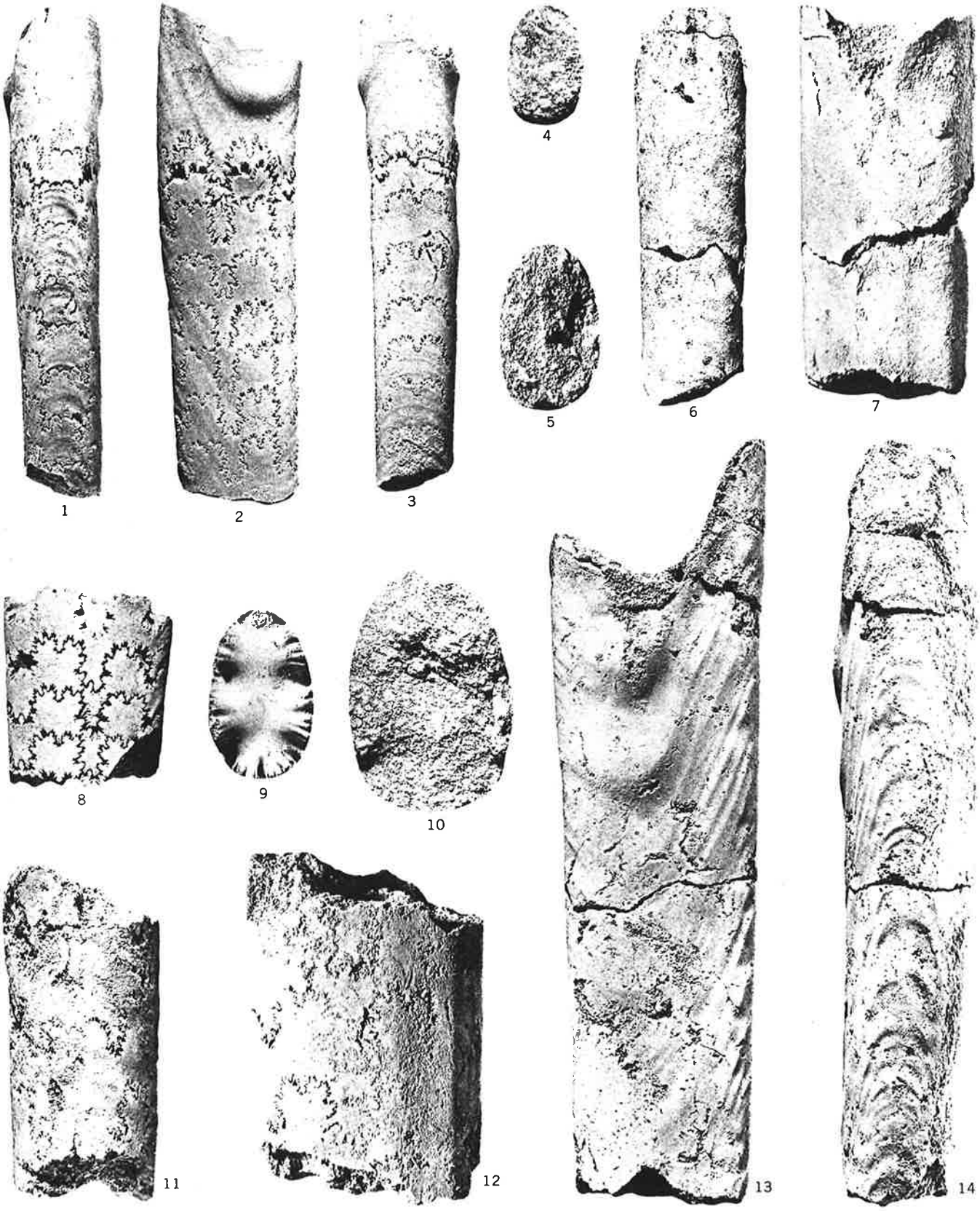
1–4. Ventral, lateral, dorsal, and end views of a young adult showing a rather abrupt rise in the flank ribbing. Hypotype USNM 182452.

5–7. End, ventral, and lateral views of part of an adult body chamber that has a dorsolateral depression like that of *B. clinolobatus* Elias. Hypotype USNM 182453.

8, 9. Lateral and end views of a septate fragment typical of the species. Hypotype USNM 182454.

10–12. End, ventral, and lateral views of a septate fragment of an adult that has a dorsolateral depression similar to that of the specimen shown in figures 5–7. Hypotype USNM 182455.

13, 14. Lateral and ventral views of most of an adult body chamber showing the shape of the aperture. Hypotype USNM 182456.



BACULITES OVATUS

PLATE 3

[All figures natural size]

FIGURES 1–6, 9–11. *Baculites ovatus* Say (p. 3).

From the basal part of the Navesink Formation at Atlantic Highlands, N.J.

1–3. Ventral, lateral, and dorsal views of a juvenile showing curvature. Hypotype USNM 182457.

4, 5. Lateral and end views of a septate fragment showing a suture that has a lateral lobe similar to that of *B. scotti* Cobban. See text-figure 4*C* for the suture. Hypotype USNM 182458.

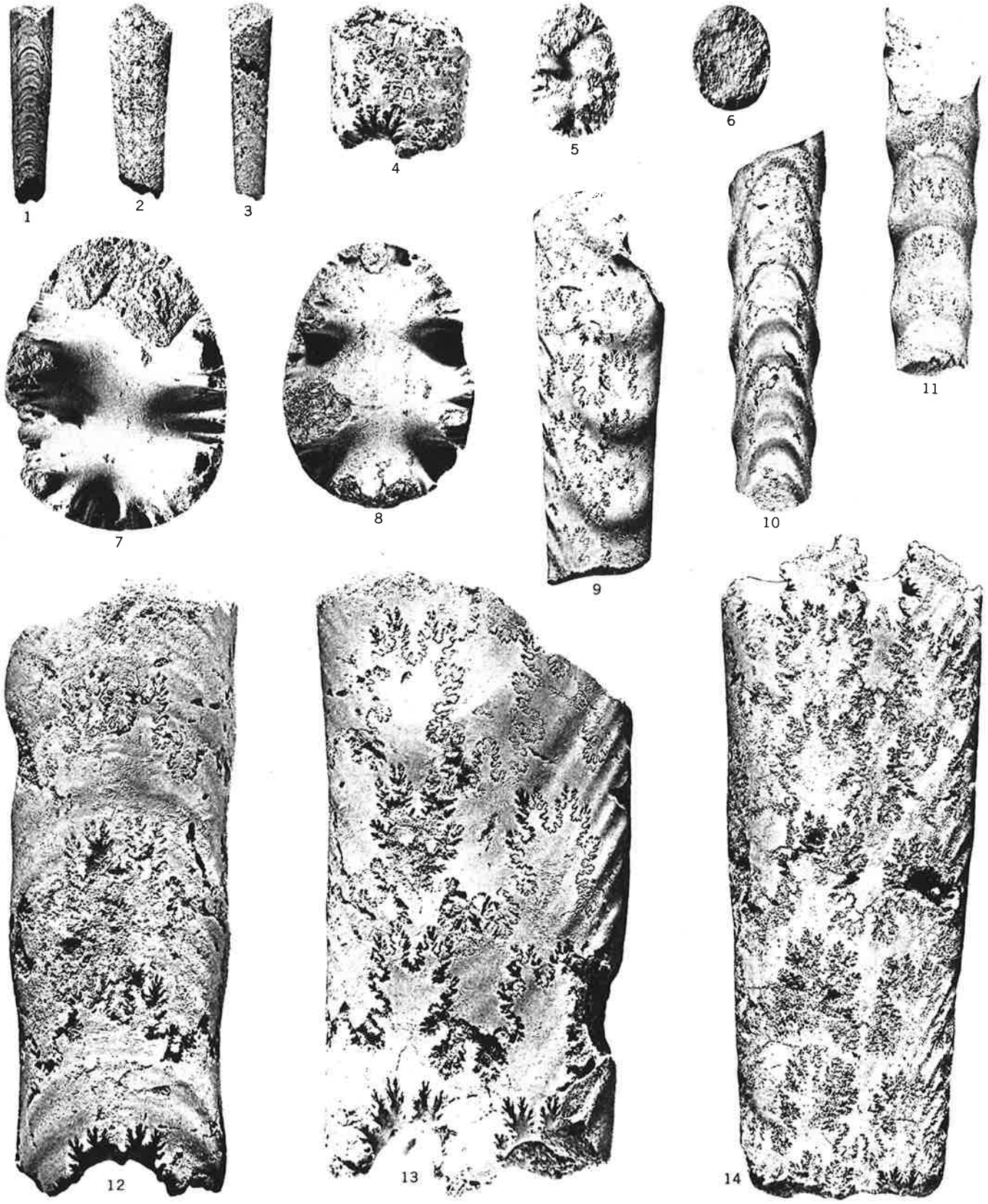
6, 9–11. End, lateral, ventral, and dorsal views of an unusually strong ribbed young adult. Private collection of Harold Mendryk and Christopher Laskowich.

7, 8, 12–14. *Baculites claviformis* Stephenson (p. 5).

From the basal part of the Navesink Formation at Atlantic Highlands, N.J.

7, 12, 13, End, dorsal, and lateral views of a large septate fragment. Hypotype USNM 182460.

8, 14, End and lateral views of a smaller septate specimen. Hypotype USNM 182461.



BACULITES OVATUS AND *BACULITES CLAVIFORMIS*

PLATE 4

[All figures natural size]

FIGURES 1–21. *Nostoceras helicinum* (Shumard) (p. 8).

From the basal part of the Navesink Formation at Atlantic Highlands, N.J. Arrows indicate the base of body chambers.

1–4. Four views of a small nearly complete adult. Hypotype USNM 182462.

5–7. Three views of a nearly complete body chamber that has a constriction bordered by high ribs near the aperture. Hypotype USNM 182463.

8–10. Part of a small adult showing alternate arrangement of tubercles on the older part of the body chamber. Hypotype USNM 182466.

11. Last part of the septate spire of a specimen and basal part of the body chamber. Hypotype USNM 182464.

12–14. Three views of the last part of a very large septate whorl showing the impressed area. See text-figure 6 for the suture. Hypotype USNM 182465.

15–17. Part of the living chamber of a small specimen showing tubercles connected by looped ribs as well as alternate ribs. Hypotype USNM 182467.

18–21. Four views of a nearly complete body chamber. Hypotype USNM 182468.

NOSTOCERAS HELICINUM

PLATE 5

[All figures natural size]

FIGURES 1–21. *Nostoceras hyatti* Stephenson (p. 10).

From the basal part of the Navesink Formation at Atlantic Highlands, N.J. Arrows indicate the base of body chambers.

1, 2. Part of the smallest body chamber in the Mendryk collection. Hypotype USNM 182469.

3–5. Part of another small adult that had a short body chamber. Hypotype USNM 182470.

6, 7. Most of a sparsely ribbed body chamber. Hypotype USNM 182471.

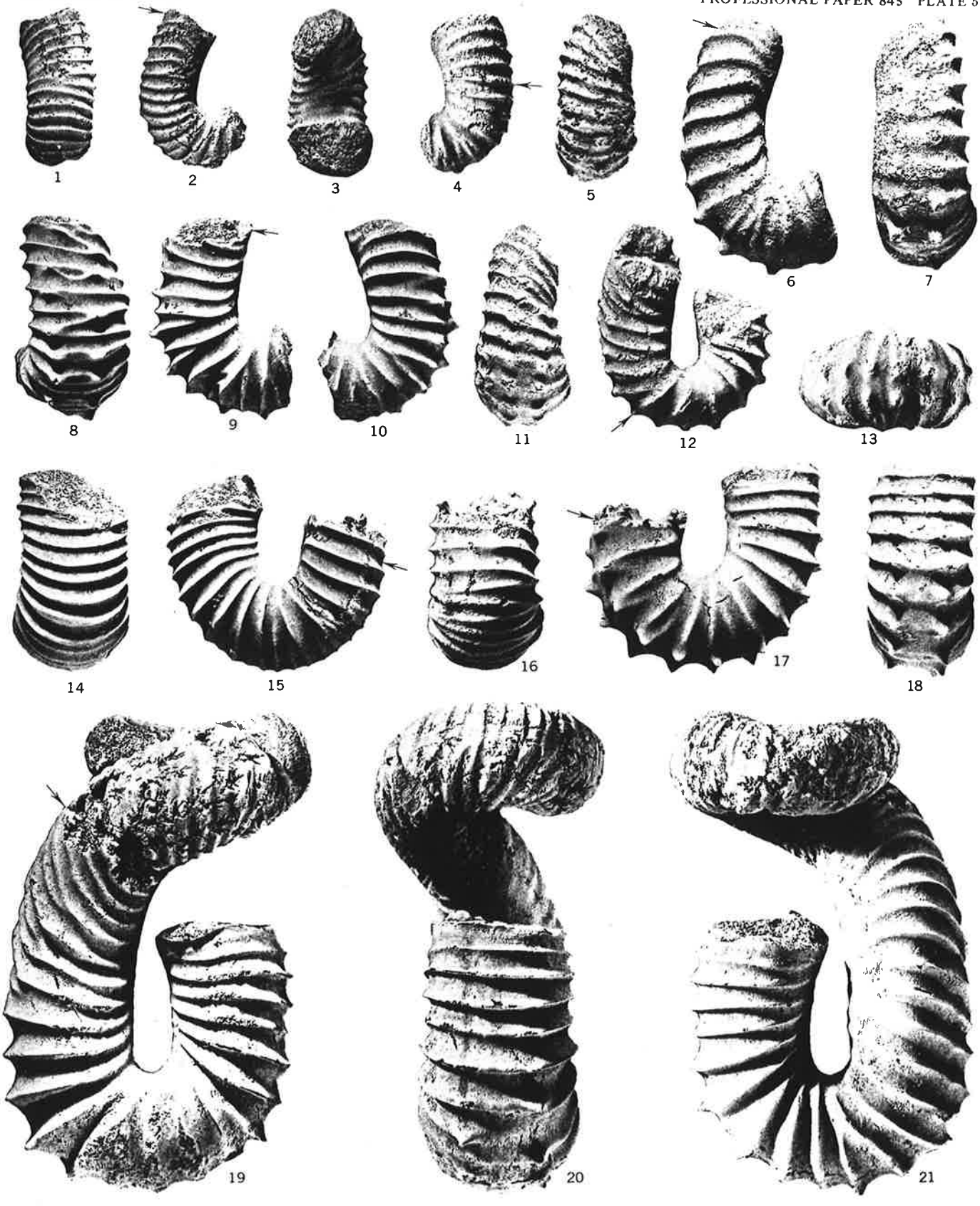
8–10. Part of a body chamber that has sharp ribs and tubercles. Hypotype USNM 182472.

11–13. Three views of a small adult that had an unusually short body chamber. Private collection of John Brzostoski.

14–16. Body chamber of a sharp-ribbed adult that never developed tubercles. Hypotype USNM 182473.

17, 18. Nearly complete body chamber of an adult of average size. Hypotype USNM 182474.

19–21. Three views of a body chamber and the adjoining complete septate whorl. Hypotype USNM 182475.



NOSTOCERAS HYATTI

PLATE 6

[All figures natural size]

FIGURES 1–12. *Nostoceras hyatti* Stephenson (p. 10).

From the basal part of the Navesink Formation at Atlantic Highlands, N.J. Arrows indicate base of body chambers.

1–4. Four views of the hook of a moderately large specimen. Hypotype USNM 182476.

5–8. Complete body chamber and part of the adjoining septate whorl of a specimen showing a conspicuous constriction. Hypotype USNM 182477.

9–11. Three views of a body chamber and some of the adjoining septate part of a large adult. Hypotype USNM 182478.

12. Older part of an unusually lengthy body chamber. Hypotype USNM 182526.

NOSTOCERAS HYATTI

PLATE 7

[All figures natural size]

FIGURES 1–10. *Nostoceras hyatti* Stephenson (p. 10).

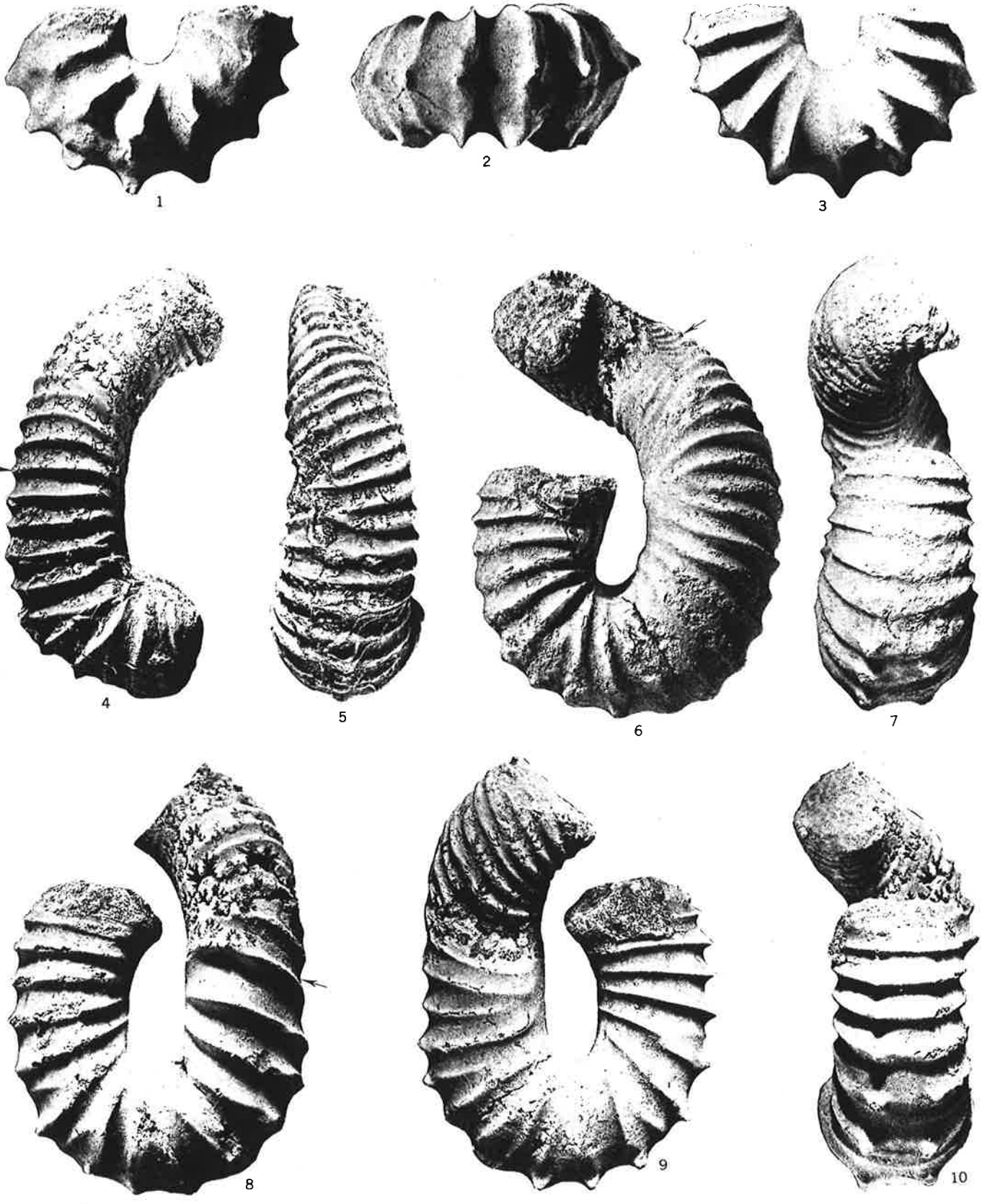
From the basal part of the Navesink Formation at Atlantic Highlands, N.J. Arrows indicate base of body chambers.

1–3. Three views of part of a very sparsely ribbed body chamber. Hypotype USNM 182479.

4, 5. Lateral and ventral views of a specimen with more than average rib number. See text-figure 8 for the suture. Hypotype USNM 182480.

6, 7. Views of a large adult with an unusually long body chamber extending into the impressed area. Hypotype USNM 182481.

8–10. Three views of a sparsely ribbed large adult that has a body chamber of average length. Hypotype USNM 182482.



NOSTOCERAS HYATTI

PLATE 8

[All figures natural size]

FIGURES 1–30. *Nostoceras hyatti* Stephenson (p. 10).

From the basal part of the Navesink Formation at Atlantic Highlands, N.J.

1, 2. Top and lateral views of part of a whorl showing the impressed area and change in tubercles from flat to pointed. Hypotype USNM 182483.

3–5. Lateral, top, and bottom views of a larger whorl that has flat tubercles and two constrictions. Hypotype USNM 182484.

6, 7. Lateral and top views of the smallest spire in the Mendryk collection. Several constrictions are visible. Hypotype USNM 182485.

8, 9. Lateral and bottom views of part of a whorl showing widely spaced sutures. Hypotype USNM 182486.

10, 11. Lateral and top views of part of a spire. Arrow points to change from round ribs and flat tubercles to sharp ribs and pointed tubercles. Hypotype USNM 182487.

12. Lateral view of two whorls showing the abrupt rise of pointed tubercles in the middle of the larger whorl. Hypotype USNM 182488.

13. 14. Top and laateral views of a complete whorl that has flat tubercles and round ribs. Hypotype USNM 182489.

15, 16. Top and lateral views of another whorl that has blunt ribs and tubercles. Hypotype USNM 182490.

17–19. Three views of two whorls. Arrow points to change from blunt ribs and tubercles to sharp ribs and tubercles. Hypotype USNM 182491.

20, 21. Top and lateral views of a large whorl that has blunt ribs and tubercles and wide constrictions. Hypotype USNM 182492.

22, 23. Bottom and lateral views of part of a large spire that has blunt ribs and tubercles. Hypotype USNM 182493.

24, 25. Top and lateral views of parts of two sparsely ribbed whorls that have flat-topped tubercles. Hypotype USNM 182494.

26, 27. Top and lateral views of part of a large whorl that has flat-topped ribs. Hypotype USNM 182495.

28–30. Two lateral views and a top view of a specimen consisting of part of the spire and part of the uncoiled whorl. Arrow points to the change from blunt ribs and tubercles to sharp ribs and pointed tubercles. Hypotype USNM 182496.

NOSTOCERAS HYATTI

PLATE 10

[All figures natural size]

FIGURES 1–17. *Nostoceras mendryki* Cobban, n. sp. (p. 13).

1–3. Top, lateral, and bottom views of the smallest specimen at hand. Navesink Formation near Ramanessin Brook 1½ miles northeast of Holmdel, Monmouth County, N.J. Paratype USNM 182509.

4, 5. Top and lateral views of a small whorl that has sharp tubercles. Basal part of the Navesink Formation at Atlantic Highlands. Paratype USNM 182508.

6–8. Lateral, bottom, and top views of the holotype from Atlantic Highlands. See text-figure 11 for the suture. USNM 182507.

9–11. Bottom, lateral, and top views of part of a whorl from Atlantic Highlands just beginning to show its retroversal coiling. A little of the impressed area is visible in figure 11. Paratype USNM 182510.

12–14. Top, bottom, and lateral views of part of a whorl from Atlantic Highlands that has sharp ribs and pointed tubercles. Paratype USNM 182511.

15–17. Lateral, bottom, and top views of most of a body chamber from the Navesink Formation near Ramanessin Brook 1½ miles northeast of Holmdel, N.J. Paratype USNM 182512.

18–21. *Axonoceras* cf. *A. angolanum* Haas (p. 14).

Four views of a nonseptate fragment from the basal part of the Navesink Formation at Atlantic Highlands, N.J. Figured specimen USNM 182513.

22–35. *Exiteloceras oronense* (Lewy) (p. 15).

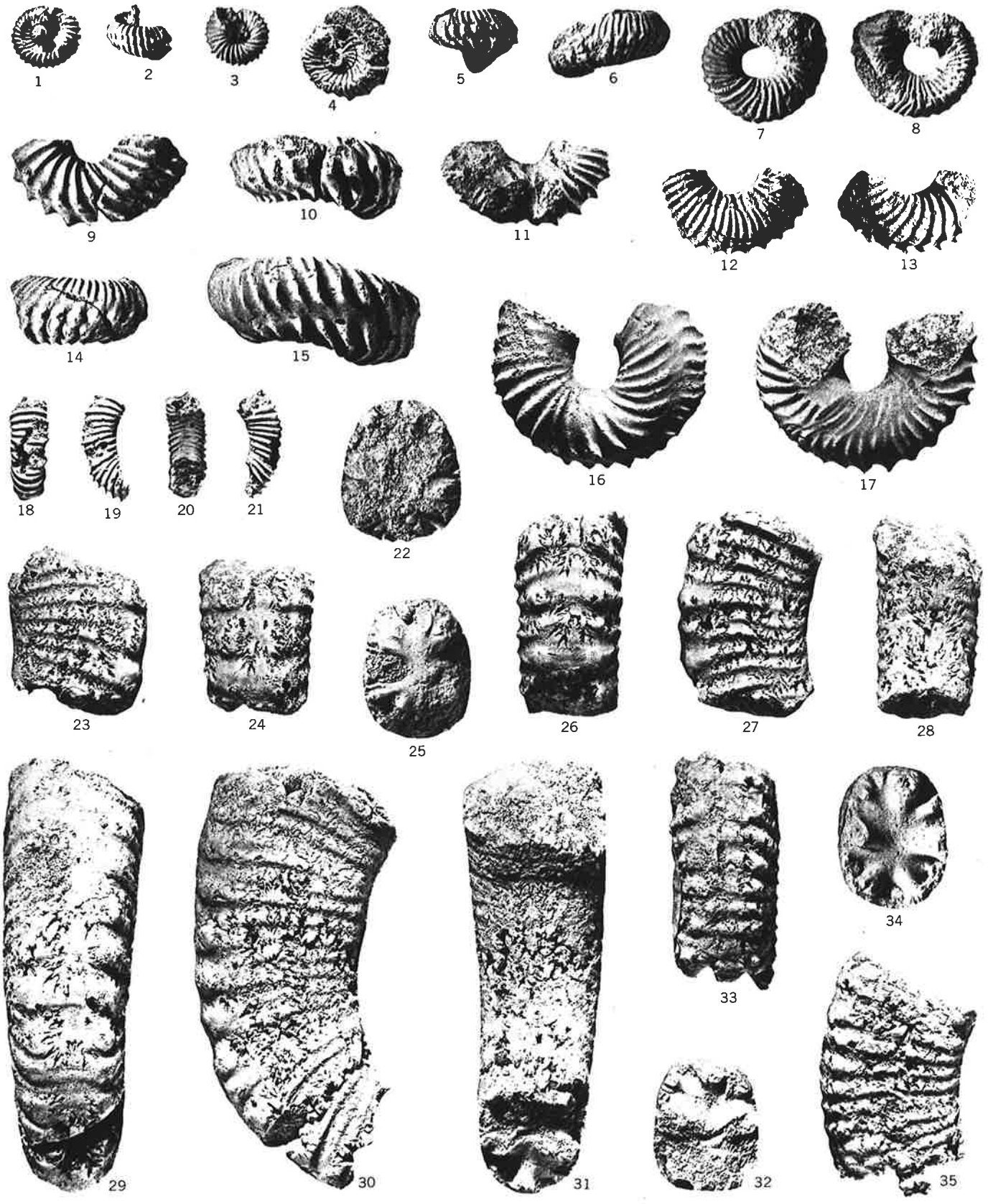
From the basal part of the Navesink Formation at Atlantic Highlands, N.J.

22–24. Lateral, side, and ventral views of a septate fragment. See text-figure 12*A* for the suture. Hypotype USNM 182514.

25–28. End, ventral, lateral, and dorsal views of a larger septate fragment. See text-figure 12*B* for the suture. Hypotype USNM 182515.

29–32. Ventral, lateral, dorsal, and end views of the largest specimen at hand. Hypotype USNM 182516.

33–35. Ventral, end, and lateral views of a septate specimen that has tubercles on every rib. Yale Peabody Mus. 68.



NOSTOCERAS MENDRYKI, AXONOCERAS CF. *A. ANGOLANUM,* AND *EXITELOCERAS ORONENSE*

PLATE 11

[All specimens shown on this plate are natural size from the basal part of the Navesink Formation at Atlantic Highlands, N.J.]

FIGURES 1–4. *Didymoceras navarroense* (Shumard) (p. 16).

1, 2, Side and top views of a septate fragment. Hypotype USNM 182517.

3, 4. Top and side views of a slightly larger septate fragment. See text-figure 13 for the suture. Hypotype USNM 182527.

5–8. *Pachydiscus* sp. (p. 18).

5, 6. Side and end views of a septate fragment. Figured specimen USNM 182518.

7, 8. Rear and side views of a larger septate fragment. See text-figure 15 for the suture. Figured specimen USNM 182519.

9–12. *Hoploscaphites pumilus* (Stephenson) (p. 16).

9, 10. Side and top views of part of a body chamber interpreted as a male. Hypotype USNM 182520.

11, 12. Rear and side views of a complete body chamber interpreted as a female. Hypotype USNM 182521.

13–19. *Hoploscaphites* sp. (p. 18).

13, 24. Side and rear views of a septate fragment that has closely spaced tubercles. Figured specimen USNM 182522.

15, 16. Rear and side views of part of a large stout septate whorl. See text-figure 14 for the suture. Figured specimen USNM 182523.

17, 18, Side and front views of another large stout specimen. Figured specimen USNM 182524.

19. Fragment of a large body chamber. Figured specimen USNM 182525.

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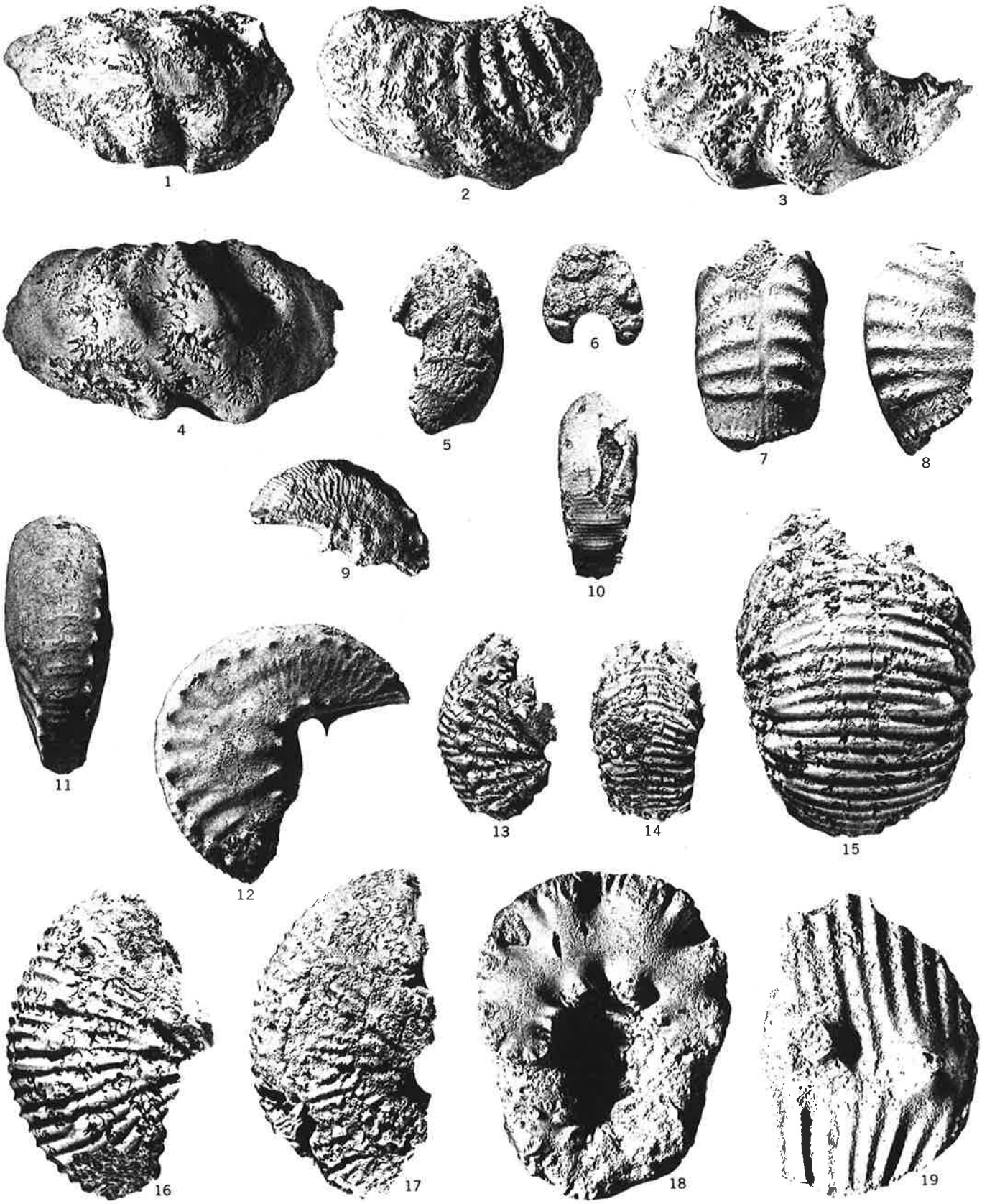

DIDYMOCERAS NAVARROENSE, PACHYDISCUS SP., *HOPLOSCAPHITES PUMILUS,* AND *HOPLOSCAPHITES* SP.