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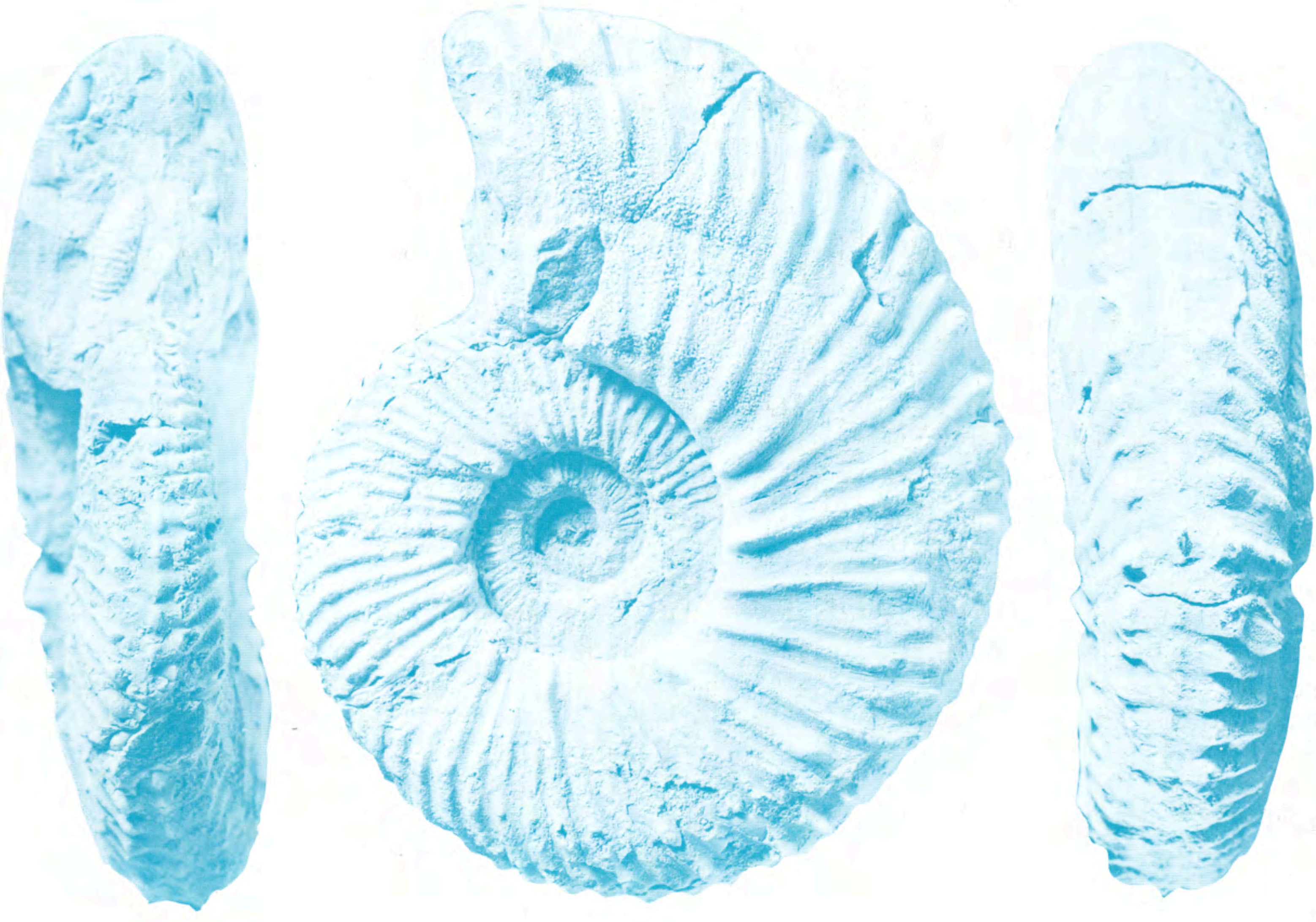

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Upper Cretaceous rocks and ammonite faunas of southwestern New Mexico

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Contents

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Abstract—Upper Cretaceous rocks in southwestern New Mexico crop out in the following areas from east to west: Cookes Range, Silver City–Santa Rita area, Little Burro Mountains, Big Burro Mountains, and Virden area. In these areas, marine rocks of late Cenomanian through early Turonian age have been included in the Colorado Formation, a sequence of shale, siltstone, and sandstone as much as 2000 ft (610 m) thick. In the Cookes Range, on the east side of the area, the Colorado Formation rests disconformably on the upper Albian and lower Cenomanian Sarten Sandstone. In the rest of the area, the Colorado Formation rests on the Beartooth Quartzite, a resistant unit that has not been dated, but is assumed to be Late Cretaceous (Cenomanian).

The lower part of the Colorado Formation consists of shale, limestone, siltstone, and sandstone of marine origin, whereas the upper part is chiefly mudrocks and sandstone of nonmarine origin. This report concerns only the marine part and its ammonite faunas. These marine rocks are the age equivalents of most of the Greenhorn Limestone (Cenomanian and Turonian) of the Great Plains region. In the Cookes Range, the Colorado Formation is divided into the following units from oldest to youngest: flag member, lower shale member, Bridge Creek Limestone Member, upper shale member, and sandstone and shale member. In the rest of the area, the Colorado is divided into a shale member overlain by a sandstone member.

Eight ammonoid zones are recognized in the Colorado Formation. The lower five, of late Cenomanian age, are separated from the upper three, of early Turonian age, by a hiatus that probably represents latest Cenomanian time.

The oldest zone, that of *Calycoceras canitaurinum, is* most fossiliferous in the Cookes Range where it contains 16 kinds of ammonites representing the following nine genera: *Borissiakoceras, Moremanoceras, Cunningtoniceras, Calycoceras, Tarrantoceras, Metoicoceras, Hamites, Turrilites,* and *Neostlingoceras. Moremanoceras costatum* and *Neostlingoceras bayardense* are new species. This zone is found in the flag member in the Cookes Range and in the basal part of the shale member in the Silver City–Santa Rita area, but it is not known farther west.

The second zone, that of *Metoicoceras mosbyense,* is more widely distributed. Fossils of this zone have been found in limestone concretions in the basal part of the Bridge Creek Limestone Member in the Cookes Range and in concretions in the equivalent part of the shale member of the Colorado Formation as far west *as* the Virden area. Twenty-two species of ammonites are present in this zone and represent the genera *Moremanoceras, Placenticeras, Forbesiceras, Cunningtoniceras, Calycoceras, Eucalycoceras, Euomphaloceras, Metoicoceras, Nannometoicoceras, Vascoceras, Hamites, Metaptychoceras,* and *Neostlingoceras*. New species named are *Cunningtoniceras novimexicanum, C. cookense, Calycoceras inflatum, Euomphaloceras merewetheri, Hamites salebrosus, Metaptychoceras hidalgoense, Neostlingoceras procerum,* and *N. virdenense.*

The third zone is that of *Sciponoceras gracile,* which lies in the upper part of the Bridge Creek Limestone Member in the Cookes Range and in the equivalent part of the shale member of the Colorado Formation as far west as the Virden area. Ammonoid genera include *Moremanoceras, Placenticeras, Calycoceras, Pseudocalycoceras, Sumitomoceras, Euomphaloceras, Metoicoceras, Vascoceras, locrioceras, Neostlingoceras, Sciponoceras,* and *Worthoceras*. Thirteen species are recognized, of which only *Neostlingoceras apiculatum* is new.

The fourth zone, that of *Burroceras clydense,* represents a very thin zone that is known with certainty only in the Big Burro Mountains, where it contains 10 species of the genera *Placenticeras, Burroceras* (new), *Paraburroceras* (new), *Vascoceras, Hamites, Sciponoceras,* and *Worthoceras*. New species or subspecies named are *Burroceras clydense, Paraburroceras minutum, Vascoceras barcoicense exile,* and *Hamites pygmaeus.*

The next zone of *Neocardioceras juddii* is the highest Cenomanian zone widely recognized in southwestern New Mexico. Fossils of this zone occur at a hiatus horizon at the top of the Bridge Creek Limestone Member in the Cookes Range and in the equivalent part of the shale member of the Colorado Formation farther west to Virden. The extensive ammonoid fauna consists of 23 species of the genera *Placenticeras, Neocardioceras, Watinoceras, Euomphaloceras, Burroceras, Pseudaspidoceras, Vascoceras, Fagesia, Rubroceras, Hamites, Anisoceras, Sciponoceras,* and *Worthoceras*. New species named are *Neocardioceras woodwardi, Watinoceras odonnelli, Burroceras irregulare, B. transitorium, Rubroceras alatum, R. burroense, R. rotundum,* and *Anisoceras coloradoense.*

Hiatuses at the top of the Bridge Creek Limestone Member and in the base of the overlying upper shale member of the Colorado Formation in the Cookes Range and in the equivalent parts of the shale member of the Colorado farther west probably represent latest Cenomanian time—probably the time span of the zone of *Nigericeras scotti* of southeastern Colorado and northeastern New Mexico.

The lowest Turonian zone in southwestern New Mexico is that of *Pseudaspidoceras flexuosum.* Fossils, which are scarce and poorly preserved, are found in thin sandy beds in the lower part of the upper shale member of the Colorado Formation in the Cookes Range and in the equivalent part of the shale member farther west. The few ammonites identified include *Watinoceras* sp., *Quitmaniceras reaseri* (Powell), *Pseudaspidoceras flexuosum* Powell, *Vascoceras* sp., and *Fagesia catinus* (Mantell). A possible *Kamerunoceras* was also collected.

The second lower Turonian zone is that of *Vascoceras birchbyi,* which is found in the lower part of the sandstone and shale member of the Colorado Formation in the Cookes Range and in the basal part of the sandstone member farther west. Nine species of ammonites of the genera *Watinoceras, Nigericeras, Vascoceras, Fagesia, Neoptychites,* and *Thomasites* are known. No new forms are named.

The highest ammonite zone in southwestern New Mexico is that of *Mammites nodosoides* of latest Turonian age. This fauna, which is known only from the east side of the Cookes Range, occurs in the youngest sandstone bed of the sandstone and shale member of the Colorado Formation. The sparse ammonoid fauna consists of *Watinoceras sp., Mammites nodosoides* (Schluter), *Infabricaticeras lunaense* gen. et sp. nov., and *Thomasites?* sp.

Introduction

Upper Cretaceous rocks crop out at many localities in Grant County and at a few localities farther east in Luna County and farther west in Hidalgo County (Fig. 1). These rocks, which are usually called the Colorado Formation, are the age equivalents of most of the Greenhorn Limestone of the central Great Plains (Fig. 2). The Colorado Formation consists of a lower sequence of marine shale and sandstone and an upper unit of clayey and sandy rocks. The marine sequence consists of a basal sandstone, a thicker medial unit of dark-gray shale, and an upper regressive sandstone unit. All outcrops are in areas of structural deformation and igneous intrusives, where the Colorado Formation is metamorphosed to varying degrees. Molluscan fossils, however, are abundant in parts of the formation, and the ammonites have yielded the most refined upper Cenomanian sequence known in the Western Hemisphere. Furthermore, there is a mingling of northern Western Interior species with Tethyan forms best known from as far afield as Spain and Portugal, Niger and Angola, as well as northwestern Europe, Brazil, Japan, and Turkmenian S.S.R.

Cobban and Hook did most of the field work for this report. Kennedy joined in the description of the ammonites following the completion of the field work.

Acknowledgments

Orin J. Anderson, New Mexico Bureau of Mines & Mineral Resources, aided us in measuring a Cretaceous section at Riley Canyon near Virden and helped in collecting fossils. E. R. Landis, U.S. Geological Survey, provided us with measured sections and fossils near Virden, at Schmitt Draw in Silver City, and at two localities in the Cookes Range. Former members of the New Mexico Bureau of Mines & Mineral Resources and students at New Mexico Institute of Mining & Technology who aided us in collecting fossils are **J. R.** Wright, G. Stachura, D. E. Tabet, and D. Kalvalage. R. R. Cobban helped collect fossils in 1977, 1981, and 1987. D. E. Hattin, University of Indiana, Bloomington, visited one of us (SCH) in the field and helped in measuring a section and collecting fossils. J. E. Cunningham, Western New Mexico University, Silver City, provided a collection of fossils and data concerning outcrop areas. Dr. Peter Bengtson, Uppsala University, Sweden, loaned us important vascoceratid ammonites from Nigeria as an aid in our study. Mr. and Mrs. James Reed, Bayard, New Mexico, drew our attention to a fossiliferous locality in the Big Burro Mountains and donated some ammonites. David R. Woodward, Tyrone, kindly gave us permission to collect on his property (Bald Mountain Ranch) and aided us in other ways. Tom McCauley, Cliff, aided us in access to the outcrops in the northwest side of the Big Burro Mountains.

Frank E. Kottlowski, Director, New Mexico Bureau of Mines & Mineral Resources, greatly encouraged us in this work and provided many services.

We are greatly indebted to Leedrue Hyatt and the late Thomas Hyatt, Hyatt Ranch near Deming, New Mexico, for graciously allowing us access to the important Cretaceous outcrops on the east side of Cookes Range.

R. E. Burkholder, U.S. Geological Survey, helped us in the field in 1982, prepared many of the fossils, and made the photographs of all the specimens shown in Figs. 6496. Robert O'Donnell, of the U.S. Geological Survey, also prepared many of the fossils.

Geologic setting

The area of Upper Cretaceous outcrops lies in the southeastern edge of the Colorado Plateau and in the adjacent Basin and Range province (Drewes, 1982, fig. 1). Cretaceous rocks are offset by numerous faults and in places are extensively intruded by plutons, dikes, and sills of Late Cre-

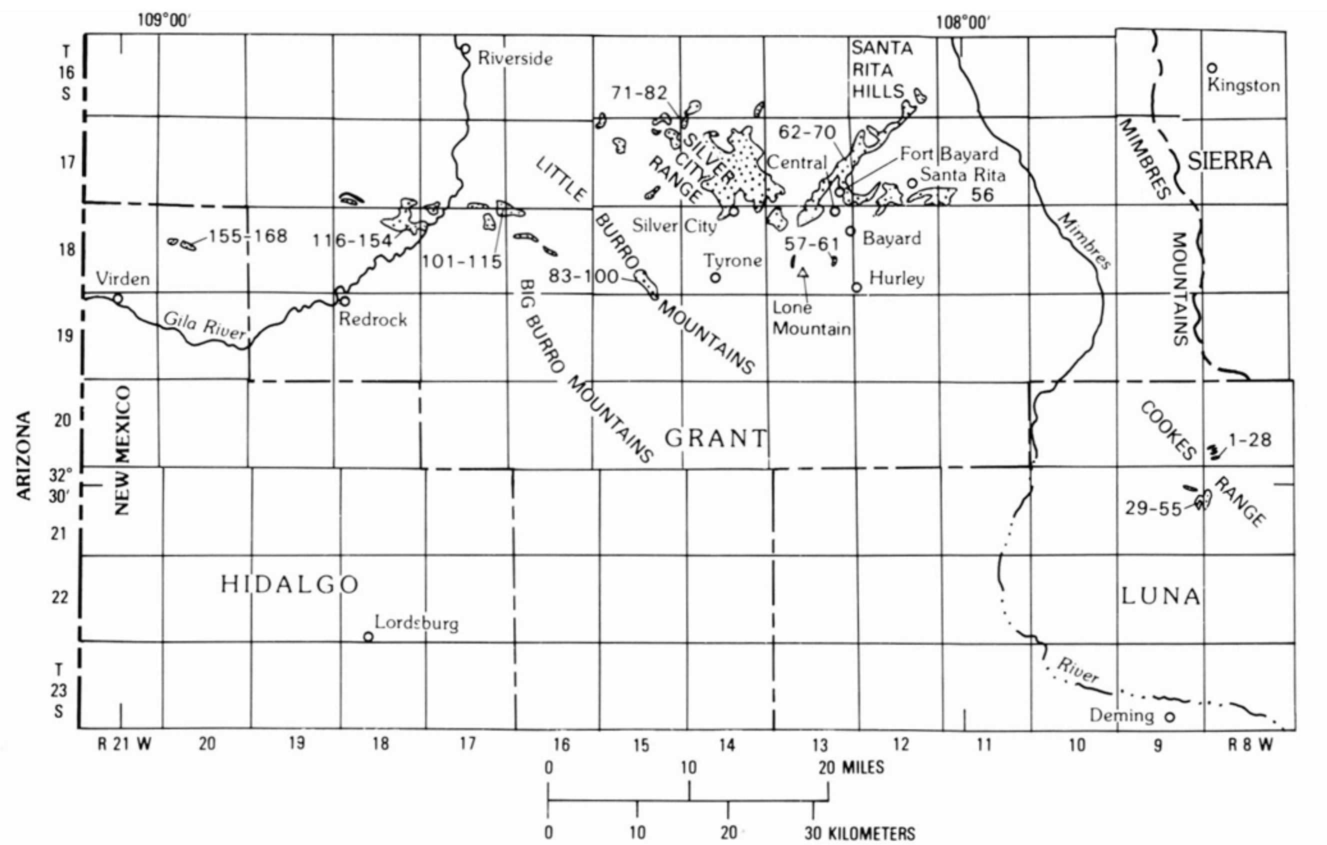

FIGURE 1—Map of parts of Hidalgo, Grant, Luna, and Sierra Counties, New Mexico, showing areas of Upper Cretaceous outcrops (stippled) and generalized localities of fossil collections referred to in the text and in Table 1.

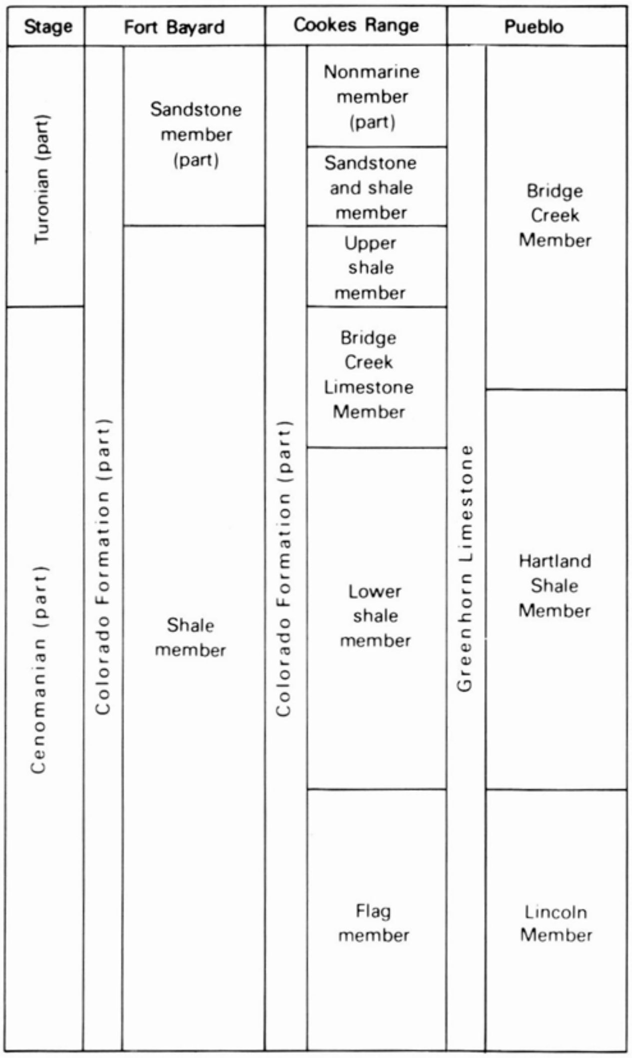

FIGURE 2—Chart showing correlation of Colorado Formation in the Silver City and Cookes Range areas in southwestern New Mexico with the Greenhorn Limestone at Pueblo, Colorado.

taceous(?) and early Tertiary age (for general geologic maps of all or most of the area, see Dane & Bachman, 1965; Trauger, 1972, fig. 2; Drewes et al., 1985).

A large southeast-trending feature known as the Burro uplift (Elston, 1958) crosses most of the area (Thompson, 1982, fig. 3). The name was derived from the Big Burro Mountains, where Upper Cretaceous rocks rest unconformably on Precambrian granite. This uplift arose in Late Mississippian time and became better defined by the end of Pennsylvanian time (Sheppy, 1982). On the northeast flank of the uplift, Upper Cretaceous rocks progressively truncate Paleozoic formations in a southwesterly direction and finally come to rest on Precambrian rocks. The Burro uplift lies along the crest of a larger tectonic feature known as the Deming axis that extends from southeastern Arizona to Trans-Pecos Texas (Turner, 1962).

Stratigraphic summary

Upper Cretaceous rocks in southwestern New Mexico were first described by Darton (1916) and Paige (1916), who applied the name Colorado Shale to a dominantly marine fossiliferous unit in the Cookes Range and Silver City area. In addition, Paige (1916: 5) gave the name Beartooth Quartzite to a unit of quartzitic sandstone with minor interbedded shale that underlies the Colorado Shale in the Silver City area.

Darton (1916, 1917) described the Colorado Shale as dark-gray shale with some interbedded sandstone, limestone, and concretions. The thickness was given as at least 300 ft. A few marine molluscan fossils were listed. In a later report Darton (1928: 41, 329) referred to these beds as Mancos Shale in one part of his summary and as Colorado Shale in another part. Following Darton's reports on the Cookes Range, no further studies were made of the Colorado in that area until the work of Jicha (1954), who also gave a thickness of 300 ft and listed six species of ammonites. Later Griswold (1961) reported on the mineral deposits of the Cookes Range but gave no further information regarding the Colorado Shale. At a much later date, Hook & Cobban (1981) applied the named Colorado Formation in the Cookes Range and described a Bridge Creek Limestone Member that separated two unnamed shale members. Many ammonites were listed from the Bridge Creek Member, and attention was drawn to discontinuity surfaces in the uppermost part of the member. An internationally important ammonite, *Pseudaspidoceras pseudonodosoides* (Choffat, 1899), found in great abundance on one of the discontinuity surfaces, was illustrated by Hook & Cobban (1981) as well as in a later report (Cobban & Hook, 1983b). Since the completion of the present manuscript, Lucas et al. (1988) treated part of the Colorado Formation in the Cookes Range and assigned it to the Mancos Formation—an assignment favored earlier by Molennar (1983) for southwestern New Mexico. We are retaining the older established nomenclature until more regional stratigraphic studies are completed.

Farther west, in the Silver City area, Paige (1916, 1922) reported thicknesses of 90-125 ft for the Beartooth Quartzite and as much as 2000 ft for the Colorado Shale. Some molluscan fossils were listed from 100 and 300 ft above the base of the Colorado. In a later report, Spencer & Paige (1935: 30, 31) reported a thickness of 920 ft for the Colorado Shale in the Santa Rita area east of Silver City and noted that the formation was composed of three members; a lower dark-gray to black shale with some thin beds of sandstone and sandy limestone, a middle calcareous sandstone that occurs in massive beds and contains fossiliferous, sandy limestone in places, and an upper member of dull-green shale, sandy shale, and sandstone. Fossil bivalves and gastropods were listed from the shale member 85-115 ft above the base. In a report on the Bayard area, between Santa Rita and Silver City, Lasky (1936: 22-26) gave thicknesses of 66-140 ft for the Beartooth and 320-350 ft for the Colorado. He applied the named Colorado Formation rather than Colorado Shale and noted that it consisted of a lower shale member 190220 ft thick and an upper sandstone member 130 ft thick (Fig. 2). A few marine bivalves and a gastropod were listed from the shale member 105-115 ft above the base, and three marine bivalves were listed from the sandstone member. Hernon, Jones & Moore (1964) also applied the name Colorado Formation on their map of the Santa Rita quadrangle. In their later detailed report on this quadrangle, Jones, Her-non & Moore (1967) noted that the Colorado Formation was at least 1000 ft thick and divisible into a lower shale member and an upper sandstone member. Three measured sections were given, and molluscan fossils were listed including the first mention of ammonites in the Silver City-Bayard-Santa Rita area. In a later report on the Bayard area, Jones, Moore & Pratt (1970) recorded a thickness of 2200 ft for the Colorado Formation. Since the completion of the present manuscript, Mack et al. (1988) have applied the names Mancos, Atarque, and Moreno Hill as members of the Colorado Formation in the Santa Rita area.

The names Beartooth Quartzite and Colorado Shale were extended west of Silver City into the area of the Big Burro Mountains by Hewitt (1959: 78-81). The Beartooth was described as mostly well-sorted, fine- to medium-grained quartz sand cemented by quartz. A thickness of about 60 ft was given at one locality. Hewitt observed that the formation rested unconformably on Precambrian granite, and that the Beartooth had a basal conglomerate as well as a bed of conglomerate near the top. The Colorado Shale was described as chiefly blue-black carbonaceous shale with some thin beds of sandy shale and limestone and a few nodules of dark-gray limestone. A thickness of 1100 ft was estimated at one locality in the western part of the area. Gillerman (1964) followed Hewitt in using the name Colorado Shale in this area. Trauger (1972), however, applied the name Colorado Formation in the area, and that seems to be the accepted U.S. Geological Survey usage (e.g., Hedlund, 1980; Finnell, 1987). In a recent work, Chafetz (1982) referred to the Beartooth as the Beartooth Sandstone and to the Colorado as the Colorado Shale. That the Beartooth is mostly sandstone with some silicified beds was indicated earlier by Spencer & Paige (1935: 28-29), who gave a 132 ft thick measured section near Santa Rita in which all the arenaceous beds are referred to as sandstone. Lasky (1936: 2223), likewise, described many of the beds as either sandstone or quartzitic sandstone in his measured sections in the Bayard area. We follow the general practice of referring to the formation as the Beartooth Quartzite.

Upper Cretaceous rocks in the Virden area west of the Big Burro Mountains were first reported by Elston (1956), who assigned the beds to the Beartooth Sandstone and Colorado Shale and gave a total thickness of about 800 ft. Elston noted that the Beartooth rested on Precambrian rocks. Later, Elston (1960) showed the area of Cretaceous outcrops on a map (scale 1:126,720). The Beartooth, referred to as the Beartooth Quartzite, was described briefly as 60 ft of unfossiliferous orthoquartzite resting on coarse Precambrian microcline granite. The Colorado Shale was described briefly as gray, fossiliferous, marine shale and sandstone 800 ft thick. A sequence of nonmarine fanglomerate, fluvial conglomerate, tuffaceous sandstone, and gray shale that rested on the Colorado Shale was named the Virden Formation and dated by fossil plants as Late Cretaceous. A few years later, Morrison (1965) mapped the area in more detail (scale 1:48,000) and referred the Cretaceous rocks to the Beartooth Quartzite (85 ft), Colorado Formation (possibly as much as 700 ft), and unnamed nonmarine shale, sandstone, and conglomerate. The Colorado was divided into a basal shale 230 ft thick, a medial shale and sandstone unit about 200 ft thick, and an upper 100 ft thick unit of shale with interbedded sandstone. A few marine bivalves were listed from the Colorado.

Localities of ammonite collections

Ammonites from the Colorado Formation were collected at 168 localities that can be grouped into 10 areas: (1) east side of Cookes Range, (2) south side of Cookes Range, (3) Santa Rita area, (4) Lone Mountain area, (5) Fort Bayard area, (6) Silver City Range, (7) Little Burro Mountains, (8) northeast side of Big Burro Mountains, (9) northwest side of Big Burro Mountains, and (10) Virden area. These areas, which are numbered from east to west, are shown in Fig. 1. Table 1 gives the U.S. Geological Survey Mesozoic locality numbers and locality descriptions. These localities have been assigned map locality numbers 1 through 168. Collections mentioned in the text are in most cases referred to by their map locality number.

Stratigraphy and faunas of Colorado Formation East side of Cookes Range

Darton (1916: 44, pl. 1) noted that the Colorado cropped out "in a small syncline 2 miles southwest of Cookes Peak" where "there are about 200 feet of beds exposed." The area

TABLE 1—Localities at which fossils were collected.

Locality (Fig. 1)	U.S. Geological Survey Mesozoic locality	Locality description
Cookes Range (east side)		
1	D11107	SE¼SW¼ sec. 19, T20S, R8W
2	D12811	SW¼SW¼ sec. 29, T20S, R8W
3	D12740	N½N½ sec. 30, T20S, R8W
4	D6835	N½N½ sec. 30, T20S, R8W
5	D6836	N½N½ sec. 30, T20S, R8W
6	D6837	N½N½ sec. 30, T20S, R8W
7	D6838	N½N½ sec. 30, T20S, R8W
8	D6840	N½N½ sec. 30, T20S, R8W
9	D6841	N½N½ sec. 30, T20S, R8W
10	D6842	N½N½ sec. 30, T20S, R8W
11	D6843	N½N½ sec. 30, T20S, R8W
12	D6844	N½N½ sec. 30, T20S, R8W
13	D10194	N½N½ sec. 30, T20S, R8W
14	D10195	N½N½ sec. 30, T20S, R8W
15	D10196	N½N½ sec. 30, T20S, R8W
16	D11066	N½N½ sec. 30, T20S, R8W
17	D11483	N½N½ sec. 30, T20S, R8W
18	D12741	N½N½ sec. 30, T20S, R8W
19	D12742	N½N½ sec. 30, T20S, R8W
20	23562	N½N½ sec. 30, T20S, R8W
21	D12754	NW¼NE¼ sec. 30, T20S, R8W
22	D10144	SE¼SE¼ sec. 30, T20S, R8W
23	D10146	SE¼SE¼ sec. 30, T20S, R8W
24	D10147	SE¼SE¼ sec. 30, T20S, R8W
25	D11755	SE¼SE¼ sec. 30, T20S, R8W
26	D12765	SE¼SE¼ sec. 30, T20S, R8W
27	D12766	SE¼SE¼ sec. 30, T20S, R8W
28	D12770	SE¼SE¼ sec. 30, T20S, R8W
Cookes Range (south side)		
29	D10105	NW¼NW¼ sec. 18, T21S, R8W
30	D10106	NW¼NW¼ sec. 18, T21S, R8W
31	D10107	NW¼NW¼ sec. 18, T21S, R8W
32	D10108	NW¼NW¼ sec. 18, T21S, R8W
33	D10186	NW¼NW¼ sec. 18, T21S, R8W
34	D10526	NW¼NW¼ sec. 18, T21S, R8W
35	6533	[sec. 13, T21S, R9W]
36	D10109	NE¼NE¼ sec. 13, T21S, R9W
37	D10110	NE¼NE¼ sec. 13, T21S, R9W
38	D10111	NE¼NE¼ sec. 13, T21S, R9W
39	D10112	NE¼NE¼ sec. 13, T21S, R9W
40	D10113	NE¼NE¼ sec. 13, T21S, R9W
41	D10114	NE¼NE¼ sec. 13, T21S, R9W
42	D10115	NE¼NE¼ sec. 13, T21S, R9W
43	D10116	NE¼NE¼ sec. 13, T21S, R9W
44	D10188	NE¼NE¼ sec. 13, T21S, R9W
45	D10189	NE¼NE¼ sec. 13, T21S, R9W
46	D10190	NE¼NE¼ sec. 13, T21S, R9W
47	D10192	NE¼NE¼ sec. 13, T21S, R9W
48	D10193	NE¼NE¼ sec. 13, T21S, R9W
49	D10191	NE¼NE¼ sec. 13, T21S, R9W
50	D11210	NE¼NE¼ sec. 13, T21S, R9W
51	D11516	NW¼NE¼ sec. 13, T21S, R9W
52	D11531	NW¼NE¼ sec. 13, T21S, R9W
53	D10187	S½NE¼ sec. 13, T21S, R9W
54	D11530	SW¼NE¼ sec. 13, T21S, R9W
55	D10530	N½SE¼ sec. 13, T21S, R9W
Santa Rita area		
56	D12057	SW¼ sec. 30, T17S, R11W
Lone Mountain area		
57	D11030	NE¼SE¼ sec. 23, T18S, R13W
58	D11031	NE¼SE¼ sec. 23, T18S, R13W
59	D11550	NE¼SE¼ sec. 23, T18S, R13W
60	D11561	NE¼SE¼ sec. 23, T18S, R13W
61	D11562	NE¼SE¼ sec. 23, T18S, R13W
Fort Bayard area		
62	D11541	SW¼NE¼ sec. 24, T17S, R13W
63	D11548	SW¼NE¼ sec. 24, T17S, R13W

TABLE 1—(cont'd)

Locality (Fig. 1)	U.S. Geological Survey Mesozoic locality	Locality description
64	D12809	SW1/4NE1/4 sec. 24, T17S, R13W
65	D11542	Center of sec. 24, T17S, R13W
66	D11760	Center of sec. 24, T17S, R13W
67	D11761	Center of sec. 24, T17S, R13W
68	D911	sec. 24, T17S, R13W
69	19459	sec. 24, T17S, R13W
70	D11185	SE1/4NE1/4 sec. 36, T17S, R13W
Silver City Range		
71	D11023	NW1/4SE1/4 sec. 8, T17S, R15W
72	D11024	NW1/4SE1/4 sec. 8, T17S, R15W
73	D11025	NW1/4SE1/4 sec. 8, T17S, R15W
74	D11026	NW1/4SE1/4 sec. 8, T17S, R15W
75	D11028	SE1/4 sec. 8, T17S, R15W
76	D11027	Center of sec. 8, T17S, R15W
77	D10516	NE1/4NE1/4 sec. 34, T17S, R15W
78	D10513	NW1/4NW1/4 sec. 35, T17S, R15W
79	D11015	SW1/4SW1/4 sec. 6, T17S, R14W
80	D11016	SW1/4SW1/4 sec. 6, T17S, R14W
81	D11017	SW1/4SW1/4 sec. 6, T17S, R14W
82	D9035	SW1/4NE1/4 sec. 33, T17S, R14W
Little Burro Mountains		
83	D11001	SE1/4NW1/4 sec. 27, T18S, R15W
84	D11003	SE1/4NW1/4 sec. 27, T18S, R15W
85	D11004	SE1/4NW1/4 sec. 27, T18S, R15W
86	D11005	SE1/4NW1/4 sec. 27, T18S, R15W
87	D11007	SE1/4NW1/4 sec. 27, T18S, R15W
88	D11010	NW1/4NW1/4 sec. 27, T18S, R15W
89	D11296	NW1/4NW1/4 sec. 27, T18S, R15W
90	D11009	NW1/4SE1/4 sec. 27, T18S, R15W
91	D12072	NW1/4SE1/4 sec. 27, T18S, R15W
92	D12080	NW1/4SE1/4 sec. 27, T18S, R15W
93	D11018	Center of sec. 27, T18S, R15W
94	D12907	NE1/4NE1/4 sec. 28, T18S, R15W
95	D10527	NE1/4NE1/4 sec. 28, T18S, R15W
96	D11011	NE1/4NE1/4 sec. 28, T18S, R15W
97	D12073	SE1/4NE1/4 sec. 28, T18S, R15W
98	D11303	NE1/4NE1/4 sec. 34, T18S, R15W
99	D11012	SW1/4NW1/4 sec. 35, T18S, R15W
100	D11002	Center of sec. 2, T19S, R15W
Big Burro Mountains (northeast side)		
101	D9875	SW1/4SW1/4 sec. 1, T18S, R17W
102	D11118	NW1/4NW1/4 sec. 1, T18S, R17W
103	D11119	NW1/4NW1/4 sec. 1, T18S, R17W
104	D9030	SW1/4SW1/4 sec. 2, T18S, R17W
105	D9978	SW1/4SE1/4 sec. 2, T18S, R17W
106	D11013	SE1/4SE1/4 sec. 2, T18S, R17W
107	D11014	SE1/4SE1/4 sec. 2, T18S, R17W
108	D7078	NW1/4NE1/4 sec. 11, T18S, R17W
109	D9031	NW1/4NE1/4 sec. 11, T18S, R17W
110	D10533	NW1/4NE1/4 sec. 11, T18S, R17W
111	D11111	NW1/4NE1/4 sec. 11, T18S, R17W
112	D11532	NW1/4SE1/4 sec. 5, T18S, R16W
113	D11533	NW1/4SE1/4 sec. 5, T18S, R16W
114	D11534	NW1/4SE1/4 sec. 5, T18S, R16W
115	D11652	NW1/4SW1/4 sec. 5, T18S, R16W
Big Burro Mountains (northwest side)		
116	D11299	SW1/4SE1/4 sec. 35, T17S, R18W
117	D11543	SE1/4SE1/4 sec. 35, T17S, R18W
118	D10995	SW1/4NW1/4 sec. 36, T17S, R18W
119	D11513	NW1/4SW1/4 sec. 36, T17S, R18W
120	D11514	NW1/4SW1/4 sec. 36, T17S, R18W
121	D10996	SE1/4SE1/4 sec. 31, T17S, R17W
122	D11510	SE1/4SE1/4 sec. 31, T17S, R17W
123	D11511	SE1/4SE1/4 sec. 31, T17S, R17W
124	D11512	SE1/4SE1/4 sec. 31, T17S, R17W
125	D11547	SE1/4SE1/4 sec. 31, T17S, R17W
126	D11551	SE1/4SE1/4 sec. 31, T17S, R17W
127	D11546	NE1/4SW1/4 sec. 32, T17S, R17W

TABLE 1—(cont'd)

Locality (Fig. 1)	U.S. Geological Survey Mesozoic locality	Locality description
128	D12101	SE1/4NE1/4 sec. 2, T18S, R18W
129	D11478	S1/2NE1/4 sec. 10, T18S, R18W
130	D11479	S1/2NE1/4 sec. 10, T18S, R18W
131	D11480	S1/2NE1/4 sec. 10, T18S, R18W
132	D11481	S1/2NE1/4 sec. 10, T18S, R18W
133	D11482	S1/2NE1/4 sec. 10, T18S, R18W
134	D11752	S1/2NE1/4 sec. 10, T18S, R18W
135	D11540	SE1/4NE1/4 sec 10, T18S, R18W
136	D11545	SE1/4NE1/4 sec. 10, T18S, R18W
137	D11553	SE1/4NE1/4 sec. 10, T18S, R18W
138	D11300	SE1/4NE1/4 sec. 10, T18S, R18W
139	D11297	NW1/4NE1/4 sec. 11, T18S, R18W
140	D11298	NW1/4NE1/4 sec. 11, T18S, R18W
141	D11301	SW1/4NW1/4 sec. 11, T18S, R18W
142	D11302	SW1/4NW1/4 sec. 11, T18S, R18W
143	D11460	SW1/4NW1/4 sec. 11, T18S, R18W
144	D11529	NW1/4NE1/4 sec. 11, T18S, R18W
145	D11538	NE1/4NE1/4 sec. 11, T18S, R18W
146	D11539	NE1/4NE1/4 sec. 11, T18S, R18W
147	D11544	SW1/4NW1/4 sec. 11, T18S, R18W
148	D12739	SW1/4NE1/4 sec. 11, T18S, R18W
149	D11524	NE1/4NE1/4 sec. 12, T18S, R18W
150	D11525	NE1/4NE1/4 sec. 12, T18S, R18W
151	D11526	NE1/4NE1/4 sec. 12, T18S, R18W
152	D11527	NE1/4NE1/4 sec. 12, T18S, R18W
153	D11528	NE1/4NE1/4 sec. 12, T18S, R18W
154	D12078	NE1/4NE1/4 sec. 12, T18S, R18W
Virden area		
155	D6845	SE1/4SW1/4 sec. 17, T18S, R20W
156	D6846	SE1/4SW1/4 sec. 17, T18S, R20W
157	D6847	SE1/4SW1/4 sec. 17, T18S, R20W
158	D11556	SE1/4SW1/4 sec. 17, T18S, R20W
159	D10201	NE1/4NW1/4 sec. 20, T18S, R20W
160	D12053	SE1/4NW1/4 sec. 21, T18S, R20W
161	D12054	SE1/4NE1/4 sec. 20, T18S, R20W
162	D12743	SW1/4NW1/4 sec. 21, T18S, R20W
163	D12744	SW1/4NW1/4 sec. 21, T18S, R20W
164	D12745	SW1/4NW1/4 sec. 21, T18S, R20W
165	D12746	SW1/4NW1/4 sec. 21, T18S, R20W
166	D12747	SW1/4NW1/4 sec. 21, T18S, R20W
167	D12748	SW1/4NW1/4 sec. 21, T18S, R20W
168	D12749	SW1/4NW1/4 sec. 21, T18S, R20W

of outcrop was shown on Darton's map (1916, pl. 1) and in more detail on the later maps of Jicha (1954, pl. 1) and Seager et al. (1982). A road log into the outcrop area was given by Kottlowski & Trice (1958).

Darton (1916: 44) described the beds as mainly dark-gray shale with interbedded sandstone and sandy shale and "several thin beds of dark blue-gray limestone which weathers to a dirty buff color." Seven genera of marine bivalves and three genera of gastropods were identified by T. W. Stanton from a sandy unit. Jicha (1954: 27) listed six kinds of ammonites, identified by J. B. Reeside, Jr. from the NE1/4 sec. 30, T20S, R8W, along the road to the ghost town of Cooke (loc. 20). These fossils are as follows, with Jicha's spellings corrected and the updated names in brackets: *Romaniceras* n.sp. aff. *R. loboense* Adkins [*Cunningtoniceras cookense* sp. nov.], *Neocardioceras septemseriatum* (Cragin) [*Euomphaloceras septemseriatum* (Cragin)], *Parapuzosia?* n. sp. [*Moremanoceras scotti* (Moreman)], *Acanthoceras? kanabense* Stanton [*Euomphaloceras septemseriatum* (Cragin)], *Baculites* cf. *gracilis* Shumard [*Sciponoceras gracile* (Shumard)], and *Buchiceras* cf. *swallovi* Shumard [*Metoicoceras geslinianum* (d'Orbigny)].

Owing to faulting and small, scattered areas of outcrops, an accurate thickness of the Colorado Formation was not measured in this area by us. From measured sections pieced together near the center of the N1/2N1/2 sec. 30, T20S, R8W, and in the vicinity of Shale Spring in the SW1/4 sec. 29 and 5E1/4 sec. 30, T20S, R8W, we determined the following sequence for the Colorado Formation (Fig. 3) with approximate thicknesses: a 30 ft (9 m) basal flag member, a 40 ft (12 m) lower shale member, a 30 ft (9 m) Bridge Creek Limestone Member, a 57 ft (17 m) upper shale member, a 127 ft (39 m) sandstone and shale member, and a 280 ft (85 m) nonmarine shale and sandstone member. This gives a total thickness of about 557 ft (170 m).

The flag member consists of a basal sandstone and thin beds of hard siltstone and silty shale with some silty, concretionary limestone and several thin beds of hard, white claystone that represent altered volcanic ash. Fossils are scarce and consist mostly of fragments of *Inoceramus prefragilis* Stephenson. At loc. 18 in Hadley Draw, a few poor impressions of *Moremanoceras costatum* sp. nov. and *Metoicoceras* sp. were found in the lower 10 ft (3 m) of the member. A bit of a whorl of *Neostlingoceras kottlowskii* Cobban & Hook was also collected in the basal 5 ft at loc. 4 in Hadley Draw. A bed of hard, silty limestone 17 ft (5 m) above the base at loc. 19 in Hadley Draw contains poor fragments of *Cunningtoniceras arizonense* Kirkland & Cobban. All of these ammonites from the lower part of the flag member are of early late Cenomanian age (zone of *Calycoceras canitaurinum).* The base of the flag member is probably also of this age, inasmuch as poorly preserved impressions of *Metoicoceras* were observed on bedding surfaces of the basal sandstone exposed on the floor of Hadley Draw.

The lower shale member is poorly exposed, and no collections of fossils were made.

About a dozen beds of limestone concretions and a few beds of limestone are present in the Bridge Creek Limestone Member. The concretions are chiefly grouped in a 20 ft thick unit of calcareous shale (Figs. 3, 4). Most beds of concretions weather white, but three conspicuous beds of large, hard concretions near the top of the member weather bright orange. Ammonites from the white-weathering concretions and limestone beds in the lower part of the member include fragments of very large species of *Forbesiceras, Calycoceras,* and *Euomphaloceras.* A bed of white limestone 10 ft (3 m) below the lowest of the orange concretions at loc. 17 contains *Moremanoceras scotti* (Moreman), *Eucalycoceras pentagonum* (Jukes-Browne), *Euomphaloceras euomphalum* (Sharpe), and *Vascoceras diartianum* (d'Orbigny) of late Cenomanian age. The three beds of orange-weathering concretions are poorly fossiliferous, but small interbedded limestone concretions contain *Sciponoceras gracile* (Shumard), *Euomphaloceras septemseriatum* (Cragin), and *Metoicoceras geslinianum* (d'Orbigny), all good guide fossils to the zone of *Sciponoceras gracile.* Above the orange-weathering concretions is a thin but widespread bed of bentonite, and above it a bed of white-weathering hiatus concretions that are the same as those described by Hook & Cobban (1981) on the south side of the Cookes Range that carry the *Neocardioceras juddii* fauna of very late Cenomanian age.

The lithology changes abruptly above the hiatus concretions, and the upper shale member is a silty, noncalcareous shale with occasional thin beds of very fine-grained sandstone (Fig. 3). Fossils are scarce except in the basal 5 ft where a small, smooth oyster is abundant along with a few specimens of *Mytiloides columbianus* (Heinz), a lower Turonian bivalve. Only three specimens of ammonites were found, all as float in the lower 15 ft (4.5 m) of the member (locs. 12, 22). Two of the specimens are small, poorly preserved, flattened *Watinoceras* sp., and the other is a bounce mark of *a Kamerunoceras?* sp.

With the exception of the uppermost sandstone bed, fossils are scarce and poorly preserved in the sandstone and shale member (Figs. 3, 6). Ammonites were found at two levels. The older collection (loc. 23) is from a brown-weathering silty limestone bed that becomes concretionary in places. This bed, 49 ft (15 m) above the base of the member, contains poorly preserved *Pseudospidoceras* sp., *Mammites?* sp., *Neoptychites* sp., and *Baculites* sp. associated with a few fragments of *Mytiloides columbianus* (Heinz) and an occasional gastropod. The other level (locs. 1, 11, 24), at the top of the member, is from brown-weathering sandstone concretions in an 8 ft thick sandstone bed. Ammonites are fragmentary and include *Watinoceras* sp., *Mammites nodosoides* (Schluter), *Infabricaticeras lunaense* sp. nov., and *Thomasites* cf. *adkinsi* (Kummel & Decker) associated with a large variety of bivalves and gastropods. Among the bivalves is *Mytiloides mytiloides* (Mantell) of late early Turonian age.

The nonmarine member is well exposed in the SE1/4 sec. 30, T20S, R8W (Fig. 7). The only fossil observed was petrified wood.

South side of Cookes Range

Darton (1916: 44) noted that the most extensive outcrops of the Colorado Shale in the Cookes Range were "21/2 miles northwest of Fryingpan Spring, where the shale occupies an area of nearly 1 square mile and the strata dip gently to the southwest." On the present Massacre Peak 71/2-minute quadrangle, Fryingpan Spring lies in the SE1/4SW1/4SE1/4 sec. 20, T21S, R8W, and the outcrops are certainly those south of Rattlesnake Ridge in the NE1/4 sec. 13, T21S, R9W and in the NW1/4 sec. 18, T21S, R8W (Fig. 1, locs. 29-55). These outcrop areas are shown on Darton's maps (1916, 1917) and in more detail on the maps by Clemons (1982) and Seager et al. (1982).

The Colorado Formation on the south side of Cookes Range differs from that on the east side mainly in having a more fossiliferous flag member, more fossiliferous concretions at the top of the Bridge Creek Member, and a thinner upper shale member (Fig. 3). Only the lower part of the sandstone and shale member is preserved in the Rattlesnake Ridge area. Although the two areas (Rattlesnake Ridge and Shale Spring) are only about 4.5 mi (7 km) apart, they are separated by a large fault that trends a little west of north.

The flag member is about 27 ft (8.2 m) thick in the arroyo leading into Starvation Draw near the center of the SE1/4 sec. 13, T21S, R9W. Here the member consists of thin, hard beds of siltstone and shale with several beds of hard, white claystone as much as 9 cm thick and with a thick-bedded basal sandstone (Fig. 8). Where bedding surfaces can be seen on nearby outcrops in the E1/2E1/2 sec. 13, fairly numerous fragments of inoceramids and ammonites can be found. These fossils are chiefly *Inoceramus prefragilis* Stephenson, *Moremanoceras costatum* sp. nov., *Calycoceras canitaurinum* (Haas), *Tarrantoceras* cf. *sellardsi* (Adkins), *Cunningtoniceras arizonense* Kirkland & Cobban, *Metoicoceras aff. praecox* (Haas), and *Neostlingoceras kottlowskii* Cobban & Hook. In addition to many of these species, a 15 cm thick bed of gray, hard, concretionary limestone locally contains abundant ammonoid nuclei.

A sandstone unit several feet thick, consisting of one or more beds, forms the base of the flag member and rests unconformably on the Sarten Sandstone of late Albian and early Cenomanian age. The sandstone unit is in places coarse-grained to pebbly, with small pebbles of gray and white chert and gray quartz.

The lower shale member is about 40 ft (12 m) thick and consists of calcareous shale with several thin beds of white claystone (altered volcanic ash) and calcarenite. No ammonites were observed.

The Bridge Creek Limestone Member is about 37 ft (11 m) thick. White-weathering limestone concretions and limestone beds characterize the lower part of the member,

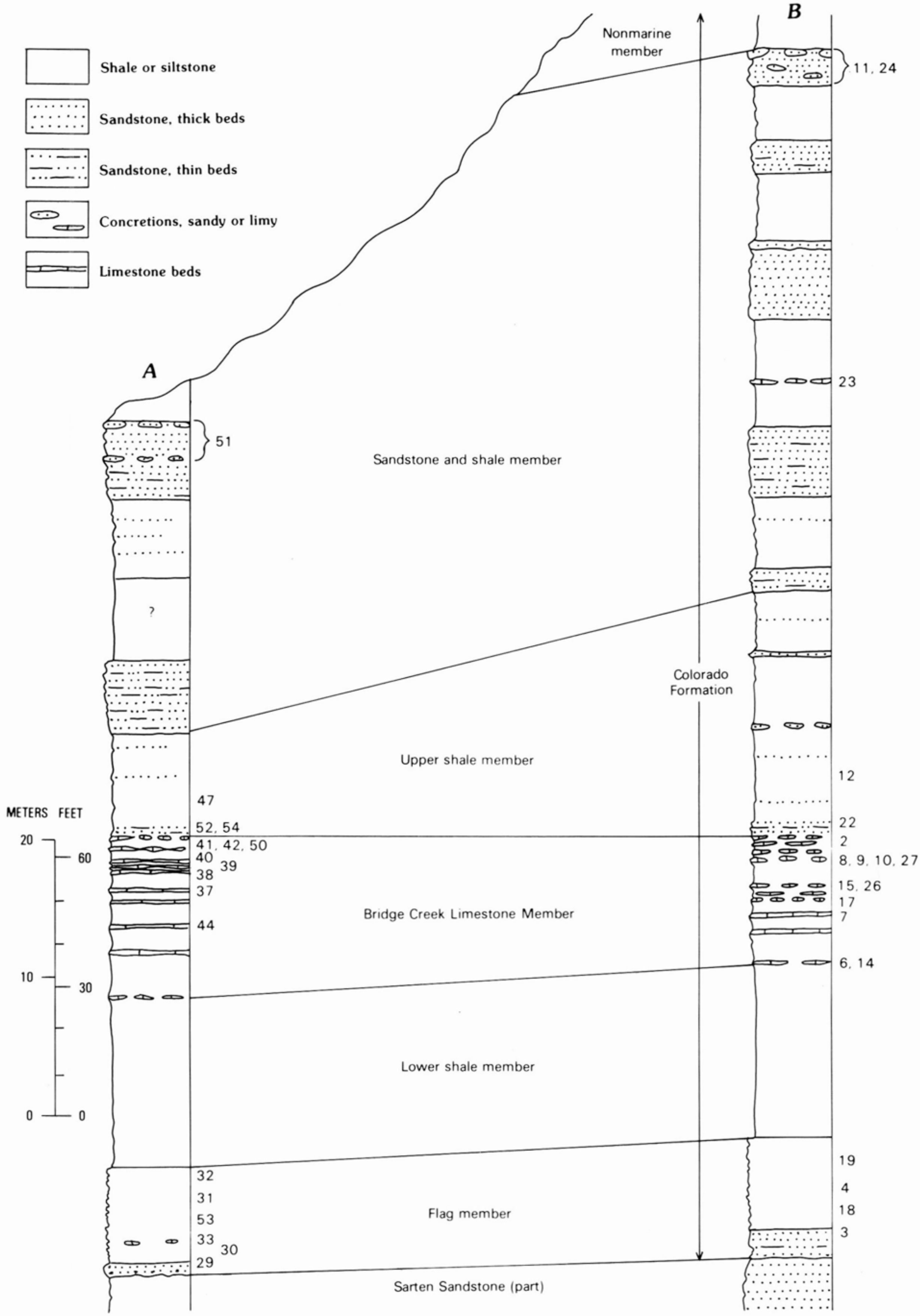

FIGURE 3—Columnar sections of the Colorado Formation in the Rattlesnake Ridge area (A) on the south side of the Cookes Range and in the Shale Spring area (B) on the east side of the Cookes Range. Numbers refer to localities of collections in Table 1.

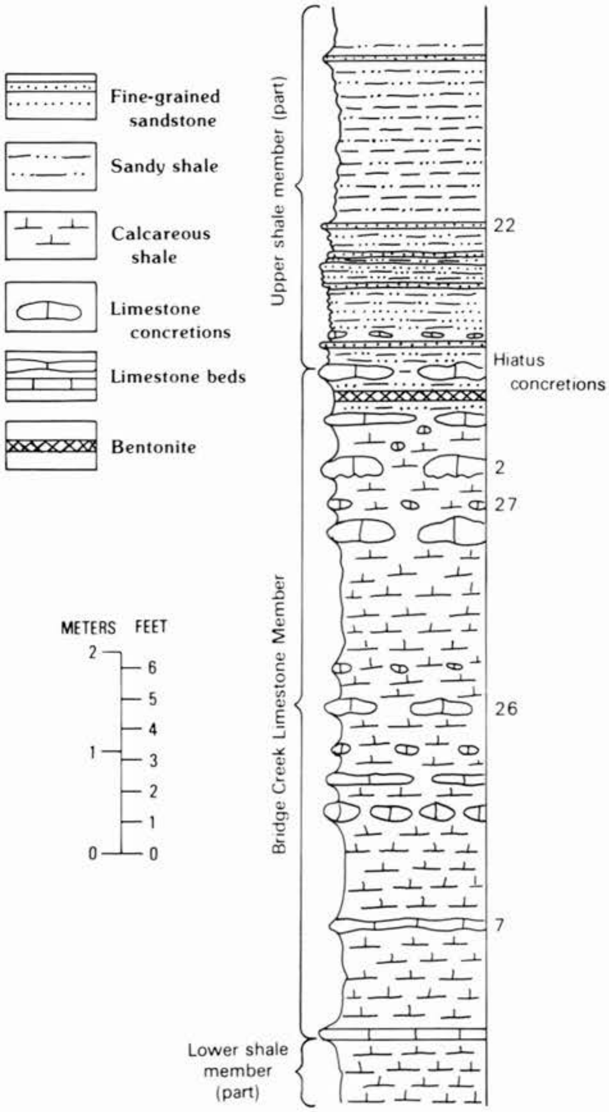

FIGURE 4—Columnar section of the Bridge Creek Limestone Member and the basal part of the overlying unnamed upper shale member of the Colorado Formation upstream from Shale Spring in the SW¼NW¼SW¼ sec. 29, T20S, R8W, Luna County, New Mexico. Numbers to right of section refer to locations of collections in Table 1.

FIGURE 5—Middle part of the Bridge Creek Limestone Member of the Colorado Formation in the arroyo upstream from Shale Spring in the SW¼NW¼SW¼ sec. 29, T20S, R8W, Luna County, New Mexico. Four beds of white-weathering limestone concretions are visible in the lower half of the photograph (hammer rests on top bed). The basal bed of the orange-weathering limestone concretions is in the upper part of the photograph. See Fig. 4 (interval from 7 to 2).

FIGURE 6—Thin-bedded sandstone unit 16 feet (5 m) thick with a 10° dip in the lower part of the shale and sandstone member of the Colorado Formation near the center of the SE¼ sec. 30, T20S, R8W, Luna County, New Mexico.

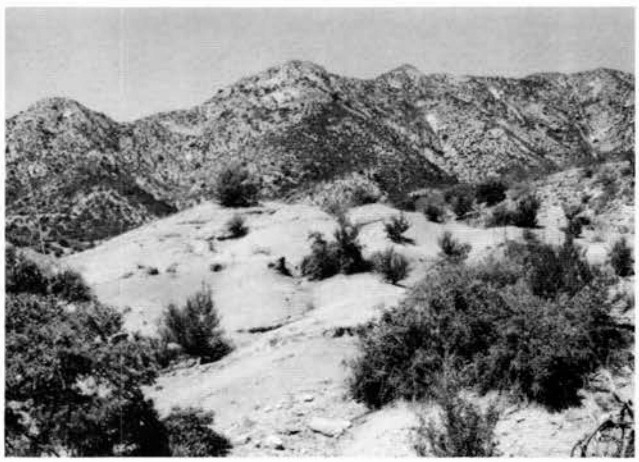

FIGURE 7—Mudstone with irregular ferruginous concretions in the nonmarine member of the Colorado Formation in the SE¼ sec. 30, T20S, R8W, Luna County, New Mexico.

FIGURE 8—Flag member of Colorado Formation dipping 15° south near center of the SE¼ sec. 13, T21S, R9W. Thick-bedded quartzitic sandstone underlies the flaggy beds and forms the floor of the arroyo. See Fig. 7.

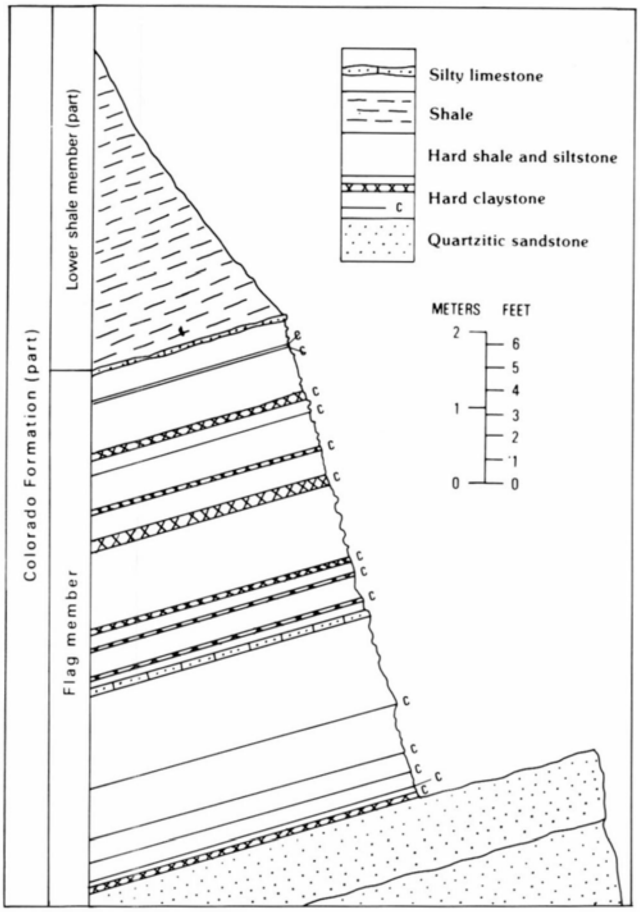

FIGURE 9—Columnar section of flag member of Colorado Formation consisting of hard siltstone and shale with several beds of hard claystone near center of the SE¼ sec. 13, T21S, R9W on the south side of the Cookes Range. The member forms a steep bluff above thick, massive beds of quartzitic sandstone and underlies softer, slope-forming shale. See Fig. 6. The sandstone at base is probably the base of the Colorado Formation.

whereas orange-weathering beds of concretionary limestone and concretions characterize the upper part as on the east side of the Cookes Range. Molluscan fossils indicative of the *Sciponoceras gracile* zone are present in the upper part of the Bridge Creek Member. Among the ammonites are *Calycoceras naviculare* (Mantell), *Pseudocalycoceras angolaense* (Spath), *Euomphaloceras septemseriatum* (Cragin), *Metoicoceras geslinianum* (d'Orbigny), *Sciponoceras gracile* (Shumard), and *Worthoceras vermiculus* (Shumard). Near the top of the member, white hiatus-limestone concretions contain abundant *Pseudaspidoceras pseudonodosoides* (Choffat) and a few *Neocardioceras juddii* (Barrois & de Guerne) and vascoceratid ammonites. This is the bed described by Darton (1916: 45) as "One limestone layer near the middle of the beds exposed contains many scattered cephalopods, which are difficult to obtain in good condition." Darton's collection (loc. 35) consists of several weathered specimens of *P. pseudonodosoides* and a fragment of *Metoicoceras geslinianum* from the underlying beds.

The shale overlying the Bridge Creek Member is silty to very finely sandy. Except for *Mytiloides columbianus* (Heinz), fossils are scarce, but a few poorly preserved fragments of internal molds of the lower Turonian *Watinoceras* and *Vascoceras birchbyi* Cobban & Scott have been collected. A crushed fragment of *Pseudaspidoceras flexuosum* Powell was found near the base (loc. 54).

The sandstone and shale member is transitional from the underlying shale and contains similar fossils in its basal 15 ft thick, thin-bedded, very fine-grained sandstone. A covered interval perhaps 10-15 ft thick separates this sandstone from the base of a 20 ft thick sandy shale unit exposed in an arroyo in the NE¼NW¼NE¼ sec. 13, T21S, R9W. A 30 ft thick sandstone unit above this sandy shale has fossiliferous, brown-weathering-sandstone concretions (loc. 51) that contain *Mytiloides columbianus,* and fragments of *Mammites nodosoides* (Schlüter)?, *Neoptychites? sp .* , *Vascoceras birchbyi?,* and *Fagesia* sp. Associated with these is a variety of bivalves and gastropods. This sandstone is overlain by a few feet of black, carbonaceous shale that seems to be the top of the preserved Colorado Formation.

Santa Rita area

Jones et al. (1967: 33) noted that in the Santa Rita quadrangle the Beartooth Quartzite ranges from 50 to 140 ft and consists of fine- to very fine-grained sandstone that is nearly everywhere changed to quartzite by silicification. They mention the presence of thin lenses of conglomerate near the base and top that contain pebbles of quartzite and black and white chert. Spencer & Paige (1935: 30) noted earlier that chert conglomerate near or at the top of the formation may represent the boundary between the Lower and Upper Cretaceous. We assume that the upper conglomerate marks the base of the Colorado Formation.

Spencer & Paige (1935: 30) recognized three divisions for the Colorado Formation, "a lower carbonaceous shale member, a middle member characterized by prominent beds of light-colored calcareous sandstone, and an upper member made up of prevailing dull-green shale, sandy shale, and fine-grained sandstone." They further noted that the lower shale member was everywhere about 200 ft thick and that it consisted of a lower well-laminated clay shale 80-90 ft thick, a middle 25-35 ft thick unit of shale alternating with thin beds of sandstone and fossiliferous sandy limestone, and an upper shale that sands upward. The three major divisions of the Colorado seem to correlate to the Colorado Formation of the Cookes Range as follows: the lower shale member is the equivalent of the flag member, the lower shale member, the Bridge Creek Limestone Member, and the upper shale member; the middle sandstone member is the equivalent of the sandstone and shale member; and the upper member is the equivalent of the nonmarine member. The "well-laminated dark-colored clay shale" at the base (Fig. 10) closely resembles the outcrops of the flag member. Inasmuch as the Colorado Formation is considerably baked by igneous intrusives in the Santa Rita area, the equivalents of both the flag member and lower shale member of the

FIGURE 10—Lower part of the shale member of the Colorado Formation east of Santa Rita in the SE¼ sec. 30, T17S, R11W, Grant County, New Mexico.

Cookes Range are indurated and are included in Spencer & Paige's basal shale unit of the lower shale member. A major change occurs in the equivalent of the Bridge Creek Member, which is very sandy and lacks most of the distinctive limestone beds of the Cookes Range. However, sandy, fossiliferous, limestone concretions as well as two beds of orange-weathering limestone concretions are present. Spencer & Paige (1935: 30) gave thicknesses of 25-35 ft for this sandy unit, which compares favorably with the 30-37 ft for the Bridge Creek Member of the Cookes Range. Outcrops of this sandy member are limited in the Santa Rita area, and no ammonites were found during our field work. A bit of *Fagesia* sp. was found, however, as float from the basal part of the overlying shale (loc. 56).

Spencer & Paige (1935: 30) noted that the sandstone member of the Colorado Formation was at least 130 ft thick and occurred in rather massive beds. They also recorded the presence of several beds of sandy limestone, some with fossils in places.

Lone Mountain area

Pratt (1967: 43) gave a partial section of 105 ft of Beartooth Quartzite at a locality 0.5 mi northwest of Lone Mountain (Fig. 1). He pointed out that the Colorado Formation was exposed in two small areas north and northeast of Lone Mountain, and he estimated a thickness of 1650 ft. Pratt gave two measured sections of the Colorado, but they are too generalized for comparison to the Colorado of the Santa Rita area. Two of us (WAC, SCH) examined Pratt's section along the floor of Cameron Creek and made some collections from limy concretions in an argillaceous sandstone that is the same as the sandy unit in the lower shale member described by Spencer & Paige (1935) as well as by Jones et al. (1967) in the Santa Rita area. This sandstone, about 20 ft (6 m) thick, yielded *Metoicoceras mosbyense* Cobban at 3, 5, and 17 ft above the base (locs. 57, 59, 60, 61). *Moremanoceras scotti* (Moreman) was also found at loc. 61. A little farther down Cameron Creek and at a higher stratigraphic level (loc. 58), *Fagesia catinus* (Mantell) and *Nigericeras* cf. *scotti* Cobban were collected from a bed of very fine-grained sandstone.

Fort Bayard area

Lasky (1936: 22, 23) measured thicknesses of 66-140 ft for the Beartooth Quartzite and recorded a pebbly to conglomeratic bed at or near the top. This conglomerate, as much as 3 ft thick in places, consists of rounded quartzite and chert pebbles. We assume that the base of this conglomerate marks the base of the Colorado Formation.

Lasky (1936: 23-26) divided the Colorado into two members, a lower shale 190-220 ft thick and an upper sandstone member at least 450 ft thick. A generalized section through the shale member showed the following sequence, from oldest to youngest: 80-85 ft of black and gray shale, 25 ft of calcareous sandstone, 80-105 ft of partly sandy shale, and 8-10 ft of dark-gray to black, very sandy shale. Several species of bivalves and a gastropod were listed from the shale member. A few bivalves were also listed from a sandy-limestone bed 15-17 ft above the base of the sandstone member. Lasky (*in* Jones et al., 1967: 37) also collected two ammonites, identified by J. B. Reeside, Jr. as *Neoptychites* and *Thomasites,* from the lower part of the sandstone member 2 mi southeast of Fort Bayard (loc. 69).

Collections made by two of us (WAC, SCH) in the Ansones Creek area northeast of Fort Bayard in sec. 24, T17S, R13W (locs. 64, 66, 67) revealed the presence of the upper Cenomanian *Sciponoceras gracile* zone. Two closely spaced beds of limestone concretions in the shale member contain *Euomphaloceras septemseriatum* (Cragin), *Pseudocalycoceras angolaense* (Spath), *Metoicoceras geslinianum* (d'Orbigny), *Allocrioceras annulatum* (Shumard), and *Sciponoceras gracile* (Shumard). Brown-weathering, hard, limy-sandstone concretions in a sandstone bed about 10 ft above the base of the sandstone member contain a large molluscan fauna including *Vascoceras birchbyi* Cobban & Scott and *Fagesia catinus* (Mantell) (locs. 65, 68, 69) of early Turonian age.

Silver City Range

Small outcrops of the Colorado Formation can be seen at many places in the Silver City area, but, owing to extensive intrusives and covered intervals, continuous sections of the formation are few. Finnell (1976) mapped a shale member about 200 ft thick and a sandstone member about 1250 ft thick in the Reading Mountain 7$^{1}/2$ min. quadrangle north of Silver City. The best sections that we have seen are in Schmitt Draw at the northwest edge of Silver City, and in Cane Spring Canyon 10 mi (16 km) northwest of Silver City in the SE¼ sec. 8, T17S, R15W.

In Schmitt Draw, E. R. Landis (written comm. 1970) measured a section of 134 ft of Beartooth Quartzite overlain by the lower 304 ft of the Colorado Formation. The upper 7.5 ft of the Beartooth has small pebbles of quartzite in the lower part, which probably mark the base of the Colorado transgression. Above the Beartooth is 61 ft (18.5 m) of laminated, platy siltstone and silty shale with some beds of silty limestone. This part of the sequence seems equivalent to the flag member of the Cookes Range. The overlying 84 ft (25.6 m) is mostly concealed but includes some very fine-grained limy sandstone in the upper half. A 22 ft (6.7 m) thick unit of silty, fine- to very fine-grained sandstone that contains *Pycnodonte newberryi* (Stanton) in places lies above the largely concealed interval. A partly covered shale unit 86 ft (26 m) thick, lying above the sandstone, is probably the equivalent of the shale above the Bridge Creek Limestone Member of the Cookes Range. *Mytiloides columbianus* (Heinz), of early Turonian age, was collected in the middle of this unit. The next 51 ft (15.5 m) are partly concealed, but include enough sandstone to indicate the lower part of the sandstone member (sandstone and shale member of the Cookes Range). *Fagesia catinus* was found in a limy sandstone 28 ft (8.5 m) above the base (loc. 82). *Vascoceras birchbyi* Cobban & Scott was collected at about this stratigraphic horizon 4.5 mi farther west (loc. 78).

In Cane Spring Canyon the Beartooth Quartzite rests on a paleokarst surface developed on the Lower Mississippian Lake Valley Limestone (Fig. 11) (Chafetz, 1976, 1982). The shale member of the Colorado Formation up through the

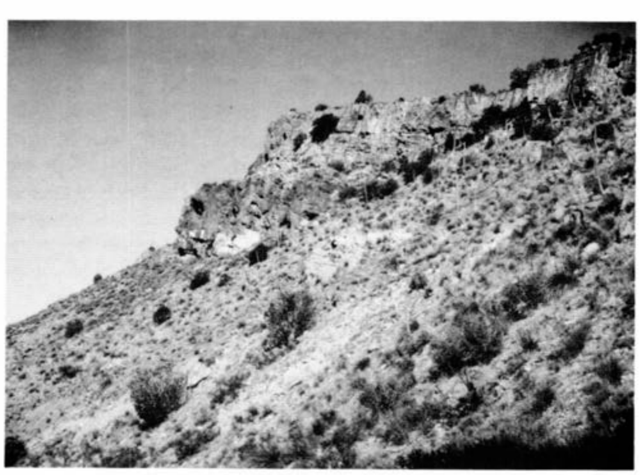

FIGURE 11—Beartooth Quartzite (dark cliff) resting on karst topography developed on the Lower Mississippian Lake Valley Limestone (light cliff) in center of S$^{1}/_{2}$ sec. 8, T17S, R15W, Grant County, New Mexico.

limy sandstone unit is well exposed. Several levels of fossils were found. A single fragment of *a Neostlingoceras kottlowskii* Cobban & Hook was found 10 ft (3 m) above the base (loc. 71), and other ammonites indicative of the zone of *Calycoceras canitaurinum* were found at 25 and 50 ft (7.5, 15.2 m) above the base (locs. 72, 73). A large, distorted specimen of *Calycoceras guerangeri* (Spath) was found higher in the shale (loc. 74), just below the calcareous sandstone unit. The calcareous sandstone, 37 ft (11 m) thick, contains abundant limy-sandstone concretions that contain excellent specimens (locs. 75-81) of *Calycoceras inflatum* sp. nov. and *Metoicoceras mosbyense,* as well as occasional fragments of *Forbesiceras* sp., *Cunningtoniceras novimexicanum* sp. nov., and *C. arizonense* Kirkland & Cobban. The sandstone grades up into a sandy limestone that contains abundant *Pycnodonte newberryi.*

Little Burro Mountains

The Beartooth Quartzite and Colorado Formation are well exposed in Redrock Canyon west of Tyrone in sec. 2, T19S, R15W, and in secs. 27, 28, and 35, T18S, R15W. Little has been published regarding these outcrops. Gillerman (1964: 23), quoting data from a thesis by Edwards (1961), recorded a thickness of only 156 ft and an age of early Turonian based on ammonites and bivalves identified by Keith Young.

The upper part of the Beartooth was examined but not measured by us. A bed of conglomerate, 1-4 in. thick, at the top may represent the beginning of the Colorado transgression. It contains gray chert and quartzite pebbles up to 2 in. in diameter.

A reliable section from the base of the Colorado to the limy-sandstone unit was not measured. The lower part of the shale member consists of the usual hard, platy, flaggy shale about 76 ft (23 m) thick. *Tarrantoceras* sp. and *Metoicoceras* sp. were collected 43 ft (13 m) above the base (loc. 97).

The limy-sandstone unit is at least 10 ft (3 m) thick and consists of argillaceous, poorly bedded, very fine-grained sandstone with gray sandy-limestone concretions. *Metoicoceras mosbyense* was collected (loc. 89). About 13 ft (4 m) of sandy shale separates this sandstone from a younger 3 ft thick zone of small gray-limestone concretions that contain *Pseudaspidoceras pseudonodosoides* (Choffat), *Euomphaloceras costatum* sp. nov., *Burroceras transitorium* gen. et sp. nov., *B. irregulare* sp. nov., *Neocardioceras juddii* (Barrois & de Guerne), *Vascoceras* cf. *gamai* Choffat, *V. barcoicense exile* subsp. nov., *Anisoceras coloradoense* sp. nov., and *Worthoceras* sp. (locs. 85, 100). This zone of concretions is overlain by a thin bed of tan, fine-grained sandstone containing abundant *Pycnodonte newberryi.* About 349 ft (12 m) of sandy shale separates the *P. newberryi* bed from the base of the sandstone member.

The lower 36 ft (11 m) of the sandstone member consist of sandy shale and two beds of sandstone up to 4 ft thick. *Fagesia catinus* (Mantell) was found in the basal bed (loc. 86). Above this lower unit of shale and sandstone is a 38 ft (11.6 m) thick sandstone that contains brown-weathering, fossiliferous, sandstone concretions at the top. Well-preserved *Fagesia catinus* and *Vascoceras birchbyi* Cobban & Scott were collected along with rare fragments of *Neoptychites* and *Thomasites* (locs. 87, 88, 90). A variety of bivalves and gastropods also occur in these concretions. At least 45 ft (13.7 m) of sandy shale and sandstone overlie the fossiliferous sandstone, but no fossils were observed. A little higher are volcaniclastic rocks of Late Cretaceous or early Tertiary age (Hedlund, 1978).

Big Burro Mountains

The Beartooth Quartzite and Colorado Formation are exposed at many places around the northern end of the Big Burro Mountains (Fig. 1). Detailed descriptions have not been given. Cunningham (1966) mentioned the occurrence of a vertebrate fossil along with two bivalve species and two cephalopod species, but generic and specific names were not provided.

The Beartooth, of variable thicknesses, rests unconformably on Precambrian granite. Near the head of Jack Canyon in the SW1/4NE1/4 sec. 11, T18S, R18W, rocks that we interpret as Beartooth are as little as 14 ft (4.3 m) thick and consist of light-gray, thick-bedded quartzitic sandstone and olive-gray, hard claystone. Resting on these rocks is 4-7 in. of conglomerate (Fig. 12) that we regard as the base of the Colorado transgression. Pebbles consist of light- and dark-gray chert and quartzite up to 1 in. in diameter. This conglomerate is overlain by 4 ft of fine-grained, argillaceous sandstone. The next 45 ft (13.7 m) consist of hard, calcareous shale with a concretion-bearing unit of shale 7.5-12.5 ft above the base. Ammonites in these concretions consist of *Moremanoceras* sp., *Tarrantoceras* sp., and *Hamites sp.* (loc. 148). The 45 ft shale is the equivalent of the flag member farther east.

A small covered interval separates the flag member from a 15 ft thick bed of sandy limestone that represents a fossil coral thicket. This thicket is well exposed in Jack Canyon in the NE¼ sec. 11, T18S, R18W, and in Clyde Canyon near the center of the east line of sec. 10, T18S, R18W (Fig. 13). Much of the rock is made up of fragments of branches of *Archohelia dartoni* Wells (1933) (Fig. 14). This sandy coral thicket seems to be a facies of the limy-sandstone unit in the lower shale member of the Colorado Formation of the Silver City Range. In the uppermost part of this thicket and just above it are limestone concretions that contain *Pseudocalycoceras angolaense* (Spath), *Metoicoceras geslinianum* (d'Orbigny), *Sciponoceras gracile* (Shumard), and other upper Cenomanian fossils (locs. 138, 139, 145). About 4 or 5 ft higher is a bed of limestone concretions that contain a fauna characterized by *Burroceras clydense* gen. et sp. nov., *Paravascoceras minutum* gen. et sp. nov., and *Vascoceras barcoicense exile* subsp. nov. Four feet above this bed is a 5 ft thick unit of shale that contains four beds of limestone concretions with a *Neocardioceras juddii*—*Pseudaspidoceras pseudonodosoides* fauna of very late Cenomanian age. Hiatus concretions represent the highest bed. Poorly preserved internal molds of *Quitmaniceras reaseri* Powell have been found just above the hiatus concretions 1 mi east of Jack Canyon (locs. 153, 154) and farther northeast at Foxtail Creek (loc. 123). This species, which is characteristic of the lowest Turonian zone of

FIGURE 12—Seven-inch-thick bed of conglomerate (at hammer) at base of Colorado Formation resting on Beartooth Quartzite near head of Jack Canyon in the SW¼NE¼ sec.11, T18S, R18W, Grant County, New Mexico.

Pseudaspidoceras flexuosum, represents the youngest ammonite known from the Big Burro Mountains. At Clyde Canyon, in the N½ secs. 10 and 11, T18S, R18W, at least 75 ft (23 m) of marine shale lies above the hiatus concretions, but only the early Turonian bivalve *Mytiloides columbianus* (Heinz) has been found in these beds. Hewitt (1959: 81) estimated a thickness of 1100 ft (335 m) for the Colorado in this area.

The lower part of the sandstone member is exposed farther east in the Wild Horse Canyon area in the N½ sec. 11,

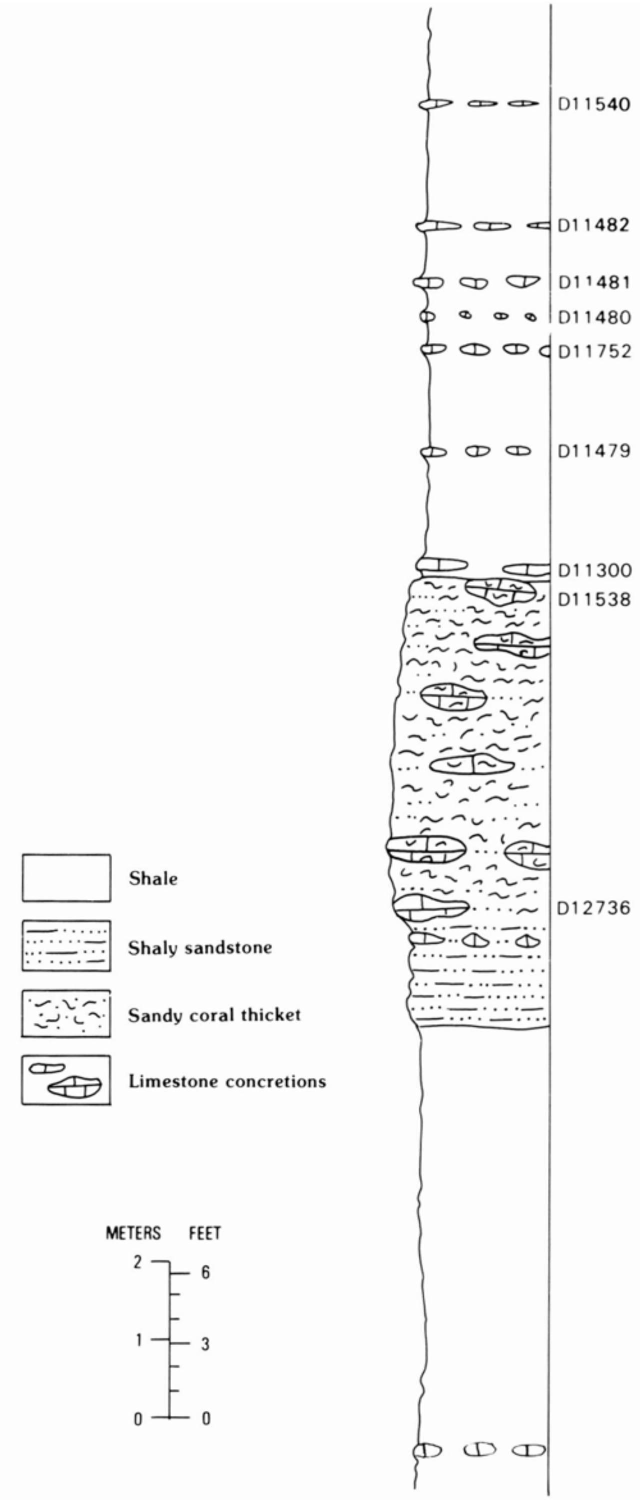

FIGURE 13—Columnar section of the coral thicket and adjacent beds in the shale member of the Colorado Formation in the area of Jack Canyon and Clyde Canyon in the NE¼ sec. 10 and NE¼ sec. 11, T18S, R18W, Grant County, New Mexico.

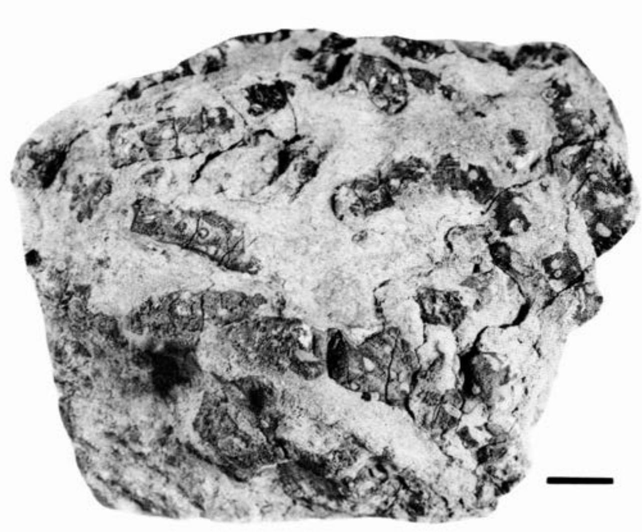

FIGURE 14—Fragments (dark) of the branching coral *Archohelia dartoni* Wells in a light-gray matrix of sandy limestone from a coral thicket in Clyde Canyon near the center of the west line of sec. 11, T18S, R18W, Grant County, New Mexico. USNM 425124. Natural size.

T18S, R17W. Here sandstone concretions contain poorly preserved molluscan fossils including *Mytiloides columbianus* and *Vascoceras birchbyi (loc.* **111).**

Virden area

Cretaceous rocks crop out in a small area northeast of Virden (Fig. 1, locs.155-168). The basal part of the sequence is well exposed along Riley Canyon in NW¼ sec. 21, T18S, R2OW (Fig. 15). Here the Colorado Formation rests unconformably on Precambrian granite. The basal 36 ft (11 m) of the Colorado is chiefly fine- to very fine-grained, thin-bedded, ledge-forming sandstone and siltstone. A poorly preserved impression of *Calycoceras* sp. was found 21 ft (6.4 m) above the base (loc. 162). The basal sandy unit is overlain by 31 ft (9.4 m) of silty shale that contains in its upper part a few thin concretionary beds. A flattened fragment of *Eucalycoceras pentagonum* (Jukes-Browne) was found in this upper part (loc. 163). A concretion-bearing unit of shale 55 ft (16.7 m) thick overlies the silty shale unit. Limestone concretions at the base (Fig. 14, loc. 164) contain *Metoicoceras geslinianum* (d'Orbigny), and this ammonite also occurs in a conspicuous, orange-weathering, hard sandstone bed 9 ft higher (loc. 165), which contains abundant small gray-limestone concretions and fragments of concretions. Higher in the concretion unit, a specimen of *Euomphaloceras costatum* sp. nov. was collected (loc. 167), and near the top *Pseudaspidoceras pseudonodosoides* (Choffat) was found (loc. 168). Hiatus concretions (Hook & Cobban, 1981) lie at the top of the unit. At least 75 ft (23 m) of olive-gray shale that contains many thin, brown-weathering lenses and concretions of silty limestone overlies the concretion unit in Riley Canyon. Fossils were not observed.

The Colorado Formation is also exposed 1 mi or less northwest of the outcrops in Riley Canyon. An elongated limestone concretion (Fig. 16) just above a thin white-claystone bed in the lower part of the formation yielded a varied fauna of *Moremanoceras scotti* (Moreman), *Cunningtoniceras* sp., *Euomphaloceras merewetheri* sp. nov., *Metoicoceras mosbyense* Cobban, *Hamites* cf. *simplex* d'Orbigny, *H. salebrosus* sp. nov., and *Metaptychoceras hidalgoense* sp. nov. (loc. 159). This important collection is probably from the stratigraphic position of the claystone bed shown in Fig. 15 nearly mid-

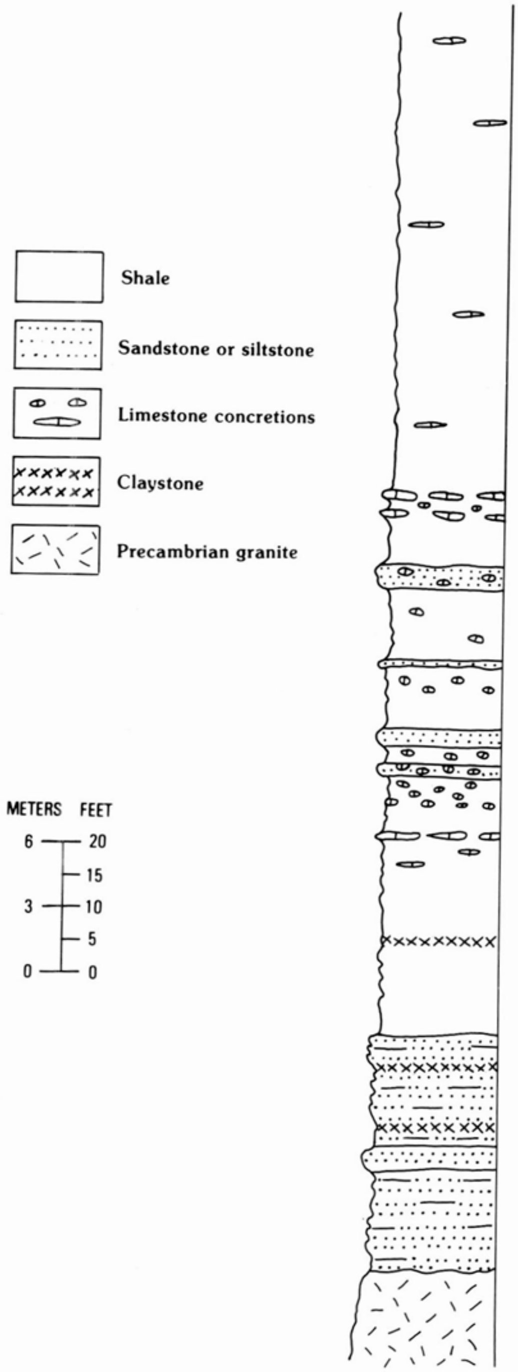

FIGURE 15—Columnar section of the lower part of the Colorado Formation resting on Precambrian granite northeast of Virden in the NW¼ sec. 21, T18S, R20W, Hidalgo County, New Mexico.

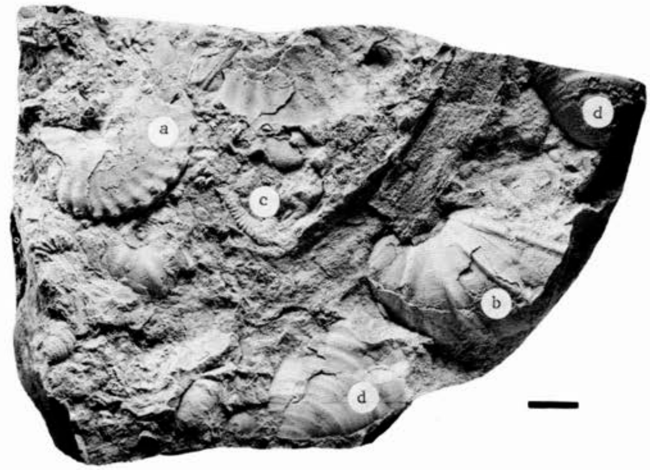

FIGURE 16—Part of a concretion from loc. 159 in the Virden area; A, inner whorls of *Metoicoceras mosbyense* Cobban, B, *Moremanoceras scotti* (Moreman), C, *Hamites* cf. *simplex* d'Orbigny, D, *Inoceramus* sp., E, plant stem. USNM 425123. Natural size.

STAGE		AMMONOID ZONE
Turonian	Lower	*Mammites nodosoides*
		Vascoceras birchbyi
		Pseudaspidoceras flexuosum
Cenomanian	Upper	*Neocardioceras juddii*
		Burroceras clydense
		Sciponoceras gracile
		Metoicoceras mosbyense
		Calycoceras canitaurinum

FIGURE 17—Ammonoid zonation in the marine part of the Colorado Formation of southwestern New Mexico.

way between the basal sandstone unit and the concretion-bearing unit.

In the area northwest of Riley Canyon about 88 ft (27 m) of shale separate the concretion-bearing unit of the shale member from the base of the sandstone member. Brown-weathering sandstone concretions in a 7 ft thick shaly sandstone and siltstone unit 45-52 ft (14-16 m) above the base contain a varied bivalve fauna including *Mytiloides columbianus* (Heinz) of early Turonian age.

Ammonite zonation

Ammonites from the Colorado Formation can be fitted into the zonal scheme already established for the southern part of the Western Interior (Cobban, 1984a, fig. 2), with the addition of a new zone of *Burroceras clydense.* The sequence of ammonoid zones is shown in Fig. 17. A gap in the sequence is indicated at the top of the Cenomanian between the zones of *Neocardioceras juddii* and *Pseudaspidoceras flexuosum.* Throughout southwestern New Mexico, rocks at the top of the Cenomanian contain hiatus concretions that lie at an abrupt lithologic change from clayey, calcareous rocks to sandy, poorly calcareous to noncalcareous rocks. This break in the sequence is filled in southeastern Colorado by a zone of *Nigericeras scotti,* which contains inoceramids of Cenomanian aspect.

Systematic paleontology

All dimensions are given in millimeters, with D = diameter, Wb = whorl breadth, Wh = whorl height, Wb:Wh = whorl breadth to height ratio, and U = umbilical diameter. Figures in parentheses are percentages of the diameter; c = costal, is = intercostal. Suture terminology is that of Wedekind (1916) as propounded by Kullmann & Wiedmann (1970).

In the suture drawings, the heavy straight line marks the venter or the position of the siphuncle, the lighter solid curved line marks the umbilical seam, and the dashed curved line marks the umbilical shoulder. Some suture drawings have, in addition, the positions of tubercles and ribs marked by lines of short dashes. In drawings of whorl sections, the solid line represents the costal section and the dashed line marks the intercostal section.

Repositories of specimens are as follows: USNM, National Museum of Natural History, Washington, D.C.; AMNH, American Museum of Natural History, New York: MNA, Museum of Northern Arizona, Flagstaff; TMM, Texas Memorial Museum, Austin; BMNH, British Museum (Natural History), London; MNHP, Museum d'Histoire Naturelle, Paris.

Class CEPHALOPODA Cuvier, 1797
Order AMMONOIDEA Zittel, 1884
Suborder AMMONITINA Hyatt, 1889
Superfamily HAPLOCERATACEAE Zittell, 1884
Family BINNEYITIDAE Reeside, 1927
Genus *BORISSIAKOCERAS* Arkhanguelsky, 1916

Type species-By original designation, *Borissiakocera: mirabilis* Arkhanguelsky, 1916, p. 55, pl. 8, figs. 2, 3.

Diagnosis-This small genus is characterized by its greatly compressed whorl section, rounded to flat venter, fairly small umbilicus, and nearly smooth shell. Sutures are crowded and little incised; lobes are unusually narrow, anc saddles are broad with the second lateral saddle being much higher than the first.

Occurrence-Borissiakoceras is known from many locali• ties of middle to late Cenomanian age in the Western In terior. The genus may range up into the lower Turonian Outside North America, *Borissiakoceras* has been recordec from France, U.S.S.R., Africa (Zululand), Australia, anc possibly New Zealand.

BORISSIAKOCERAS sp.
Fig. 96C

Material-A single impression of a small, involute, corm pressed ammonite that has a well-defined ventrolatera shoulder seems assignable to *Borissiakoceras.* The impression (Fig. 96C) has a diameter of 19 mm and an umbilicus of mm (ratio of 0.17). The umbilical shoulder is well rounded, the flanks are flat and smooth, and the venter appears to be flattened.

Discussion-The impression resembles *Borissiakoceras or biculatum* Stephenson (1955: 64, pl. 6, figs. 1-4) in its flat, smooth flanks and well-defined ventrolateral shoulder, but that species has a wider umbilicus (ratio of 0.22 for the holotype).

Occurrence-The specimen is from a silty limestone bed in the flag member of the Colorado Formation in the Cooke Range (loc. 53). Associated fossils include *Inoceramus prefragilis* Stephenson and *Neostlingoceras kottlowskii* Cobban & Hook, which suggest the lower upper Cenomanian zone of *Calycoceras canitaurinum.*

Superfamily DESMOCERATACEAE Zittel, 1895
Family DESMOCERATIDAE Zittel, 1895
Subfamily DESMOCERATINAE Zittel, 1895
Genus *MOREMANOCERAS* Cobban, 1972

Type species-By original designation, *Desmoceras scotti* Moreman, 1942, p. 208, pl. 33, fig. 8, text-fig. 2d. *Discussion-Desmoceras (Moremanoceras)* was proposed originally (Cobban, 1972: 5) as a subgenus of *Desmoceras* Zittel (1895), from which it differs chiefly in that it has a simpler suture with much broader L and shorter auxiliary lobes. The present investigation confirms observations of Kennedy, Cobban & Hook (1988) that *Moremanoceras* of late Cenomanian age was derived from a middle Cenomanian form that has a siphonal ridge in middle and late growth stages and *a Moremanoceras* suture, and that is then derived from ribbed and constricted middle Cenomanian *M. straini* Kennedy, Cobban & Hook, 1988. Accordingly, *Moremanoceras* seems so far removed from *Desmoceras* as to justify raising the former to full generic rank and amending the definition to include forms with a siphonal ridge as well as those without it. In addition, *Moremanoceras* differs from *Desmoceras* in usually having three or four auxiliary lobes instead of five or six. *Damesites* Matsumoto, 1942, resembles *Moremanoceras in* its general appearance, but *Damesites* has a narrower keel and a suture characterized by a narrower L and by six or seven auxiliary lobes. The origin of *Moremanoceras* is not known, but presumably it came from some *Desmoceras* of late Albian or early Cenomanian age. The earliest *Moremanoceras* is the very small middle Cenomanian ammonite described as *Desmoceras (Pseudouhligella) elgini* Young, 1958 (p. 292, pl. 39, figs. 4-20, 24, 25, 30, 31; text-fig. 1a-e) from the base of the Boquillas Limestone in Trans-Pecos Texas. The external suture illustrated by Young (1958, text-fig. la) shows a simple, broad, trifid L much like that of *Moremanoceras.* Other specimens from Texas that may be Young's species were identified as *Desmoceras?* sp. by Stephenson (1953: 197, pl. 45, figs. 1-4; 1955: 58, pl. 4, figs. 12, 13).

MOREMANOCERAS SCOTTI (Moreman, 1942)
Figs. 18, 64L-Z

1927. *Pachydiscus* sp. A, Moreman, p. 94, pl. 15, fig. 4.
1942. *Tragodesmoceras scotti* Moreman, p. 208, pl. 33, fig. 8, text-fig. 2d.
1960. *Onitschoceras? scotti* (Moreman): Matsumoto, p. 46, text-fig. 10A-C.
1972. *Desmoceras (Moremanoceras) scotti* (Moreman): Cobban, p. 6, pl. 2, figs. 1-23, text-figs. 3-5.
1977. *Desmoceras (Moremanoceras) scotti* (Moreman): Kauffman, pl. 16, figs. 1, 2.
1986. *Moremanoceras scotti* (Moreman): Cobban, fig. 3a, b.
1988. *Desmoceras (Moremanoceras) scotti* (Moreman): Kennedy, p. 22, pl. 1, figs. 1-13.

Types-Hypotypes USNM 425126-425132.

Diagnosis-This species has a well-rounded venter with no trace of a siphonal ridge. Thick, rounded falcoid ribs, numbering about six per half whorl, bound the adapical side of constrictions. These ribs, which begin at or near the umbilical shoulder, are highest on crossing the venter, where they arch forward a little. Striae are abundant between the ribs and parallel them. An occasional specimen lacks the thick periodic ribs and has instead weak, closely spaced ribs (Cobban, 1972, pl. 2, figs. 12-14). The suture, which has been figured by Matsumoto (1960, text-fig. 10C) and Cobban (1972, text-fig. 3A, *B),* has a broad, trifid L and usually four or five much smaller auxiliary lobes.

Discussion-Moremanoceras scotti has been found in the Bridge Creek Limestone Member of the Colorado Formation in the Cookes Range and farther west near Virden. The species also occurs in the basal bed of the Bridge Creek Member of the Greenhorn Limestone near Capitan, New Mexico. Specimens from the Cookes Range range in diameter from 8 to 93 mm. The largest individual (Fig. 64Y, Z) is a crushed adult that has three-fourths of a whorl of body chamber. Ribs number 10 on the last half whorl. Another specimen from the Cookes Range, 60 mm in diameter, may be an unusually small and slender adult that has about three-fourths of a whorl of body chamber (Fig. 64P, W, X).
The external suture is also unusual in having only three auxiliary lobes (Fig. 18).

Occurrence-Only three specimens of M. *scotti* have been illustrated previously from the Western Interior. One came from the basal part of the Mancos Shale in the Black Mesa area of northeastern Arizona (Cobban, 1972: 7, pl. 2, figs.

FIGURE 18—Most of the external suture at a whorl height of 18 mm of *Moremanoceras scotti* (Moreman) from the Bridge Creek Limestone Member of the Colorado Formation at loc. 20 in the Cookes Range. USNM 425128 (Fig. 64P, W, X).

18, 19), one from the base of the Bridge Creek Member of the Greenhorn Limestone in southeastern Colorado (Cobban, 1972: 7, pl. 2, figs. 22, 23), and the last one from the base of the Bridge Creek Limestone Beds of the Mancos Shale in south-central New Mexico (Cobban, 1986, fig. 3A, B). An unusually large but badly crushed specimen 86 mm in diameter was found in 1942 in the Greenhorn Limestone Member at USGS Mesozoic locality 18864 about 27 km south of Santa Fe, New Mexico. The species was recorded later from that area (Coates & Kauffman, 1973, text-fig. 3). Outside New Mexico, M. *scotti* has been found in the Benton Shale in the Middle Park area of north-central Colorado. In Wyoming, the species has been found in the Greenhorn Formation on the west flank of the Black Hills and farther west in the Frontier Formation on the west margin of the Powder River Basin. Most specimens of M. *scotti* have come from the *Sciponoceras gracile* zone. A few specimens have been found slightly below it in southwestern New Mexico (loc. 17). The species has been found also in the Twowells Tongue of the Dakota Sandstone near the middle of the eastern boundary of Arizona, in the basal part of the Mancos Shale in the Black Mesa area of northeastern Arizona, in the Benton shale of north-central Colorado, in the Frontier Formation in south-central and north-central Wyoming, and in the Belle Fourche Shale along the west side of the Black Hills in northeastern Wyoming.

In southwestern New Mexico, M. *scotti* has been found in the Bridge Creek Limestone Member of the Colorado Formation in the Cookes Range (locs. 10, 15, 17, 20, 40) and in the shale member of the Colorado Formation near Virden (loc. 159). Associated fossils include *Sciponoceras gracile* of late Cenomanian age.

MOREMANOCERAS COSTATUM sp. nov.

Figs. 19, 64A-K, 65A-D, G, H

1964. *"Puzosia"* n.sp., Robinson, Mapel & Bergendahl, p. 59. 1964. *Puzosia (Latidorsella)* n.sp., Robinson, Mapel & Bergendahl, p. 63.
1975. *Desmoceras* (s.1.) sp., Hattin, pl. 2, fig. P.
1977. *Desmoceras?* s.l. sp., Kauffman & Powell, p. 101, pl. 9, figs. 2, 6.
1981. *Damesites* n. sp., Cobban & Hook, pp. 24-26.
1984b. *Moremanoceras* sp., Cobban, p. 18, pl. 4, figs. 12, 16, pl. 5, fig. 7.

Types—Holotype USNM 425133, from the Colorado Formation at loc. 33 in the Cookes Range, Luna County, New Mexico, late Cenomanian zone of *Calycoceras canitaurinum.* Paratypes USNM 423683, 425134-425142.

Dimensions	D	Wb	Wh	Wb:Wh	U
USNM 425133 (Holotype)	50.0(100)	22.6(45.2)	26.0(52.0)	0.87	5.4(10.8)
USNM 423683 (Paratype)	58.0(100)	28.0(48.3)	32.5(56.0)	0.86	5.0(8.6)

Description—This stout, involute species is characterized by its broad, well-defined siphonal ridge and conspicuous arcuate ribs on the outer half of the flank. Whorls are compressed, with flattened flanks and rounded venter raised into a low, broad keel. Maximum whorl breadth is at about midflank. The umbilicus is small and deep, with narrowly rounded shoulder. Ornament consists of low, broad ribs that arise near midflank, curve back at first, and then bend forward and either disappear at the base of the siphonal ridge or cross it. Rib counts per whorl, which could be made on only two specimens in the type lot, gave 33 and 37. Many specimens have constrictions or raised ribs or both that follow the course of the ribs. A raised rib may bound the adapical side of a constriction.

The holotype (Fig. MD, E) is a phragmocone 50 mm in diameter, which has an umbilical width of 5.4 mm (11%) and a whorl height of 26 mm. Ribs number about 33 per whorl. Only parts of the suture are visible. A much better preserved suture of a specimen from the lower part of the Greenhorn Formation on the west side of the Black Hills in the southeast corner of Montana is shown in Fig. 19. This suture has a large, broad, trifid L and only three much smaller auxiliary lobes.

The holotype and three figured paratypes (Fig. 64A-E, K) came from a lot of 25 specimens from limestone concretions in the lower part of the Colorado Formation at loc. 33 in the Cookes Range. An unfigured paratype (USNM 425139) from this locality includes part of a body chamber that has a diameter of 48 mm at its base.

A late form of this species from loc. 70 in the Fort Bayard area has reduced ribbing, but still retains a prominent siphonal ridge (Fig. 65A-D, G, H).

Discussion—*Moremanoceras costatum* differs from the younger M. *scotti* (Moreman, 1927: 94, pl. 15, fig. 4; 1942: 208, pl. 33, fig. 8) chiefly in having a siphonal ridge or keel. *Moremanoceras elgini* (Young, 1958: 292, pl. 39, figs. 4-20, 24, 25, 30, 31), which is older than M. *costatum,* was based on very small specimens that are probably juveniles. The suture of one of these small specimens figured by Young (1958, text-fig. la) is typical of *Moremanoceras* in having a broad L and a few much smaller auxiliary lobes. *Moremanoceras straini* Kennedy, Cobban & Hook (1988), from the middle Cenomanian zone of *Acanthoceras amphibolum,* has a weak siphonal ridge, but lacks the ribbing of M. *costatum.* Specimens from the zone of *A. amphibolum* were figured *as Desmoceras (Pseudouhligella)* aff. *D. japonicum* Yabe (Cobban, 1977a: 22, pl. 11, figs. 1-6, 9, 10).

Moremanoceras costatum is a Cenomanian homeomorph of the Turonian *Tragodesmoceroides subcostatus* Matsumoto (1942:

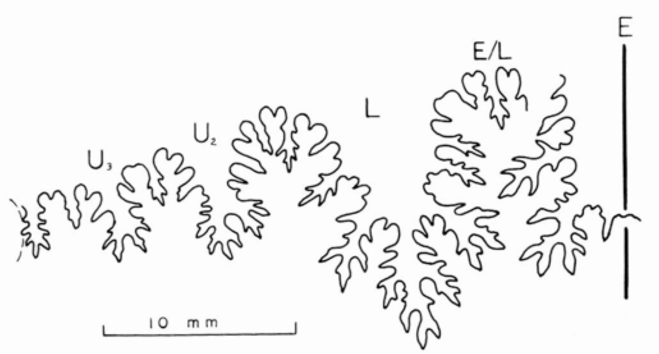

FIGURE 19—Second from last external suture of *Moremanoceras costatum* sp. nov., from the base of the Greenhorn Formation at USGS Mesozoic loc. 12740 in NE¼ sec. 6, T9S, R59E, Carter County, Montana. This specimen (Fig. 64F, H, I) was listed as *Puzosia* (*Latidorsella*) n. sp. (Robinson et al., 1964: 63). Paratype USNM 423683.

25, fig. 1d) of Japan. Both are stout, involute forms with falcoid ribs on the outer half of the flank that project forward on the venter and cross a siphonal ridge. The ribbing on the Japanese form, however, projects forward much more than that on M. *costatum,* and the sutures are entirely different.

Occurrence—Moremanoceras costatum occurs in the lower upper Cenomanian zone of *Calycoceras canitaurinum.* The holotype was associated with *Inoceramus prefragilis* Stephenson, *C. canitaurinum* (Haas), *Cunningtoniceras arizonense* Kirkland & Cobban, *Metoicoceras aff. praecox* Haas, *Hamites cimarronensis* Kauffman & Powell, and *Neostlingoceras kottlowskii* Cobban & Hook.

Aside from the Cookes Range, where the species occurs in limestone concretions and in siltstone beds in the lower shale member of the Colorado Formation (locs. 29, 30, 31, 33, 34, 53, 55), M. *costatum* has been found in New Mexico only in a bed of concretionary limestone in the lower part of the Mancos Shale at locality D10517 in the Sierra Cuchillo northwest of Truth or Consequences. Outside New Mexico, the species occurs in the lower part of the Hartland Shale Member of the Greenhorn Limestone in western Oklahoma (Kauffman & Powell, 1977: 101, pl. 9, figs. 2, 6), in the Lincoln Member of the Greenhorn Limestone in central Kansas (Hattin, 1975, pl. 2, fig. P), in the Benton Shale of north-central Colorado, in the basal part of the Greenhorn Formation and upper part of the underlying Belle Fourche Shale in the Black Hills area (Robinson et al., 1964, locs. 12650 and 12651 on p. 59, and loc. 12740 on p. 63, all recorded *as "Puzosia"* n.sp.), and in the Frontier Formation in south-central and north-central Wyoming.

MOREMANOCERAS sp. nov.
Fig. 72N, 0

Material—Figured specimen USNM 423692, from the shale member of the Colorado Formation at loc. 159 near Virden.

Description—The specimen consists of a little more than a quarter of a whorl of a stout phragmocone that has a whorl height of 24.8 mm and a breadth of 26.2 mm. The umbilicus is not preserved. Flanks and venter are broadly rounded. Ornament consists of closely spaced ribs that begin a little below the middle of the flank; they become strongest at the ventrolateral shoulder and then weaken on crossing the venter. The ribs are sinuous and bend forward a little on crossing the venter; they probably numbered about 16 per half whorl. The suture closely resembles that of M. *costatum* sp. nov. (Fig. 19).

Discussion—This specimen resembles M. *costatum* sp. nov. in that both have closely spaced ribs on the outer part of the flank, but the ribs are more projected on the venter of M. *costatum.* The Virden specimen lacks the raised siphonal ridge of M. *costatum,* and in this respect it resembles M. *scotti* (Moreman). The ornament of the latter, however, is quite different.

Occurrence—Moremanoceras sp. nov. is known in southwestern New Mexico only from this one specimen. Associated fossils include M. *scotti* (Moreman) and *Metoicoceras mosbyense* Cobban, which indicate a position high in the zone of M. *mosbyense.*

Superfamily HOPLITACEAE H. Douvillé, 1890
Family PLACENTICERATIDAE Hyatt, 1900
Genus *PLACENTICERAS* Meek, 1876

Type *species—Ammonites placenta* DeKay, 1828, p. 278, by original designation by Meek, 1876, p. 462.

Diagnosis—This genus includes ammonites that are typically compressed and very involute, and have at most growth stages a narrow, flattened venter. Many auxiliaries characterize the suture. Kennedy & Wright (1983) treated the genus and family in depth and pointed out the importance of sexual dimorphism.

Occurrence—The genus is widely distributed over much of the world in rocks of late Cenomanian to Maastrichtian age. In North America, the last *Placenticeras* disappeared in the lower Maastrichtian zone of *Baculites reesidei* Elias.

Subgenus *KARAMAITES* Sokolov *in* Casey, 1965

Type species—By original designation, *Placenticeras grossouvrei* Semenov, 1899, p. 97.

Diagnosis—This form, treated herein as a subgenus, was proposed as a genus for early placenticeratids that have the fourth lateral lobe smaller than the fifth (Fig. 20), whereas *in Placenticeras (Placenticeras),* the opposite is true.

Occurrence—This subgenus is known from upper Albian through Cenomanian rocks in Europe, central Asia, and in the Gulf Coast and Western Interior of the United States.

PLACENTICERAS (KARAMAITES) CUMMINS' Cragin
Figs. 20, 75A–E, %Z

1893. *Placenticeras syrtalis* Morton var. *cumminsi* Cragin, p. 237.

1894. *Placenticeras placenta* DeKay?: Stanton, p. 169 (pars), pl. 39, figs. 2, 3 only.

1903. *Placenticeras stantoni* Hyatt, p. 214.

1903. *Placenticeras stantoni* var. *bolli Hyatt,* p. 214, pl. 40, figs. 3-7, pl. 41, figs. 1-7, pl. 42, figs. 1, 2, p1. 43, figs. 1, 2.

1903. *Placenticeras pseudoplacenta Hyatt,* p. 216 *(pars).*

1903. *Placenticeras pseudoplacenta* var. *occidentale Hyatt,* p. 217 *(pars),* pl. 45, fig. 2 only.

1910. *Placenticeras stantoni* Hyatt: Grabau & Shimer, p. 219, fig. 1496c, d.

1928. *Placenticeras cumminsi* Cragin: Adkins, p. 253.

1942. *Proplacenticeras cumminsi* (Cragin): Moreman, p. 219.

1942. *Proplacenticeras stantoni* var. *bolli* (Hyatt): Moreman, p. 219.

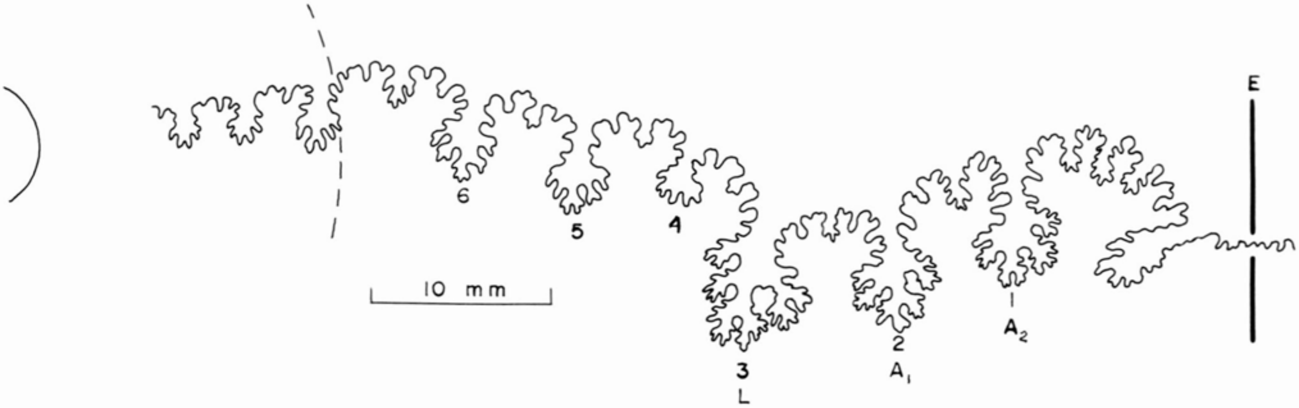

FIGURE 20—External suture at a diameter of 106 mm of *Placenticeras* (*Karamaites*) *cumminsi* Cragin, from the Britton Formation at USGS Mesozoic loc. 22604 about 2½ miles (4 km) northeast of Britton, Ellis County, Texas. Lateral lobes are numbered 1 to 6, although 3 would be usually referred to as the lateral lobe and 1 and 2 would be auxiliary lobes. USNM 411451.

1942. *Proplacenticeras pseudoplacenta* var. *occidentale (Hyatt):* Moreman, p. **219.**

1988. *Placenticeras cumminsi* Cragin: Kennedy,. 26, pl. 1, figs. 29-36, pl. 3, figs. 10-15, text-figs. 9, 10A, C, G, 11C, 12-19.

Types-Holotype, TMM 21679, from the upper Cenomanian Britton Formation on Hackberry Creek, Dallas County, Texas. Hypotypes USNM 425143-425145.

Description-Cragin's types are from the zone of *Sciponoceras gracile* **in the Britton Formation of north Texas. Large collections at hand of** *P. cumminsi* **from the Britton Formation reveal sexual dimorphism with large, slender, more or less smooth forms (macroconchs) and smaller, stouter, ornamented forms (microconchs).**

The largest specimen (Fig. 96Z) of *P. cumminsi* **from southwestern New Mexico is a macroconch 295 mm in diameter, with an umbilical ratio of 0.12, from the Bridge Creek Limestone Member of the Colorado Formation in the Cookes Range at loc. 2. The specimen is an internal mold, one side of which is badly corroded. The body chamber occupies little more than half a whorl. Parts of the phragmacone are missing; its diameter at the base of the body chamber is estimated at 225 mm. The specimen is entirely smooth. In the suture, the fourth lateral lobe is smaller than the fifth, which is typical of the subgenus** *Karamaites.*

Other specimens from southwestern New Mexico are only fragments, and most are from juveniles. All have compressed whorl sections with sharp ventrolateral shoulders and narrow, slightly concave venters. Some are smooth, and others have low, broad, concave ribs on the outer part of the flank that terminate in long, low clavi alternating in position across the venter.

Occurrence-Most specimens from southwestern New Mexico are from the zone of *Sciponoceras gracile* **(Cookes Range locs. 2, 15, 17; Virden area loc. 156), the zone of** *Burroceras clydense* **(Big Burro Mountains locs. 141, 142), and the zone of** *Neocardioceras juddii* **(Big Burro Mountains loc. 134). A few nonseptate fragments of** *Placenticeras* **that could be** *P. cumminsi* **have been found in the Virden area (locs. 156, 158).**

Superfamily ACANTHOCERATACEAE de Grossouvre, 1894
Family FORBESICERATIDAE Wright, 1952
Genus *FORBESICERAS* Kossmat, 1897

Type *species-Ammonites largilliertianus* **d'Orbigny, 1841: 320, pl. 95; by subsequent designation by Diener, 1925: 180.**

Remarks-The genus and the family Forbesiceratidae have been treated in detail by Wright & Kennedy (1984: 80-96), and the reader is referred to their work. The genus ranges throughout the Cenomanian.

FORBESICERAS sp.
Figs. 21, 66A, B

Material-Figured specimens USNM 425146-425150.

Description-Fragments of internal molds of 16 specimens of a large species of *Forbesiceras* **were collected from the Colorado Formation at two localities in the Cookes Range and at one near Silver City. The specimens are smooth and compressed, with a whorl breadth to height ratio of 0.35. Four specimens (USNM 425146-425149) have whorl heights of approximately 157, 170, 182, and 198 mm at the end of the phragmocone. In** their large size, cress **section, smoothness, and suture, these specimens match the large specimens of** *Forbesiceras bicarinatum* **Szász (1976: 170, pls. 1-3, text-figs. 1, 2) from the Cenomanian of the southern Carpathians in Romania, as well as the large phragmocone from western France figured as** *Forbesiceras* **sp. aff.** *largilliertianum* **(d'Orbigny) by Kennedy, Juignet** *&* **Hancock (1981: 39, figs. 7, 10A, B). However, none of the New Mexican specimens reveals the bicarinate venter of the Romanian specimens; instead, they have a narrowly rounded venter on the internal mold. Cooper (1973: 48-50) described large, weathered internal molds from Angola that are much like the specimens from the Cookes Range in their size and preservation. The Angola specimens were assigned to** *F. obtectum* **Sharpe (1853: 20, pl. 7, figs. 4 a-c). Sutures (Fig. 21) of the Cookes Range specimens are typical of the genus and resemble those figured by Szász (1976, figs. 1, 2), Kennedy et al. (1981, fig. 10B), and Cooper (1973, fig. 5).**

FIGURE 21—Last external suture at a whorl height of about 115 mm of *Forbesiceras* sp. from the Colorado Formation at loc. 14 in the Cookes Range, Luna County, New Mexico. USNM 425150.

Occurrence-All but one of the specimens are from a calcareous shale unit in the Colorado Formation a little below the Bridge Creek Member at locs. 6, 14, and 26 in the Cookes Range. A single fragment of a large phragmocone was found at loc. 75 near Silver City. All specimens are from a little below the lowest occurrence of *Metoicoceras geslinianum* **(d'Orbigny).**

Family ACANTHOCERATIDAE de Grossouvre, 1894
Subfamily ACANTHOCERATINAE de Grossouvre, 1894 Genus *CUNNINGTONICERAS* Collignon, 1937

Type species-By original designation, *Ammonites cunningtoni* **Sharpe, 1855, p. 35, pl. 15, fig. 2.**

Diagnosis-Collignon (1937: 64) proposed this genus for ammonites having a quadrangular whorl section; umbilical, inner and outer ventrolateral and siphonal tubercles; and the venter with multiplication of the ribs and tubercles or with just ribs or tubercles only. Ornament weakens with age except for the inner ventrolateral tubercles which enlarge. Collignon assigned to this genus the species *Ammonites cunningtoni* **Sharpe, 1855,** *A. meridionale* **Stoliczka, 1865 and the varieties** *africana* **Pervinquiere, 1907 and** *tuberculata* **Pervinquiere, 1907,** *Acanthoceras cunningtoni* **var.** *inermis* **Pervinquiere, 1907 and var.** *cornuta* **Kossmat, 1897,** *A. diadema* **Spath, 1926a,** *A. lonsdalei* **Adkins, 1928,** *A. latum* **Crick, 1907,** *A. quadratum* **Crick, 1907, and** *A. aberrans* **Kossmat, 1896.**

Discussion-Cu *nningtoniceras* **has been regarded as a synonym of** *Euomphaloceras* **by Wright & Wright (1951: 29) and subsequent authors including Collignon. Of the species referred to** *Cunningtoniceras* **by Collignon (1937: 64),** *Acanthoceras aberrans* **Kossmat (1895: 202, pl. 24, fig. 4a-c) has been made the type of** *Lotzeites* **Wiedmann (1960: 731),** *A. latum* **and** *A. quadratum* **Crick (1907: 192, 195, pl. 12, fig. 2, 2a; pl. 13, fig. 2, 2a) have been regarded** *as Acanthoceras* **(Kennedy & Hancock, 1970: 474, 479, 487), and the rest have been assigned to** *Euomphaloceras* **Kennedy & Hancock, 1970: 93; Kennedy, 1971, 85, 92-96). The suture of** *"E." diadema* **Spath has not been figured, but the rest of the species and varieties assigned to** *Euomphaloceras (cunningtoni, inerme, cornuta, meridionale, lonsdalei)* **have typical** *Acanthoceras* **sutures with broad bifid E/L saddle and narrower, bifid L. This type of suture contrasts greatly with that of** *Euomphaloceras euomphalum,* **which has a broad deeply bifid L.**

Cunningtoniceras is **accepted in our report as a valid independent genus of middle to late Cenomanian age; Wright & Kennedy (1987) reached the same conclusion indepen-**

dently. The lineage of the genus, however, is complex, inasmuch as several species of *Acanthoceras* gave rise to forms that have cunningtoniceratid venters. Kennedy & Hancock (1970, pl. 93) have drawn attention to forms transitional from *Acanthoceras rhotomagense* var. *sussexiense* (Mantell) to *Euomphaloceras [Cunningtoniceras* of the present report]. The holotype of *Cunningtoniceras inerme* Pervinquiere (1907: 277), originally figured by Sharpe (1855, pl. 15, fig. la-d) as *Ammonites sussexiensis* Mantell, 1822, could be interpreted as an *Acanthoceras rhotomagense* var. *sussexiense* that has cunningtoniceratid inner whorls.

The presence of more siphonal tubercles than outer ventrolateral ones seems to be characteristic of the older forms of *Cunningtoniceras*. Examples are the holotype of *C. cunningtoni* from the top of the *Turrilites costatus* subzone of the *Acanthoceras rhotomagense* zone at the base of the middle Cenomanian of England, and the specimen described by Stephenson (1953: 201, pl. 47, fig. 5, pl. 48, figs. 3, 4) as *Acanthoceras? eulessanum* from the Woodbine Formation of Texas. We note, however, that multiplication of ventral ornament also occurs in the independent Western Interior species described by Morrow (1935) as *Acanthoceras? amphibolum,* and this prompted Cobban (1987) to assign that species to *Cunningtoniceras.*

CUNNINGTONICERAS ARIZONENSE Kirkland & Cobban Figs. 22, 23, 67A-L

1963. *Mammites nodosoides* (Schlotheim): Miller & Breed, p. 127, fig. 1.
1982. *Plesiacanthoceras wyomingense* (Reagan): Kirkland, p. 548.
1986. *Cunningtoniceras arizonense* Kirkland & Cobban, p. 2, pls. 18, text-figs. 2, 3.

Types—Holotype MNA N3322 from the Twowells Tongue of the Dakota Sandstone of east-central Arizona; hypotypes USNM 425151-425161 from the Colorado Formation.

Description—This is an unusually large species that attains a diameter of as much as 400 mm. Whorl sections are squarish with a flattened venter. Ribs, which are all primaries, are weakened to effaced at midflank. Inner whorls have only eight or nine ribs per half whorl at a diameter of about 50 mm; inner ventrolateral tubercles are usually lengthened into spines. Rib density greatly increases to 13-17 per half whorl at a diameter of around 100 mm. Body chambers have only five or six low, slightly rursiradiate ribs per half whorl which support blunt umbilical tubercles and large ventrolateral horns that are directed outward and upward.

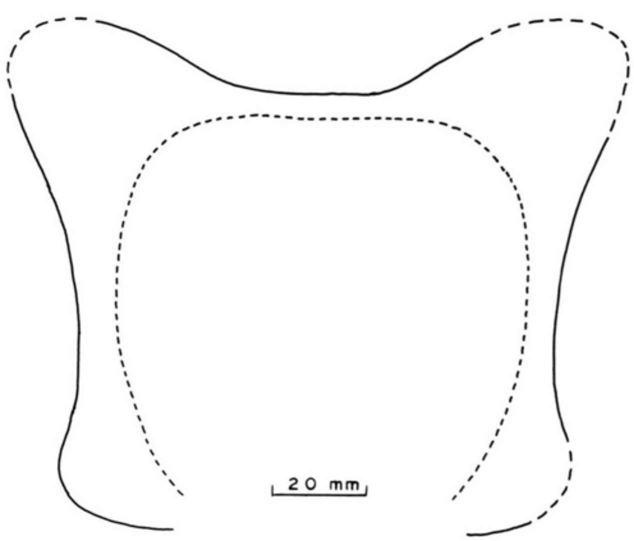

FIGURE 22—Whorl section of *Cunningtoniceras arizonense* Kirkland & Cobban from the Colorado Formation at loc. 76 in Cane Spring Canyon near Silver City, New Mexico. USNM 425161 (Fig. 65I, J).

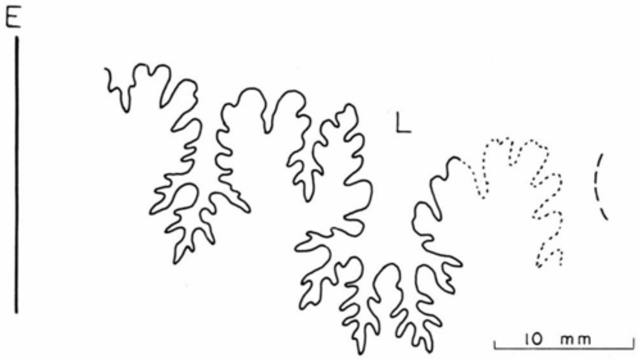

FIGURE 23—Part of external suture of *Cunningtoniceras arizonense* Kirkland & Cobban at a diameter of 91 mm from the lower part of the Colorado Formation at loc. 33 in the Cookes Range (Fig. 67I). USNM 425157.

Densely ribbed and tuberculate fragments of the inner whorls of *C. arizonense* occur flattened in siltstone or as fragments in limestone concretions in the lower part of the Colorado Formation in the Cookes Range. Ribs are mostly rectiradiate, broad, low, and effaced at midflank. Umbilical tubercles are bullate (Fig. 671) to nodate (Fig. 67J) and number 13-15 per half whorl at a diameter of about 90 mm. Inner ventrolateral tubercles are nodate to spinose and number 14-17 per half whorl at this diameter. Outer ventrolateral tubercles are mostly clavate, smaller, and slightly more numerous than the inner ones. Siphonal tubercles are nodate to clavate and about the same size and number as the outer ventrolateral ones. The older half of an adult body chamber is represented by an uncrushed internal mold from a limestone concretion at loc. 76 near Silver City. Its intercostal whorl section is about as wide as high, but the costal section is wider than high (Fig. 22).

The suture (Fig. 23) resembles that of *C. cunningtoni* (Sharpe) figured by Kossmat (1897, pl. 5, fig. 1c) as *Acanthoceras cunningtoni* n. var. *cornuta* in that E/L is broad and bifid and L has a narrow stem and expanded lower elements.

Occurrence—The holotype and paratypes of *Cunningtoniceras arizonense* were associated with *Moremanoceras scotti* (Moreman), *Calycoceras obrieni* Young, *Metoicoceras mosbyense* Cobban, and *Hamites salebrosus* sp. nov., which suggest a position high in the zone of *Metoicoceras mosbyense.* Specimens from southwestern New Mexico that seem referable to *C. arizonense* have been found only in the Cookes Range (locs. 30, 31, 33, 34, 53) and near Silver City (loc. 76). Some of the specimens were, associated with *Moremanoceras costatum* sp. nov., which suggests a slightly older age than that of the types.

CUNNINGTONICERAS NOVIMEXICANUM sp. nov. Figs. 24, 68I-K

Types—Holotype USNM 425162, paratypes USNM 425163425166, from the Colorado Formation in Cane Spring Canyon near Silver City, New Mexico.

Diagnosis—This species is characterized by sparse primary ribs that support large umbilical tubercles and inner ventrolateral horns, and twice as many smaller outer ventrolateral and siphonal tubercles. Secondary ribs are absent on the flanks. Outer ventrolateral and siphonal tubercles disappear on the outer whorl of the phragmocone, and the inner ventrolateral tubercles become large horns.

Description—The holotype (Fig. 681, J) is an internal mold of a phragmocone 98 mm in diameter, with an umbilicus of 34 mm (ratio of 0.35). Inner whorls are not preserved. Whorl section is depressed, with steeply sloping umbilical wall, narrowly rounded umbilical shoulder, flat flanks, bevelled ventrolateral shoulder, and flattened venter. Near the

FIGURE 24—Lateral lobe (L) and part of E/L saddle of a large fragment of *Cunningtoniceras novimexicanum* sp. nov. from the lower part of the Colorado Formation at loc. 75 near Silver City, New Mexico. Paratype USNM 425166.

larger end of the specimen, the intercostal whorl section is 32 mm high and 37 mm wide. Ribs are broad, low, and effaced at midflank. Each arises from a conspicuous rounded to elongate umbilical bulla and then trends straight across the flank and rises into a large, nodate to slightly clavate inner ventrolateral tubercle or horn. From this tubercle, the rib crosses the venter traversely as a low, rounded ridge that supports a nodate to slightly clavate outer ventrolateral tubercle and a smaller and lower siphonal clavus. Each two primary ribs on the venter are separated by an equally sized secondary rib that bears outer ventrolateral and siphonal tubercles of the same dimensions as those on the primaries. At a diameter of 74 mm, umbilical and inner ventrolateral tubercles number eight per half whorl, and outer ventrolateral and siphonal tubercles number 16. Only bits of the suture are preserved on the holotype, but the lateral lobe (L) and the preserved part of the E/L saddle of a paratype (Fig. 24) are much like the equivalent part of the suture of *C. arizonense* Kirkland & Cobban (1986, fig. 3).

Along with the holotype are 10 fragments of other specimens. All are internal molds that have sparse ribs and large umbilical and inner ventrolateral tubercles or horns. Outer ventrolateral and siphonal tubercles disappear at a whorl height of about 50-55 mm, but umbilical bullae and inner ventrolateral horns are present on the largest specimens at hand. The species attained a large size; one fragment (paratype USNM 425164) has an intercostal height of about 100 mm, and another fragment (paratype USNM 425165) has an intercostal height of 93.5 mm and a breadth of 102.5 mm at the base of the body chamber.

Discussion—Fragments of large adults suggest that body chambers are indistinguishable from those of *C. arizonense* Kirkland & Cobban. The species are also much alike in their suture pattern and in the absence of secondary ribs on the flanks. *Cunningtoniceras arizonense*, however, has twice as many ribs on the inner whorls. Inasmuch as there are no intermediate forms in this rib density, the two species are retained separately.

Occurrence—The types and many unfigured specimens are from a sandy unit in the Colorado Formation that may be an equivalent of the Twowells Tongue of the Dakota Sandstone farther north in west-central New Mexico and central and eastern Arizona. The specimens are from loc. 75 in Cane Spring Canyon in the SE1/4 sec. 8, T17S, R15W, Grant County. Other specimens have been found in the Cookes Range (locs. 14, 19).

CUNNINGTONICERAS COOKENSE sp. nov.

Figs. 25, 65E, F, 69A, B

Types—Holotype USNM 425167, paratype USNM 425168, from the Colorado Formation in the Cookes Range probably fairly high in the upper Cenomanian zone of *Metoicoceras mosbyense.*

Diagnosis—A huge, very evolute species that has whorls wider than high and ornament of low primary ribs that bear umbilical, inner and outer ventrolateral, and siphonal tubercles; these ribs are separated by a secondary one that has outer ventrolateral and siphonal tubercles like those on the primaries, but a much smaller and weaker inner ventrolateral tubercle or none.

Description—The holotype (Fig. 69) is an internal mold of most of the younger half of the outer whorl of a phragmocone that had a diameter estimated at 250 mm and an umbilicus estimated at 105 mm (ratio of 0.42). One side is complete although somewhat corroded, whereas the younger two-thirds and venter of the other side are mostly worn away. The smaller unworn end of the specimen has an intercostal height of 61 mm and a breadth of 65 mm. The whorl section is polygonal, with well-rounded umbilical shoulder, flat flanks, bevelled ventrolateral shoulder, and flattened venter. Ribs are low, broad, rectiradiate, and effaced at midflank; they cross the venter transversely as low, broad swellings. Nine primary ribs per half whorl arise each

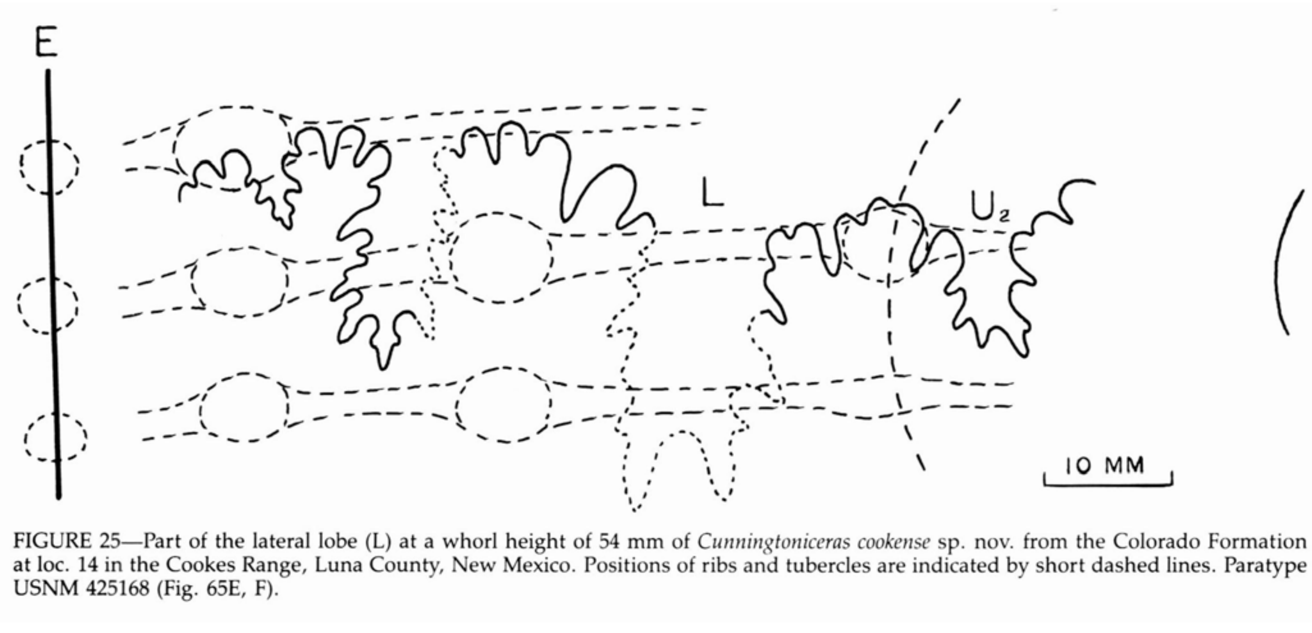

FIGURE 25—Part of the lateral lobe (L) at a whorl height of 54 mm of *Cunningtoniceras cookense* sp. nov. from the Colorado Formation at loc. 14 in the Cookes Range, Luna County, New Mexico. Positions of ribs and tubercles are indicated by short dashed lines. Paratype USNM 425168 (Fig. 65E, F).

from a large, rounded umbilical bulla and nearly disappear at midflank before rising into large, rounded inner ventrolateral tubercles and nearly as large rounded outer ones. Each is matched by a low, rounded siphonal tubercle. The primaries are separated by a secondary rib that arises at midflank and then usually forms a low, rounded inner ventrolateral bulla before rising into a rounded outer ventrolateral tubercle and rounded siphonal one, both of which are equal in size to those on the primaries. Outer ventrolateral and siphonal tubercles number 18 per half whorl.

Sutures are poorly preserved but show a broad, bifid E/L saddle and a narrower, rectangular lateral lobe like that of other species of *Cunningtoniceras* (Fig. 25).

A paratype (Fig. 65E, F), that consists of a fragment of a phragmocone, has an intercostal whorl height of 51 mm and a breadth of 58.5 mm. Ornament is similar to that of the holotype.

Aside from the types, fragments of four other specimens were found at the type locality.

Discussion—Cunningtoniceras cookense represents a very late species of the *Cunningtoniceras* stock. Of the named forms, only the one described by Pervinquiere (1907: 280, pl. 15, figs. 5, 6) as *Acanthoceras meridionale* Stoliczka var. *tuberculata,* and the one described by Collignon (1967: 28, pl. 13, figs. 1, 2) *as Euomphaloceras lehmanni* have ventral ornament reminiscent of *C. cookense.* Pervinquiere's types are small internal whorls that have one to two secondary ribs between the primaries; they have been assigned to *C. cunningtoni* (Sharpe) by Wright (1963: 609) and Kennedy (1971: 93). *Cunningtoniceras lehmanni* has more depressed whorls than *C. cookense* and one to two secondary ribs; it may be the same as Pervinquiere's form.

Occurrence—The types are from a calcareous shale unit that underlies the Bridge Creek Limestone Member of the Colorado Formation at loc. 14 in the NE1/4NW^1/4 sec. 30, T20S, R8W, Luna County. This is the only known locality of this species.

UNDETERMINED AMMONITE
Fig. 96V

Material—Figured specimen USNM 425169, from the flag member of the Colorado Formation on the south side of the Cookes Range.

Description—This very evolute ammonite has only one side preserved. Its diameter is 18.3 mm, and the umbilicus is 9.3 mm (0.51). The umbilical shoulder is narrowly rounded, the flanks are flattened, and the ventrolateral shoulder is well rounded; the venter is not preserved. Inner whorls are poorly preserved, but seem to be smooth. Ornament on the outer whorl consists of straight, rectiradiate ribs with alternate ones arising from low umbilical bullae. The suture is not preserved.

Discussion—This specimen is from the zone of *Calycoceras canitaurinum.* The only fairly evolute ammonite known from this zone is *Cunningtoniceras arizonense* Kirkland & Cob-ban (1986), and it is possible the present specimen represents the innermost whorls of that species.

Occurrence—Loc. 30 in the Cookes Range.

Genus *CALYCOCERAS* Hyatt, 1900

Type *species—Ammonites navicularis* Mantell, 1822: 198, pl. 22, fig. 5; by designation under the Plenary Powers (ICZN opinion no. 557).

Diagnosis—This genus includes fairly evolute, generally stout ammonites that have subquadrate to rounded whorls ornamented by long and short rounded to flattened ribs that in most species bear outer ventrolateral and siphonal tubercles in early growth stages. A row of lateral tubercles is present in some species.

Subgenus *CALYCOCERAS (CALYCOCERAS)* Hyatt, 1900
CALYCOCERAS (CALYCOCERAS) NAVICULARE (Mantell, 1822) Fig. 70A-T

For the extensive synonymy see Wright & Kennedy (1981: 34, 35) and Kennedy (1988: 39).

Types—Holotype BMNH 5681, by monotypy, the original of Mantell (1822, pl. 22, fig. 5); also figured by Crick (1919, pl. 4), Kennedy (1971, pl. 33), and Wright & Kennedy (1981, pl. 4). Hypotypes USNM 425170-425177, from the Colorado Formation in the Cookes Range and near Silver City.

Description—Kennedy (1971: 71) summarized this late Cenomanian species as follows: "Inflated, depressed evolute *Calycoceras* with many (usually about 30 or more) ribs per whorl. Siphonal and lateral tubercles lost early in ontogeny. Umbilical tubercles very strong. Ventral tubercles rounded. Body chamber with strong, coarse, alternately long and short ribs, venter tabulate between strong ventrolateral tubercles."

The holotype, which probably came from the Plenus Marls of Sussex, England (Wright & Kennedy, 1981: 35), is a badly crushed specimen that shows the middle growth stage of the species. Kennedy (1971: 72) described the different growth stages of the species based on a series of phosphatized specimens from southeast England (Bed C of the Cenomanian Limestone) that are distinctly older than the type. Between diameters of 20 and 40 mm, 25-32 ribs are present per whorl, and these consist of long ribs alternating with one or two short ones. The long ribs have strong umbilical tubercles and, in addition, lateral tubercles, which disappear at a diameter of about 25 mm. Each rib also bears outer ventrolateral and siphonal tubercles that weaken and disappear by a diameter of 30-35 mm. The ventrolateral shoulder remains somewhat angular, and a rounded ventrolateral tubercle may form at diameters of 40-50 mm. Ribs number 35-37 in specimens larger than 40 mm in diameter.

Specimens that seem assignable to *C. naviculare* occur in the Colorado Formation at several localities in the Cookes Range and at one locality near Silver City. The smallest specimens are well-preserved internal molds from a limestone concretion found as float, but probably from the zone of *Sciponoceras gracile* (Shumard) in the Cookes Range at loc. 15. Two specimens (Fig. 70A-F) are only 9.5 mm in diameter, but at this small size they have on the last half whorl about seven umbilical bullae and 15 to 17 rounded, rectiradiate ribs that cross the flanks and venter. A larger specimen (Fig. 70G-I), 24 mm in diameter, has an umbilical ratio of 0.28 and depressed whorls with the greater breadth at the narrowly rounded umbilical shoulder. Ribs are alternately long and short, rounded, rectiradiate, and about as wide as the interspaces. Long ribs begin on the umbilical wall, rise into bullae on the umbilical shoulder, and then trend straight across the flank and venter. Secondary ribs arise on the umbilical shoulder. Total number of ribs crossing the venter on the complete whorl is 30. Tubercles, other than umbilical bullae, are absent in this specimen as well as in the two smaller specimens. Another small specimen (Fig. 70J, K), 18.2 mm in diameter, differs from the others from this locality in having small, nodate, closely spaced umbilical and lateral tubercles on the primary ribs. From the same locality, but found as float from a different concretion, is a specimen (Fig. 70Q, R) 53 mm in diameter that has about 30 ribs per whorl. This specimen is of interest in that ventrolateral tubercles (outer only) first appear at a diameter of about 50 mm.

The largest specimen assigned to *C. naviculare is* from loc. 75 near Silver City. This specimen (Fig. 70S, T) has a diameter of 132 mm and an umbilicus of 44.4 mm (ratio of 0.34). On the outer whorl, umbilical bullae number 18 and ribs number 42. Ribs mostly alternate in length, but in places two secondaries separate primaries. Siphonal and ventrolateral tubercles are absent.

Occurrence—Zone of *Sciponoceras gracile* (Shumard) in the Cookes Range (locs. 15, 17, 36, 38, 40, 44, 45, 55) and in the Silver City Range (loc. 75).

CALYCOCERAS (CALYCOCERAS) INFLATUM sp. nov.
Fig. 71A-F

Types—Holotype USNM 425178, paratypes USNM 425179, 425180, all from a sandy unit in the Colorado Formation in Cane Spring Canyon (loc. 80) in the SW1/4SW1/4 sec. 6, T17S, R15W, Grant County.

Diagnosis—An inflated species that has conspicuous ornament of strong ribs with umbilical, lateral, outer ventrolateral, and siphonal tubercles.

Description—The holotype (Fig. 71E, F) is an internal mold that has a diameter of 109 mm and an umbilical width of 30.5 mm (ratio of 0.28). Whorls are depressed, with a height of 49.5 mm and a breadth of 73.0 mm. The costal whorl section is polygonal, with the greatest width at the umbilical shoulder. Owing to the depressed whorls, the umbilicus is deep, with almost vertical walls. Ribs are strong, rounded, and as wide as the interspaces. Primary ribs arise singly or in pairs from nodate umbilical tubercles. A secondary rib that begins low on the flank separates each pair of primaries. Most ribs have a small, nodate lateral tubercle, and all ribs have strong, clavate outer ventrolateral tubercles and low siphonal swellings. In addition, some ribs have a swelling where inner ventrolateral tubercles should be located. The outer whorl has 12 umbilical and lateral tubercles and 30 outer ventrolateral tubercles. Sutures are not preserved in the holotype nor in the paratypes.

A paratype (Fig. 71C, D) is slightly smaller and more slender than the holotype. This paratype has a diameter of 102 mm and an umbilicus of 31.5 mm (ratio of 0.31). Intercostal whorl height near the larger end is 44 mm and the breadth is 55 mm. Ornament is much like that of the holotype, with strong, rounded ribs that bear conspicuous clavate outer ventrolateral tubercles and low siphonal swellings. Primary ribs arise from strong umbilical bullae and have a small nodate lateral tubercle low on the flank. A few ribs have a low inner ventrolateral swelling. The outer whorl has 14 umbilical tubercles and 34 outer ventrolateral ones. A small paratype (Fig. 71A, B) has 30 ribs at a diameter of 60 mm.

Discussion—Calycoceras inflatum **sp. nov. is most closely related to *C. guerangeri* from which it differs in its more inflated form, stronger ornament, and persistence of lateral tubercles to large diameters.**

Occurrence—Colorado Formation high in the zone of *Metoicoceras mosbyense* in the Silver City Range at locs. 75 and 80.

Subgenus *CALYCOCERAS (PROEUCALYCOCERAS)* Thomel, 1972

Type *species—Calycoceras (Eucalycoceras) besairiei* **Collignon (1937: 37, pl. 3, figs. 1-4; pl. 8, fig. 5) from the Cenomanian of Ankomaka, Madagascar.**

Diagnosis—Thomel (1972: 81) proposed this subgenus for *Calycoceras* that have densely ribbed inner whorls and sparsely ribbed outer whorls. Inner whorls have flat flanks and a somewhat flattened venter, and ornament of flexuous ribs with umbilical bullae and ventrolateral and siphonal tubercles. Outer whorl has strong umbilical bullae and widely spaced ribs with outer ventrolateral tubercles.

CALYCOCERAS (PROEUCALYCOCERAS) GUERANGERI (Spath)
Figs. 26, 72P-R, T, U

1863. *Ammonites cenomanensis* d'Archiac: Pictet, p. 28 (pars), pl. 3, fig. 1 (outer part only).
1867. *Ammonites Rothomagensis?* Lamk.: Gueranger, p. 5, pl. 4, fig. 4.
1899. *Acanthoceras* cfr. *rotomagense* Defrance: Choffat, p. 72, pl. 4, fig. 5.
1926b. *Metacalycoceras guerangeri* Spath, p. 431.
1937. *Metacalycoceras guerangeri* Spath: Collignon, p. 48 (24).
1940. *Metacalycoceras bruni* Fabre, p. 230, pl. 8, figs. 1, 2, text-fig. 34.
1951. *Calycoceras bruni* Fabre: Wright & Wright, p. 26.
1951. *Calycoceras* cf. *guerangeri* (Spath): Wright & Wright, p. 26.
1960. *Calycoceras aff. planecosta* (Kossmat): Hancock, p. 251.
1960. *Calycoceras* aff. *vergonense* Collignon: Hancock, p. 251.
1960. *Calycoceras newboldi* var. *spinosum* (Kossmat): Hancock, p. 251.
1960. *Calycoceras guerangeri* (Spath): Hancock, p. 251.
1960. *Calycoceras bruni* (Fabre): Hancock, p. 251.
1972. *Calycoceras (Calycoceras) stoliczkai* (Collignon): Thomel, p. 56 *(pars)*, p1. 18, figs. 5-7 only.
1972. *Calycoceras (Calycoceras) boehmi* (Spath): Thomel, p. 58 *(pars)*, pl. 20, figs. 7, 8 only.
1972. *Calycoceras (Calycoceras) bruni* (Fabre): Thomel, p. 60, pl. 18, fig. 8.
1972. *Calycoceras (Calycoceras) guerangeri* (Spath): Thomel, p. 61, pl. 20, figs. 3, 4.
1972. *Calycoceras (Calycoceras) guerangeri alpinum* Thomel, p. 62, pl. 20, figs. 1, 2.
1972. *Calycoceras (Calycoceras) robustum* Thomel, p. 63, pl. 19, figs. 1-5.
1976. *Calycoceras bruni* (Fabre): Juignet & Kennedy, p. 105, pl. 23, figs. 1, 3.

Types—The lectotype designated by Wright & Kennedy (in press) is Gueranger's figured specimen from the upper Cenomanian zone of *Calycoceras guerangeri* of France. Hypotypes USNM 425181-425184 from the Colorado Formation of the Cookes Range and Silver City Range.

Diagnosis—This robust, sparsely ribbed species has umbilical, outer ventrolateral, and siphonal tubercles, and a costal whorl section with ventrolateral facets and a flattened venter.

Description—Sparsely ribbed, robust specimens from the Colorado Formation in the Cookes Range can be assigned to C. *guerangeri*. One specimen (Fig. 72Q, R) from loc. 25 closely resembles the specimen figured by Juignet & Kennedy (1976, pl. 23, fig. la-c), the lectotype of *C. bruni* (Fabre, 1940: 230, pl. 8, figs. 1, 2, text-fig. 34) which is a synonym of *C. guerangeri*. The Cookes Range specimen is the body chamber of an adult microconch that has a diameter of 97 mm an an umbilical ratio of 0.32. Ribs are slightly rursiradiate and number 15 in half a whorl. Primary ribs begin from strong umbilical bullae and are separated by one or two secondaries that arise low on the flank. All ribs in the older half of the specimen have clavate outer ventrolateral tubercles and weak clavate siphonal tubercles. These tubercles weaken and disappear in the younger half. Another specimen (Fig. 72P, T, U), from the same stratigraphic level but at a nearby locality (20), is more inflated and the tuberculation is more persistent. This individual, 106 mm in diameter with an umbilical ratio of 0.31, has five umbilical bullae and 14 ribs per half whorl. Ribs in the older half have incipient inner ventrolateral tubercles in addition to the outer ones.

The largest specimen from the Cookes Range assigned to *C. guerangeri* consists of a little more than half a whorl of a body chamber from loc. 6. This specimen (USNM 425184) has a diameter of 220 mm and umbilical ratio of 0.34. Ornament of the last half whorl consists of 14 thick, rounded ribs of which every other one is a primary arising from an umbilical bulla.

A single crushed specimen from loc. 74 in the Silver City Range may represent the adult stage of *C. guerangeri* (Fig. 26). This specimen (USNM 425183) is 322 mm in diameter, with an umbilical ratio of 0.33. Only the outer whorl is preserved. Ribs are strong, rectiradiate, rounded, and narrower than the interspaces. Long ribs, which alternate with short ones, arise from umbilical bullae. All ribs are highest

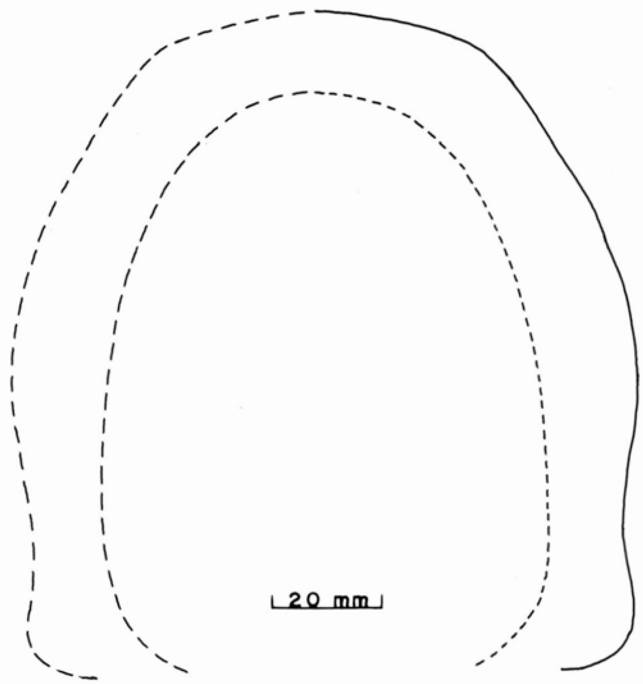

FIGURE 26—Whorl section, natural size, of a large crushed adult of *Calycoceras guerangeri* (Spath) from the Colorado Formation at loc. 74 in Cane Spring Canyon near Silver City. USNM 425183.

at the ventrolateral shoulder, where their crests bend abruptly and trend transversely across the venter. Ribs number 11 per half whorl.

Occurrence—All specimens from the Cookes Range are from below the base of the upper Cenomanian zone of *Sciponoceras gracile at* **locs. 6, 20, and 25. Associated fossils include large** *Forbesiceras* **sp. or** *Metoicoceras mosbyense.*

CALYCOCERAS (PROEUCALYCOCERAS) CANITAURINUM **(Haas) Figs. 73P-X, 741**

1949. *Mantelliceras canitaurinum* Haas, p. 9, pls. 1-3, pl. 4, figs. 1, 2, 4, text-figs. 1-4.
1973. *Calycoceras? canitaurinum* (Haas): Cobban & Scott, p. 60, pl. 21, fig. 2.
1975. *Calycoceras? canitaurinum* (Haas): Hattin, pl. 4, figs. A, C.
1977a. *Calycoceras? canitaurinum* (Haas): Cobban, p. 23, pl. 21, fig. 17.
1977b. *Calycoceras? canitaurinum* (Haas): Cobban, fig. 5i.
1977. *Calycoceras? canitaurinum* (Haas): Hattin, p. 185, text-fig. 5 (4).
1978. *Calycoceras? canitaurinum* (Haas): Hattin & Siemers, text-fig. 6 (4).

Types—Syntypes AMNH 26413:1 and 26413:2, from the Cody Shale northeast of Greybull, Wyoming. Hypotypes USNM 425185-425191, from the Colorado Formation in the Cookes Range, Luna County, New Mexico.

Diagnosis—A large, robust species that has densely ribbed early whorls with umbilical, lateral, inner and outer ventrolateral, and siphonal tubercles; later whorls have quadrate sections and more widely spaced ribs with umbilical bullae and a prominent ventrolateral bullate tubercle formed by the fusion of the inner and outer ventrolateral ones. Ribs tend to be flattened on the outer part of the flank and venter.

Description—Several collections from the Cookes Range and from the Silver City area contain fragments of ammonites referable to *Calycoceras (Proeucalycoceras) canitaurinum* **(Haas). Most specimens are flattened fragments (Fig. 73R, V) in thin beds of siltstone, but some specimens in limestone concretions are distorted but not too badly crushed (Fig. 73S-U, W, X). A limestone concretion at loc. 33 in the Cookes Range yielded a specimen (Fig. 73S-U) that reveals the inner whorls at a diameter of about 51 mm. Flanks and venter are flattened, and the closely spaced, somewhat flexuous ribs number 35 on the outer whorl. Primary ribs, which begin from umbilical bullae, are separated by two or three secondaries. Lateral and inner ventrolateral tubercles are absent on the outer whorl. Small, nodate siphonal tubercles disappear at a diameter of about 32 mm, but the small, clavate outer ventrolateral ones persist to the end of the whorl.**

Intermediate growth stages are shown by fragments from a limestone concretion at loc. 70 in the Silver City area. One specimen (Fig. 73W, X) has very depressed whorls with flattened flanks and venter. Closely spaced ribs are separated by interspaces that are of the same size as the ribs or somewhat narrower. Each rib is narrow and rounded on the flank but becomes flattened and much broader on the ventrolateral shoulder and venter. The ribs have low, nodate inner ventrolateral tubercles and higher clavate outer ones. Siphonal tubercles have disappeared.

Rather poorly preserved adult specimens occur at locs. 33 and 70. An adult (USNM 425191) from loc. 33 has a diameter of 265 mm, with an umbilical ratio of 0.28. The outer whorl has 11 umbilical bullae and 21 ribs. Only bits of the suture are preserved.

Occurrence—Haas' syntypes are from the upper Cenomanian zone of *Dunveganoceras pondi* **Haas in the Big Horn Basin of Wyoming. The types are from silty concretions in the basal part of the Cody Shale. Other ammonites in these concretions** *are D. pondi, Metoicoceras praecox* **Haas, and** *Idiohamites* **sp. nov. Specimens assigned to** *C. canitaurinum* **in southwestern New Mexico were found with** *Metoicoceras praecox* **and other fossils in the Cookes Range (locs. 29, 30, 33), Silver City Range (locs. 70, 72), and Little Burro Mountains (locs. 92, 94).**

CALYCOCERAS (PROEUCALYCOCERAS) **sp. nov. Fig. 74H**

Type—Figured specimen USNM 425192.

Description—A slightly distorted internal mold from loc. 6 in the Cookes Range is most unusual in that it has sparse primary ribs that bear lateral, inner and outer ventrolateral, and siphonal tubercles. The specimen consists of about two-thirds of a whorl that has a diameter of 111.5 mm and an umbilical ratio of 0.35. Whorls are broader than high, with a polygonal section. Four conspicuous umbilical bullae are present on the last half whorl. Each gives rise to one or two rounded, rectiradiate ribs, and each rib or pair is separated from its neighbor by one or two secondaries. At least two of the umbilical bullae support small, nodate lateral tubercles. All ribs have a nodate inner ventrolateral tubercle and similarly sized clavate outer ventrolateral and siphonal tubercles.

Discussion—In its sparse ribbing, the specimen resembles *C. guerangeri,* **but that species does not have well-developed inner ventrolateral tubercles, nor does it have lateral tubercles at this large diameter.**

Occurrence—The specimen was found below the zone of *Sciponoceras gracile* **in the Colorado Formation at loc. 6 in the SW[1]/4NEI/4 sec. 30, T20S, R8W, Luna County.**

CALYCOCERAS (PROEUCALYCOCERAS) **sp. Fig. 27**

Material—Figured specimens USNM 425193-425195.

Description—Fragments of very large, robust *Calycoceras* **were found as float on slopes underlying several concretionary beds of limestone that contain the** *Sciponoceras gracile* **fauna. Limestone concretions also occur in the underlying shale. Some of the** *Calycoceras* **may be from the** *S. gracile* **beds, but others are more likely from the underlying unit.**

Parts of three huge body chambers were found in place

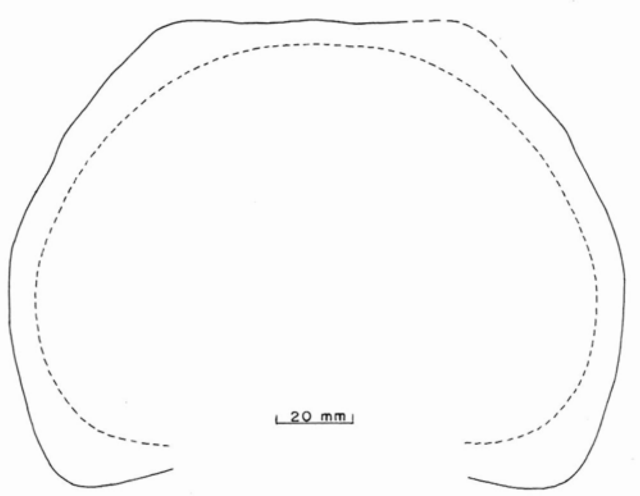

FIGURE 27—Whorl section, natural size, of a large *Calycoceras* (*Proeucalycoceras*) sp. from the Colorado Formation at loc. 21 in the Cookes Range. USNM 425193.

several meters below the *S. gracile* beds. One specimen (USNM 425193) that consists of about two-thirds of a half whorl has an estimated diameter of 410 mm. Its depressed intercostal whorl section has a height of 102 mm and a breadth of 142 mm (Fig. 27). Ribs are rectiradiate, rounded, and about half as wide as the interspaces; they number about 11 per half whorl and alternate in length. Primary ribs begin from strong, rounded umbilical bullae, and secondaries arise at midflank. Some ribs have a weak inner ventrolateral swelling, but all ribs rise into conspicuous, rounded outer ventrolateral bullae and then trend straight across the venter. The ribs may be depressed a little on the venter; they may have a slight siphonal swelling; or they may be perfectly flat. The second specimen, USNM 425194, consists of about a quarter of a whorl; its intercostal height is 117 mm and its breadth is 145 mm. Ornament is similar to that of the other specimen, with an estimated 11 ribs per half whorl. The third specimen, USNM 425195, which consists of about two-thirds of a whorl, also has about 11 ribs per half whorl. The specimen is 329 mm long. At its middle, the costal whorl height is 127 mm and the costal breadth is 155 mm. Alternate ribs begin from umbilical bullae, and all ribs are flat on crossing the venter transversely. The impressed area on the dorsum reveals that the venter of the penultimate whorl had a flat venter crossed by broad, flat ribs bordered by low, broad, clavate ventrolateral tubercles.

Discussion—These huge body chambers possibly represent large macroconchs of *C. guerangeri,* although specimens assigned to that species are much smaller.

Occurrence—Colorado Formation in the Cookes Range at locs. 7, 21, and 28.

Genus *EUCALYCOCERAS* Spath, 1923

Type *species—Ammonites pentagonus* Jukes-Browne *(in* Jukes-Browne & Hill, 1896: 156, pl. 5, figs. 1, la).

Diagnosis—This medium-sized, somewhat evolute, compressed ammonite has flattened flanks and a polygonal whorl section in the inner whorls and a later section of flattened flanks and rounded venter. Ornament consists of numerous ribs and umbilical, inner and outer ventrolateral, and siphonal tubercles. Ribs on the later whorls usually become effaced at midflank, and those near the aperture become flattened and have steeper adoral than adapical faces. Suture usually has a long, narrow lateral lobe and a broad first lateral saddle.

EUCALYCOCERAS PENTAGONUM (Jukes-Browne, 1896)
Figs. 28, 73A—D

1864. *Ammonites harpax* Stoliczka, p. 72 (pars), pl. 38, fig. 2 only.
1896. *Ammonites pentagonus* Jukes-Browne, p. 156, pl. 5, fig. 1. 1897. *Acanthoceras pentagonum* Jukes-Browne: Kossmat, p. 14(121), pl. 4(15), fig. 3.
1899. *Acanthoceras pentagonum* Jukes-Browne and Hill: Choffat, p. 71, pl. 4, fig. 4, pl. 6, figs. 3, 4.
1907. *Acanthoceras pentagonum* Jukes-Browne and Hill: Pervinquiere, p. 271.
1907. *Acanthoceras Villei* Coquand: Pervinquiere, p. 300 *(pars),* pl. 16, figs. 14, 15 only.
1923. *Eucalycoceras pentagonum* (Jukes-Browne): Spath, p. 144. 1925. *Acanthoceras pentagonum* Jukes-Browne et Hill: Diener, p. 164.
1940. *Eucalycoceras* cf. *pentagonum* (Jukes-Browne et Hill): Fabre, p. 229.
1951. *Eucalycoceras pentagonum* (Jukes-Browne): Wright & Wright, p. 26.
1964. *Eucalycoceras pentagonum* (Jukes-Browne): Collignon, p. 138, pl. 370, figs. 1610, ?1611, ?1612 (var. *tazoalavensis* Collignon).
1965. *Eucalycoceras aff. pentagonum* Jukes-Browne et Hill: Collignon, p. 174(12).
1970. *Eucalycoceras pentagonum* Jukes-Browne: Ilyin, p. 13, pl. 2, fig. 2, pl. 3, fig. 1.
1971. *Eucalycoceras pentagonum* (Jukes-Browne): Kennedy, p. 81, pl. 48, figs. 1-4, 6, *non* fig. 5 (= *E. rowei* Spath, 1926b), pl. 49, fig. 1.
1971. *Eucalycoceras rowei* (Spath): Kennedy, p. 83 (pars), pl. 50, fig. 4 only.
1972. *Eucalycoceras (Eucalycoceras) pentagonum* (Jukes-Browne and Hill): Thomel, p. 83, pl. 28, figs. 1, 10.
1973. *Eucalycoceras pentagonum* (Jukes-Browne et Hill): Pop & Szász, p. 189, pl. 10, fig. 1, pl. 11, fig. 1.
1975. *Eucalycoceras pentagonum* (Jukes-Browne and Hill): Matsumoto, p. 106, pl. 11, fig. 1.
1975. *Eucalycoceras* sp. aff. *E. spathi* (Collignon): Matsumoto, p. 108, pl. 11, fig. 2.
1978. *Eucalycoceras pentagonum* (Jukes-Browne): Kennedy & Hancock, pl. 11, fig. 7.
1983. *Eucalycoceras pentagon= saharense* Collignon and Roman, *in* Amard, Collignon & Roman, p. 101, pl. 14, fig. 1.
1983. *Eucalycoceras pentagonum* (Jukes-Browne): Szász, p. 252, pl. 20, figs. 4, 5.

Types—Hypotypes USNM 400775, 400776.

Description—This is a large, compressed to stout species with numerous closely spaced ribs that may be effaced at midflank on the body chamber. Ventrolateral and siphonal tubercles disappear on older part of body chamber, and ribs become flattened with steep adoral faces on younger part of body chamber. Kennedy (1971: 81) observed that the holotype is a poorly preserved, phosphatic internal mold of which nearly one-half of the last whorl is body chamber. Jukes-Browne *(in* Jukes-Browne & Hill, 1896: 156) gave its diameter as 4 in. (102 mm). Kennedy noted that the holotype was moderately involute; that the whorl section of the phragmocone was compressed with flat sides and high, arched venter; and that the venter became broadly rounded on the body chamber. Ribs are numerous, fairly straight, and mostly rectiradiate. Long ribs begin from conspicuous umbilical tubercles, and short ones arise near midflank. All ribs on the phragmocone bear slightly clavate inner ventrolateral tubercles, slightly clavate but stronger outer ones, and slightly bullate siphonal ones. All ventrolateral and siphonal tubercles disappear on the older part of the body chamber, and ribbing is effaced there at midflank. On the younger part of the body chamber, ribs become flattened and wide on crossing the broadly rounded venter. The ribs are wider than the interspaces and have steep adoral faces. The effaced ribbing at midflank is shown very well in two large specimens illustrated by Kennedy (1971, pl. 48, fig. lb, pl. 49, fig. 1c). Some specimens of comparable size from other regions do not show this (Kossmat, 1897, pl. 4, fig. *3a;* Thomel, 1972, pl. 28, figs. 1, 10).

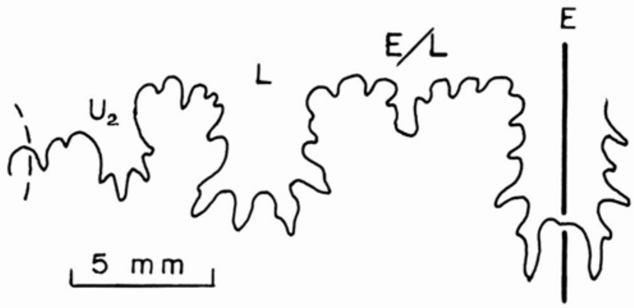

FIGURE 28—External suture of *Eucalycoceras pentagonum* (Jukes-Browne) at a diameter of 32.3 mm of a specimen from the Colorado Formation at loc. 17 in the Cookes Range. USNM 400775 (Fig. 73A, B).

Two specimens from loc. 17 in the Cookes Range are referred to this species. One specimen (Fig. 73A, B) consists of inner whorls that have a diameter of 36 mm and an umbilical ratio of 0.30. Seventeen umbilical bullae give rise to narrow, rectiradiate to prorsiradiate ribs. Each pair of primaries is usually separated by a secondary rib that arises low on the flank. The total ribs on the outer whorl number 28. Each rib rises into a conical inner ventrolateral tubercle from which a broad rib leads to a larger clavate outer one and then crosses the arched venter transversely. Siphonal tubercles are small and clavate. A larger fragment (Fig. 73C, D) has flattened flanks and effaced midflank ribbing.

The suture (Fig. 28) has a broad, bifid E/L saddle and a rectangular, bifid L.

Occurrence—The holotype of *Eucalycoceras pentagonum* came from the remanié phosphatic late Cenomanian *Calycoceras guerangeri* zone fauna of Bed C of the Cenomanian Limestone near Lyme Regis in Dorset, England (Kennedy, 1971: 81). Specimens compared to *E. pentagonum* from southeastern Colorado are from the upper Cenomanian *Sciponoceras gracile* zone of the basal bed of limestone in the Bridge Creek Member of the Greenhorn Limestone at USGS Mesozoic localities 18686 and 22899 on the east flank of the Model anticline. A large collection of *Calycoceras naviculare* (Mantell) as well as specimens of *Moremanoceras scotti* (Moreman) and *Anisoceras plicatile* (J. Sowerby) were described from this bed at this locality (Cobban, 1972). The last species is assigned to *A. coloradoense* sp. nov. in the present paper. Fragments of specimens referable to *E. pentagonum* from the Black Hills area came from the Greenhorn Formation at USGS Mesozoic locality 23060. These fragments were not associated with other fossils. The specimens from southwestern New Mexico were with *Eucalycoceras euomphalum* (Sharpe), *Metoicoceras* sp., *Vascoceras diartianum* (d'Orbigny), and other small ammonites indicating the upper part of the upper Cenomanian *Metoicoceras mosbyense* zone.

Genus *TARRANTOCERAS* Stephenson, 1955

Type Species—By original designation, *Tarrantoceras rotatile* Stephenson, 1955, p. 59, pl. 5, figs. 1-10; = *Mantelliceras sellardsi* Adkins, 1928, p. 239, pl. 25, fig. 1, pl. 26, fig. 1.

Diagnosis—This genus includes small to medium-sized, moderately evolute ammonites that have flattened flanks and whorls higher than wide. Venter is flattened on the phragmocone and on part or all of the body chamber. Ornament is conspicuous and consists of numerous, mostly rectiradiate, slightly flexuous, narrow primary and secondary ribs that cross the venter transversely and bear inner and outer ventrolateral and siphonal tubercles. Primary ribs arise from umbilical bullae. Suture is characterized by a broad E/L saddle, small bifid L, and a much smaller lobe at the umbilical shoulder.

Occurrence—Tarrantoceras is known only from middle and upper Cenomanian rocks of Morocco, Angola, Colombia, and the United States. In the Western Interior, the genus has been found in Trans-Pecos Texas, New Mexico, western Oklahoma, Colorado, Kansas, and eastern Wyoming.

TARRANTOCERAS cf. SELLARDSI (Adkins, 1928)
Figs. 68A-E, H, 72S

Material—Figured specimens USNM 425196-425201, 425479.

Description—Flattened impressions of a *Tarrantoceras* are fairly common in the lower flag member of the Colorado Forination in the Cookes Range. These impressions have 6-11 umbilical and 12-24 ventrolateral tubercles per half whorl, which compares favorably to counts of 5-9 umbilical and 13-23 ventrolateral tubercles per half whorl for the specimens figured by Stephenson (1955, pls. 5, 6) as the new species of *T. rotatile, T. stantoni,* and *T. lillianense* from the basal part of the Eagle Ford Group of Texas. These forms were regarded as one variable population by Cobban & Scott (1973: 65), who selected *T. rotatile* as the name of the species. However, the ammonite described by Adkins (1928: 239, pl. 25, fig. 1, pl. 26, fig. 4) as *Mantelliceras sellardsi* from a horizon in the basal part of the Eagle Ford Group comparable to that which yielded Stephenson's material, is a large speciment of *T. rotatile,* and Adkins' name has priority. The holotype of *T. sellardsi* consists of three-fourths of a faulted whorl that has a diameter of about 68 mm. The flattened flanks and venter are crossed by very slightly flexuous to straight rectiradiate or rursiradiate ribs. Umbilical tubercles are bullate and number eight per whorl. Only a trace of the inner ventrolateral tubercles remains on the older part of the whorl. Clavate outer ventrolateral tubercles and much smaller clavate siphonal tubercles number about 22 per half whorl. A fragment of *Acanthoceras amphibolum* Morrow, 1935, is in the matrix.

The impressions from the Cookes Range have narrow, straight to flexuous, prorsiradiate, rectiradiate, or rursiradiate ribs. Umbilical tubercles are conspicuous and bullate to nodate. Inner ventrolateral tubercles are nodate, and the outer ones are clavate (Fig. 68B). None of the impressions shows details of the venter. Several impressions are of specimens (Fig. 68C) with whorl heights of as much as 40 mm, which is much greater than the largest whorls illustrated by Stephenson (about 25 mm). Larger specimens than those figured by Stephenson, however, are present in collections made at a later date from the area of Stephenson's lots, and two of these specimens have whorl heights of 32 and 34 mm. The smallest specimen (Fig. 68H), an impression 16.8 mm in diameter, has sparse ribs and conspicuous tubercles similar to those on the inner whorls of specimens of T. *stantoni* Stephenson (1955).

Occurrence—Calycoceras canitaurinum zone in the flag member of the Colorado Formation in the Cookes Range at locs. 29, 30, 31, 32, 34, 53, and 55; also at loc. 72 in the Silver City Range.

TARRANTOCERAS sp.
Fig. 68F, G

Material—Figured specimens USNM 425202, 425203.

Description—Two small impressions are densely ribbed. The smaller has 30 flexuous ribs at a diameter of 14.3 mm, and the other has 39 ribs at a diameter of 19.0 mm. Nodate umbilical and inner ventrolateral tubercles are present, but whether the outer ventrolateral and siphonal tubercles are present cannot be determined.

Discussion—None of the inner whorls visible in the specimens of *Tarrantoceras* illustrated by Stephenson (1955) reveals this dense ribbing. A small crushed specimen from southeastern Colorado, about 14.5 mm in diameter, assigned to T. *rotatile* Stephenson by Cobban & Scott (1973, pl. 10, fig. 1), has about 29-30 narrow, flexuous ribs in half a whorl, which is even denser ribbing than in New Mexico specimens. A small specimen from Colombia, about 20 mm in diameter, assigned to *Tarrantoceras* cf. *rotatile* by Bürgl (1957, pl. 12, fig. 2), has more than 40 ribs per whorl.

Occurrence-Both impressions are from the lower part of the Colorado Formation in the Cookes Range at locs. 29 and 31. Associated fossils include *Tarrantoceras* cf. *sellardsi* (Adkins).

Genus *PSEUDOCALYCOCERAS* Thomel, 1969

Type species-By original designation, *Ammonites harpax* Stoliczka, 1864: 72, pl. 39, fig. 1 only.

Diagnosis-This genus is closely allied to *Tarrantoceras* Stephenson, from which it differs chiefly in its more robust shell, more pronounced rursiradiate ribbing, and more lengthy lateral lobe in the suture.

Occurrence-Pseudocalycoceras is known from upper Cenomanian rocks of England, France, Spain, Romania, Israel, Syria, Tunisia, Angola, Madagascar, India, Japan, and the United States.

PSEUDOCALYCOCERAS ANGOLAENSE (Spath, 1931)
Figs. 29, 73E-0, 74A-G

1927. *Acanthoceras* sp. A, Moreman, p. 95, pl. 15, fig. 2
1931. *Acanthoceras lyelli* Leymerie: Douvillé, p. 31, pl. 1, fig. la, b.
1931. *Protacanthoceras angolaense* Spath, p. 316.
1939. *Acanthoceras (Mantelliceras) mantelli* (Sowerby): Dacqué, p. 87, pl. 2, figs. 13-14.
1942. *Eucalycoceras dentonense* Moreman, p. 205, pl. 33, figs. 4, 5, text-fig. 2k.
1942. *Eucalycoceras indianense* Moreman, p. 206, pl. 33, figs. 9, 10, text-fig. 2L.
1942. *Eucalycoceras lewisvillense* Moreman, p. 206, pl. 33, figs. 6, 7, text-figs. 2n, u.
1959. *Eucalycoceras dentonense* Moreman: Matsumoto, p. 97, text-fig. 51.
1959. *Eucalycoceras indianense* Moreman: Matsumoto, p. 98.
1963. *non Protacanthoceras angolaense* Spath: Avnimelech & Shoresh, p. 531.
1963. *Eucalycoceras underwoodi* Powell, p. 315, pl. 31, fig. 17, text-fig. 3e, g.
1969. *Eucalycoceras (Proeucalycoceras) dentonense* Moreman: Thomel, p. 650.
1969. *Eucalycoceras (Proeucalycoceras) lewisvillense* Moreman: Thomel, p. 650.
1973. *Pseudocalycoceras dentonense* (Moreman): Cobban & Scott, p. 63, pl. 13, figs. 11-29, pl. 15, figs. 1-7, 10-13 (1972 imprint).
1975. *Pseudocalycoceras dentonense* (Moreman): Hattin, pl. 6, figs. F, G.
1975. *Pseudocalycoceras* sp. aff. *P. dentonense* (Moreman): Matsumoto & Kawano, p. 13, pl. 1, fig. 1, text-fig. 3.
1977. *Pseudocalycoceras dentonense* (Moreman): Kauffman, pl. 18, figs. 5, 6.
1977. *Pseudocalycoceras dentonense* (Moreman): Hattin, text-fig. 5.13.
1978b. *Pseudocalycoceras angolaense* (Spath): Cooper, p. 96, text-figs. 4A-C, H-K, 61, J, 10F, G, 14A, 18E, F, 19A, B, 23-25, 26F-K (with additional synonymy).
1978. *Pseudocalycoceras dentonense* (Moreman): Hattin & Siemers, text-fig. 6.13.
1981. *Pseudocalycoceras dentonense* (Moreman): Wright & Kennedy, p. 37, pl. 5, fig. 4a-c, pl. 6, figs. 3, 6, 7, text-figs. 15A, B, E-H, 19S, T (with full synonymy).
1983. *Pseudocalycoceras dentonense* (Moreman): Moreau, Francis & Kennedy, text-fig. 7a, b.
1983. *Pseudocalycoceras cf. dentonense* (Moreman): Moreau, Kennedy & Francis, p. 326, text-fig. 7c, d.
1983. *Pseudocalycoceras dentonense* (Moreman): Forster, Meyer & Risch, p. 131, pl. 2, figs. 1-4.
1987. *Pseudocalycoceras dentonense* (Moreman): Hattin, fig. 8D.
1988. *Pseudocalycoceras angolaense* (Spath): Kennedy, p. 42, pl. 4, figs. 1, 2, 6-9, 11, 12, pl. 5, pl. 8, figs. 7, 8, pl. 22, figs. 8, 9, text-figs. 10H, 11B, E.

Types-Hypotypes USNM 400789-400791, 400796, 400798, 400799, 425204, 425205.

Diagnosis-This highly variable, stout to moderately compressed species has straight to flexuous, generally rursiradiate ribs that have steep adoral faces on the younger part of the body chamber.

Description-Pseudocalycoceras angolaense is present in several collections of fossils from the Colorado Formation of the Cookes Range and Big Burro Mountains. The largest collection, from Clyde Creek in the Big Burro Mountains loc. 144, consists of 20 fragments and specimens 14.5-60.0 mm in diameter. This collection is of special interest in that the very early whorls can be observed in six individuals. One specimen (USNM 400792) has ventral ornament at a diameter of only 3 mm. In some specimens the outer ventrolateral tubercles appear first, but in some others the inner and outer ventrolateral and siphonal tubercles seem to arise together. Ventral ribs usually form somewhat later. One individual (USNM 400789) has umbilical, inner and outer ventrolateral tubercles, and siphonal tubercles at 6.5 mm diameter (Fig. 731, J). As the shell enlarges, the ventral ribs and tubercles tend to occur in groups of three or four separated by smooth areas (Fig. 73K, L). This grouping of ventral ornament may persist to a diameter of as much as 33 mm. Larger specimens show considerable variation from coarsely ornamented forms (Fig. 73 E, F) somewhat resembling *"Acanthoceras" haugi* (Pervinquiere, 1907: 270, pl. 14, fig. la, b) to finer and more densely ribbed forms (Fig. 73G, H). The largest adult from southwestern New Mexico has a diameter of 97 mm and an umbilical ratio of 30% (Fig. 74B-D). Ventrolateral and siphonal clavi disappear at about the end of the older half of the body chamber. The ribs then become asymmetric with the steep side forward, as in *Eucalycoceras* Spath, 1923.

The suture (Fig. 29) is fairly simple, with broad, bifid E/L saddle and narrower, bifid L and U_2. The holotype of *P. harpax* (Stolickza, 1864, pl. 39, fig. 1, la, lb), the type species of *Pseudocalycoceras,* has a little more digitate suture.

Occurrence-Upper Cenomanian *Sciponoceras gracile* zone in the Cookes Range (locs. 10, 15, 20, 40), Fort Bayard area (loc. 64), Little Burro Mountains (loc. 99), and Big Burro Mountains (loc. 144, 145). Outside southwestern New Mexico, *P. angolaense* occurs in the basal part of the Mancos Shale in the Black Mesa area of northeastern Arizona, in the basal part of the Bridge Creek Member of the Greenhorn Limestone in southeast Colorado, and in the middle part of the Hartland Shale Member of the Greenhorn Limestone in south-central Kansas. It also occurs in southern England, northern France, Angola, and Japan. Records from Lebanon and Israel (Basse, 1940; Avnimelech & Shoresh, 1963) are of a significantly older species.

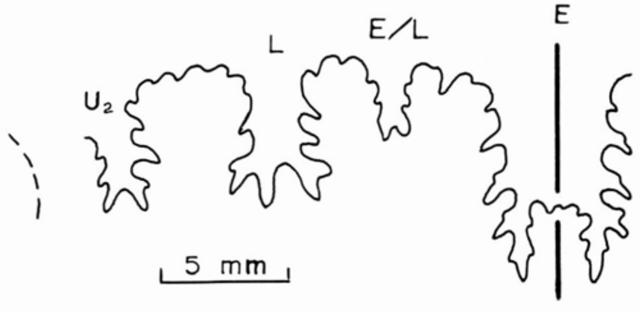

FIGURE 29—External suture of *Pseudocalycoceras angolaense* (Spath) at a whorl height of 16.5 mm. USNM 400792 from loc. 144 in the Big Burro Mountains.

Genus *Sumitomoceras* Matsumoto, 1969

Type Species—By original designation, *Sumitomoceras faustum* Matsumoto & Muramoto, 1969, *in* Matsumoto et al., 1969: 283, pl. 38, figs. 1-4, text-fig. 8.

Diagnosis—This is a small, moderately evolute ammonite that has whorls higher than wide, with flattened flanks and rounded venter. Ornament consists of ribs that cross the venter and umbilical and inner and outer ventrolateral tubercles and, in the very early growth stage, weak siphonal tubercles. Ribs are straight to slightly flexuous and long and short, and are separated in places by shallow constrictions. The only published suture is that of a paratype of *Sumitomoceras faustum* Matsumoto & Muramoto (*in* Matsumoto et al., 1969, text-fig. 8), which has a long and narrow bifid L and U_2.

Occurrence—Upper Cenomanian of north-central and Trans-Pecos Texas, New Mexico, Colorado, southern England, northern France, and Japan.

SUMITOMOCeraS BENTONIANUM (Cragin, 1893)
Figs. 30, 72K-M

1893. *Pulchellia bentoniana* Cragin, p. 239.
1931. *Eucalycoceras* bentonianum (Cragin): Adkins, p. 63.
1942. *Eucalycoceras* bentonianum (Cragin): Moreman, p. 207, text-fig. 2E.
1951. *Eucalycoceras bentonianum* (Cragin): Adkins & Lozo, pl. 6, figs. 9, 10.
1971. *"Eucalycoceras" bentonianum* (Cragin): Kennedy, pl. 121.
1978. *Eucalycoceras bentonianum* (Cragin): Young & Powell, p. XXV.15.
1978b. *Tarrantoceras bentonianum* (Cragin): Cooper, p. 96,
1981. *Tarrantoceras (Sumitomoceras) bentonianum* (Cragin): Wright & Kennedy, p. 39.
1988. *Tarrantoceras (Sumitomoceras) bentonianum* (Cragin): Kennedy, p. 49, pl. 6, figs. 6, 7, 25, 26.

Types—Holotype, by monotypy, TMM 21680, from the Britton Formation of Dallas County, Texas. Hypotype USNM 400810.

Diagnosis—This is a small, moderately evolute species that has thin, sharp ribs much narrower than the interspaces.

Description—The holotype consists of most of an adult body chamber. Ribs are high, rectiradiate, and straight. Long ribs, which extend from the umbilicus, are separated by one or two shorter ones rising low on the flank. Shallow constrictions bound the adoral side of several of the long ribs. Outer ventrolateral tubercles are present on the oldest three ribs, but only a trace of the inner ones remains. Cragin mentioned only the inner and outer ventrolateral tubercles, but Moreman (1942, text-fig. 2e) indicated siphonal tubercles also. There are no siphonal tubercles on a plaster cast of the holotype before us.

A few fragments and a coil from the Colorado Formation of the Cookes Range and Big Burro Mountains seem assignable to S. *bentonianum.* The largest specimen (Fig. 72K-M) is a coil 42 mm in diameter, with an umbilical ratio of 0.35 and a rib count of 36 per whorl. Ribs are narrow and rectiradiate to prorsiradiate; some are a little flexuous. A few poorly defined constrictions are present. One half of the whorl is body chamber. The last half whorl of the phragmocone has six nodate umbilical tubercles that usually give rise to two ribs. These ribs, as well as a few intercalated ones, cross the flank and rise into sharp nodate inner ventrolateral tubercles. The ribs then bend forward a little to the nodate outer ventrolateral tubercles. From there the ribs flatten a little and trend straight across the venter. The outer ventrolateral tubercles weaken on the younger part of this whorl and disappear at the end of the first quarter of the body chamber. Inner ventrolateral tubercles are irregular in strength and persist to the end of the specimen. Umbilical tubercles are nodate on the older part of the body chamber

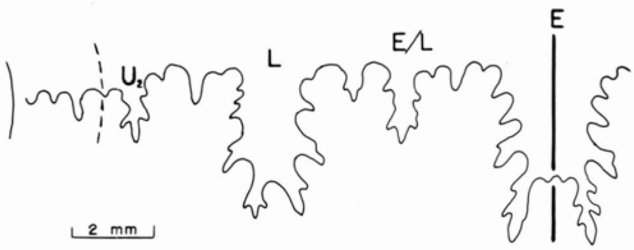

FIGURE 30—Complete external suture of *Sumitomoceras bentonianum* (Cragin) at a diameter of 28.6 mm. USNM 400810, from loc. 10 in the Cookes Range. See Fig. 72K–M.

and bullate on the younger part. The external suture has a broad, bifid E/L and narrow, bifid L (Fig. 30).

Occurrence—Upper Cenomanian *Sciponoceras gracile* zone in the Cookes Range (locs. 10, 15) and Big Burro Mountains (loc. 144). Aside from southwestern New Mexico, *S. bentonianum* is represented in the Western Interior by a few specimens from the base of the Bridge Creek Member of the Greenhorn Limestone in southeastern Colorado.

SUMITOMOCeraS CONLINI Wright & Kennedy, 1981
Figs. 31, 72A-J

1981. *Tarrantoceras (Sumitomoceras) conlini* Wright & Kennedy, p. 39, text-fig. 16A.
1988. *Tarrantoceras (Sumitomoceras) conlini* Wright & Kennedy: Kennedy, p. 44, pl. 6, figs. 1-5, 8-13, 16, 17, text-fig. 10B.

Types—Holotype USNM 400803, hypotypes USNM 400805-400808.

Diagnosis—This species has whorls higher than wide, with flattened flanks and numerous ribs.

Description—A complete specimen 36 mm in diameter and some fragments from the Cookes Range that have flattened flanks, numerous ribs, and uniform inner and outer ventrolateral tubercles closely resemble the similarly sized penultimate whorl of the holotype of *Sumitomoceras conlini* (Wright & Kennedy, 1981: 39, text-fig. 16A). Umbilical and inner and outer ventrolateral tubercles *are* small and nodate; the outer ones are a little larger than the inner. Ribs are flexuous and number about 20 per half whorl, compared to 21 for half of the similarly sized whorl of the holotype. Ribs weaken on crossing the venter. The suture has a moderately narrow, bifid L and much broader, bifid E/L saddle (Fig. 31).

E

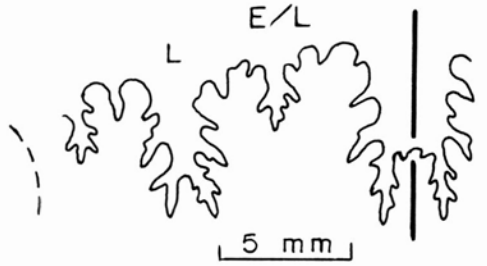

FIGURE 31—Most of the external suture of *Sumitomoceras conlini* Wright & Kennedy at a whorl height of 11.5 mm. USNM 400807, from loc. 15 in the Cookes Range. See Fig. 72F, G.

Occurrence—Upper Cenomanian *Sciponoceras gracile* zone in the Cookes Range (loc. 15) and Big Burro Mountains (loc. 144). The species has been found at a few other localities in New Mexico, southeastern Colorado, and north-central and Trans-Pecos Texas.

Genus *NEOCARDIOCeraS* Spath, 1926a

Type species—By original designation, *Ammonites juddii* Barrois & de Guerne, 1878: 46, pl. 1, figs. 1, 2.

Diagnosis-Neocardioceras is a fairly small, moderately evolute, generally compressed ammonite that has prominent and usually very numerous rectiradiate to prorsiradiate ribs and umbilical, inner and outer, and siphonal tubercles. Primary ribs begin in the umbilicus or rise from umbilical tubercles, and secondary ribs arise farther out on the flank. The ribs bend forward at the position of the inner ventrolateral tubercles and cross the venter as chevrons, where they support the outer ventrolateral and siphonal tubercles.

Discussion-Spath (1926a: 81) proposed this genus for ammonites "resembling *Prionocyclus* Meek, except in its *'Quenstedtoceras'* keel." Wright (1957: 414) and Wright & Kennedy (1981: 49) defined the genus in more detail.

The cotypes of *N. juddii* (Barrois & de Guerene, 1878: 46, pl. 1, figs. la, b, 2a, b) were very small, pyritized inner whorls that apparently have been lost. These specimens came from the Plenus Marls of the Paris Basin at Novy-Chevrieres (Département de Ardennes, France).

Considerable confusion as to the scope of *Neocardioceras* followed the assignment of the Angolan ammonite *Prionotropis echinatus* Douvillé (1931: 34, pls. 3, 4) to *Neocardioceras* by Spath (1931: 316). The Angolan species is a typical *Eucalycoceras septemseriatum* (Cragin), which is widely distributed in Texas and the Western Interior. Examples of the assignment of *septemseriatum* to *Neocardioceras* are Adkins (1933: 437), Moreman (1942: 213), Gregory (1950: 104), and Cobban & Reeside (1952: 1017). *Neocardioceras* was also assigned to some specimens of *Kamerunoceras* before that genus was established (Cobban & Reeside, 1952: 1018; Repenning & Page, 1956: 268).

Occurrence-Neocardioceras is known only from upper Cenomanian rocks of England, France, Germany, Czechoslovakia, Brazil, and the United States (Texas, New Mexico, Arizona, Utah, Wyoming, and Montana).

NEOCARDIOCeraS JUDDII (Barrois & de Guerne)
Figs. 33, 75F-DD, II-MM

1875. *Ammonites neptuni* Geinitz, pl. 6, figs. 4a, b.
1878. *Ammonites juddii* Barrois *Sr* de Guerre, p. 46, pl. 1, figs. la, b, 2a, b.
1926a. *Neocardioceras juddii* (Barrois & de Guerne): Spath, p. 81.
1978. *Neocardioceras juddii* (Barrois & de Guerre): Kennedy & Hancock, pl. 15, figs. 2a, b, 6a, b only.
1981. *Neocardioceras juddii* (Barrois & de Guerre): Wright & Kennedy, p. 49, pl. 8, fig. la, b, pl. 9, figs. 1-10, 12-20, text-figs. 17 (la, b, 2a, b), 19 (H-J, L).
1981. *Neocardioceras juddii* (Barrois & de Guerre): Hook & Cobban, pl. 1, figs. 5-8.
1986. *Neocardioceras juddii juddii* (Barrois & de Guerne): Kennedy, Amédro & Colleté, fig. 5m, p.

Types-Hypotypes USNM 307357, 356890,400819, 400822, 400824-400829, 400831, 425206-425208.

Diagnosis-This variable species ranges from compressed forms that have dense ribs and small, sharp tubercles to more robust forms that have fewer ribs and more rounded tubercles.

Description-The cotypes of *Neocardioceras juddii* (Barrois & de Guerne, 1878, pl. 1, figs. la, b, 2a, b) were only 4 and 5 mm in diameter, with umbilical ratios of 0.38 and 0.40. Barrois's drawings indicate 18-23 ribs per half whorl.

Wright & Kennedy (1981: 50) divided their English and French specimens of *N. juddii* into two groups, *N. juddii juddii* and *N. juddii barroisi* Wright & Kennedy. The eight examples of *N. juddii juddii* illustrated by them from England range in diameter from about 13-40 mm. Ornament consists of narrow, rectiradiate to prorsiradiate primary and secondary ribs, thin umbilical bullae, and small bullate inner and outer ventrolateral tubercles and siphonal clavi. About 20-28 siphonal clavi are present per half whorl. Wright & Kennedy's *N. juddii barroisi* differs from *N. juddii juddii* in having stouter whorls and broader and more rounded ribs that are not as projected on crossing the venter. Ribs are also fewer; the eight English specimens illustrated by them, for which half-whorl rib counts can be made or estimated, number 14-22. The ammonite figured by Geinitz (1875, p1. 62, fig. 4a, b) *as Ammonites neptuni* and assigned to *N. juddii barroisi* by Wright & Kennedy combines the stoutness of that form with the narrow and abundant ribs of *N. juddii juddii.*

Ammonites referable to *N. juddii* are abundant in limestone concretions in the Colorado Formation in the Cookes Range and in the Little and Big Burro Mountains. Preservation is good, and all growth stages can be observed.

The first 3.5-4 whorls are very evolute and smooth (Fig. 75L), and whorl sections are about as broad as high, with well-rounded flanks and venter. Ribbing, outer ventrolateral tubercles, and siphonal tubercles appear together at some diameter between 3.5 and 4.5 mm. By a diameter of 6 or 7 mm the flanks flatten considerably and the whorl section becomes higher than wide. Ribs on these early whorls are closely spaced, sinuous, and slightly prorsiradiate; each begins at the umbilicus. These ribs become bullate at the ventrolateral shoulder, where they bend forward and rise again into conspicuous bullate or nodate outer ventrolateral tubercles. Ribbing differentiates into primaries and secondaries at an early growth stage and continues in this manner through maturity. In many specimens (Fig. 75Q, V) single primary ribs arise from narrow, sharp umbilical bullae, but in other individuals a pair of primaries may arise from a bullate umbilical tubercle. Secondary ribs are long and usually begin close to the umbilical shoulder. Umbilical tubercles are conspicuous only in the larger specimens and number 4-10 per half whorl. These tubercles are usually of irregular strength (Fig. 75Q), but they may be more uniform and conspicuous in some individuals (Fig. 75V), Ribs and tubercles persist on the adult body chamber to the aperture. Each rib has a uniformly sized nodate outer ventrolateral tubercle and a slightly nodate to clavate siphonal tubercle. Inner ventrolateral tubercles are nodate to bullate and usually of irregular height, the larger ones located on the primary ribs. The body chamber occupies about half a whorl (75Z, JJ). The largest adult has a diameter of 69 mm (Fig. 751I-KK).

Although *N. juddii is* present in 11 fossil collections from southwestern New Mexico, two collections have many specimens suitable for either rib and tubercle counts or determination of umbilical ratios. Locality 110 in the Big Burro Mountains ($N^1/2$ sec.11, T18S, R17W, Grant County) has 28 specimens suitable for measurements, and loc. 41 in the Cookes Range ($NE^1/4$ sec. 13, T215, R9W, Luna County) has 17 measurable specimens. These measurements are shown in Fig. 32.

Much variation is revealed by the large collections of *N. juddii* from southwestern New Mexico. The more compressed specimens (e.g., Fig. 75X, Y) tend to be more densely ribbed than the more robust ones (e.g., Fig. 75V, W) and the ribs are more flexuous. Some specimens have several secondary ribs between the primaries (Fig. 75M), whereas in others a single secondary separates the primaries (Fig. 75DD).

The suture of *N. juddii is* fairly simple (Fig. 33). E is moderately wide and deep; the E/L saddle is broader than E/L saddle; the second lateral saddle is high, bifid and smaller than L; and U_2 is small and deeply bifid.

Occurrence-Neocardioceras juddii marks a distinct ammonite zone at the base of the Middle Chalk in southeastern England (Hancock, Kennedy & Wright, 1977: 157, 158; Wright & Kennedy, 1981, table 1). The ammonites occur as remanié fossils in the *Neocardioceras* Pebble Bed (Kennedy, 1970: 659; Wright & Kennedy, 1981: 9-13). Just below this bed is chalk containing *Sciponoceras gracile* (Shumard), *Eucalycoceras septemseriatum* (Cragin), *Calycoceras naviculare* (Mantell), and other species indicative of the upper Cenomanian zone of *S. gracile* (Kennedy & Hancock, 1978: V.16); above the *Neocardioceras* Pebble Bed is chalk containing *Mammites nodosoides* (Schlüter) and other ammonites of early Turonian age. *Neocardioceras juddii is* found at a similar horizon in France (Haute Normandie, Sarthe, and Aube), Czechoslovakia, and the German Federal Republic.

In the United States, *N. juddii* also marks a distinct zone just above rocks containing the *Sciponoceras gracile* fauna. The southwestern New Mexico occurrences of *N. juddii are all* just above beds containing the *S. gracile* fauna. In the Black Mesa area of northeastern Arizona and farther south in east-central Arizona, *N. juddii* occurs a little above beds that contain the S. *gracile* fauna. In southern Utah, *N. juddii* has been found in the lower part of the Tropic Shale but above limestone concretions containing the *S. gracile fauna. Neocardioceras juddii* also occurs above *S. gracile* in the well-documented section of Greenhorn Limestone at Pueblo, Colorado (Cobban, 1985: 136, 137). In south-central Montana, *N. juddii* occurs sparsely in limestone concretions in a bed of bentonite (bed M of Knechtel & Patterson, 1956: 19, 20) at the base of the Greenhorn Calcareous Member of the Cody Shale. Limestone concretions 15 m above bed M contain the *Vascoceras thomi* fauna of Reeside (1923).

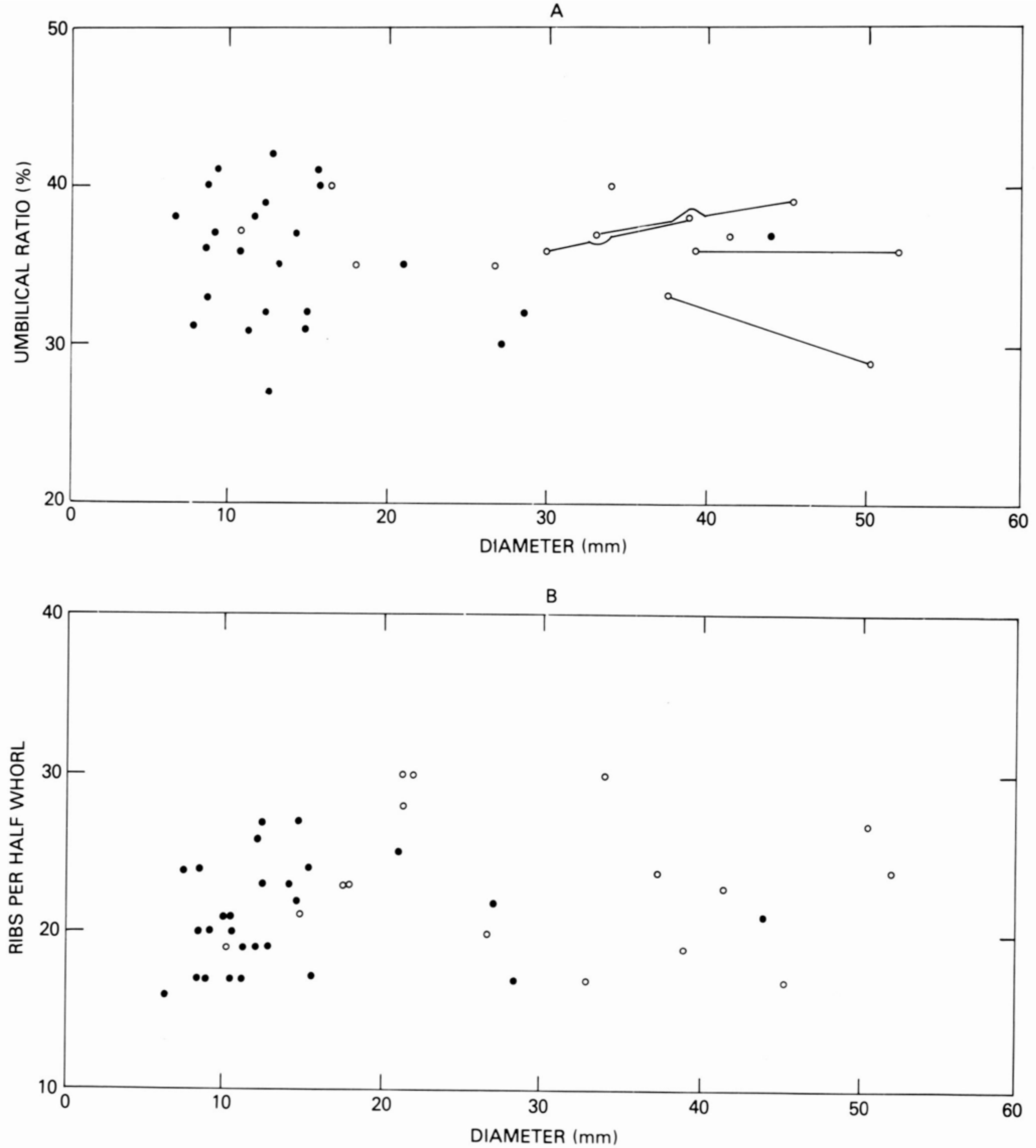

FIGURE 32—Scatter diagrams showing (A) umbilical ratios in percent and (B) number of siphonal tubercles in half a whorl of *Neocardioceras juddii* from loc. 110 (closed circles) and loc. 41 (open circles). Circles connected by lines represent measurements on a single specimen.

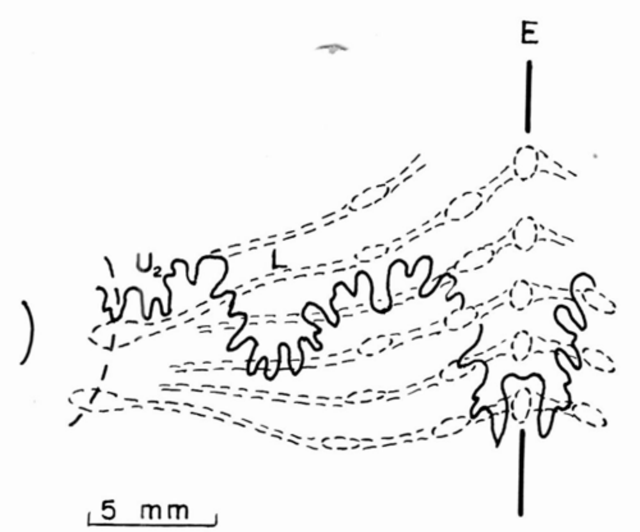

FIGURE 33—External suture at a diameter of 28 mm of *Neocardioceras juddii* (Barrois & de Guerne) from the Colorado Formation at loc. 110 in the N$^{1}/_{2}$ sec. 11, T18S, R17W, Grant County, New Mexico. USNM 400826 (Fig. 75S, U).

NEOCARDIOCeraS WOODWARDI sp. nov.
Fig. 76A-C

Types—Holotype USNM 425209.

Etymology—The species is named for Mr. David R. Woodward, Bald Mountain Ranch, Tyrone, who kindly gave us permission to collect on his property and aided us in other ways.

Description—This species differs from *N. juddii* in its much smaller size, more involute shell, and loss of tuberculation on the body chamber. The holotype, an adult, has a diameter of 16.2 mm and a thickness of 6.5 mm. The specimen is broken and distorted at the base of the body chamber, which has there a diameter of 12.7 mm. The undamaged last half of the outer septate whorl has an umbilical ratio of 0.27 and a rib count of 21. Long, weak ribs are present on the phragmocone and body chamber. Most ribs begin at the umbilical shoulder or arise in pairs from weak umbilical bullae. Each rib on the phragmocone crosses the flank in a sinuous manner and curves forward on the outer part, where it rises into a small bullate or nodate outer ventrolateral tubercle. The ribs cross the venter as chevrons and bear small nodate siphonal tubercles. All tubercles disappear at about the base of the body chamber. Ribs on the body chamber are fine, numerous and sinuous, and cross the venter with forward arching (not as chevrons). The body chamber occupies half a whorl.

Neocardioceras woodwardi is known only from the holotype, which came from the lower part of the Colorado Formation at loc. 95 in the NE$^{1}/4$ sec. 28, T18S, R15W, Grant County. Associated ammonites include *N. juddii* and *Worthoceras* sp. nov.

NEOCARDIOCeraS sp.
Fig. 76D, E.

Material—Figured specimens USNM 425210, 425211.

Description—Several specimens differ from the large collections of *N. juddii* in having abundant fine ribs and greatly reduced tubercles. The smallest one, 20.4 mm in diameter, has an umbilical ratio of 0.40 and a rib count of 39 on the last half whorl (Fig. 76D). Another specimen, 27 mm in diameter, has a rib count of 34 on the last half whorl, which is mostly a body chamber (Fig. 76E.)

Occurrence—Neocardioceras juddii zone of the Colorado Formation at loc. 41 in the Cookes Range and loc. 85 in the Little Burro Mountains.

AMMONITE, gen. nov.?
Fig. 76F-K

Material—Figured specimens USNM 425212, 425213.

Description—One small specimen and an impression of a larger one may represent a new, small, involute genus that has a serrate keel and greatly reduced ornament. The small specimen (Fig. 76F-I) has a diameter of 11.7 mm, an umbilical ratio of 0.20, flat flanks, and well-rounded venter. The last half whorl is mostly crushed, and the last half of it may be the older part of the body chamber. Ornament consists of fine and numerous prorsiradiate ribs, thin and weak inner and outer ventrolateral bullae, and a well-notched keel. Ribs begin at the rounded umbilical shoulder, cross the flank and bend forward at the position of the inner ventrolateral bullae, and then continue beyond the outer ventrolateral bullae to the base of the keel. There seems to be one bullate tubercle on the keel for each outer ventrolateral bulla. Umbilical bullae are lacking. Only a trace of the suture is visible.

The larger specimen (Fig. 76J, K) is an impression that probably represents most of an adult body chamber. This whorl has flat flanks and broadly rounded venter with a low keel. Faint rectiradiate to prorsiradiate ribs rise into inner ventrolateral bullae and then bend forward to the position of the outer ventrolateral bullae, which is mostly marked by a low ridge.

These two specimens were associated with *Neocardioceras juddii* and may be some derivative of that genus.

Occurrence—Both specimens are from the lower part of the Colorado Formation. The smaller specimen is from loc. 95 in the Little Burro Mountains, and the larger one is from loc. 118 in the Big Burro Mountains.

Genus *WATINOCeraS* Warren, 1930

Type species—By original designation, *Watinoceras reesidei* Warren, 1930: 67, pl. 3, fig. 2, pl. 4, figs. 9-12.

Diagnosis—This genus includes small to medium-sized, somewhat involute to fairly evolute ammonites that have a generally smooth, narrow, flat venter, and well-ribbed flanks with umbilical and inner and outer ventrolateral tubercles.

Occurrence—Widely distributed in rocks of early Turonian age in western Europe, Turkestan, Africa, Japan, Alaska, the Western Interior of Canada and the United States, Mexico, Venezuela, and Brazil.

WATINOCeraS ODONNELLI sp. nov.
Fig. 96X, Y

Type—Holotype USNM 425214, from the late Cenomanian zone of *Neocardioceras juddii* in the Big Burro Mountains.

Etymology—Named for Robert O'Donnell, Museum Specialist of the U.S. Geological Survey, for his outstanding preparatory work on Cretaceous fossils.

Diagnosis—A coarsely ornamented, moderately involute species with strong umbilical and inner and outer ventrolateral tubercles.

Description—The holotype is an incomplete shell that probably represents most of an adult. Sutures are not preserved. Diameter is 39.7 mm, and the umbilicus is 11.8 mm (ratio 0.30). The last quarter whorl, which probably is the older half of the body chamber, is somewhat crushed but has a whorl height greater than the whorl breadth. At the larger end of what we assume to be the phragmocone, the costal breadth is 14.1 mm, and the height is 15.0 nun (Wb:Wh = 0.94). Intercostal section there has a narrowly rounded umbilical wall, slightly flattened flank, sloping ventrolateral shoulder, and narrow but slightly flattened venter. Greatest breadth is at the umbilical shoulder. Four strong umbilical bullae are present on the last half whorl of the specimen, and each gives rise to two slightly flexuous, prorsiradiate primary ribs. Between these umbilical bullae, one or two other primary ribs.begin on the umbilical wall and, like the other primaries, are prorsiradiate and somewhat flexuous on crossing the flank. Each of the primaries is separated by a secondary rib that arises below midflank. All ribs bear small nodate to bullate inner ventrolateral tubercles and larger nodate to clavate outer ones, and all ribs are flattened as they cross the narrow venter. Seventeen ribs cross the venter on the last half whorl.

Discussion-This species is of considerable interest in that it represents the oldest known form of *Watinoceras.* The oldest species described from England by Wright & Kennedy (1981: 51-54) are more evolute and possess more umbilical bullae.

Occurrence-From the shale member of the Coloradc Formation at loc. 131 on the west side of the Big Burrc Mountains. The holotype came from a limestone concretion that contained several specimens of *Neocardioceras juddii* from less than 20 mm to 38 mm in diameter.

WATINOCERAS sp.
Fig. 76W-Y, GG

Material-Figured specimens USNM 425215-425217.

Description-A few fragments of *Watinoceras* occur in sandy beds in the Colorado Formation in the Cookes Range above beds that contain *Neocardioceras juddii.* The oldest specimens, from a few meters above *N. juddii,* include bits of small specimens (Fig. 76Y) that have numerous narrow, flexuous ribs like those on the inner whorls of *Watinoceras reesidei* Warren (1930, pl. 4, figs. 9-12; 1947, pl. 30, fig. 6). Associated with these are poorly preserved fragments of larger specimens of which the largest (Fig. 76GG) is an internal mold of sandstone 43 mm in diameter that has prominent nodate umbilical tubercles and weak prorsiradiate ribs with nodate inner ventrolateral tubercles and clavate outer ones.

A better preserved but much smaller specimen (Fig. 76W, X) was found at a higher stratigraphic position. This specimen has a diameter of 7 mm and ornament of 26 prorsiradiate ribs per whorl that bend forward at the ventrolateral shoulder and cross the venter as chevrons. Primary ribs arise singly or in pairs from umbilical bullae and one or two secondaries separate the primaries. All ribs bear small, conical inner ventrolateral tubercles and larger, clavate outer ones.

Occurrence-The oldest specimens, from locs. 12, 22, 43, and 47 in the Cookes Range, were collected a little above a bed that contained *Pseudaspidoceras flexuosum* Powell. The youngest specimen (Fig. 76W, X) is from loc. 24 in the Cookes Range, where it was associated with *Mammites.*

Genus *QUITMANICeraS* Powell, 1963

Type species-By original designation, *Quitmaniceras reaseri* Powell, 1963: 313, pl. 32, figs. 5, 13, text-fig. 3h, j.

Diagnosis-This is a small, compressed, fairly evolute ammonite that has a carinate venter in juveniles and an arched venter in adults, usually with a raised siphonal line. Ribs are very weak to moderately strong, flexuous, mostly prorsiradiate, and bend forward at the ventrolateral shoulder. Weak umbilical bullae and small nodate outer ventrolateral tubercles are usually present, and the more strongly costate specimens may have small inner ventrolateral tubercles. Weak siphonal clavi may be present.

QUITMANICeraS REASERI Powell, 1963
Fig. 75EE-HH

1923. *Pseudotissotia (Choffaticeras)* sp.?, Reeside, p. 30, pl. 12, figs. 3-6.

1963. *Quitmaniceras reaseri* Powell, p. 313, pl. 32, figs. 5, 13, text-fig. 3H, J.

1963. *Quitmaniceras brandi* Powell, p. 314, pl. 32, figs. 6, 8, 11-12, 14-16, text-fig. 3i, p. q.

1987. *Quitmaniceras reaseri* Powell: Kennedy, Wright & Hancock, p. 30, pl. 1, figs. 1-38, text-fig. 2A-C.

Types-Hypotypes USNM 425218-425220.

Description-Small, poorly preserved specimens from three localities in the Big Burro Mountains have the flexuous, prorsiradiate ribs and sharp keel characteristic of compressed forms of this variable species that has been described at length by Kennedy, Wright & Hancock (1987). All are less than 27 mm in diameter. Weak umbilical bullae are present, but other tubercles are not visible.

Occurrence-Lower Turonian zone of *Pseudaspidoceras flexuosum* Powell in the Colorado Formation at locs. 123, 153 and 154 in the Big Burro Mountains, Grant County. In Trans-Pecos Texas, the species occurs with *P. flexuosum* and various species of *Kamerunoceras, Mammites, Vascoceras, Fagesia, Neoptychites, Wrightoceras, Thomasites, Allocrioceras, Sciponoceras,* and *Worthoceras.*

Genus *NIGERICeraS* Schneegans, 1943

Type *species-Nigericeras gignouxi* Schneegans, 1943: 119, pl. 5, figs. 10-15; by subsequent designation by Reyment, 1955: 62.

Diagnosis-Nigericeras is characterized by inner whorls that have umbilical, inner and outer ventrolateral, and siphonal tubercles. Body chamber is smooth or has weak fold-like ribs and umbilical tubercles.

Occurrence-Upper Cenomanian and lower Turonian. Mainly found in Africa, but there are records from Israel, Turkestan, and England (Devon).

NIGERICeraS cf. *scorn* Cobban
Fig. 76LL, MM

Compare 1972. *Nigericeras scotti* Cobban, p. 18, pl. 9, figs. 1-4, pl. 18, figs. 1-9, text-figs. 15-17.

Material-Figured specimen USNM 425221.

Description-A rather battered specimen from the Little Burro Mountains may be a microconch of this species. The specimen, a complete adult, has a diameter of 72.5 mm and an umbilical ratio of 0.33. At least half of the outer whorl is body chamber; its whorl section is broader than high, with rounded flanks and venter. Strong, rounded umbilical tubercles are visible on the older part of the outer whorl and on the penultimate whorl; they number 10 per whorl. The body chamber has umbilical bullae and low, foldlike, rectiradiate ribs that cross the venter transversely. Only bits of the suture are preserved.

Occurrence-The specimen is from a very fine-grained bed of sandstone in the Colorado Formation at loc. 58 along Cameron Creek in the NE^1/4SE^1/4 sec. 23, T18S, R13W, Grant County. *Fagesia* sp. was found with it. In southeastern Colorado, *N. scotti* forms a narrow zone between *Neocardioceras juddii* and the earliest form of *Watinoceras.* The Cameron Creek specimen is probably from a *Watinoceras* zone.

Subfamily EUOMPHALOCERATINAE Cooper, 1978b
Genus *EUOMPHALOCeraS* Spath, 1923

Type *species-Ammonites euomphalus* Sharpe, 1855: 31, pl. 13, figs. 4a-c; by monotypy.

Diagnosis-This genus includes medium-sized, moderately evolute ammonites that have depressed whorls generally with rounded flanks and ornament of ribs of irregular strength, umbilical tubercles, inner and outer ventrolateral and, usually, siphonal tubercles. Inner ventrolateral tubercles, which are larger and fewer than the outer ones, bear spines that may cause the umbilicus to have a polygonal outline. Constrictions are present on some forms. The suture is characterized by a very broad, deeply bifid L.

EUOMPHALOCeraS EUOMPHALUM (Sharpe)
Figs. 34, 76L-P, U, V

1855. *Ammonites euomphalus* Sharpe, p. 31, p1. 13, fig. 4a-c.

1899. *Douvilleiceras euomphalum* (Sharpe): Crick, p. 251, figs. 1, 2.
1903. *Acanthoceras* gr. *nodosocastatum* Pervinquiere, p. 74.
1907. *Acanthoceras giltairei* Pervinquiere, p. 285, pl. 15, figs. 8a—c, 9a, b, text-fig. 108.
1923. *Euomphaloceras euomphalum* (Sharpe): Spath, 143.
1925. *Acanthoceras euomphalum* (Sharpe): Diener, p. 160.
1937. *Acanthoceras guggenbergeri* Collignon, p. 51 (27), pl. 6, fig. 2, pl. 9, fig. 5.
1951. *Euomphaloceras euomphalum* (Sharpe): Wright & Wright, p. 29.
1957. *Euomphaloceras euomphalum* (Sharpe): Matsumoto, Saito & Fukada, p. 35, fig. 13.
1957. *Euomphaloceras euomphalum* Wright, p. L414, fig. 534-2a, b.
1958. *Euomphaloceras euomphalum* Luppov & Drushchits, p. 119.
1963. *Euomphaloceras euomphalum* Wright, p. 609
1964. *Metasigaloceras trituberculatum* Colignon, p. 148, pl. 374, fig. 1626.
1971. *Euomphaloceras euomphalum* (Sharpe): Kennedy, p. 91, pl. 43, fig. 1, pl. 59, figs. 1-5.
1978. *Euomphaloceras euomphalum* (Sharpe): Kennedy & Hancock, pl. 11, fig. 4a—d.
1981. *Euomphaloceras euomphalum* (Sharpe): Wright & Kennedy, pl. 11, figs. 1-8.

Types—Hypotypes USNM 425222-425226.

Description—Four internal molds from a limestone concretion in the Cookes Range are assigned to *E. euomphalum.* The smallest (Fig. 76L-0) has a diameter of 8.4 mm and an umbilical ratio of 0.33. Whorls are very depressed and much broader than high; the whorl section has steep umbilical walls, well-rounded flanks, and broadly rounded venter. Ribs are weak and irregular in height. Inner ventrolateral tubercles vary from large and conical (probably spine-bearing) to small and bullate; outer ventrolateral and siphonal tubercles are weak and bullate. Less than half a whorl of a slightly larger specimen (Fig. 76P) shows a well-developed constriction bordered by tuberculated ribs. The other two specimens (Fig. 76U, V) are much larger, but each consists of about a quarter of a whorl or less. Widely spaced primary ribs that bear large, conical inner ventrolateral tubercles and smaller bullate outer ventrolateral and siphonal tubercles are separated by several very weak secondary ribs with weak, bullate outer ventrolateral and siphonal tubercles.

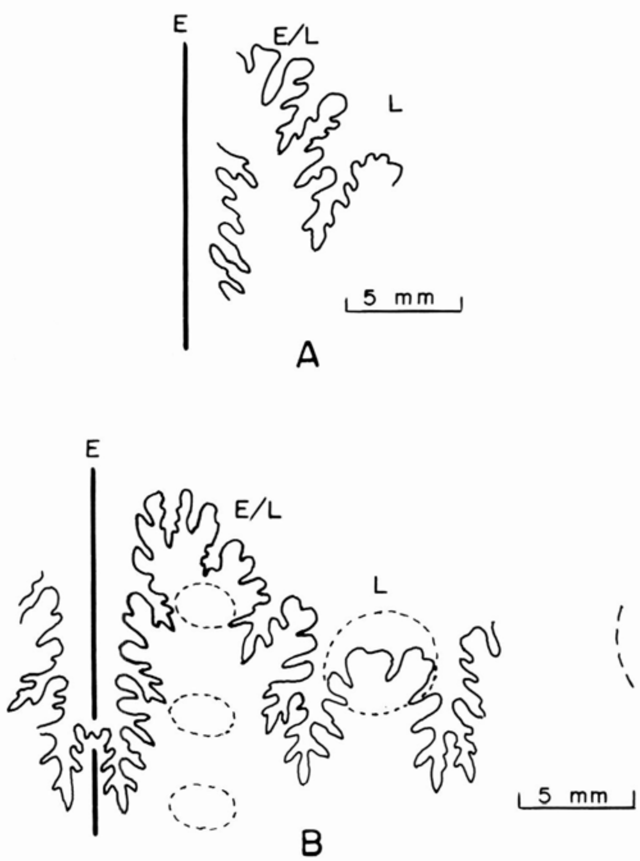

FIGURE 34—Parts of external sutures of *Euomphaloceras euomphalum* (Sharpe). A, USNM 425224 from the lower part of the Colorado Formation at loc. 17 in the Cookes Range (Fig. 76U). B, topotype USNM 425226 from the upper Cenomanian Bed C at Whitlands, Devon, England. This specimen, from the James P. Conlin collection (numbered J.P.C. 9744), was originally provided by C. W. Wright, Beaminster, Dorset, England.

Only bits of the suture are preserved. A small part of the external suture of one of the larger specimens is shown in Fig. 34 along with most of the external suture of a topotype from England for comparison.

Occurrence—Upper part of the upper Cenomanian zone of *Metoicoceras mosbyense at* loc. 17 in the Cookes Range. These specimens, which are the only known representatives of *Euomphaloceras euomphalum* from North America, were collected from a bed of gray-weathering concretionary limestone 3 m below the lowest of several beds of orange-weathering concretionary limestone containing the *Sciponoceras gracile* fauna. Ammonites associated with *E. euomphalum* include *Calycoceras naviculare* (Mantell) and *Vascoceras diartianum* (d'Orbigny).

EUOMPHALOCeraS SEPTEMSERIATUM (Cragin)
Figs. 35, 76Q-T, Z-FF, HH-PP

1893. *Scalphites septem-seriatus* Cragin, p. 240.
1894. *Acanthoceras? kanabense* Stanton, p. 181, pl. 36, figs. 6-8. 1898. *Acanthoceras? kanabense* Stanton: Logan, pl. 107, figs. 4-6. 1927. *Acanthoceras knabense* [sic] Stanton: Moreman, p. 95, pl. 13, fig. 5.
1928. *Scaphites septem-seriatus* Cragin: Adkins, p. 259.
1931. *Kanabiceras kanabense* (Stanton): Reeside & Weymouth, p. 11.
1931. *Neocardioceras septem-seriatum* (Cragin): Adkins, p. 60, 72. 1931. *Neocardioceras* n.sp., Adkins, p. 61, pl. 2, figs. 7, 9.
1931. *Prionotropis echinatus* Douvillé, p. 34, pls. 3, 4; text-figs. 3, 4.
1931. *Neocardioceras echinatum* (Douvillé): Spath, pl. 316.
1942. *Neocardioceras septemseriatum* (Cragin): Moreman, p. 213, pl. 33, figs. 11, 12, text-fig. 2f.
1951. *Neocardioceras [septemseriatum* (Cragin)]: Adkins & Lozo, pl. 6, figs. 7, 8.
1957. *Kanabiceras septemseriatum* (Cragin): Wright, p. L414, text-fig. 534-5a, b.
1958. *Lyelliceras stanislausense* Anderson, p. 247, pl. 8, figs. 5, 5a.
1959. *Kanabiceras septemseriatum* (Cragin): Matsumoto, p. 99, pl. 24, figs. la—c, text-figs. 52, 53.
1963. *Kanabiceras septemseriatum* (Cragin): Powell, p. 316, pl. 31, figs. 9, 10.
1969. *Kanabiceras septemseriatum* (Cragin): Matsumoto, *in* Matsumoto, Muramoto & Takahashi, p. 279, pl. 37, figs. 1-3.
1973. *Kanabiceras septemseriatum* (Cragin): Cobban & Scott, p. 72, pl. 12, figs. 5-27.
1973. *Kanabiceras septemseriatum* (Cragin): Wright & Kennedy, *in* Juignet, Kennedy & Wright, p. 230.
1975. *Kanabiceras septemseriatum* (Cragin): Hattin, pl. 6, figs. D, I.
1976. *Kanabiceras septemseriatum* (Cragin): Offodile & Reyment, p. 42, fig. 11a, b.
1976. *Kanabiceras septemseriatum* (Cragin): Cobban, p. 120, pl. 1, figs. 5, 6.
1976. *Kanabiceras septemseriatum* (Cragin): Juignet & Kennedy, p. 123, pl. 29, fig. 6a—c.
1977. *Kanabiceras septemseriatum* (Cragin): Kauffman, pl. 18, figs. 3, 4.
1978. *Kanabiceras septemseriatum* (Cragin): Kennedy & Hancock, pl. 13, fig. 4.
1978. *Kanabiceras septemseriatum* (Cragin): Young & Powell, pl. 3, figs. 17, 18.
1978. *Kanabiceras septemseriatum* (Cragin): Viaud, pl. 7, figs. 4, 4a.
1978a. *Kanabiceras septemseriatum* (Cragin): Cooper, pl. 2, figs. b, c.
1978b. *Euomphaloceras (Kanabiceras) septem-seriatum* (Cragin): Cooper, p. 106, text-figs. 4N, 0, 10A—E, 12E—H, 18G, H, 19G—L, 26A, B, 28.

1981. *Euomphaloceras septemseriatum* (Cragin): Wright & Kennedy, p. 55, pl. 12, figs. 1-8, pl. 13, figs. 1-6, pl. 14, figs. 5-9.
1981. *Euomphaloceras septemseriatum* (Cragin): Kennedy & Juignet, p. 38, text-fig. 9b-d.
1981. *Euomphaloceras septemseriatum* (Cragin): Kennedy, Juignet & Hancock, p. 56, pl. 9, figs. 3-5, text-fig. 11D, E.
1987. *Euomphaloceras septemseriatum* (Cragin): Hattin, fig. 8A.
1988. *Euomphaloceras septemseriatum* (Cragin): Kennedy, p. 53, pl. 8, figs. 1-6, 9, pl. 9, figs. 1-3, 5-7, 9-12, pl. 22, fig. 3, text-figs. 10E, 11D.

Types-Hypotypes USNM 356910, 425227-425234.

Diagnosis-Most specimens of *E. septemseriatum* have sharp ribs and tubercles of very irregular strength. Ribs usually begin at the umbilical seam and are either rectiradiate or slightly prorsiradiate on crossing the well-rounded flank. At the position of the inner ventrolateral tubercles, the ribs bend forward and weaken on crossing the venter with forward arching. Irregular striae may parallel the ribs on the flanks and venter. Sharp umbilical bullae are usually present on the larger ribs. Inner ventrolateral tubercles are large and nodate, and support long spines. Outer ventrolateral tubercles are nodate to bullate, smaller, and more numerous than the inner ones. Siphonal tubercles are nodate, clavate or bullate, and as numerous as the outer ventrolateral tubercles.

Description-Euomphaloceras septemseriatum occurs in the Colorado Formation at several localities in the Cookes Range and Big Burro Mountains. The largest collection, from limestone concretions at loc. 144 in the Big Burro Mountains, has 16 specimens suitable for measurements of dimensions as well as for tubercle counts. These specimens range in diameter from 4.7 to 45.2 mm. Umbilical and inner ventrolateral tubercles are bullate to nodate and number five to seven per whorl. Outer ventrolateral tubercles are usually bullate, but some are nodate. Siphonal tubercles are clavate, nodate, or bullate and, like the outer ventrolateral ones, number 15-26 per half whorl (average 18). The suture of one of the larger specimens is shown in Fig. 35. The largest individual from southwestern New Mexico (Fig. 76 00, PP), loc. 38 in the Cookes Range, is half of an adult body chamber 97 mm in diameter.

Occurrence-Upper Cenomanian *Sciponoceras gracile* zone and correlatives. The holotype of *E. septemseriatum* is from the Britton Formation of Dallas County, Texas. Wright & Kennedy (1981: 56) drew attention to the wide distribution of this species in England, France, Nigeria, Angola, Japan, Mexico, and the United States. In the Western Interior, the species has been found in the basal part of the Bridge Creek Member of the Greenhorn Limestone of southeast Colorado and in the equivalent part of the Mancos Shale of central, south-central, and west-central New Mexico; in the Bridge Creek Member of the Colorado Formation of southwestern New Mexico; in the basal part of the Mancos Shale in Black Mesa, northeastern Arizona; in the lower part of the Tropic Shale of south-central Utah; in the basal part of the Mancos Shale of central Utah; in the basal part of the Bridge Creek Member of the Greenhorn Limestone of southwestern Kansas; in the middle of the Hartland Shale Member of the Greenhorn Limestone of central and north-central Kansas; in the Greenhorn Formation of the north flank of the Black Hills uplift in southeastern Montana; and in the Frontier Formation of north-central Wyoming.

In southwestern New Mexico, the species has been collected in the Cookes Range (locs. 10, 15, 20, 37, 38), in the Fort Bayard area (loc. 66), and in the Big Burro Mountains (locs, 129, 144, 145, 150).

EUOMPHALOCERAS MEREWETHERI sp. nov.
Figs. 36, 77A-R

Types-Holotype USNM 425235, paratypes USNM 425236425243.

Etymology-For E. A. Merewether, of the U.S. Geological Survey, who collected the types and added much to our knowledge of the Cretaceous stratigraphy of Wyoming.

Diagnosis-A well-defined keel in the early growth stages characterizes this species, and, in some specimens, notching of the keel is hardly visible. In later growth stages the keel becomes well notched and resembles that of some specimens of *E. septemseriatum.*

Description-The species has been found in southwestern New Mexico at only one locality near Virden (loc. 159), where many small fragments occur. A better specimen from the Belle Fourche Shale on the west flank of the Black Hills uplift in eastern Wyoming is selected as the holotype (Fig. 77N, 0). This specimen, a phragmocone 24 mm in diameter, with an umbilicus of 8.5 mm (0.35), has whorls wider than high and flattened flanks. On the last half of the outer whorl and on the penultimate whorl, prorsiradiate ribs are conspicuous and regular, and each bears a bullate umbilical tubercle and an inner ventrolateral spine. About two bullate outer ventrolateral tubercles are present for each inner one. On the last half of the outer whorl, ribs and umbilical bullae become irregular in strength. About seven inner ventrolateral tubercles and 13 or 14 outer ones are on this last half whorl. The outer ones are bullate and set at an angle to the prominent keel from which they are separated by a groove. The top of the keel is undulated into low siphonal clavi equal in number to the outer ventrolateral bullae. The suture (Fig. 36) is much like that of *E. septemseriatum. Euomphaloceras merewetheri* is somewhat older than *E. septemseriatum,* from which it differs by its better developed keel bounded by ventral grooves and by flattened flanks and outer ventrolateral tubercles as high as the siphonal ones.

Occurrence-Upper Cenomanian *Metoicoceras mosbyense* zone. The holotype and one paratype are from limestone

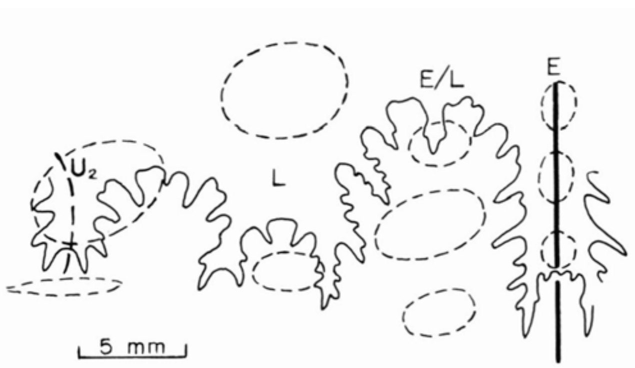

FIGURE 35—External suture at a diameter of 38 mm of *Euomphaloceras septemseriatum* (Cragin) from the Colorado Formation at loc. 144 in the Cookes Range. USNM 425231 (Fig. 76FF, HH).

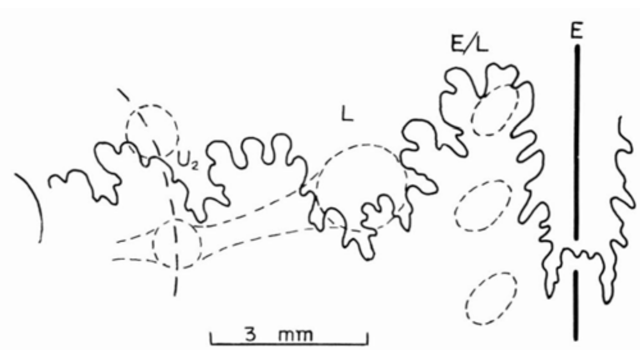

FIGURE 36—External suture at a diameter of 13.5 mm of *Euomphaloceras merewetheri* sp. nov., from the Belle Fourche Shale at USGS Mesozoic locality D8314 in the NW1/4 sec. 33, T50N, R66W, Crook County, Wyoming. Paratype USNM 425236 (Fig. 77P–R).

concretions in the Belle Fourche Shale at USGS Mesozoic locality D8314 in the NW1/4 sec. 33, T5ON, R66W, Crook County, Wyoming. Aside from the Virden area and the west flank of the Black Hills, *E. merewetheri* is known only from a few impressions in the Benton Shale in the Middle Park area of north-central Colorado.

EUOMPHALOCeraS COSTATUM sp. nov.

Figs. 37, 77S-EE, 78A-H

1981. *Kamerunoceras aff. puebloense* (Cobban & Scott): Wright & Kennedy, p. 56, pl. 14, figs. 3, 11.

Types-Holotype USNM 419966, from the Colorado Formation at loc. 41 in the Cookes Range, Luna County, New Mexico. Paratypes USNM 419967-419974, 425244-425247.

Description-Rounded whorls and prominent, closely spaced, narrow ribs characterize this species. The holotype (Fig. 77V-X), from loc. 41 in the Cookes Range, is representative of the inner whorls; it is a well-preserved specimen 45 mm in diameter, with an umbilicus of 16.5 mm (37%). Whorls are about as high as wide, with broadly rounded flanks and venter and more narrowly rounded umbilical and ventrolateral shoulders. The whorls are ribbed down to the smallest diameter preserved, about 6 mm. Ribs on the penultimate whorl are primary and secondary, whereas those on the outer whorl are largely primary. Ribs on this last whorl begin on the umbilical wall, rise into low umbilical bullae at the base of the flank, cross the flank prorsiradially, rise into nodate inner ventrolateral tubercles, and then bend forward obliquely onto the venter, where they terminate in small nodate to bullate outer ventrolateral tubercles. Each outer ventrolateral tubercle is matched by a similarly sized nodate tubercle on a low siphonal ridge. The last whorl has 19 major ribs and inner ventrolateral tubercles, and about 44 outer ventrolateral tubercles.

An impression of some of the inner whorls of another specimen from the type locality reveals striae between many of the ribs. Several specimens from a single limestone con

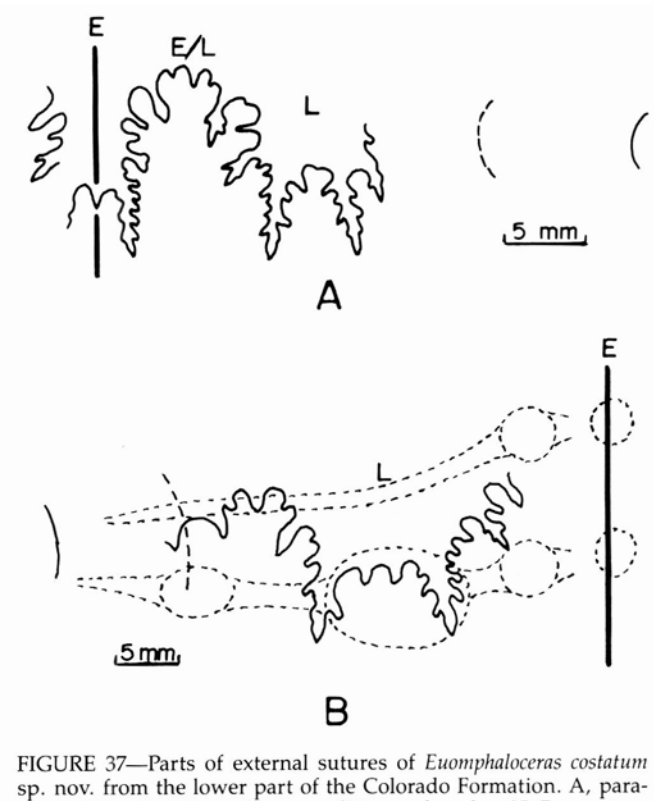

FIGURE 37—Parts of external sutures of *Euomphaloceras costatum* sp. nov. from the lower part of the Colorado Formation. A, paratype USNM 419974 at a diameter of 51 mm, from loc. 95. B, paratype USNM 419973 at a whorl height of 30 mm, from loc. 118.

cretion at loc. 134 at Clyde Canyon in the Big Burro Mountains have very striated innermost whorls (Fig. 77Z), including some as small as 5 mm in diameter. Diameters at which the striations change to ribs may be as small as 15 mm or as large as 20 mm.

Only fragments of the adult whorls have been found at the type locality (Fig. 77BB, CC). In the Big Burro Mountains, adult whorls of *E. costatum* are fairly abundant (Fig. 77DD, EE). The whorls are about as wide as high and have very broadly rounded flanks and venter and somewhat more narrowly rounded umbilical and ventrolateral shoulders (Fig. 78C). Ribs are usually closely spaced, narrow, sharp, and rectiradiate to slightly prorsiradiate.

The suture is typical of the genus (Fig. 37).

Occurrence-Upper Cenomanian *Neocardioceras juddii* zone in southwestern New Mexico and Chispa Summit, Trans-Pecos Texas; upper Cenomanian of southern England. In southwestern New Mexico, the species has been found in the Cookes Range (loc. 41), Little Burro Mountains (loc. 83), Big Burro Mountains (locs. 100, 101, 107, 109, 110, 112, 113, 118, 119, 121, 134, 151, 152), and Virden area (loc. 167).

EUOMPHALOCeraS sp.

Fig. 79U

Material-Figured specimen USNM 425248.

Description-Part of an unusually large *Euomphaloceras* was found as float from the shale member of the Colorado Formation at loc. 121 at Foxtail Creek in the Big Burro Mountains. The specimen consists of the older part of a body chamber and the last two chambers of the phragmocone. At the base of the body chamber, the breadth is 66.5 mm. The incomplete flanks are flattened, and the venter is very broadly rounded. Ornament consists of large, blunt, nodate inner ventrolateral tubercles, smaller nodate outer ventrolateral tubercles set ahead of the inner ones, and weak siphonal clavi. The specimen is possibly a huge *E. costatum.*

BURROCeraS gen. nov.

Etymology-For the Big Burro Mountains, Grant County, New Mexico.

Type *species-Burroceras clydense* **sp.** nov.

Diagnosis-This genus includes slightly to moderately evolute, medium-sized ammonites that have robust whorls with flattened flanks and ornament of weak to strong ribs, umbilical tubercles, inner and outer ventrolateralr tubercles and, at some growth stage, siphonal tubercles. Inner ventrolateral tubercles are larger and fewer than the outer ones. Innermost whorls are smooth except for periodic raised tuberculate ribs that may border weak constrictions. External suture has a very broad, deeply bifid lateral lobe (L).

Discussion-Burroceras combines the shell form and suture of *Pseudaspidoceras pseudonodosoides* (Choffat, 1899), of which it is the direct ancestor, with the tuberculation of its ancestor *Euomphaloceras*. The earliest species, *Burroceras clydense* sp. nov. (Fig. 79D-J, N-T) has a nearly smooth, constricted early stage which immediately distinguishes it from *E. septemseriatum* (Cragin). The constrictions are flanked by collar ribs that bear ventrolateral and siphonal tubercles which first appear at a shell diameter of approximately 10 mm. Beyond this, there is a characteristic convex, slightly asymmetric ventral ribbing that continues to maturity, and the shell form, with flat sides and differentiated tubercles, foreshadows *Pseudaspidoceras*. Siphonal tubercles persist to maturity, and grooves on the flank point to the presence of long inner ventrolateral horns, as in *Euomphaloceras*. Some medium-size specimens show a remarkable resemblance to *Euomphaloceras* (Fig. 79A-C), except for the characteristic innermost whorls. *Burroceras clydense* is succeeded by *Burroceras transitorium* sp. nov. (Figs. 79A-C, 80D-R), in which the early development of a flat-sided shell with flank ribs and differentiation of ventrolateral tubercles approaches yet more closely *Pseudaspidoceras pseudonodosoides; B. transitorium* differs chiefly in the continuing presence of very feeble siphonal tubercles on a siphonal ridge, both of which disappear on the adult body chamber.

The type species is from very late Cenomanian rocks in the Big Burro Mountains. The genus was derived from *Euomphaloceras* by acquiring smooth innermost whorls with periodic raised ribs and by flattening of the flanks on later whorls. *Nigericeras* Schneegans (1943: 118) and *Kamerunoceras* Reyment (1954: 250) also have inner and outer ventrolateral tubercles and siphonal tubercles, but these genera have a much more narrow lateral lobe in the external suture. The type *Kamerunoceras, Acanthoceras eschii* Solger (1904: 124, pl. 4, figs. 1-4, text-fig. 21) has outer ventrolateral tubercles larger than the inner ones, which is the opposite of *Burroceras.*

Occurrence—Upper Cenomanian zones of *Burroceras clydense* and *Neocardioceras juddii.*

BURROCeraS CLYDENSE sp. nov.

Figs. 38, 79D-J, N-T

Types—Holotype USNM 425249, paratypes USNM 425250425255.

Etymology—From the type locality, Clyde Canyon in secs. 10 and 11, T185, R18W, Grant County, New Mexico.

Description—The holotype (Fig. 79S, T), from loc. 142 at Clyde Canyon, is most of an adult 107 mm in diameter, with an umbilicus of 40 mm (37%). Much of one side of the outer whorl has been worn away, but the unworn older part has a whorl section wider than high (Wb:Wh = 1.2). The flanks are flat, the venter is very broadly rounded, and the ventrolateral and umbilical shoulders are narrowly rounded. Very weak, broad, rectiradiate ribs are present on the outer whorl and on the last half of the penultimate whorl, but ribs seem to be absent on the older whorls. Fourteen major bullate to nodate umbilical tubercles occur on the last complete whorl, and these are located on the umbilical shoulder. Seventeen nodate tubercles are on the ventrolateral shoulder of this last whorl. On the penulti mate whorl, these ventrolateral tubercles support spines. Much smaller and weaker nodate outer ventrolateral tubercles are present on the venter of the outer whorl, where they number about 25. Each inner ventrolateral tubercle corresponding to an outer one is set a little ahead of it. A low clavate siphonal tubercle is present for each outer ventrolateral one. Weak ribs of irregular height and spacing cross the venter with gentle forward arching. The last quarter of the outer whorl is the older part of the adult body chamber.

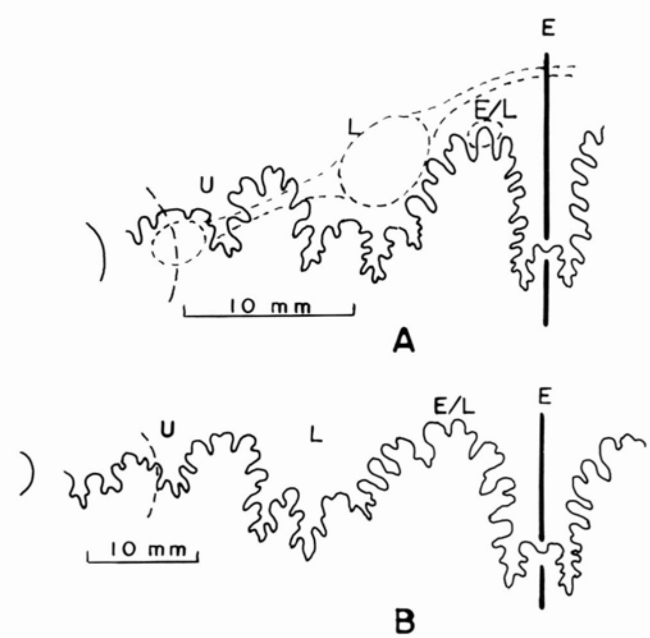

FIGURE 38—External sutures of *Burroceras clydense* gen. et sp. nov., from the lower part of the Colorado Formation at Clyde Canyon in the Big Burro Mountains. A, paratype USNM 425255 at a diameter of 42 mm, from loc. 142. B, paratype USNM 425254 at a diameter of 70 mm, from loc. 141 (Fig. 79P, R).

Part of an inner whorl from the same locality as the holotype (loc. 142) has nearly smooth flanks, strong inner ventrolateral tubercles, and well-ribbed venter with constrictions and nodate siphonal tubercles as large as the outer ventrolateral ones (Fig. 79G, H). The impressed dorsal area reveals that the inner whorls are smooth to a diameter of 9 mm at minimum.

The early ornament is visible on a small paratype (Fig. 79D-F) from a nearby locality (141). In this individual, 16.4 mm in diameter with an umbilicus of 4.5 mm (27%), regular ornament begins at 10.7 mm. The half whorl up to this diameter is smooth except for periodic raised arcuate ventral ribs that number about four per half whorl and bear weak inner ventrolateral tubercles.

The holotype, which has a diameter of 91 mm at the base of the body chamber, is about average size for an adult. Three other adults from Clyde Canyon localities have diameters of 81.5, 90, and 104 mm at the base of the body chamber.

The suture has a very broad, deeply bifid L and a peculiar E/L saddle that has the side farthest from the venter inclined (Fig. 38). Most of the flank consists of this saddle and the lateral lobe.

Occurrence—Upper Cenomanian *Burroceras clydense* zone of southwestern New Mexico at locs. 127, 130, 136, 141, and 142 in the Big Burro Mountains.

BURROCeraS IRREGULARE sp. nov.

Figs. 39, 805-V

Types—Holotype USNM 425256, paratype USNM 425257. Etymology—For the irregular ornament.

Description—Ornament of irregular strength characterizes this species, which is represented by 10 specimens from three localities in the Little and Big Burro Mountains. All are fragments, and most are distorted.

The holotype (Fig. 80S, T) consists of the older half of a body chamber and half of the penultimate whorl. The specimen is moderately evolute, with an umbilical ratio of about 0.44. Strong, widely spaced ribs and tubercles, numbering eight per whorl, characterize the inner whorl, which has a diameter of 42 mm. Umbilical tubercles are sharp, bullate, and located well out on the umbilical shoulder. Inner ventrolateral tubercles are large and spinose. The outer whorl has a cross section about as high as wide, with very broadly rounded venter and slightly flattened flanks. Ornament, which is subdued, consists of weak to very weak, narrow, prorsiradiate ribs that bear bullate umbilical and inner ventrolateral tubercles and blunt nodate outer ventrolateral tubercles. The stronger tubercles are on the stronger ribs. A low siphonal ridge has very weak bullate tubercles corresponding to the ribs.

The largest specimen in the collection is most of an adult body chamber 123 mm in diameter (Fig. 80U, V). Widely spaced, narrow prorsiradiate primary ribs number about 10 per half whorl. Umbilical tubercles are lacking and the ventrolateral ones are small, bullate and inconspicuous. The siphonal ridge has almost disappeared. Only part of the suture is visible (Fig. 39).

Discussion—The spinose inner whorls of the holotype are much like the inner whorls of *Kamerunoceras puebloense*

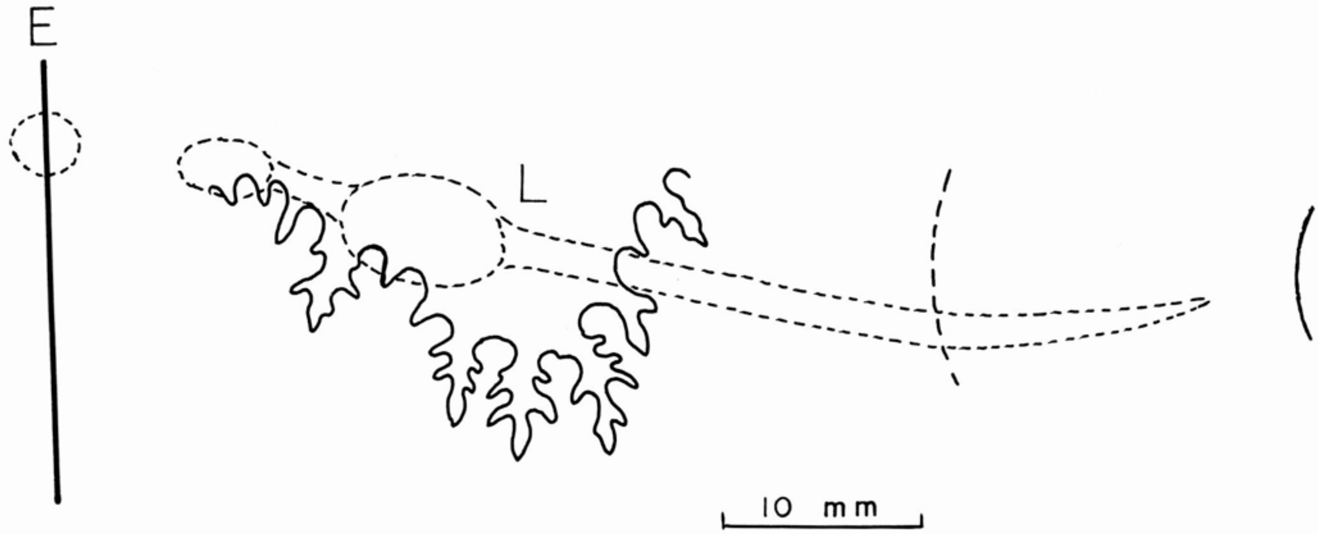

FIGURE 39—Lateral lobe of the last external suture of *Burroceras irregulare* gen. et sp. nov., from loc. 90 in the Little Burro Mountains. Paratype USNM 425257 (Fig. 80U, V).

(Cobban & Scott, 1973: 73, pl. 15, figs. 8, 9, pl. 37, figs. 18, pl. 38, fig. 1) from the Bridge Creek Member of the Greenhorn Limestone in the Pueblo area of Colorado. The outer whorls of *K. puebloense*, however, are more strongly and regularly ribbed than those of *B. irregulare.*

Occurrence—Upper Cenomanian *Neocardioceras juddii* zone in the Little Burro Mountains (loc. 95) and Big Burro Mountains (locs. 100, 121).

BURROCERAS TRANSITORIUM sp. nov.

Figs. 40, 79A-C, 80D-R

Types—Holotype USNM 425258, paratypes USNM 425259425266.

Etymology—For the transitional morphology, towards *Pseudaspidoceras* Hyatt, 1903.

Description—Very weak siphonal tubercles characterize this species, which is transitional to *Pseudaspidoceras* Hyatt, 1903. In some specimens, the siphonal tubercles are so feeble that they can barely be detected under oblique lighting.

The holotype (Fig. 80N-P) is an internal mold of a stout specimen 74 mm in diameter, with an umbilicus of 26.8 mm (36%). About a fifth of the body chamber is attached to a complete phragmocone. Whorls are broader than high; the intercostal breadth of the part of body chamber preserved is 34.4 mm, and its height is 27.4 (Wb:Wh = 1.3). The whorl section is rectangular with flat flanks, flattened to very broadly rounded venter and narrowly rounded umbilical and ventrolateral shoulders. Ribs are low, broad, rounded, and rectiradiate, and are weakest at midflank. Most ribs rise from strong nodate umbilical tubercles, which are located on the umbilical shoulder and number 10 on the last whorl. The ribs rise again into large nodate inner ventrolateral tubercles on the ventrolateral shoulder, where they number 14 on the last whorl. From these tubercles, the ribs bend forward obliquely onto the venter and terminate in nodate outer ventrolateral tubercles that are smaller than the inner ones. A very low siphonal ridge on the phragmocone supports faint tubercles. This ridge disappears at the base of the body chamber. The phragmocone, if found by itself, would certainly be assigned to *Burroceras,* but the body chamber, by itself, would probably be placed in *Pseudaspidoceras.*

Eleven specimens from the type locality (121) are suitable for measurements of dimensions and tubercle counts. Diameters range from 19 to 74 mm and umbilical ratios range from 25 to 38% (average 31%). Tubercle counts per half whorl are: umbilical 4-7 (average 5), inner ventrolateral 6-

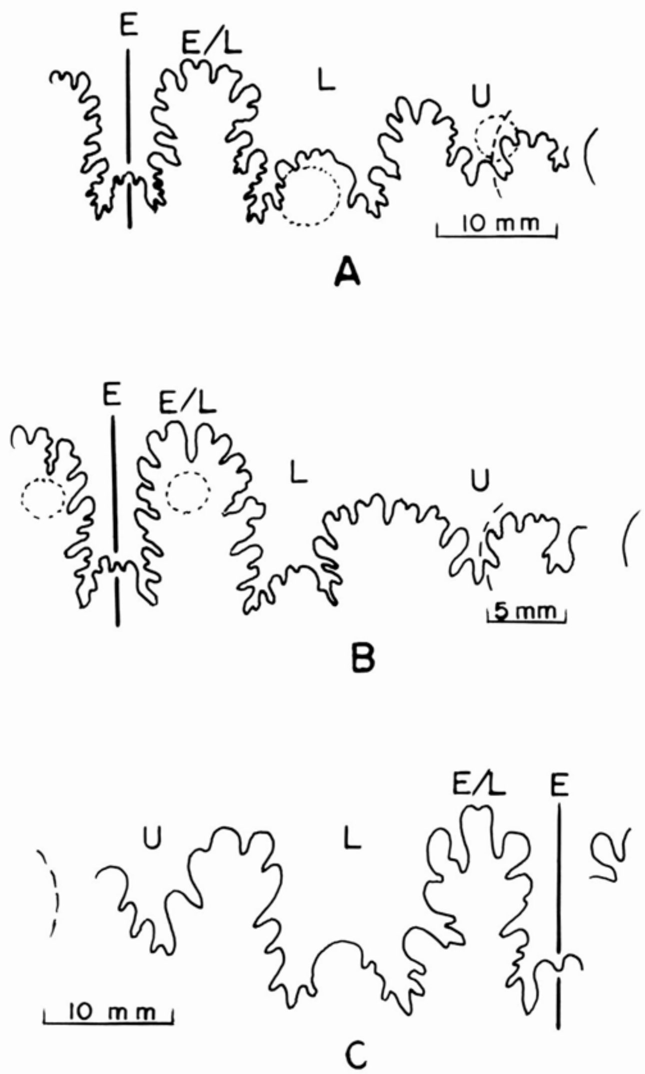

FIGURE 40—External sutures of *Burroceras transitorium* gen. et sp. nov., from the lower part of the Colorado Formation in the Big Burro Mountains. A, paratype 425265 at a diameter of 53 mm, from loc. 109. B, paratype USNM 425266 at a whorl height of 18 mm, from loc. 121. C, last suture of the holotype USNM 425258 (Fig. 80N–P).

11 (average 8.2), and outer ventrolateral 7-18 (average 12.5). Siphonal tubercles are as numerous as the outer ventrolateral ones. Early whorls are smooth, followed by a stage having periodic tuberculate ribs or weak constrictions (Fig. 801, K). In some specimens a low constriction separating a pair of ribs may persist to diameters of as much as 23 mm (Fig. 80J, K).

The suture (Fig. 40) is typical for the genus, with a very broad, deeply bifid L.

Discussion-As interpreted by us, *Burroceras transitorium* shows much variation in stoutness and ornament. This size of ventrolateral tubercles may be fairly regular (Fig. 80J, K) or very irregular (Fig. 80Q, R).

Occurrence-Upper Cenomanian zone of *Neocardioceras juddii* in the Little Burro Mountains (loc. 95) and Big Burro Mountains (lots. 100, 101, 103, 105, 109, 110, 112, 118, 119, 121, 132, 140, 143, 146).

PARABURROCeraS gen. nov.

Type *species-Paraburroceras minutum* sp. nov.

Diagnosis-Progenic dwarf offshoots of *Burroceras.* Most of phragmocone is smooth. Ornament on last part of phragmocone and body chamber consists of prorsiradiate ribs that are asymmetrically convex over the venter where they have equal inner and outer ventrolateral and siphonal tubercles on the phragmocone; ribs on body chamber have strong inner ventrolateral tubercles that are fewer in number than the outer ventrolateral and siphonal ones.

Discussion-Early smooth stage, tuberculation, and curious asymmetry of ventral ribs ally this genus with *Burroceras.* We know of no other genus with which it might be confused.

Occurrence-Upper Cenomanian *Burroceras clydense* zone of southwestern New Mexico at loc. 141 in the Big Burro Mountains, Grant County.

PARABURROCeraS MINUTUM sp. nov.
Fig. 79K-M, 80A-C

Types-Holotype USNM 425267, paratype USNM 425268. Etymology-minutus (Latin) = small.

Description-This tiny species is represented by two adults that differ considerably from each other. We take them to be a macroconch and a microconch. The holotype (Fig. 79K-M), 9.3 mm in diameter with an umbilicus of 3.1 mm (33%), has a diameter of 6.5 mm at the base of the body chamber, which occupies the last half whorl. The last half whorl of the phragmocone is a little broader than high, with broadly rounded flanks and venter and a somewhat more narrowly rounded umbilical and ventrolateral shoulders. Ornament is lacking on the phragmocone except on its last half whorl, where three widely spaced low ribs cross the venter with gentle forward convexity and support feeble, equal-sized nodate inner and outer ventrolateral and siphonal tubercles. Regular ornament appears abruptly at the base of the body chamber, where narrow ribs rise from nodate inner ventrolateral tubercles or from smaller inner ventrolateral bullae and arch forward on crossing the venter. These ribs support small, sharp outer ventrolateral bullae and small nodate siphonal tubercles. About two outer ventrolateral bullae are present for each of the larger inner ones.

The other specimen (Fig. 80A-C), 12.3 mm in diameter with an umbilicus of 4 mm (33%), has a body chamber of half a whorl. This specimen is more slender and more weakly ornamented than the holotype, but similarly to the holotype, has ornament mostly confined to the body chamber. Ribs number 13 on the body chamber and are strongest in the middle of the venter. Inner ventrolateral tubercles are weak and bullate.

The suture of *Paraburroceras minutum* is like that of *Burroceras clydense* sp. nov. in having a broad, bifid L and narrower E/L saddle with one side inclined.

Occurrence-Upper Cenomanian *Burroceras clydense* zone. Both specimens are from limestone concretions in the lower part of the Colorado Formation at loc. 141 at Clyde Canyon in the Big Burro Mountains. Associated fossils include *Burroceras clydense.*

Genus *PSEUDASPIDOCeraS* Hyatt, 1903

Type species-By original designation, *Ammonites footeanus* Stoliczka, 1864: 101, pl. 52, figs.1, 2.

Discussion-Pseudaspidoceras is a moderately evolute ammonite that has a square to rectangular whorl section and, at some growth stage, rather widely spaced ribs, umbilical tubercles, and inner and outer ventrolateral tubercles. Innermost whorls have periodic constrictions and/or periodic raised ribs; later juvenile whorls have uniform tuberculate ribs; and adult whorls may lose their ribs, but usually retain umbilical and inner ventrolateral tubercles. Suture is characterized by its very broad, deeply bifid lateral lobe (L).

Stoliczka (1864, pl. 52, figs. 1, la-c, 2, 2a) figured two specimens of his *Ammonites footeanus* from southern India. The larger specimen, 260 mm in diameter, has been designated the lectotype by Wright & Kennedy (1981: 82). Stoliczka (1864, pl. 52, fig. lb) showed a front view of the inner whorls of this specimen at a diameter of about 38 mm. The whorls at that size are well ribbed and have umbilical and inner and outer ventrolateral tubercles. American specimens of *Pseudaspidoceras at* that diameter also have tuberculate ribs, but smaller whorls of these specimens have constrictions or periodic raised ribs. The earliest whorls of *P. footeanum* have not been described; we assume that they are like those in the American forms.

PSEUDASPIDOCeraS PSEUDONODOSOIDES (Choffat)
Figs. 41, 81-83

1899. *Acanthoceras(?) pseudonodosoides* Choffat, p. 65, pl. 16, figs. 5-8, pl. 22, figs. 32, 33.
1912. *Mammites pseudonodosoides* (Choffat): Roman, p. 12, p1.2, fig. 2, pl. 3, fig. 2.
1925. *Mammites pseudonodosoides* (Choffat): Diener, p. 175.
1935. *?Pseudaspidoceras cornucostale* Morrow, p. 469, pl. 51, fig. lac, text-fig. 5.
1969. *Pseudaspidoceras* cf. *P. pseudonodosoides* (Choffat): Freund & Raab, p. 14, pl. 1, figs. 10, 11, text-fig. 4j-k.
1981. *Pseudaspidoceras* n.sp., Hook & Cobban, p1. 1, figs. 1-4, 9-11, p1. 2, figs. 6-11, pl. 3, figs. 1-4.
1983b. *Pseudaspidoceras pseudonodosoides* (Choffat): Cobban & Hook, p. 37, figs. 2, 3.

Types.-Hypotypes USNM 307365, 337428-337430, 356915, 425269-425289.

Description-Aside from drawings of whole sections and sutures, Choffat (1899, pl. 16, fig. 5) illustrated his species with only one photograph of a specimen which is here designated the lectotype. This specimen, a phragmocone, has a diameter of 90 mm and an umbilicus of 34 mm (38%). Its whorl section is broader than high (Wb:Wh = 1.4). Flanks are flat and venter very broadly rounded. Ornament consists of strong umbilical and inner ventrolateral tubercles, weak outer ventrolateral tubercles, and low rectiradiate flank ribs. The umbilical tubercles are large, nodate, and number 10 on the last whorl. Each umbilical tubercle is connected to an equally large nodate inner ventrolateral tubercle by a low rib weakest at midflank. Outer ventrolateral tubercles disappear at a diameter of about 60 mm. The suture of the lectotype (Choffat, 1899, pl. 22, fig. 32) has a broad, deeply bifid L.

Choffat (1899, pl. 16, figs. 6-8) showed whorl sections of two other specimens at diameters of 90 and 153 mm, and of a smaller one whose diameter was not given. The largest section shows a slightly concave venter, whereas the two smaller sections show broadly rounded venters.

Specimens assignable to *P. pseudonodosoides* are abundant in the Colorado Formation in southwestern New Mexico.

The largest collection, from a discontinuity surface at loc. 41 in the Cookes Range (Hook & Cobban, 1981), contains 75 specimens suitable for measurements of dimensions as well as for tubercle counts. These specimens range in size from 13 to 183 mm. Whorl sections are usually a little broader than high, but an occasional individual has depressed whorls. Flanks are flat and venters are flattened to very broadly rounded. Umbilical and ventrolateral shoulders are narrowly rounded. Umbilical ratios range from 20 to 43%, increasing with overall diameter.

Ornament of the specimens from loc. 41 is much like that of Choffat's specimens. Ribs are usually rounded and very weak, especially at midflank where they may disappear. A few specimens have narrow, almost sharp ribs, and an occasional individual has a rather strongly ribbed body chamber. Umbilical tubercles, which are large and typically nodate, number three to seven per half whorl (average 5). Inner ventrolateral tubercles are also large and nodate; they are located on the ventrolateral shoulder, where they number four to twelve per half whorl (average 7). Outer ventrolateral tubercles, located on the outer part of the venter, are nodate and much smaller than the inner ones, and number seven to seventeen per whorl (average 12). The outer tubercles usually weaken and disappear at some diameter from 60 to 70 mm, but they may persist to diameters as much as 110 mm. Specimens that retain the outer tubercle to a large diameter generally have that tubercle and the inner one set on a thick rib that trends somewhat obliquely towards the siphonal area (Fig. 82L, M). The rib usually does not cross the middle of the venter, which remains a depression separating opposite ribs (Fig. 82N).

Inner septate whorls usually have stronger ribs than those on the outer septate whorls. The ribs bend forward at the inner ventrolateral tubercle, cross the outer part of the venter obliquely, and generally terminate at the outer tubercle. In some individuals the ribs continue transversely across the venter, although weakening greatly on the siphonal part. Whorls less than 20 mm in diameter have periodic ventral constrictions separated by smooth areas. The constrictions are arched forward and usually bordered by elevated tuberculate ribs. Constrictions number about six per whorl and may persist to diameters as much as 25 mm. Some specimens have constrictions bounded on the adapical side by a strong tuberculate rib and on the adoral side by a much weaker tuberculate rib. Occasional individuals up to diameters of 50 mm may have inner and outer ventrolateral tubercles in pairs separated by smooth or weakly ornamented areas (Fig. 81CC-EE).

Many specimens from loc. 41 include parts of body chambers. Diameters at the base of the body chambers range from 61 to 182 mm. Grouping into two general sizes, as would be expected for sexual dimorphism, is not apparent. In some adult body chambers, the spacing of ornament becomes very great (Fig. 82N, 0). The species may have attained diameters as much as 300 mm. One septate fragment has a whorl height of 80 mm (hypotype USNM 425288).

Sutures are preserved in many specimens from several localities in southwestern New Mexico. Most sutures closely resemble the two external sutures figured by Choffat (1899, pl. 22, figs. 32, 33). An occasional specimen has a suture with an unusually broad L and narrow E/L saddle (Fig. 41).

Occurrence-Upper Cenomanian *Neocardioceras juddii* zone and correlatives in southwestern New Mexico, northeastern Arizona, Trans-Pecos Texas, Portugal, Tunisia, and Israel. In southwestern New Mexico, *P. pseudonodosoides* has been found in the Cookes Range (locs. 35, 41, 42, 50), Little Burro Mountains (locs. 84, 85, 95, 99), northeast side of Big Burro Mountains (locs. 101, 103, 104, 109, 110, 112, 113, 115), northwest side of Big Burro Mountains (locs. 116, 118, 120, 121, 124, 125, 127, 132, 133, 140, 141, 143, 146, 152), and Virden area (loc. 168).

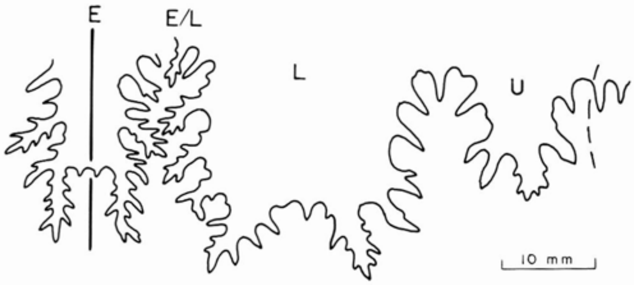

FIGURE 41—External suture of *Pseudaspidoceras pseudonodosoides* (Choffat) at a whorl height of 41 mm from loc. 113 in the Big Burro Mountains. USNM 425289.

PSEUDASPIDOCERAS FLEXUOSUM Powell, 1963
Fig. 91L

1963. *Pseudaspidoceras flexuosum* Powell, p. 318, pl. 32, figs. 1, 9, 10, text-figs. 2 a-c, f, g.
1986. *Pseudaspidoceras flexuosum* Powell: Cobban, fig. 9J.
1987. *Pseudaspidoceras flexuosum* Powell: Kennedy, Wright & Hancock, p. 34, pl. 2, figs. 1-4, 8-13, 16, 17, text-figs. 3A-C, 5, 6C, D, 7A-C (with full synonymy).

Types-Holotype TMM 30842, from the Ojinaga Formation in Calvert Canyon, Hudspeth County, Texas. Hypotype USNM 425290.

Description-An occasional fragment of a large crushed ammonite can be assigned to *Pseudaspidoceras flexuosum.* The largest specimen, part of a body chamber (Fig. 91L), has a whorl height of 95 mm. Ornament consists of narrow umbilical bullae and narrow, flexuous ribs of variable strength, some of which support small, nodate ventrolateral tubercles.

Occurrence-Lower Turonian *Pseudaspidoceras flexuosum* zone in Trans-Pecos Texas, northern Mexico (Chihuahua), southwestern and south-central New Mexico, and central and eastern Arizona. The specimens from southwestern New Mexico are from the base of the sandy beds that overlie the *Pseudaspidoceras pseudonodosoides* bed at locs. 43 and 54 in the Cookes Range.

Subfamily MAMMITINAE Hyatt, 1900
Genus *MAMMITES* Laube & Bruder, 1887

Type species-By monotypy, *Ammonites nodosoides* Schluter, 1871: 19, pl. 8, figs. 1-4.

Diagnosis-Mammites includes moderately sized to fairly large, somewhat evolute, robust ammonites that have a rectangular adult whorl section with conspicuous nodate umbilical and ventrolateral tubercles. Ribbing is usually weak. Inner whorls have umbilical and inner and outer ventrolateral tubercles. Suture with rather long and narrow lateral lobe (L).

Occurrence-Widely distributed in Turonian rocks of Europe, Asia, West Africa, and North and South America.

MAMMITES NODOSOIDES (Schluter)
Figs. 42, 90D-H, M, N

1871. *Ammonites nodosoides* (Schlüter), p. 19, pl. 8, figs. 1-4.
1981. *Mammites nodosoides* (Schluter): Wright & Kennedy, p. 75, pl. 17, fig. 3, pl. 19, fig. 3, pl. 20, fig. 4, pl. 22, fig. 4, pl. 23, figs. 1-3, pl. 24, figs. 2, 3, text-figs. 19b, 23, 24 (with full synonymy).
1983a. *Mammites nodosoides* (Schluter): Cobban & Hook, p. 8, pl. 1, figs. 14, 15, pl. 3, figs. 21, 22, pl. 4, figs. 4-9, 17, 18, pl. 5, figs. 1-3, text-fig. 2.

Types-Hypotypes USNM 425291-425294.

Description-This species is described in detail by Wright & Kennedy (1981) and Cobban & Hook (1983a). Crushed fragments that seem to be M. *nodosoides* occur in brown-weathering sandstone concretions in the sandstone and shale member of the Colorado Formation in the Cookes Range.

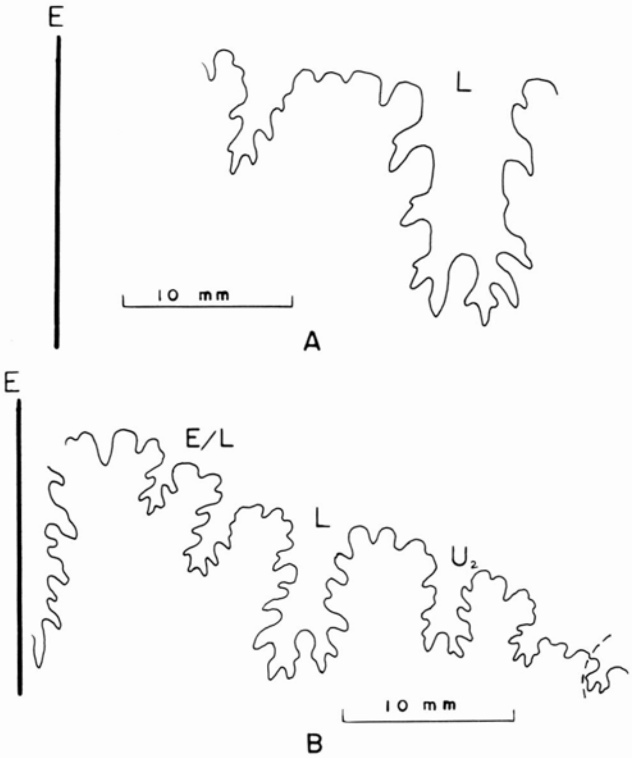

FIGURE 42—External sutures of *Mammites nodosoides* (Schlüter) from the Cookes Range. A, USNM 425293 (Fig. 90G, H) at a diameter of about 67 mm, from loc. 24. B, USNM 425292 (Fig. 90E, F) at a diameter of about 60 mm from loc. 51.

None of the specimens is large. The largest specimen is an internal mold of phragmocone 75 mm in diameter (Fig. 90G, H). Ribs are weak, but tubercles are strong and conspicuous; in half a whorl, there are four large, nodate umbilical tubercles and 10 clavate inner and outer ventrolateral tubercles. The smallest specimen (Fig. 90M, N), 29.5 mm in diameter, has in half a whorl three nodate umbilical tubercles, 11 nodate to clavate inner ventrolateral tubercles, and 11 clavate outer tubercles. Sutures of two specimens are shown in Fig. 42. The lateral lobe (L) is long and narrow, and the E/L saddle is broad as in typical M. *nodosoides* from Europe. Costal dimensions of three specimens are as follows:

	D	Wb	Wh	Wb:Wh	U
USNM 425292 (Fig. E, F)	46.2	17.4 (38)	23.9 (52)	0.73	7.7 (17)
USNM 425293 (Fig. G, H)	75.0				17.2 (23)
USNM 425294 (Fig. M, N)	31.5	13.2 (42)	15.4 (49)	0.86	5.5 *(17)*

Occurrence—Widely distributed in rocks of early Turonian age in Colorado, New Mexico, Arizona, Utah, and Trans-Pecos Texas; southern and eastern England, France, Spain, Germany, Czechoslovakia, Romania, Algeria, Morocco, Tunisia, Nigeria, Madagascar, Lebanon, Israel, Turkestan, Mexico, Colombia, Peru, and Brazil. In southwestern New Mexico the species has been found in the sandstone and shale member of the Colorado Formation in the Cookes Range (locs. 24 and 51).

Genus *METOICOCERAS* Hyatt, 1903

Type *species—Ammonites swallovi* Shumard, 1860: 591, by subsequent designation by Shimer & Shrock, 1944: 591.

Diagnosis—Metoicoceras is a very involute to moderately involute ammonite that typically has compressed whorls, a slightly uncoiled body chamber, and ornament of primary and secondary ribs, umbilical bullae, and usually inner and outer ventrolateral tubercles. Ribs are straight to slightly flexuous and strongest on the outer part of the flank, where they may flatten on the ventrolateral shoulder. The venter may be crossed transversely by broad ribs, or it may be flat or even slightly concave and bordered by clavate outer ventrolateral tubercles. Inner ventrolateral tubercles, where present, usually weaken and disappear on or before the penultimate whorl, but may persist onto the adult body chamber. The suture is fairly simple, with little divided saddles and a rectangular, bifid L narrower than the E/L saddle. *Metoicoceras* is known only from Cenomanian rocks.

METOICOCERAS GESLINIANUM (d'Orbigny)
Fig. 84A-W, AA

1841. *Ammonites catillus* d'Orbigny, p. 325, pl. 97, figs. 1, 2.
1850. *Ammonites geslinianus* d'Orbigny, pl. 146.
1981. *Metoicoceras geslinianum* (d'Orbigny): Wright & Kennedy, p. 62, pl. 17, fig. 2, pl. 18, figs. 1, 2, pl. 19, figs. 1, 2, pl. 20, figs. 1-3, pl. 21, figs. 1, 2, text-figs. 19C—E, 20, 21A—D (with full synonymy).
1981. *Metoicoceras geslinianum* (d'Orbigny): Kennedy & Juignet, pl. 39, text-figs. 7d—e, 8a—c, 9a, e, 10a.
1983. *Metoicoceras geslinianum* (d'Orbigny): Förster, Meyer & Risch, p. 132, pl. 3, figs. 12-16.
1983. *Metoicoceras geslinianum* (d'Orbigny): Moreau, Francis & Kennedy, p. 335, text-figs. 10c, d.
1986. *Metoicoceras geslinianum* (d'Orbigny): Cobban, fig. 3j, k. 1987. *Metoicoceras geslinianum* (d'Orbigny): Hattin, fig. 8E.
1988. *Metoicoceras geslinianum* (d'Orbigny): Lucas et al., p. 156, fig. 9A, **B,** 10.
1988. *Metoicoceras geslinianum* (d'Orbigny): Kennedy, p. 58, pl. 9, fig. 8, pl. 11, figs. 25-27, pl. 22, figs. 16, 17, text-figs. 20-23.

Types—Hypotypes USNM 425295-425305.

Diagnosis—This is a compressed, involute species that has conspicuous inner and outer ventrolateral tubercles on both the phragmocone and body chamber. The venter is flattened on the phragmocone and on most of the body chamber.

Description—The largest collection, from a bed of limestone concretions at loc. 144 at Clyde Canyon in the Big Burro Mountains, contains 27 specimens 3-80 mm in diameter that are suitable for measurements of dimensions and tubercle counts. The smallest whorls examined are about as high as wide, with flattened flanks and very broadly rounded venter. Nodate inner ventrolateral tubercles and slightly smaller nodate outer ventrolateral tubercles first appear at a diameter of about 3 mm. The outer ones are located a little ahead of the inner ones, and a low arcuate ventral constriction bounds the line of tubercles on the adoral side. Each line of tubercles and its bounding constriction are separated from the next set by a smooth area. There are four to six of these ornamented rows per half whorl in specimens up to a diameter of about 9 mm. An occasional individual may have a row of weaker tubercles on the adoral side of a constriction in addition to the stronger row on the adapical side. At diameters larger than 9 mm the constrictions disappear, the tubercles become more uniform in size, and a low rib arises and connects each inner and outer tubercle. As the whorls enlarge, the ribs extend onto the outer part of the flank, and every third or fourth rib crosses the flank and rises into a low umbilical bulla. In the 22 specimens larger than 14 mm, umbilical bullae number three to six per half whorl, and ventrolateral tubercles number 11-17 (average 13.7). Outer ventrolateral tubercles change from a nodate to a clavate form at a small diameter, but the inner ones tend to remain nodate, although on an occasional large specimen these tubercles become clavate. The rib connecting inner and outer tubercles usually broadens and flattens at a diameter between 23 and 27 mm, and this flattening persists to the largest diameters. Most specimens from loc. 144 have very small umbilici and very weak umbilical bullae, but a few specimens that are somewhat more evolute have more robust ornament (Fig. 84S, T).

Only small fragments of adults are present in the collection from loc. 144. However, large adults and sizeable parts of large adults are present in the collections from the Cookes Range. The largest one (USNM 425305) is the younger two-thirds of a body chamber of an individual that probably had a diameter of about 225 mm. Inner and outer ventrolateral tubercles gradually merge into the ribs and disappear on the older part of the specimen. At the apertural end, ribs become much more closely spaced, narrower, lower, and projected on the venter.

Discussion-Many species of *Metoicoceras* have been proposed. Recently Kennedy, Juignet & Hancock (1981: 60-76) and Wright & Kennedy (1981: 62-73) concluded that all French and English forms occur in one zone, the M. *geslinianum* zone, and represent a single variable dimorphic species of which M. *geslinianum* (d'Orbigny, 1850) is the oldest available name. A lectotype of M. *geslinianum* was selected by Kennedy et al. (1981: 64, text-fig. 13). The lectotype, a crushed adult 134 mm in diameter with an umbilical ratio of 27% has 32 low, broad ribs on the outer half of the flank of the last whorl. About every third rib crosses the flank and rises into a low umbilical bulla, of which 11 are present on the outer whorl. Ventrolateral clavi border the flattened venter on the older three-fourths of the outer whorl. Some ribs are accentuated a little at the position where inner ventrolateral tubercles occur in more strongly ornamented forms of *Metoicoceras*.

Among the French species synonymized with M. *geslinianum* by Kennedy et al. (1981: 62) are the five forms described by de Grossouvre (1912) as *Mammites pervinquierei, M. gourdoni, M. petraschecki, M. bureaui,* and M. *dumasi*. These forms, all good *Metoicoceras,* range from a compressed, very involute, nearly smooth type *(bureaui)* that lacks outer ventrolateral tubercles on the body chamber, to a much stouter, more evolute, strongly ornamented form *(gourdoni)* that has both rows of ventrolateral tubercles on the body chamber. Kennedy et al. (1981: 74) regarded the lectotype of M. *geslinianum* as more closely resembling *M. gourdoni* than any of the others.

The range of variation shown by de Grossouvre's five forms can be matched fairly well by specimens of *Metoicoceras* from the zone of *Sciponoceras gracile* in the Britton Formation of north-central Texas and, to a lesser extent, in specimens of the same age in the Western Interior. Although several species were proposed for the American forms by Hyatt (1903) and Moreman (1927, 1942), most specimens have been referred to M. *whitei* Hyatt (1930); as recently pointed out by Cooper (1978b: 114), M. *gibbosum* Hyatt has page priority.

The much figured lectotype of M. *geslinianum* (Sornay, 1955; Cooper, 1978b, text-fig. 29; Kennedy & Hancock, 1978, pl. 13, fig. 3; Kennedy & Juignet, 1981, text-fig. 8a-c; Wright & Kennedy, 1981, text-fig. 21A, B; Kennedy et al., 1981, text-fig. 13) cannot be matched exactly to any specimens from the Western Interior. The combination of a wide umbilicus, prominent umbilical bullae, and lack of distinct inner ventrolateral tubercles on the body chamber is more like some of the older *Metoicoceras*. Considering the wide variation of forms assigned to M. *geslinianum* by Kennedy et al. (1981), we accept those authors' assignment of Hyatt & Moreman's species to M. *geslinianum*.

Occurrence-Upper Cenomanian *Sciponoceras gracile* zone and correlatives. *Metoicoceras geslinianum* is widely distributed in the Western Interior. The species has been recorded, usually as M. *whitei* Hyatt (1903), from the basal part of the Mancos Shale in the Black Mesa area of northeastern Arizona (Repenning & Page, 1956: 267; Cobban, 1975: 110; Decourten & Sundberg, 1977); from the lower part of the Tropic Shale in southern Utah (as *Buchiceras swallovi* Shumard in White, 1877: 202, and in Stanton, 1894: 35, 169; as M. *whitei* in Gregory, 1950: 104); from the lower part of the Bridge Creek Member of the Greenhorn Limestone in southeastern Colorado (Dane et al., 1937: 214; Cobban & Scott, 1973: 74); from the upper part of the Hartland Shale Member of the Greenhorn Limestone in central Kansas (Hattin, 1975: 32); and from the Greenhorn Formation on the north flank of the Black Hills uplift in southeastern Montana (Cobban, 1951: 2185). In addition to the localities in southwestern New Mexico, M. *geslinianum* has been found in the Mancos Shale at several localities in the south-central and west-central parts of the state. The species also occurs in Trans-Pecos and north-central Texas, northern Mexico, southern England, France, Spain, Germany, Czechoslovakia, Iran(?), Angola, Nigeria, and possibly Morocco.

In southwestern New Mexico, M. *geslinianum* has been found in the Bridge Creek Member of the Colorado Formation in the Cookes Range (locs. 8, 9, 10, 15, 27, 35, 38, 39, 40, 45, 46) and in the shale member of the Coloradc Formation of the Silver City Range (locs. 77, 81), Big Burrc Mountains (locs. 102, 129, 137, 138, 139, 144, 145, 147), and Virden area (locs. 160, 165).

METOICOCERAS MOSBYENSE Cobban
Figs. 85C-T, 86L, M

1953. *Metoicoceras mosbyense* Cobban, p. 48, pl. 6, figs. 1-14, pl. 7, figs. 1-3.
1953. *Metoicoceras muelleri* Cobban, p. 49, pl. 6, figs. 15, 16, pl. 8, figs. 1-7, pl. 9.
1957. *Metoicoceras defordi* Young, p. 1169, pl. 149, figs. 1-8, text-fig. 2a, e, g, i.
1970. *Metoicoceras muelleri* Cobban: Ilyin, text-fig. 2b.
1973. *Metoicoceras* cf. M. *defordi* Young: Cobban & Scott, p. 75.
1977. *Metoicoceras muelleri* Cobban: Kauffman, p. 258, pl. 21, pl. 22, figs. 17, 18.
1979. *Metoicoceras defordi* Young: Merewether, Cobban & Cavanaugh, pl. 2, figs. 17, 20-22.

Types-Holotype USNM 108315, from the Mosby Sandstone Member of the Belle Fourche Shale of central Montana. Hypotypes USNM 425306-425317.

Diagnosis-This species has a well-ribbed body chamber that lacks ventrolateral tubercles. The species is herein interpreted as dimorphic, consisting of a robust, moderately involute, strongly ornamented form (microconch) and a larger, more involute form that is more slender and weakly ornamented (macroconch). The smaller form, probably the male, was described as *Metoicoceras mosbyense,* and the larger form, probably the female, was described as M. *muelleri*. The types of both forms are from the Mosby Sandstone Member of the Belle Fourche Shale, where they occur associated.

Description-Metoicoceras *mosbyense* is characterized by its well-ribbed body chamber that lacks ventrolateral tubercles. The holotype (Cobban, 1953, pl. 7), an internal mold 180 mm in diameter with an umbilical ratio of 0.20, consists of an incomplete phragmocone and about a third of a whorl of body chamber. Ribs are broad and slightly prorsiradiate on most of the outer whorl of the phragmocone, but on the last part and on the body chamber they become narrow, more prorsiradiate, and arch forward slightly on crossing the venter. Twelve ribs are present on the last half whorl. Eight paratypes have 10-18 ribs per half whorl (Cobban, 1953, table on p. 49). Umbilical and inner and outer ventrolateral tubercles are present on the inner whorls. Inner ventrolateral tubercles weaken and disappear usually by a diameter of 45 mm, and the outer ones disappear between diameters of 110 and 130 mm.

The larger and more involute form of the species (macroconch) loses its inner ventrolateral tubercles at a smaller diameter than that of the smaller, robust form, and umbilical bullae are weaker or absent. Ribs tend to be flatter and broader in the macroconch, and at diameters 100-200 mm they may be twice as wide as the interspaces. Macroconchs attain diameters of as much as 300 mm.

The suture of *M. mosbyense* (Cobban, 1953, pl. 6, fig. 7, pl. 7, fig. 3, pl. 8, fig. 4) is typical of the genus and like that of M. *geslinianum*.

Discussion-In the Mosby Sandstone Member of central Montana the two forms of M. *mosbyense* are about equal in numbers, but farther south in Wyoming macroconchs become scarce and specimens like the holotype are also uncommon. Instead the dominant form of *Metoicoceras* tends to be about the size of the holotype or slightly smaller and to have a somewhat more densely ribbed body chamber. The name M. *defordi* Young has been applied to these specimens, but inasmuch as the types of M. *defordi* (Young, 1957: 1169, pl. 149, figs. 1-8, text-fig. 2a, e, g, i) can be matched to specimens from the Mosby Sandstone Member, the name *defordi* seems to have only varietal meaning.

Metoicoceras mosbyense occurs in the Colorado Formation in the Cookes Range, Silver City, and Virden areas. Specimens less than 50 mm in diameter are not present in the collections from the Cookes Range and Silver City areas, but several complete adults are present. The best collection is from limy concretions in an argillaceous, very fine-grained sandstone unit in the shale member of the Colorado Formation at loc. 75 in Cane Spring Canyon near Silver City. The largest specimen, an incomplete adult 255 mm in diameter (unfigured specimen USNM 425316), has a quarter of a whorl of body chamber. Ornament is very weak, with low, narrow, prorsiradiate ribs numbering about 33 on the last half whorl. Another large adult (USNM 425317), 231 mm in diameter, has a complete body chamber of less than half a whorl that has a ventral swelling just before the aperture. In the area of the swelling, ribs become very closely spaced. This specimen has 31 fairly closely spaced, narrow ribs on the last half whorl. The oral end of a fragment of another large adult (Fig. 86L) shows the same crowding of narrow ribs near the aperture, but this individual has very broad, flat ribs farther back on the body chamber.

Small specimens occur in limestone concretions at loc. 159 near Virden, where several septate coils 16-38 mm in diameter were collected. The smallest individual (Fig. 85J, K) has primary and secondary ribs and prominent nodate inner and clavate outer ventrolateral tubercles. One specimen, 30 mm in diameter, is unusual in having very slender whorls that are nearly smooth (Fig. 85C, D).

Occurrence-Metoicoceras mosbyense has been found at many localities in the Western Interior from north-central Montana to southwestern New Mexico. The species has been recorded, as M. *muelleri,* from northern Spain where, according to Wiedmann (1960: 725), it marks a zone high in the Cenomanian but below beds containing M. *geslinianum* (Wiedmann, 1978, table 1). In southwestern New Mexico, M. *mosbyense* has been found in the Cookes Range (loc. 6), in the Lone Mountain area (locs. 57, 59, 60, 61), in the Silver City Range (loc. 75), in the Little Burro Mountains (loc. 89), and in the Virden area (locs. 155, 157, 159, 161).

METOICOCERAS PRAECOX Haas
Fig. 85A, B

1949. *Metoicoceras whitei* Hyatt *praecox* Haas, p. 15, pls. 5-7, text-figs. 5-9.
1952. *Metoicoceras praecox* Haas: Cobban & Reeside, p. 1017.
1970. *Metoicoceras praecox* Haas: Ilyin, fig. 2e.

Types-Holotype AMNH 26415:2, from the basal part of the Cody Shale northeast of Greybull, Bighorn County, Wyoming. Hypotype USNM 425318, from the Fort Bayard area.

Diagnosis-The adult of this species is more evolute than most species of *Metoicoceras* and lacks ventrolateral tubercles on the body chamber. Siphonal tubercles are present in the early growth stages. Inner ventrolateral tubercles are lacking.

Description-A juvenile 21.8 mm in diameter from loc. 70 is referred to this species. Coiling is involute, with a ratio to the diameter of 0.14. Two umbilical bullae are present on the younger part, and each gives rise to one or two primary ribs. Farther out on the flank, two or three secondary ribs separate the primaries. On the younger half of the outer whorl, each rib bears a strong, clavate outer ventrolateral tubercle that is matched on the venter by a weak siphonal clavus. The specimen compares well with juveniles of M. *praecox* from the type area in northern Wyoming.

Occurrence-Haas' types are from the zone of *Dunveganoceras pondi* of early late Cenomanian *age. Metoicoceras praecox* is known from many localities of this age in Montana, South Dakota, Wyoming, Colorado, and New Mexico. The specimen from southwestern New Mexico is from a limestone concretion in the shale member of the Colorado Formation at loc. 70 in the Fort Bayard area. Associated fossils include *Calycoceras canitaurinum* (Haas), a species found with M. *praecox at* its type locality.

METOICOCERAS FRONTIERENSE Cobban
Figs. 43, 84X-Z, 86C-K

1988. *Metoicoceras frontierense* Cobban, p. 13, pl. 3, figs. 1-3, pl. 13, figs. 1, 2, pl. 14, text-fig. 12.

Types-Holotype USNM 376927, from the Frontier Formation south of Buffalo, Johnson County, Wyoming. Hypotypes USNM 425319-425329 from the lower part of the Colorado Formation in the Cookes Range-Silver City area of southwestern New Mexico.

Diagnosis-This small to medium-sized species has a body chamber with a smooth or nearly smooth venter except for prominent ribs near the aperture.

Description-Flattened internal molds in the flag member or in the lower part of the shale member of the Colorado Formation can be assigned to M. *frontierense.* Ribs tend to disappear at the ventrolateral shoulder on the adult whorls. This disappearance of the ribbing causes the venter to be smooth except near the aperture where strong ribbing may reappear and cross the venter.

The smallest specimens availabe, 22-25 mm in diameter, have fairly strong, narrow primary and secondary ribs that bear very weak nodate inner ventrolateral tubercles, strong clavate outer tubercles, and faint siphonal clavi (Fig. 86F, G). Primary ribs, which cross the entire flank, begin on the umbilical wall and usually rise into low umbilical bullae. The inner ventrolateral tubercles disappear at some diameter between 25 and 30 mm, but the weak siphonal clavi are still visible in one individual of 35 mm diameter (Fig. 86C), as well as in a fragment of a larger specimen (Fig. 86D, E). Adult whorls lack ventrolateral tubercles and have well- to weakly ribbed flanks (Fig. 86H, I) and smooth, rounded venters (Fig. 86H) except near the aperture, where several strong ribs may be present (Fig. 86J, K).

Sutures are not preserved in most specimens. An incom-

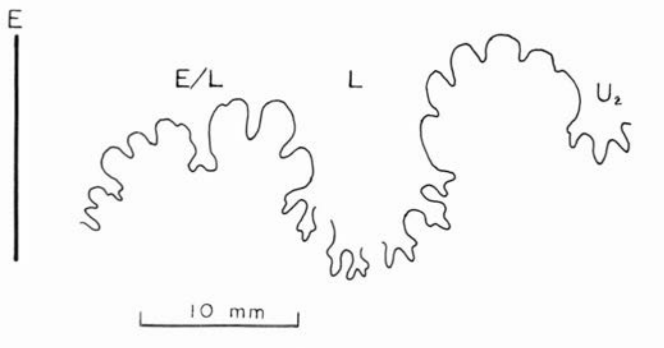

FIGURE 43—Part of the last suture of *Metoicoceras frontierense* Cobban from loc. 34 in the lower part of the Colorado Formation in the Cookes Range. USNM 425326 (Fig. 86H).

plete external suture in one individual (Fig. 43) closely resembles those illustrated by Haas (1949,figs. 5-9) for M. *praecox*.

Occurrence-*Metoicoceras frontierense* has been found at many localities in northern Wyoming, eastern Arizona, and southwestern New Mexico. Most localities are in the Cookes Range (locs. 29, 30, 31, 33, 34, 53, 55), where the species occurs as flattened internal molds in the flag member of the Colorado Formation or as distorted internal molds in limestone concretions in that member. A few flattened fragments have also been found farther west in the shale member in the Fort Bayard area (loc. 70), in the Silver City Range (locs. 72, 73), in the Little Burro Mountains (loc. 92), and in the Big Burro Mountains (loc. 106).

Genus *NANNOMETOICOCERAS* Kennedy, 1988

Type species-By original designation, *Metoicoceras acceleratum* Hyatt, 1903, p. 127, pl. 14, figs. 1-11, from the upper Cenomanian zone of *Sciponoceras gracile* in the Britton Formation of Dallas County, Texas.

Diagnosis-A very involute dwarf derivative of *Metoicoceras* characterized by high rectangular whorls with microconchs 25 mm or less in diameter and macroconchs 40 mm or less. Phragmocones have primary and secondary ribs with inner and outer ventrolateral tubercles, or they may have tubercles only. Body chambers have flat flanks and flattened venters; inner part is almost smooth, but outer part and venter are strongly ribbed with prorsiradiate ribs that bend forward at the ventrolateral shoulder and cross the venter transversely. Tubercles disappear on older parts of body chamber.

Occurrence-Known only from the upper Cenomanian zones of *Metoicoceras mosbyense* in Montana and *Sciponoceras gracile* in Texas and New Mexico.

NANNOMETOICOCERAS cf. *ACCELERATUM* (Hyatt)

Fig. 86N, 0

Material-Figured specimen USNM 425330.

Description-A quarter of a whorl of a small adult ammonite may be *N. acceleratum*. The fragment is an internal mold 17 mm in length that is part of a body chamber. It has a rectangular section with a whorl height of 10.3 mm and breadth of 6.3 mm. Flanks are flat and mostly smooth. The venter is flattened and, in the younger part, crossed transversely by bar-like ribs that begin on the outer part of the flank.

Occurrence-The specimen is from a limestone concretion in the Bridge Creek Limestone Member of the Colorado Formation at loc. 15 in the Cookes Range. Other fossils in the concretion include *Vascoceras diartianum* (d'Orbigny) and *Moremanoceras scotti* (Moreman).

Family VASCOCERATIDAE H. Douvillé, 1912
Subfamily VASCOCERATINAE H. Douvillé, 1912
Genus *VASCOCERAS* Choffat, 1898

Type *species*-*Vascoceras gamai* Choffat, 1898: 54, pl. 7, figs. 1-4, pl. 8, fig. 1, pl. 10, fig. 2, pl. 21, figs. 1-5, from the upper Cenomanian of Portugal. The holotype was destroyed in a fire at the Museum National in Lisbon, and Berthou, Chancellor & Lauverjat (1985: 67) designated as lectotype the specimen figured by Choffat, 1899, pl. 7, fig. 2. This designation is void. We here designate the same specimen as neotype.

Diagnosis-Wright & Kennedy (1981: 86) gave the following diagnosis: "Variable, inner whorls evolute to rather involute, depressed to slightly compressed, normally with strong umbilical tubercles, with or without constrictions; the ribs are not interrupted on the venter but may develop ventrolateral nodes. Later whorls are oval, subquadrate, bluntly triangular or depressed in section, with or without ribs on outer part of sides and venter, with or without rounded umbilical tubercles. The suture has variable, irregular, short, feebly indented elements."

This interruption of the genus is broad enough to include the following vascoceratid genera or subgenera: *Paravascoceras* Furon, 1935, *Pachyvascoceras* Furon, 1935, *Paracanthoceras* Furon, 1935, *Broggiiceras* Benavides-Caceres, 1956, *Discovascoceras* Collignon, 1957, *Greenhornoceras* Cobban & Scott, 1973, and *Provascoceras* Cooper, 1979. These forms, originally defined as genera or subgenera, are now included in *Vascoceras* without subgeneric designations as a result of the recent investigations of Berthou, Chancellor & Lauverjat (1985) and Kennedy, Wright & Hancock (1987). These authors have demonstrated great variation within the species of *Vascoceras* and, as a result, many names have been placed in synonymy.

Discussion-Berthou, Brower & Reyment (1975) pointed out that through time *Vascoceras* showed an increase in the degree of involution and in inflation. Berthou, Chancellor & Lauverjat (1985) verified this and, in addition, noted that it was possible to distinguish two "lineages," one uniting the species with strong umbilical tubercles and the other that included species with little or no umbilical tubercles.

Occurrence-Vascoceras is primarily a Tethyan genus known only from upper Cenomanian and lower Turonian rocks. Berthou, Chancellor & Lauverjat (1985) list it from Portugal, France, England, Spain, Yugoslavia, Germany, the Middle East, North and West Africa, Brazil, Mexico, Peru, Colombia, Venezuela, the Western Interior of the United States, Japan, and Madagascar.

VASCOCERAS cf. *GAMAI* Choffat

Figs. 44, 87W-AA, EE-RR

Material-Figured specimens USNM 356891, 425331-425337.

Description-Thirty inner whorls of a *Vascoceras* from the Big Burro Mountains resemble comparable whorls of *V. gamai* Choffat (1899, pl. 7, figs. 3, 4, pl. 10, fig. 2) in their general appearance, but the lack of adult shells hampers positive identification. Most of the specimens are small (15-53 mm in diameter), and only a few fragments of medium-sized specimens are at hand. The more slender and more weakly ornamented forms have diameters of 28-75 mm, with umbilical ratios of 0.19-0.30 (average 0.24); they have eight to thirteen umbilical tubercles per whorl and 25-30 ribs. The stouter and more strongly ornamented forms have diameters of 15-52 mm, with umbilical ratios of 0.16-0.27 (average 0.22) and four to nine umbilical tubercles per whorl. The few fragments of larger specimens show a considerable weakening in the ribbing on the larger whorls (Fig. 8700-RR). Sutures (Fig. 44) are comparable to those figured by Choffat (1899, pl. 21).

Discussion-The inner whorls from the Big Burro Mountains are a little more involute (ratios of 0.16-0.30) than those of *V. gamai* from Portugal (0.30-0.35, measured from Choffat's illustrations). This difference may be due to changes within the species owing to the great geographic distance between New Mexico and Portugal even during the Cretaceous, or to some slight difference in age. Berthou, Chancellor & Lauverjat (1985, fig. 2) show *V. gamai* to be common in the zone of *Metoicoceras geslinianum* in Portugal but to range on up through an unnamed zone and through the overlying zones of *Neocardioceras juddii* and *Watinoceras coloradoense*. This would be the same in southwestern New Mexico as being common in the zone of *Sciponoceras gracile* but ranging up through the zones of *Burroceras clydense, Neocardioceras juddii, Pseudaspidoceras flexuosum,* and *Vascoceras birchbyi*. In New Mexico, however, *V.* cf. *gamai* has been found only in the zones of *B. clydense* and *N. juddii*.

Occurrence-According to Berthou et al. (1985: 70), *V. gamai* has been recorded from Portugal, Spain, France, Morocco, Algeria, Egypt, Yugoslavia, Madagascar, Brazil, and

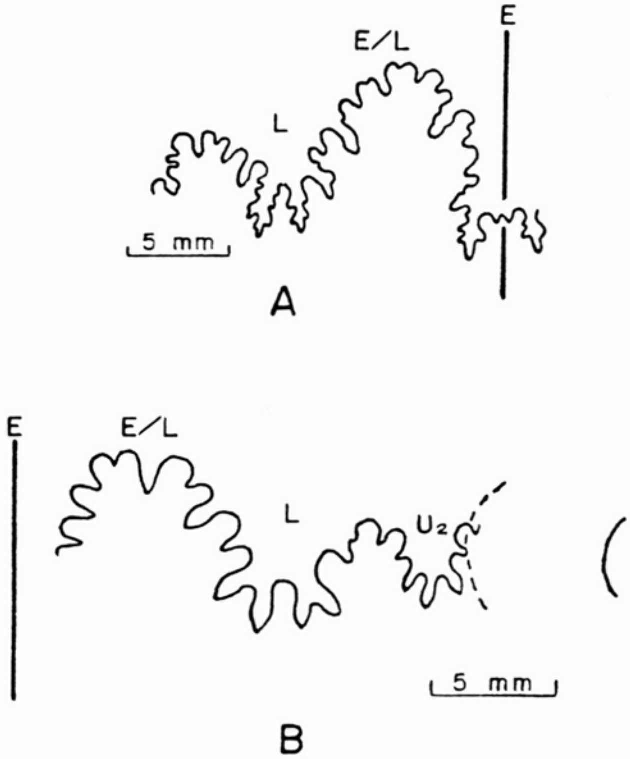

FIGURE 44—External sutures of *Vascoceras* cf. *gamai* Choffat from the Colorado Formation. A, USNM 425334 at a diameter of about 35 mm, from loc. 141 (Fig. 87LL–NN). B, USNM 356891 at a diameter of about 25 mm, from loc. 100 (Fig. 87II–KK).

Mexico. These authors noted that the records from France, Yugoslavia, and Madagascar are misidentifications. In southwestern New Mexico, *V.* **cf.** *gamai* **has been found in the zone of** *Burroceras clydense* **in the Big Burro Mountains (locs. 130, 141, 142) and in the overlying zone of** *Neocardioceras juddii* **in the Little Burro Mountains (locs. 95, 100) and in the Big Burro Mountains (locs. 119, 134).**

VASCOCERAS sp. A
Fig. 87BB-DD

Material—Figured specimen USNM 425338, from the zone of *Burroceras clydense* **in the Big Burro Mountains, Grant County, New Mexico.**

Description—An internal mold of a complete, unusually small adult *Vascoceras* **has a body chamber that occupies the last two-thirds of a whorl. Dimensions in millimeters of the specimen are as follows, with ratios of the diameter: D, 34.0; Wb, 16.8 (0.49); Wh, 15.0 (0.44); Wb:Wh (1.12); U, 8.6 (0.25). Whorl section is well rounded, with narrowly rounded umbilical shoulder and deep umbilicus. Four strong, bullate umbilical tubercles are present on the last part of the phragmocone and older part of the body chamber. These give rise to two or three low, rectiradiate ribs which, with one or two secondary ribs, cross the venter transversely where they are strongest. Ribs on the younger part of the body chamber are weaker and rectiradiate and cross the venter with slight forward arching. The aperture is normal. The suture is typical of** *Vascoceras,* **with the far side of the E/L saddle sloping away from the venter.**

Discussion—This specimen was found with *V.* **cf.** *gamai* **and possibly represents a micromorph.**

Occurrence—From a limestone concretion in the shale member of the Colorado Formation at loc. 141 on the northwest side of the Big Burro Mountains.

VASCOCERAS SILVANENSE Choffat
Figs.45, 88C-I

1899. *Vascoceras silvanensis* Choffat, p. 57, pl. 8, figs. 5a—c, pl. 21, fig. 9.
?1956. *Vascoceras* cf. *V. silvanense* Choffat: Benavides-Caceres, p. 471, pl. 56, fig. 7.
1985. *Vascoceras silvanense* Choffat; *nomen dubium:* Berthou, Chancellor & Lauverjat, p. 68.

Types—Hypotypes USNM 425339, 425340.

Description—The holotype, which is the only specimen figured by Choffat (1899), came from Silvan in the Rio Mondego area of Portugal. The specimen is an internal mold that has a depressed, triangular whorl section, smooth venter, and strong, conical umbilical tubercles numbering six or seven per whorl. Its suture is little incised and has a short, bifid L much narrower than the E/L saddle and the L/U saddle (Choffat, 1899, pl. 21, fig. 9).

Part of a septate whorl (Fig. 88G-I) embracing parts of inner whorls from the Colorado Formation at loc. 118 closely resembles the holotype. The cross section is triangular, and the outer whorl is smooth except for strong umbilical tubercles that probably number six or seven per whorl. The external suture has a short, bifid L and very broad E/L saddle (Fig. 45). Part of a smaller whorl from the same locality is also smooth except for large, blunt, nodate umbilical tubercles (Fig. 88C-F). The impressed area on the dorsum of this individual is also smooth.

Discussion—According to Berthou, Chancellor & Lauverjat (1985: 60, 68), *V. silvanense* **is known from Portugal by only the holotype. They noted that the type was a phragmocone of uncertain affinities that they considered** *a nomen dubium.* **Inasmuch as we have from southwest New Mexico two specimens that seem to be** *V. silvanense,* **we are retaining this name.**

Occurrence—Neocardioceras juddii **zone in the Colorado Formation of the Little Burro Mountains (loc. 95) and Big Burro Mountains (loc. 118), and in the same zone in the Chispa Summit Formation of Trans-Pecos Texas. Aside from these localities and Choffat's locality in Portugal,** *V. silvanense* **may occur in northern Peru, from where BenavidesCaceres (1956: 471, pl. 56, fig. 7) figured a specimen that he compared to this species. Willard (1966, pl. 42, fig. 2) also illustrated from Peru a specimen that he compared to** *V. silvanense,* **but his specimen seems to lack umbilical tubercles.**

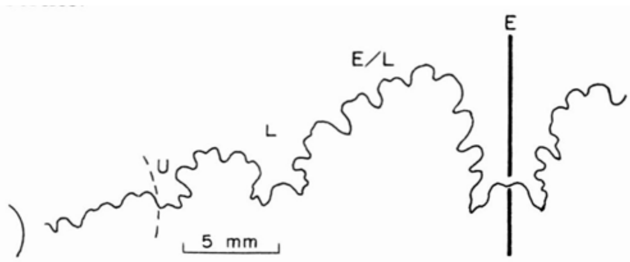

FIGURE 45—External suture at a whorl height of 14 mm of *Vascoceras silvanense* Choffat, from the Colorado Formation at loc. 118 in the Big Burro Mountains. USNM 425340 (Fig. 88G–I).

VASCOCERAS sp. B.
Figs. 46, 88J-S

Material—Figured specimens USNM 425341-425345.

Description—Six fairly small specimens seem to combine the depressed whorl section of *Vascoceras silvanense* **with the conspicuous ribbing of the inner whorls of** *V. gamai.* **In this respect, some specimens (Fig. 88L-N) resemble the inner whorls of specimens assigned by Choffat to his** *V. douvillei* **(Choffat, 1899, pl. 11, figs. 4, 5), which is considered a synonym of** *V. durandi* **(Thomas & Peron, 1890) by Berthou et al. (1985: 72). Portuguese specimens, however, have whorls**

somewhat more depressed and umbilici slightly larger (ratios of 0.26-0.28 compared to about 0.20 for the New Mexican specimens). Sutures (Fig. 46) are simple and typical of the genus.

Occurrence—Upper Cenomanian zone of *Burroceras clydense* on the northwest side of the Big Burro Mountains (locs. 130, 141, 142) and zone of *Neocardioceras juddii* in the Cookes Range (loc. 41).

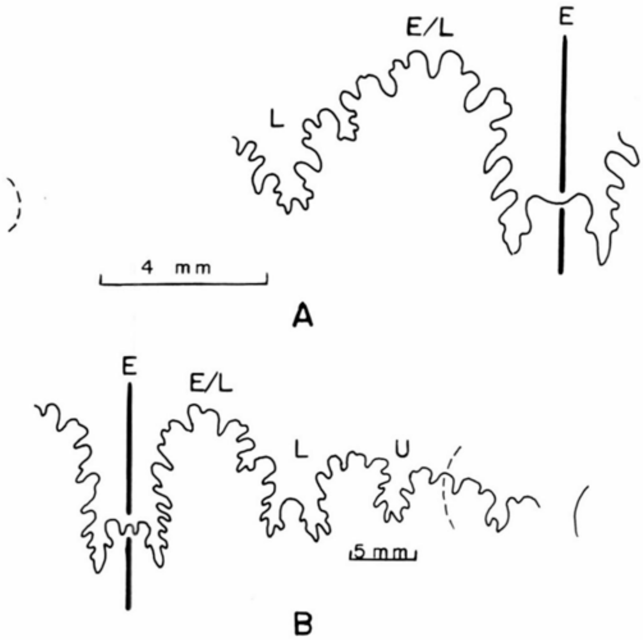

FIGURE 46—External sutures of *Vascoceras* sp. B. A, USNM 425345 at a diameter of 18 mm, from loc. 142 in the Big Burro Mountains. B, USNM 425342 at a diameter of 38.5 mm, from loc. 41 in the Cookes Range (see Fig. 88L–N).

VASCOCERAS BARCOICENSE Choffat, *EXILE* subsp. nov.

Figs. 47, 87Q-S, 89M-GG

Types—Holotype USNM 425346, from the Colorado Formation at loc. 121 in the Big Burro Mountains. Paratypes USNM 425347-425362, 425438.

Etymology—*exilis* (Latin) = thin, slender, in reference to the slender whorls, especially the inner whorls.

Diagnosis—An involute, compressed subspecies that has weakly ribbed to smooth inner whorls with poorly defined constrictions and a smooth to faintly ribbed body chamber.

Description—The holotype (Fig. 89DD-EE) is part of a phragmocone 71.5 mm in length that includes about a third of the outer whorl and most of the inner whorls. A bit of the body chamber is attached. The diameter at the base of the body chamber is estimated at 77 mm, and the diameter of the umbilicus there is 15 mm (ratio of 0.20). At a whorl height of 31.6 mm, the whorl breadth is 26.4 (ratio of 0.84). Whorls are widest at the narrowly rounded umbilical shoulder. Flanks are flattened and convergent to the well-rounded, fairly narrow venter. The outer whorl is almost smooth except for faint ribs of irregular height and spacing on the outer part of the flank and venter. Similar ribs are present on the small part of the venter that is exposed on the inner whorl. The little incised suture has a round, bifid E/L saddle and a narrower, asymmetrically bifid L that has the ventral branch smaller and higher than the dorsal one (Fig. 47).

In addition to the holotype, eight specimens were collected at loc. 121 that are complete enough to either measure the diameter at the base of the body chamber or to estimate it. These measurements, as well as those of the umbilici and ratios to the diameter, are as follows:

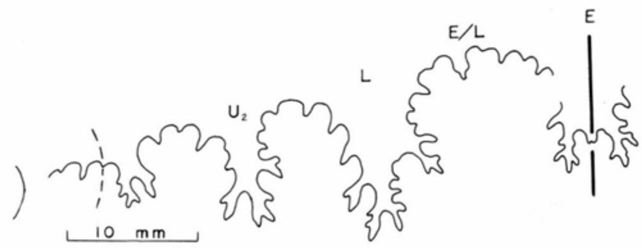

FIGURE 47—External suture of *Vascoceras barcoicense exile* subsp. nov. at a whorl height of 29 mm, from the Colorado Formation at loc. 121 in the Big Burro Mountains. Holotype USNM 425346 (Fig. 89DD, EE).

USNM	D	U	Diameter at base of body chamber
425353	33.7	5.1 (0.15)	33.7
425354	36.4	6.8 (0.19)	36.8
425355	38.3	7.8 (0.20)	43.5
425356	43.4	7.5 (0.17)	43.4
425357	43.6	9.2 (0.21)	43.6
425358	46.4	8.7 (0.19)	46.4
425359	56.1	12.2 (0.22)	56.1
425360	58.0		58.0

None of these specimens departs much from the holotype; the smaller specimens are like the inner whorls, and the larger ones are like the outer whorl. None has umbilical tubercles.

The subspecies is probably dimorphic. Specimens that appear to be complete adults have diameters from 36 to 76 mm (Fig. 89Q, FF).

One specimen (USNM 425362), from the type locality, is unusual in that it is stouter and more strongly ribbed than the others.

Discussion—This subspecies is smaller and more slender and involute than *Vascoceras barcoicense* Choffat (1899: 67, pl. 17, fig. 1, pl. 22, fig. 35, *non* pl. 16, fig. 11, pl. 22, fig. 36). It also lacks the weak umbilical tubercles of the specimen described by Berthou, Chancellor & Lauverjat (1985: 70, pl. 4, figs. 1-3). Slender forms of *V. cauvini* Chudeau (1909), as figured by Schobel (1975, pl. 4, figs. 3a-c, pl. 5, figs. 2-4), resemble *V. c. exile* in their general appearance, and this led one of us (Cobban, 1984a) to apply *V. cauvini* in New Mexico. The slender forms of *V. cauvini* are, however, more evolute and the ribbing tends to be coarser. The latter species is also much more variable and includes much stouter forms (Schöbel, 1975, pl. 4, figs. 1, 2) as well as much more coarsely ribbed forms (Chudeau, 1909, pl. 1, fig. la; Furon, 1935, pl. 4, figs. 1-3, p1. 5, fig. la, b).

Occurrence—According to Berthou, Chancellor & Lauverjat (1985, fig. 2), *V. barcoicense is* most common in Portugal in the upper Cenomanian zone of *Metoicoceras geslinianum,* but ranges on up at least through the zone of *Neocardioceras juddii.* In southwestern New Mexico *V. barcoicense exile* occurs in the zone of *Burroceras clydense* in the Big Burro Mountains (loc. 141) and in the zone of *Neocardioceras juddii* in the Cookes Range (loc. 41), Little Burro Mountains (locs. 83, 85, 95, 100) and Big Burro Mountains (locs. 118, 121, 134, 141, 152).

VASCOCERAS DIARTIANUM (d'Orbigny)

Figs. 48, 88TT-AA

1850. *Ammonites diartianus* d'Orbigny, p. 146.
1963. *Pachydiscus* sp., Jefferies, p. 4.
1977. *Vascoceras (Vascoceras) diartianum* (d'Orbigny): Kennedy & Juignet, 1977, p. 584, pl. 1, figs. 1A—F, 2A—H, pl. 2, figs. 1A—C, text-fig. 2.
1979. *Provascoceras diartianum* (d'Orbigny): Cooper, p. 123.
1981. *Vascoceras diartianum* (d'Orbigny): Wright & Kennedy, p. 86, pl. 17, figs. la, b, text-fig. 29A—F.

1983. *Vascoceras diartianum* (d'Orbigny): Förster, Meyer & Risch, p. 133, pl. 3, figs. 1-5.

Types—Holotype MNHP 6021 is a phosphatized specimen from the remanié *Metoicoceras geslinianum* zone fauna of Sarthe, France (Wright & Kennedy, 1981, p. 86). Hypo-types USNM 356892, 356893, 425363.

Description—Vascoceras diartianum is a small, globose species that was based on a single specimen from the St. Calais area in northwestern France. Although the holotype was described more than 130 years ago, no other French example was known when Kennedy & Juignet (1977) illustrated and redescribed the type. According to these authors, the holotype is a well-preserved phosphatic internal mold 30 mm in diameter, with an umbilical ratio of 0.29. The whorl section is much broader than high, with the greatest width at the umbilical shoulder. The venter is very broadly rounded. Ornament on the outer whorl consists of 10 conspicuous umbilical tubercles from which weak ribs extend onto the flank. The venter is crossed by fine striae and five constrictions on the outer whorl. Body chamber occupies the last half whorl. Most of the external suture is preserved (Kennedy & Juignet, 1977, pl. 2, fig. 1A-C, text-fig. 2). The suture is simple, with little divided lobes and saddles. The first lateral saddle is broad and bifid, and the lateral lobe is slightly narrower.

Aside from the type, only one other specimen of *V. diartianum* was known to Kennedy & Juignet (1977: 585)—an English specimen 17 mm in diameter. Subsequently, Förster, Meyer & Risch (1983) recorded 24 examples from Regensberg, German Federal Republic, and figured five of them. All European specimens are from the upper Cenomanian *Metoicoceras geslinianum* zone.

Six small, globose ammonites from the Colorado Formation at loc. 17 in the Cookes Range can be assigned to *Vascoceras diartianum.* These specimens range in diameter from 9.4 to 24 mm and have umbilical ratios from 0.18 to 0.31. Whorls are much broader than high and have their greatest width at the umbilical shoulder. The umbilici are deep and the venters are very broadly rounded. Umbilical tubercles, which are nodate to bullate, number nine to eleven per whorl. Weak ribs as well as constrictions are present and number three to five per whorl. Half of the specimens include parts of body chambers. The suture (Fig. 48) is much like that of the holotype.

Occurrence—The specimens from loc. 17 in the Cookes Range came from a thin bed of limestone in the Bridge Creek Limestone Member 10 ft below the base of several orange-weathering limestone beds that contain *a Sciponoceras gracile* fauna. Fossils associated with *V. diartianum* include *Moremanoceras scotti, Eucalycoceras pentagonum, Euomphaloceras euomphalum,* and *Calycoceras naviculare,* which indicate a low position in the zone of *Sciponoceras gracile. Vascoceras diartianum,* however, does range up higher in this zone in the

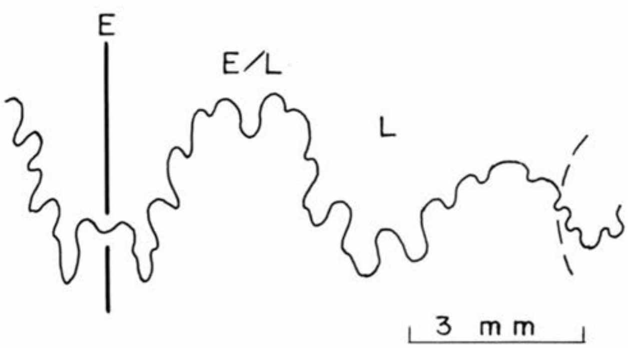

FIGURE 48—External suture at a diameter of 15 mm of *Vascoceras diartianum* (d'Orbigny), from loc. 17 in the Cookes Range. USNM 425363.

Cookes Range at loc. 15, where it is associated with *Euomphaloceras septemseriatum.*

VASCOCERAS BIRCHBYI Cobban & Scott
Figs. 71G, 88A, B, 89A-L

1973. *Vascoceras (Greenhornoceras) birchbyi* Cobban & Scott, p. 85, pl. 22, pl. 23, figs. 1-13, pl. 24, figs. 1-12, pl. 25, pl. 26, figs. 5-8, 11, 12, pl. 27, figs. 1-6, text-figs. 43-47.
1975. *Vascoceras birchbyi* Cobban & Scott: Hattin, pl. 9, fig. D.
1983. *Vascoceras (Greenhornoceras) birchbyi* Cobban & Scott: Hattin, fig. la—d.
1986. *Vascoceras birchbyi* Cobban & Scott: Hattin, fig. 48.
1987. *Vascoceras birchbyi* Cobban & Scott: Hattin, fig. 11A.

Types Holotype USNM 164022, paratypes USNM 164023-164043, from the Bridge Creek Member of the Greenhorr Limestone of southeastern Colorado. Hypotypes USNM 425364-425372.

Diagnosis—A large, moderately stout species that ha; constrictions, umbilical tubercles, and strong ribs on the early whorls, and a smooth to nearly smooth body chamber.

Description—Well-preserved juveniles, 10-31 mm in di. ameter, have been collected from sandstone concretions it the Little Burro Mountains. Coiling is somewhat evolute, and the whorl sections are rounded. Conspicuous constric• tions that number five or six per whorl are present up to diameter of about 30 mm; they are usually bordered by high ribs (Fig. 89A-E). Strong umbilical bullae give rise to single or paired straight, rectiradiate to prorsiradiate primary ribs. One to three secondary ribs arise about midflank and, with the primaries, cross the venter with very slight forward arching. There are 27-28 ribs per whorl at diameters of 2532 mm. Only one good coil is available at a larger diameter. This specimen (Fig. 89K, L), 46 mm in diameter, has 11 rectiradiate ribs per half whorl that cross the venter transversely. The last rib is accentuated slightly at the ventrolateral shoulder. Five strong, bullate to nodate umbilical tubercles are present per half whorl. Only parts of two body chambers were found. One (USNM 425371) has a diameter of 208 mm and an umbilicus of 55 mm (ratio of 0.26), and the other (USNM 425372) has a diameter of 211 mm and an umbilical ratio of about 0.28. Both are smooth except for low, broad umbilical bullae.

Occurrence—The holotype and paratypes are from slightly below the middle of the Bridge Creek Member of the Greenhorn Limestone at Pueblo, Colorado (Cobban & Scott (1973: 23, bed 97). The species is known from many localities in eastern Colorado, central and southwestern Kansas, and northeastern and southwestern New Mexico. Flattened fragments that may be this species occur in thin beds of siltstone and very fine-grained sandstone in the upper shale member and in the lower part of the sandstone and shale member of the Colorado Formation in the Cookes Range (locs. 43, 47, 48, 52). Much better specimens occur in sandstone concretions of the sandstone member in the Fort Bayard area (locs. 65, 68, 69), in the Silver City Range (loc. 78), in the Little Burro Mountains (locs. 87, 88, 90, 96), and on the northeast side of the Big Burro Mountains (loc. 111).

VASCOCERAS sp. C
Fig. 90A-C

Material—Figured specimen USNM 425373.

Description—An internal mold from loc. 65 has coarsely ribbed and constricted inner whorls with umbilical bullae and an outer whorl that is preserved to a diameter of 6065 mm where ornament is reduced to weak umbilical bullae and ribs effaced at midflank. The umbilicus is small and deep, with an overhanging umbilical wall. Flanks and venter are somewhat flattened. Decline of ornament on the outer whorl immediately distinguishes this species from *V. birchbyi,* which retains coarse flank ornament beyond a diameter where it is lost in the present specimen. The specimen more closely resembles V. *venezolanum* Renz, 1982, especially his forma e (Renz, 1982: 84, pl. 25, figs. 3-8). With one poor specimen only, we leave it in open nomenclature at this time.

Occurrence—The specimen was found in the lower part of the sandstone member of the Colorado Formation at loc. 65 in the Fort Bayard area, in association with *V. birchbyi* and *Fagesia catinus.*

VASCOCERAS HARTTI (Hyatt)

Figs. 49, 91A-D, G-K

1870. *Ceratites harttii* Hyatt, p. 386.
1875. *Buchiceras harttii* Hyatt, p. 370.
1887. *Ammonites (Buchiceras) harttii Hyatt:* White, p. 226, pl. 19, figs. 1, 2, pl. 20, fig. 3.
1903. *Vascoceras hartti* (Hyatt): Hyatt, p. 103, pl. 14, fig. 16.
1936. *Vascoceras hartti* (Hyatt): Maury, pp. 246, 247, pl. 22, figs. 1, 2.
1982. *Paravascoceras hartti* (Hyatt): Chancellor, p. 98, figs. 28C, 29-33 (with full synonymy).
1985. *Vascoceras hartti* (Hyatt): Berthou, Chancellor & Lauverjat, p. 74.
1985. *Vascoceras (Paravascoceras) harttii* (Hyatt): Berthou, Chancellor & Lauverjat, p. 74.
1985. *Vascoceras (Paravascoceras) harttii* (Hyatt): Howarth, p. 100, fig. 25.
1987. *Vascoceras harttii* (Hyatt): Kennedy, Wright & Hancock, p. 51.

Types—Hypotypes USNM 425374-425379.

Diagnosis—Hyatt never illustrated his species from Brazil, but White (1877, pl. 19, figs. 1, 2) figured a large internal mold of an adult that Berthou, Chancellor & Lauverjat (1985: 74) interpreted as one of Hyatt's syntypes. White's illustrations (drawings) show a robust specimen with a fairly wide umbilicus (ratio to the diameter of 0.28). Tubercles are absent, and the body chamber and visible part of the phragmocone are smooth.

Description—Kennedy, Wright & Hancock (1987: 46-51) documented the wide intraspecific variation shown by lower Turonian *Vascoceras proprium* Reyment, 1954, from Trans-Pecos Texas, noting the difficulty experienced in separating cadicone *Vascoceras* like the present material into species groups; Berthou, Chancellor and Lauverjat (1985) noted the same difficulty. Kennedy et al. pointed out that *Vascoceras hartti* could be distinguished from other forms by its relatively evolute coiling and umbilicus with steeply sloping sides, well shown in White's (1887, pl. 19, figs. 1, 2, pl. 20, fig. 3) and Chancellor's (1982, figs. 29-33) figures. One of White's specimens has the following proportions: D = 100, Wb = 72.4%; Wh = 34%; Wb:Wh = 2.12; U = 31.0 (taken from figures). Fragments of large cadicone *Vascoceras* from the *Neocardioceras juddii* zone at loc. 41 in the Cookes Range have the same whorl section and coiling as *V. hartti,* with whorl breadth to height ratios of 2.0. One corroded phragmocone (USNM 425378) has a diameter of 122 mm, a whorl height of 54.5 mm, and a whorl breadth of 116 mm. Also present in these collections are juveniles as small as 40 mm in diameter, which we take to be the previously undescribed early stages of the species. USNM 425377 (Fig. 91J, K) has the following dimensions: D = 42.0 (100%); Wb = 34.5 (82.1%); Wh = 18.4 (43.8%); Wb:Wh = 1.88; U = 9.8 (23.3%). The umbilical wall slopes outwards and is smooth, and the umbilical shoulder is narrowly rounded. Striae that arise at the umbilical shoulder strengthen into low, broad, rounded ribs that form a broad convexity over the venter. The same collection contains much less depressed specimens such as USNM 425376 (Fig. 91G-I); the inner whorls have the following dimensions: D = 63.8 (100%); Wb = 41.8 (65.5%); Wh = 27.8 (43.6%); Wb:Wh = 1.50; U = 15.3 (24.0%). The umbilical wall slopes outwards, and there is ventral ribbing, as in the small specimen mentioned above and the Mexican example illustrated by Chancellor (1982, figs. 29-31). Coiling and form of the umbilical wall link this and similar specimens to co-occurring cadicones like *V. hartti;* given the wide intraspecific variation seen in slightly later *V. carteri* (which is more involute with an overhanging rather than outward-sloping umbilical wall), we believe it reasonable to regard all of our specimens as a variable *V. hartti* rather than a series of species differentiated on whorl proportions alone. Tubercles are absent in all specimens. Sutures are simple and typical of the genus (Fig. 49).

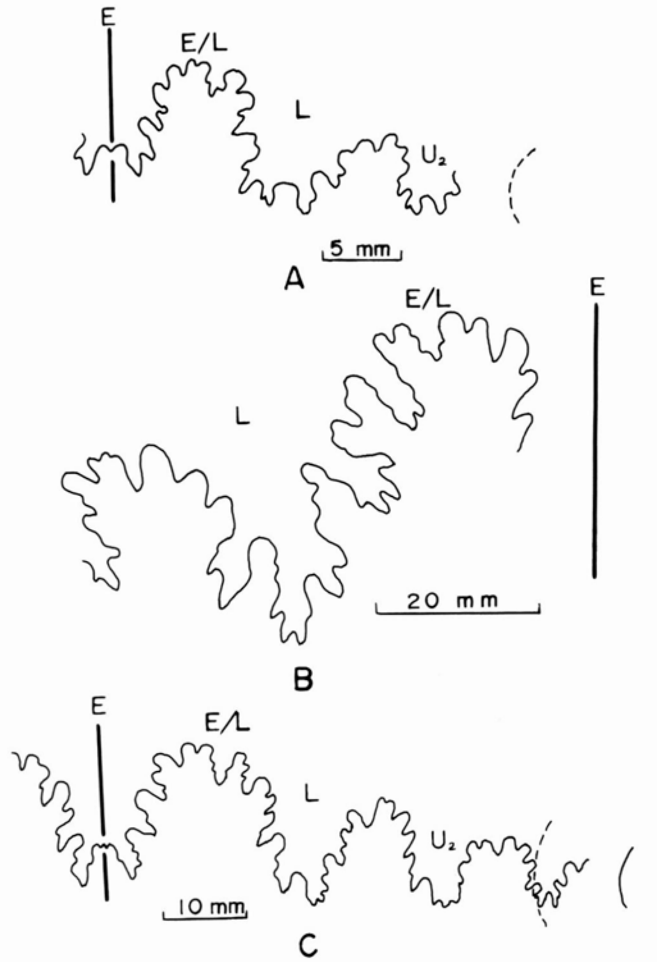

FIGURE 49—External sutures of *Vascoceras hartti* (Hyatt), from the Colorado Formation at loc. 41 in the Cookes Range. A, USNM 425374 at a diameter of 35 mm (Fig. 91A, B). B, USNM 425379. C, USNM 425376 at a diameter of 90 mm (Fig. 91G–I).

Occurrence—Vascoceras hartti has been regarded as of early Turonian age in Brazil (Bengtson, 1983: 44), Angola (Howarth, 1985: 77), and Mexico (Chancellor, 1982: 79), but it is not precisely dated by association with other taxa. In Portugal, Berthou, Chancellor & Lauverjat (1985: 58) show *V. durandi* (Peron), a possible synonym of *V. hartti,* as ranging through the uppermost Cenomanian into the lower Turonian. Specimens that we assign to *V. hartti* occur at loc. 41 in association with *Neocardioceras juddii* and *Pseudaspidoceras pseudonodosoides,* which we regard as very late Cenomanian. In the Big Burro Mountains (loc. 115), *V. hartti* is also found with these fossils.

VASCOCERAS sp.

Material—Described specimen USNM 425380.

Description—A large, crushed, smooth disc 215 mm in diameter that has an umbilical ratio of about 0.20 differs from *V. birchbyi* in being entirely smooth at a diameter where *V. birchbyi* still has low umbilical bullae and rib-like flank swellings. The umbilical shoulder is very narrowly rounded, and the umbilical wall is steep. Of the described species of *Vascoceras,* the specimen most closely resembles *V. angermanni* Bose (1920: 217, pl. 16, figs. 2, 4 only).

Occurrence-The specimen was found at loc. 153 in the Big Burro Mountains in association with *Fagesia catinus* (Mantell), *Quitmaniceras reaseri* Powell, and *Mytiloides columbianus* (Heinz).

Genus *FAGESIA* Pervinquiere, 1907

Type species-By original designation, *Olcostephanus superstes* Kossmat, 1897: 26, pl. 6, figs. la-c.

Diagnosis-Wright & Kennedy (1981: 87) gave the following concise diagnosis: "Globose, cadicone or coronate, rather involute to rather evolute. Early whorls have coarse ribs springing in twos and threes from more or less distinct umbilical bullae rather high up the side and crossing the venter transversely, on which they may weaken or not; in some cases the ribs are raised into more or less distinct bullate tubercles on either side of the siphonal line. Umbilical tubercles and ribs may persist to later whorls or not. Suture generally with rather long, narrow, deeply incised saddles but variable; the first lateral lobe is trifid but asymmetrical, so that it may in some cases appear bifid."

Occurrence-Wright & Kennedy (1981: 88) noted that this lower to middle Turonian Tethyan genus has been recorded from England, France, Spain, Portugal, Syria, Israel, Egypt, Tunisia, Algeria, Nigeria, Madagascar, India, Japan, Colombia, Brazil, Mexico, and the United States (Texas, Colorado, Montana, and California).

FAGESIA CATINUS (Mantell)
Figs. 50, 92L-KK, 96S, T

1822. *Ammonites catinus* Mantell, p. 198, pl. 22, fig. 10 (not fig. 5, which was attributed in error and is of *Ammonites navicularis).*

1981. *Fagesia catinus* (Mantell): Wright & Kennedy, p. 88, pl. 26, fig. 2a, b, text-figs. 31-36 (with full synonymy).

1981. *Fagesia* or *Vascoceras* sp.: Hook & Cobban, pl. 2, figs. 1, 2, 5.

1987. *Fagesia catinus* (Mantell): Kennedy, Wright & Hancock, p. 51, pl. 7, figs. 1-13, pl. 8, figs. 1-4, 6-9, text-figs. 2j, k, m, n, 10 (with additional synonymy).

Types-Holotype BMNH C3379, from the Middle Chalk of Lewes, Sussex, England; refigured by Wright & Kennedy, 1981, text-fig. 31. Hypotypes USNM 425381-425391, from the Colorado Formation.

Diagnosis-This species has moderately evolute early whorls with depressed sections and ornament of strong ribs and nodate umbilical tubercles. Later whorls become much more depressed, the umbilical tubercles move out to a ventrolateral position, and the ribs weaken and disappear.

Description-Well-preserved phragmocones from 16 to 80 mm in diameter occur in sandstone concretions in the Little Burro Mountains at locs. 87, 88, and 90 (Fig. 92L-KK). Constrictions, that number five per whorl, are present up to a shell diameter of about 25 mm. The constrictions are strongest on the venter, which they cross transversely (Fig. 92R, U). Strong ribs, either primary or secondary, bound the constrictions. Primary ribs rise from prominent nodate umbilical tubercles. These early whorls (up to 25 mm) have six or seven umbilical tubercles per whorl and 17-20 ribs that cross the venter transversely or with a slight forward bending. At diameters from 25 to 50 mm the specimens become more evolute and the whorls more depressed (Fig. 92DD-HH). Umbilical tubercles increase to nine or ten per whorl and ribs increase to 22 or 23. Ribs disappear at about 50 mm diameter, but the umbilical tubercles remain strong and nodate at this and larger diameters (Fig. 92IIKK) and migrate out to a ventrolateral position. Sutures have the long, narrow L and U_2 typical of the genus (Fig. 50).

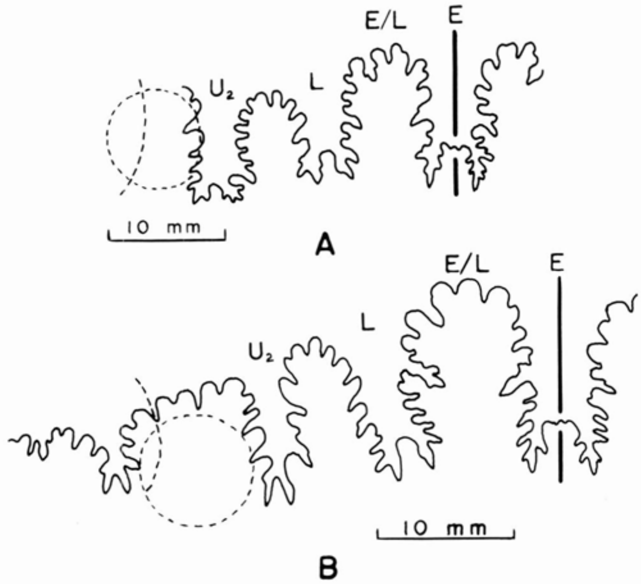

FIGURE 50—External sutures of *Fagesia catinus* (Mantell), from the Colorado Formation at loc. 90 in the Little Burro Mountains. A, USNM 425389 at a diameter of about 50 mm (Fig. 92II–KK). B, USNM 425390 at a whorl height of 22.5 mm.

Adults from southwestern New Mexico are represented by only a few poorly preserved, incomplete specimens from the Cookes Range and Big Burro Mountains. A specimen (USNM 425391) from the Cookes Range that has a diameter of 204 mm includes about two-thirds of a whorl of body chamber. Diameter at the base of the body chamber is 160 mm, and the umbilicus there is 70 mm in diameter (ratio of 0.44). The only ornament is blunt, rounded tubercles on the ventrolateral shoulder.

Occurrence-Kennedy, Wright & Hancock (1987: 56) recorded *F. catinus* from low in the Turonian of southern England, France, Venezuela, northern Mexico, Texas, Montana, and California. In southwestern New Mexico the species is fairly common in the basal part of the sandstone member of the Colorado Formation in the Fort Bayard-Silver City area (locs. 58, 65, 68) and in the Little Burro Mountains (locs. 86, 87, 88, 90, 98). Farther west the species is known only from one locality (153) in the Big Burro Mountains, where it also is from the basal part of the sandstone member. These occurrences all are in the lower Turonian zone of *Vascoceras birchbyi.* In the Cookes Range the poorly preserved adult described above was collected at the contact of the Bridge Creek Limestone Member with the overlying upper shale member of the Colorado Formation. We assume that the specimen is from the base of the *Pseudaspidoceras flexuosum* zone. Occasional corroded single chambers of some ammonite with a greatly depressed whorl section occur in the hiatus concretions at the top of the Bridge Creek Limestone Member (Hook & Cobban, 1981, pl. 2, figs. 1, 2, 5). They could be from either *Fagesia* or *Vascoceras.*

FAGESIA Sp.
Figs. 91E, F, 93H, I

Material-Figured specimens USNM 425392, 425393.

Description-Fragments of inner whorls that have very depressed sections with strong ornament are assigned to *Fagesia* without specific determination. Rounded, rectiradiate to prorsiradiate ribs arise singly or in pairs from prominent umbilical bullae and cross the venter with slight forward bending. One or two secondary ribs separate the primaries. All ribs rise into an incipient ventrolateral tubercle. These fragments could be from the inner whorls of *F. catinus.*

Occurrence—All specimens are from the upper shale member and sandstone and shale member of the Colorado Formation in the Cookes Range (locs. 11, 42, 50, 51) and from equivalent rocks in the Santa Rita area (loc. 56) and Silver City Range (loc. 82). Most specimens are from the upper Cenomanian *Neocardioceras juddii* zone, but some are from as high as the *Mammites nodosoides* zone.

INFABRICATICERAS gen. nov.

Type *species—Infabricaticeras lunaense* sp. nov., from the lower Turonian sandstone and shale member of the Colorado Formation at loc. 24 in the Cookes Range.

Etymology—Infabricatus (Latin) = unfinished or unwrought, in reference to the ornament; *kenos* (Greek) = horn.

Diagnosis—Moderately involute with trapezoidal whorls. Massive umbilical bullae or large, rounded, nodate tubercles give rise to coarse, rectiradiate or prorsiradiate primary ribs, singly or in pairs. Secondary ribs arise below midflank, and all ribs either cross the venter transversely or they may be interrupted at the middle of the venter. Low, blunt ventrolateral tubercles are present on all ribs, or there may just be broad, bullate ventrolateral swellings. Suture is fairly simple, with moderately broad, bifid E/L, broad and bifid L, and narrow L/U2 and U2.

Discussion—Paramammites(?) saenzi Wiedmann, 1960, and *P.(?) postsaenzi* Wiedmann, 1960, which may be *Infabricatiwas,* have nothing to do with *Vascoceras polymorphum* Pervinquiere, 1907, the type of *Paramammites* Furon, 1935. Instead, *Paramammites* of Wiedmann may be a hypermorphic derivative of *Fagesia.* As shown above, and by Kennedy, Wright & Hancock (1987), juveniles of *Fagesia* show flattening of the venter as well as the presence of an incipient ventrolateral tubercle; this ornament and the strong bullae simply persist to a much later ontogenetic state in *Infabricaticeras.* The long, narrow U2 of the suture is reminiscent of *Fagesia,* but the broad L is not. Alternatively, *Infabricaticeras* may be a descendant of *Vascoceras birchbyi,* which also has strong ornament on the inner whorls.

The affinities of species described *as Paramammites* by Stankevich & Pojarkova (1969) is unclear; they may be Mammitinae. In contrast, the Nigerian species *Paramammites tuberculatus* Barber, 1957, *P. raricostatus* Barber, 1957, and *P. inflatus* Barber, 1957, are from a horizon close to the Cenomanian-Turonian boundary and are in part perhaps ribbed and tuberculate derivatives of *Vascoceras* for which a new generic name is needed.

Occurrence—Known with certainty only from the lower Turonian of southwestern New Mexico and possibly Spain.

INFABRICATICERAS LUNAENSE sp. nov.

Figs. 51, 52, 53, 93J-0

Types—Holotype USNM 425395, paratypes USNM 425394, 425396-425402, from the Colorado Formation at loc. 24 in the Cookes Range.

Etymology—For Luna County, New Mexico, where the types were collected.

Diagnosis—A moderately involute, robust species that has strongly ornamented inner and outer septate whorls. Earliest whorls have collared constrictions. Ornament on inner whorls consists of strong umbilical tubercles and primary and secondary ribs that cross the venter and bear weak or incipient ventrolateral tubercles. Ornament weakens on body chamber. Suture has a fairly broad L and long, narrow U2.

Description—The holotype (Fig. 93N, 0), an internal mold worn on one side, consists of a complete inner whorl and a quarter of the outer septate whorl. Dimensions in millimeters of the inner whorl are: D = 76.3, U = 16.0 (0.21), Wh = 38.3, Wb = 37.0, Wb:Wh = 0.96. Seven strong, bullate umbilical tubercles per whorl give rise to primary ribs, either singly or in pairs. All ribs are coarse, rounded and rectiradiate and cross the venter transversely. The venter is worn, but the ribs appear to be accentuated on the ventrolateral shoulder. The outer whorl has a squarish section (Fig. 52A); its intercostal dimensions are: Wh = 59, Wb = 65, Wb:Wh = 1.10. The umbilicus is deep, and the umbilical wall is vertical, with a narrowly rounded shoulder. Flanks and venter on the outer whorl are flattened. Ornament consists of large bullate umbilical tubercles that give rise singly to broad primary ribs separated by a single broad secondary rib that arises below midflank. All ribs are accentuated on the ventrolateral shoulder before crossing the venter transversely. Only bits of the suture are preserved.

An internal mold of an adult from the basal part of the sandstone member of the Colorado Formation in the Fort Bayard area has a diameter of more than 175 mm. Half a whorl of body chamber is preserved; at its base the diameter is 155 mm, the umbilicus is 67.5 mm (ratio of 0.44), the costal whorl height is 57 mm, and the costal whorl breadth is 109 mm (Wb:Wh = 1.91). The outer whorl is very depressed and the venter is flattened. Nine large, rounded umbilical tubercles are present on the outer whorl. From each of these a broad, rounded rib extends to the ventrolateral shoulder where it may rise into a low swelling (Fig. 51). Very low, broad, weak ribs cross the venter transversely. The suture is too corroded to be meaningful.

Part of a larger septate whorl (USNM 425399) has a more depressed section (Fig. 52B). Its intercostal dimensions are: Wb = 106, Wh = 68, Wb:Wh = 1.56. Intercostal flanks are very broadly rounded and convergent to the flattened venter. Ribs are massive, straight, and rectiradiate; they are highest and strongest at the ventrolateral shoulder and then weaken greatly on crossing the venter transversely.

A quarter of a whorl of a large, massive, nonseptate internal mold (paratype USNM 425400) is interpreted as part of the body chamber. This specimen, which has only one side and the venter preserved, has a height of 91 mm and an estimated breadth of 120 mm (Wb:Wh = 1.32). The specimen has a more rounded whorl section and more subdued ornament than that of the largest phragmocones at hand. Umbilical bullae are broad and blunt. Ribs, which alternate in length, are broad and low and accentuated into broad swellings on the ventrolateral shoulder. Each rib weakens greatly on crossing the venter transversely.

Small whorls 23-36 mm in diameter are fairly common in the collections. Constrictions that number five per whorl are present in the smaller specimens; these constrictions are bounded by high ribs. On the small whorls, umbilical tubercles number seven to nine per whorl and ribs number 19-21.

The suture (Fig. 53A) on one of the small whorls resem-

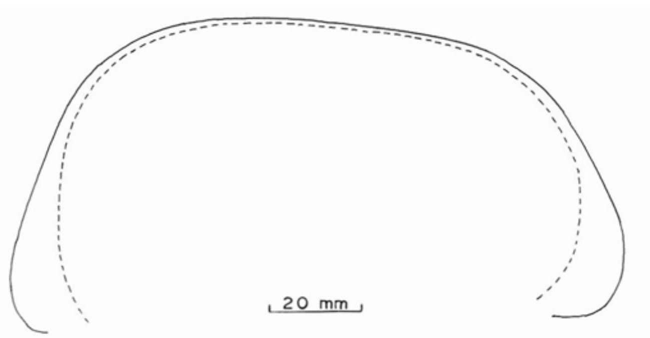

FIGURE 51—Whorl section of *Infabricaticeras lunaense* gen. et sp. nov. at a diameter of 175 mm, from the basal bed of the sandstone member of the Colorado Formation at loc. 65 in the Fort Bayard area. USNM 425394.

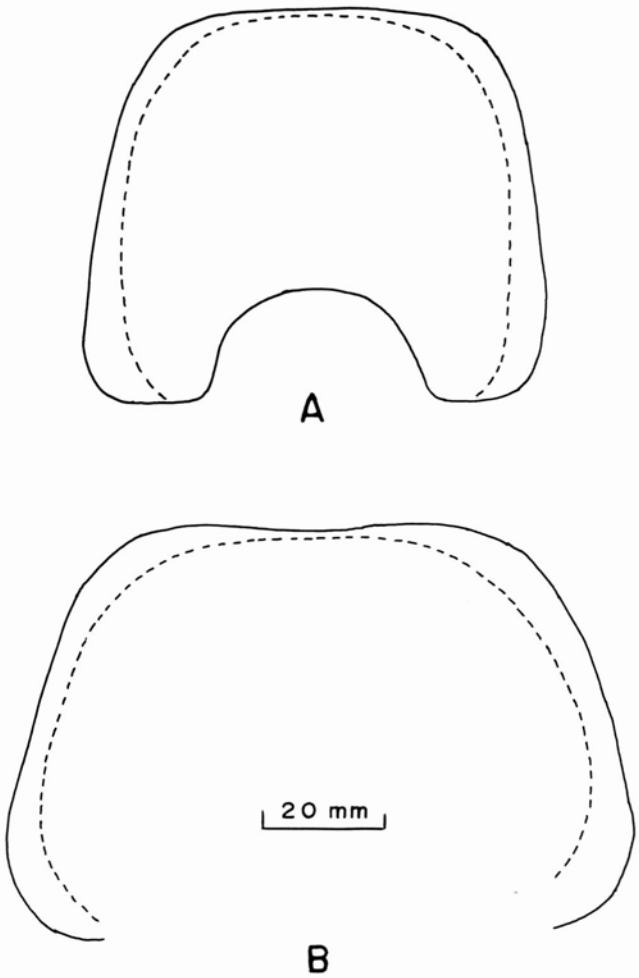

FIGURE 52—Whorl sections of *Infabricaticeras lunaense* gen. et sp. nov., from the Colorado Formation at loc. 24 in the Cookes Range. A, holotype USNM 425395 at a whorl height of 63 mm. B, paratype USNM 425399 at a whorl height of 67 mm.

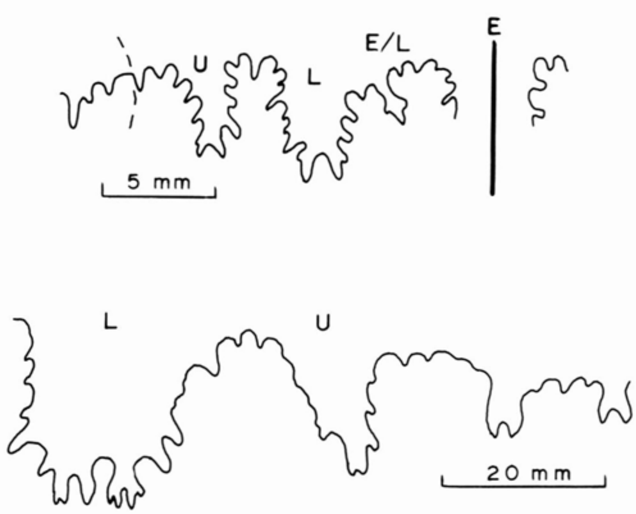

FIGURE 53—External sutures of *Infabricaticeras lunaense* gen. et sp. nov., from the Colorado Formation at loc. 24 in the Cookes Range. A, paratype USNM 425401 at a whorl height of 14.5 mm. B, paratype USNM 425402 at a whorl height of about 75 mm.

tiles that of *Fagesia* except for the slightly broader L; E/L is moderately broad and bifid, L is fairly long and moderately broad, L/U_2 is quite narrow, and U_2 is long and narrow. Part of the suture of a much larger specimen (Fig. 53B) has a much broader L.

Occurrence—Known only from the youngest sandstone unit in the sandstone and shale member of the Colorado Formation on the east side of the Cookes Range at locs. 11 and 24. Associated fossils include *Mammites nodosoides* and *Mytiloides mytiloides* (Mantell) of late early Turonian age.

Genus *NEOPTYCHITES* Kossmat, 1895

Type species—By original designation, *Ammonites telinga* Stoliczka, 1865: 125, pl. 62, figs. 1, 2 (= *A. cephalotus* Courtiller, 1860: 248, pl. 2, figs. 1-4).

Diagnosis—Kennedy & Wright (1979: 669) gave the following good diagnosis: "Medium sized, very involute, high-whorled when adult, with a tiny crater-like umbilicus and narrowly rounded or narrow, flattened venter. Earliest whorls compressed or depressed, smooth, save for sparse constrictions and associated collar-like ribs, followed by a stage with numerous low, broad ribs. Middle to late stages typically smooth, with a constricted aperture. The body chamber may remain compressed and flat-sided throughout or may show a brief phase of marked inflation of the inner flank prior to the apertural constriction. Sutures very variable, from broad, low, little incised elements in some to deep, narrow, intricately incised bifid to trifid lobes in others."

Occurrence—Widely distributed in Tethyan lower and middle Turonian rocks: France, Spain, Morocco, Algeria, Tunisia, Syria, Israel, Cameroon, Madagascar, India, Japan, Colombia?, Venezuela?, Brazil, Mexico, and the United States (Colorado, New Mexico, Trans-Pecos Texas).

NEOPTYCHITES CEPHALOTUS (Courtiller)
Figs. 54, 88BB-FF

1860. *Ammonites cephalotus* Courtlier, p. 248, pl. 2, figs. 1-4. 1907. *Neoptychites xetriformis* Pervinquiere, p. 389, pl. 27, figs. 57, text-figs. 153, 154.
1979. *Neoptychites cephalotus* (Courtlier): Kennedy & Wright, p. 670, p1. 82, figs. 3-5, pl. 83, figs. 1-3, p1. 84, fig. 3, pl. 85, figs. 1-5, pl. 86, figs. 5-6, text-fig. 2 (with full synonymy).
1979. *Neoptychites xetriformis* Pervinquiere: Kennedy & Wright, p. 679, pl. 84, figs. 1, 2, pl. 5, figs. 1-3 (with full synonymy).
1982. *Neoptychites* sp. Chancellor, p. 113, figs. 56-59.
1982. *Neoptychites xetriformis* Pervinquiere: Renz, p. 88, pl. 26, fig. 19, text-fig. 67.
1982. *Neoptychites aff. crassus* Solger: Renz, p. 88, pl. 26, fig. 16. 1982. *Neoptychites aff. telingaeformis discrepans* Solger: Renz, p. 88, p1. 26, fig. 17.
1982. *Neoptychites cephalotus* (Courtiller): Amedro & Badillet, p. 131, pl. 2, fig. 1.
1982. *Neoptychites xetriformis* Pervinquiere: Amedro & Badillet, p. 131, pl. 2, fig. 2.
1983a. *Neoptychites cephalotus* (Courtiller): Cobban & Hook, p. 14, pl. 3, figs. 9-11, pls. 9-12, text-fig. 11.

Types—Hypotypes USNM 425403, 425404.

Diagnosis—Cobban & Hook (1983a: 14, 15) observed that this species falls into two groups; one attains a small size and has stout shells, and the other attains a much larger size and has slender shells. Earliest whorls of both groups are smooth except for about four constrictions per whorl that are bordered by strong ribs highest on the venter. Ribs become more numerous and constrictions weaken and disappear on later septate whorls. Adults have a smooth body chamber that is constricted at the oral end.

Description—Two well-preserved phragmocones from the Little Burro Mountains and a weathered adult from the Fort Bayard area are referred to *N. cephalotus*. The better of the two phragmocones (Fig. 88BB-DD) has the following dimensions: D = 50.4, U = 5.8 (0.11), Wb = 26.8, Wh = 26.6, Wb:Wh = 1.01. Flanks are very broadly rounded and

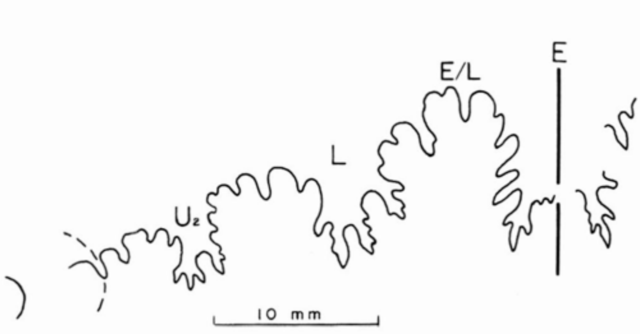

FIGURE 54—External suture of *Neoptychites cephalotus* (Courtiller). USNM 425403 at a diameter of 50 mm, from loc. 90 in the Little Burro Mountains (Fig. 88BB–DD).

convergent; venter is narrowly rounded. The umbilicus is deep, the walls are overhanging, and the shoulder is narrowly rounded. Ornament consists of prorsiradiate ribs that begin on the outer part of the flank and cross the venter with slight forward projection. These ribs number about 35 per whorl. The adult from the Fort Bayard area (Fig. 88E, FF) has part of one side weathered away including the venter of the body chamber. The diameter of this internal mold is 109 mm, but other dimensions cannot be determined. Fifteen ventral ribs are present on the last half whorl of the phragmocone; they weaken toward the end of the phragmocone, and the body chamber is smooth. Sutures are not preserved in this specimen, but they are well preserved in the two smaller phragmocones. The suture (Fig. 54) has the asymmetric L so typical of the genus and well shown by Cobban & Hook (1983a, text-fig. 11A-D).

Occurrence-*Neoptychites cephalotus* is known in the Western Interior in Colorado, New Mexico, and Trans-Pecos Texas. The species occurs in the basal part of the sandstone member of the Colorado Formation in the Fort Bayard area (loc. 69) and Little Burro Mountains (loc. 90). Large, extremely poorly preserved specimens of *Neoptychites* are present in silty, septarian concretions in the lower part of the sandstone and shale member of the Colorado Formation on the east side of the Cookes Range (loc. 23); these may be *N. cephalotus*.

MICRODIPHASOCERAS gen. nov.

Type species-*Microdiphasoceras novimexicanum* gen. et sp. nov., from the upper Cenomanian zone of *Burroceras clydense* in the Big Burro Mountains, Grant County, New Mexico.

Etymology-Micro (Greek) = small; *diphas* (Greek) = a kind of snake; *keros* (Greek) = horn.

Diagnosis-Adult at 25 mm or less. Involute, with oval, slightly depressed to compressed whorls and fastigiate venter. Ornament consists of strong, prorsiradiate, sometimes feebly bullate primary ribs separated by one or two shorter intercalated ribs; interspaces are periodically deepened into constrictions that are most obvious across the venter. All ribs have a fastigiate ventral profile with feebly developed bullate ventrolateral tubercles and siphonal clavi. The venter rounds and tubercles efface on the adult body chamber. Suture with very broad E/L that has the L side sloping away from the venter as in *Vascoceras*.

Discussion-Small adult size, ribbing style, and trituberculate, fastigiate venter distinguish *Microdiphasoceras* from all other mid-Cretaceous genera. It is a progenic dwarf derived either from some vascoceratid or from the feebly ornamented *Nigericeras* Schneegans, 1943. The trituberculation certainly recalls the inner whorls of some individuals of the latter; the asymmetric sloping E/L and small L resemble those of some Vascoceratinae (Fig. 45), and the style of ribbing resembles that of some *Vascoceras cauvini* (Schöbel, 1975, pls. 4-6). We refer the genus to Vascoceratinae rather than Acanthoceratinae, but with no great confidence.

MICRODIPHASOCERAS NOVIMEXICANUM sp. nov.
Figs. 55, 87A-P, T-V

Types-Holotype USNM 425405, paratypes USNM 425406425415, from the Colorado Formation in the Big Burro Mountains.

Etymology-For New Mexico, the type locality of the genus and species.

Description-The holotype (Fig. 87A-C) is a complete adult whose dimensions are: D = 17.6, U = 4.8 (0.27), Wb = 6.3, Wh = 7.5, Wb:Wh = 0.84. Its umbilicus has steeply sloping walls and well-rounded shoulder. Intercostal flanks are somewhat flattened, and the venter is narrowly rounded. Ornament consists chiefly of nine strong, prorsiradiate primary ribs per whorl that arise from umbilical bullae and are separated by two secondary ribs. The secondary rib just adoral to a primary one begins at or below midflank, whereas the other secondary begins on the outer part of the flank. All ribs bend forward a little and cross the venter with equal strength; 30 ribs cross the venter on the last whorl. The ribs are accentuated at the ventrolateral shoulder, and some form low bullate tubercles. Weak, rounded siphonal tubercles are present. A small ventral lappet is present at the aperture.

Constrictions, numbering six or seven per whorl, are present on the inner whorls. Two fairly strong ribs bound the constrictions. Constrictions occasionally persist onto the body chamber.

Six adults that are complete enough for rib counts per whorl have 27-35 ribs crossing the venter. All ribs become more projected forward near the aperture.

The species is dimorphic, with adults ranging from 14.2 to 22.3 mm in diameter. Diameters at the base of body chambers range from 10.2 to 12.7 mm.

Dimensions and rib counts for nine specimens for loc. 141 in the Big Burro Mountains are as follows:

USNM	D	U	D at base of body chamber	Ribs per whorl
425410	13.0	3.0 (0.23)	11.0	32
425407	14.7	3.5 (0.24)	10.5	30
425411	15.5	3.7 (0.24)	12.2	29
425412	17.0	5.3 (0.31)	11.2	
425406	17.2	3.4 (0.20)	11.4	27
425405	17.6	4.8 (0.27)	12.9	30
425413	17.6	3.4 (0.19)	11.5	35
425414	18.7	4.2 (0.22)	11.4	
425415	22.3	4.9 (0.22)	13.5	

The suture (Fig. 55) is fairly simple; E/L is broad, with the side farthest away from the venter sloping; L is short, asymmetrically bifid, and much narrower than E/L; U_2 is narrow.

Occurrence-Known only from the zone of *Burroceras clydense* in the Big Burro Mountains at locs. 141 and 142.

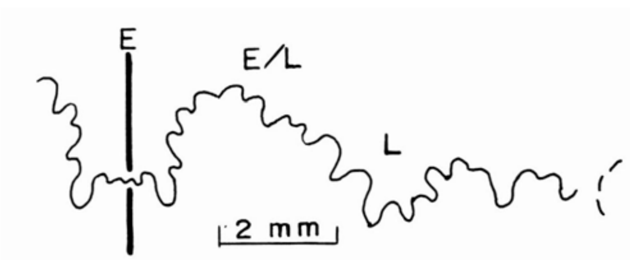

FIGURE 55—External suture of *Microdiphasoceras novimexicanum* gen. et sp. nov. at a diameter of 10.4 mm, from the Colorado Formation at loc. 141 in the Big Burro Mountains. Paratype USNM 425406 (Fig. 87D–F).

Subfamily PSEUDOTISSOTIINAE Hyatt, 1903

Genus *THOMASITES* Pervinquiere, 1907

Type species-By original designation, *Pachydiscus rollandi* Peron, 1889: 25, pl. 17, figs. 1-3, from the lower Turonian of Tunisia.

Diagnosis-Involute ammonites that are slender to globose when young, with weak ribs on the outer flank; umbilical, ventrolateral, and siphonal tubercles; and well-defined ventrolateral shoulder. Later whorls have a triangular section and weakened ornament. Adults have ventral ribs and a constricted aperture.

Occurrence-Best known from lower Turonian rocks in Tethyan regions; Tunisia, Algeria, Egypt, Israel, Jordan, Lebanon, Syria, Spain, southeastern France, and Turkestan; also lower Turonian of Nigeria, Brazil, Trans-Pecos Texas, southwestern New Mexico, and southeastern Colorado. Wright & Kennedy (1981: 99, pl. 22, fig. 1) recorded a poorly preserved specimen assigned to *Thomasites* cf. *rollandi* from the upper Cenomanian *Neocardioceras juddii* zone of England.

THOMASITES ADKINSI! (Kummel & Decker)

Fig. 86A, B

1954. *"Hoplitoides" adkinsi* Kummel & Decker, p. 316, pl. 32, fig. 6, pl. 33, fig. 3, text-figs. 7B, 8.

1982. *Pseudotissotia adkinsi* (Kummel & Decker): Chancellor, p. 166, text-figs. 2i, 66-69 (with full synonymy).

1987. *Thomasites adkinsi* (Kummel & Decker): Kennedy, Wright & Hancock, p. 61, pl. 9, figs. 1-4, 8-12, 15, 16, text-fig. 2i.

Material-Hypotype USNM 425416, from loc. 90 in the Little Burro Mountains.

Description-A few fragments of ammonites are assigned to *Thomasites adkinsi.* The best specimen (Fig. 86A, B) is the older part of a body chamber that has flat flanks, narrowly rounded ventrolateral shoulder, and broad, flat venter. Faint, low, concave, prorsiradiate ribs appear near midflank and strengthen across the outer flank where they terminate in low, blunt, bullate ventrolateral tubercles. A shallow groove separates the tubercles from a low, broad siphonal ridge that is feebly nodate.

Occurrence-The holotype (Kummel & Decker, 1954: 316, pl. 32, fig. 6, pl. 33, fig. 3, text-figs. 7B, 8) is from the lower Turonian of Coahuila, Mexico. Specimens from Trans-Pecos Texas are from the zone of *Pseudaspidoceras flexuosum.* The specimen figured here (Fig. 86A, B) is from the basal part of the sandstone and shale member of the Colorado Formation at loc. 90 in the Little Burro Mountains, where it occurs with *Fagesia catinus, Neoptychites cephalotus,* and *Vascoceras birchbyi.*

RUBROCERAS gen. nov.

Type *species-Rubroceras alatum* gen. et sp. nov., from the upper Cenomanian zone of *Neocardioceras juddii* in the Little Burro Mountains, Grant County, New Mexico.

Etymology-By anagram from Burro, for the Little Burro Mountains.

Diagnosis-Moderately evolute to moderately involute ammonites that have inflated inner whorls with large umbilical tubercles and rounded venter crossed by transverse ribs that bear weak ventrolateral and siphonal tubercles. Adult body chamber ornamented by strong rectiradiate ribs that are accentuated at the ventrolateral shoulder. Suture is moderately incised and has a fairly narrow, symmetrically to asymmetrically bifid L.

Discussion-Inner whorls are like those of inflated forms of *Thomasites* and *Nigericeras* that have rounded venters with ventrolateral and siphonal tubercles. Unlike the body chamber of *Thomasites,* which is smooth and has a triangular section, *Rubroceras* has a rounded to depressed section with conspicuous, flange-like primary ribs. Body chambers of *Nigericeras* are either smooth or very weakly ribbed and lack the ornament of *Rubroceras.* Costal sections of body whorls of some species of *Pseudaspidoceras,* such as those of *P. pseudonodosoides,* resemble those of *Rubroceras* in their flattened flanks and depressed venter, but the inner whorls of *Pseudaspidoceras* are totally different in their quadrate outline and in the lack of siphonal tubercles. Sutures of *Rubroceras are* most like those of *Thomasites* (compare Fig. 56 with the sutures of *T. rollandi* figured by Pervinquiere, 1907, text-figs. 127-129).

The outer whorls of some ammonites referred to *Paramammites* Furon (1935) resemble the outer whorls of *Rubroceras* in that they have ribs accentuated at the ventrolateral shoulder. Among them are the various forms described as new species of *Paramammites* by Stankevich & Pojarkova (1969), and the specimens described by Freund & Raab (1969) *as Paramammites* sp.

Occurrence-Rubroceras is known only from the upper Cenomanian of southwestern New Mexico.

RUBROCERAS ALATUM sp. nov.

Figs. 56, 57, 90I-L, 94N-P, T-Y

Types-Holotype USNM 425417, from the Colorado Formation at loc. 95 in the Little Burro Mountains; paratypes USNM 425418-425424, from the Cookes Range and from the Little and Big Burro Mountains.

Etymology-alatus (Latin) = winged, in reference to the flank ribs.

Description-The holotype (Fig. 901-L) is a well-preserved internal mold of a nearly complete body chamber that encloses parts of poorly preserved, spar-filled inner whorls. The specimen has a diameter of 93.5 mm and an umbilicus of 34.5 mm (ratio of 0.37). Whorl section of the body chamber is depressed, with whorl breadth to whorl height ratios of 1.2 and 1.4 for intercostal and costal sections. The intercostal section has a narrowly rounded umbilical shoulder, broadly rounded flank, and very broadly rounded venter, whereas the costal section is rectangular to slightly trapezoidal, with the greatest width at the umbilical bullae. The venter of the costal section is flat to slightly depressed (Fig. 57B). Seven narrow, rectiradiate ribs arise from umbilical bullae on the body chamber and trend straight across the flank; they become very high and accentuated on the inner ventrolateral shoulder and then cross the venter transversely with slight diminution in strength. Inter-spaces are much wider than the ribs. On the older part of the body chamber, one or two faint, broad secondary ribs are present on the venter between the primaries. The stronger of these secondaries support low, blunt, bullate outer ventrolateral tubercles. Secondaries are absent on most of the younger half of the body chamber, but two low secondaries reappear near the aperture. The body chamber occupies half a whorl. Owing to the coarsely crystalline preservation of the phragmocone, parts of it shattered when the limestone concretion that enclosed the specimen was broken in the field. The flanks of the phragmocone remained in the concretion and could not be removed intact. The material was drilled out and a latex cast was made that revealed large, rounded umbilical tubercles that number about six per whorl (Fig. 90J). Part of the damaged outer whorl of the phragmocone was also drilled out and a cast was made of its ventral area impressed on the dorsum of the body chamber. This cast revealed low ventral ribs that support low, rounded to bullate ventral tubercles and faint, rounded siphonal ones. The visible part of the next inner whorl of the phragmocone has at a diameter of 21 mm conspicuous ornament of strong, bullate umbilical tubercles and fairly narrow, rounded ribs that bend forward a little on crossing the venter where they support nodate to bullate ventral tubercles and faint, rounded siphonal ones. Umbilical tubercles number three or four per half whorl at this diameter and each gives rise to a primary rib. Two or three secondary ribs that arise on the outer part of the flank separate the primaries. About 12 ribs per half whorl cross the venter. Most of the external (siphonal) lobe, the lateral lobe (L), and the saddle that separates them (E/L) are visible on the innermost whorl (Fig. 56A). L is bifid and fairly narrow; E/L is asymmetrically bifid and about twice as wide as L.

Whorl sections of adult body chambers vary considerably from very depressed, as in paratype USNM 425419 (Fig. 57A), to moderately high as in the holotype (Fig. 57B). Venters may be fairly depressed as in paratype USNM 425423 (Fig. 57C), to quite flat as in paratype USNM 425419 (Fig. 57A). Some body chambers, such as paratype USNM 425424, have large, nodate inner ventrolateral tubercles and much smaller outer ones.

The species is probably dimorphic. A nearly complete paratype USNM 425420 (Fig. 94T, U) has a diameter of only 69 mm, and there are fragments of body chambers from specimens larger than the holotype, which is probably a small macroconch.

Discussion—Inner whorl sections closely resemble those of a specimen of the Asiatic lower Turonian species described as *Pseudotissotia koulabica* Kler (1909: 157, pl. 8, figs. 3a, b, text-fig. 6). Atabekian (1966: 77) separated Kler's specimen as a new species and assigned it to the new genus *Koulabiceras (K. kleri* Atabekian). Wright & Kennedy (1981: 98, 99) reviewed *Koulabiceras* and placed it in synonymy with *Thomasites,* as did several other authors earlier. Atabekian

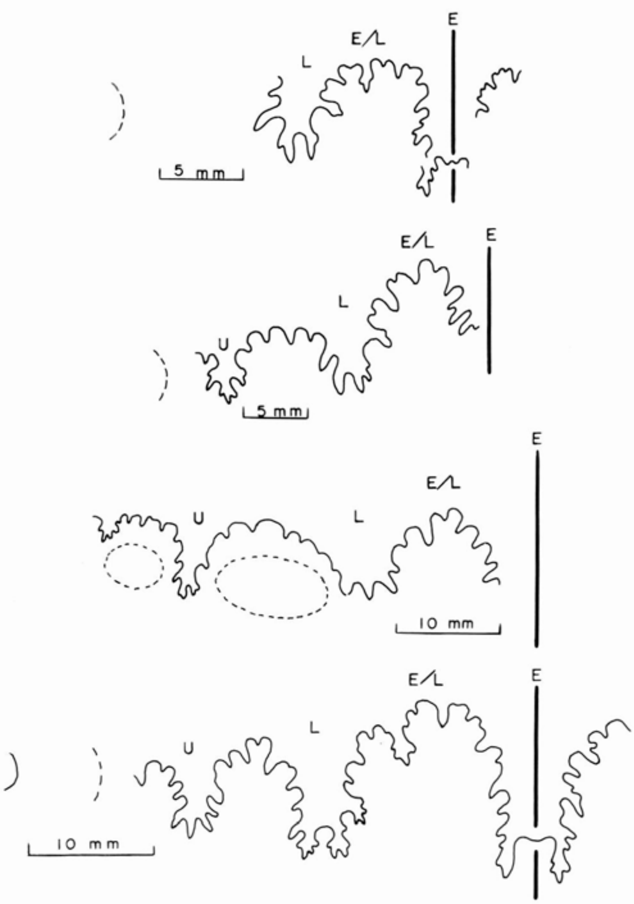

FIGURE 56—External sutures of *Rubroceras alatum* gen. et sp. nov. A, holotype USNM 425417 (Fig. 90I–L) at a diameter of approximately 32 mm, from loc. 95. B, paratype USNM 425420 (Fig. 94T, U) at a diameter of approximately 31 mm, from the same locality. C, paratype USNM 425419 (Fig. 94O, P) at a whorl width of 40 mm, from loc. 83. D, paratype USNM 425421 (Fig. 94V, W) at a whorl width of 37 mm, from loc. 95.

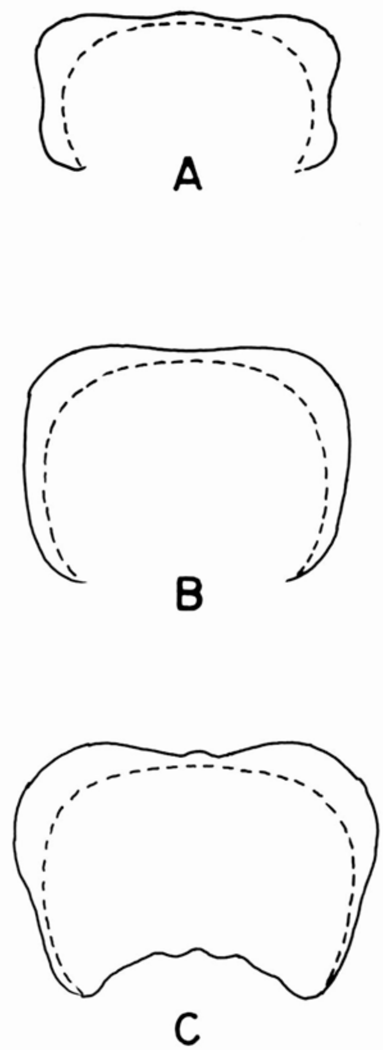

FIGURE 57—Whorl sections, natural size, of *Rubroceras alatum* gen. et sp. nov. A, paratype USNM 425419 (Fig. 94O, P), from loc. 83. B, holotype USNM 425417 (Fig. 90I–L), from loc. 95. C, paratype USNM 425423, from loc. 41.

(written comm. 1988) now believes *K. kleri* is better assigned to *Nigericeras.*

Rubroceras alatum appears to be closely related to the lower Turonian Asiatic species described as *Fallotites asiaticus* Khakimov (1972: pl. 5, fig. 3a, b). They are similar in size, general appearance, and suture pattern, but the Asiatic species lacks siphonal tubercles and has more rounded whorl section.

Occurrence—Rubroceras alatum is known only from the upper Cenomanian zone of *Neocardioceras juddii* in the Little Burro Mountains (locs. 83, 95) and in the Cookes Range (loc. 41).

RUBROCERAS BURROENSE sp. nov.

Figs. 93A-C, 94Q-S

Types—Holotype USNM 425425, from the zone of *Neocardioceras juddii* at loc. 110 west of Wild Horse Canyon in the Big Burro Mountains. Paratypes USNM 425426-425429 from locs. 118, and 121 in the Big Burro Mountains.

Etymology—For the Big Burro Mountains in Grant County, New Mexico.

Diagnosis—This species is characterized by its rounded whorl section and narrow ribs on the body chamber.

Description—The holotype (Fig. 93A-C) is the older two-thirds of a body chamber that is 70.5 mm in length, with a costal whorl height of 28.2 mm and breadth of 35.5 mm. Its umbilical shoulder is narrowly rounded, the flanks are flattened a little, and the venter is well rounded. Ornament consists of a few narrow primary ribs separated by two to four narrow secondaries. Primary ribs begin on the umbilical shoulder, trend straight across the flank, and then bend slightly forward on crossing the venter. Secondary ribs arise at midflank or farther out and become accentuated slightly at the ventrolateral shoulder before crossing the venter. Total ribs that cross the venter are estimated at 19 per half whorl. The impressed area on the dorsum indicates that the outer whorl of the phragmocone had fairly closely spaced, strong, rounded, rectiradiate ribs that supported low ventral tubercles and faint siphonal ones.

Three nearly complete body chambers of paratypes (USNM 425427-425429) have diameters of 74.5, 78.5, and 80 mm and 17, 19, and 16 ribs per half whorl that cross the venter. None has the suture preserved.

Discussion—Rubroceras burroense is easily distinguished from *R. alatum* by its rounded whorls and more numerous ribs.

Occurrence—Zone of *Neocardioceras juddii* in the Little Burro Mountains (loc. 100) and Big Burro Mountains (locs. 110, 118, 121).

RUBROCERAS ROTUNDUM sp. nov.
Figs. 58, 94Z–CC

Types—Holotype USNM 425430, from the upper Cenomanian zone of *Neocardioceras juddii at* loc. 41 in the Cookes Range, Luna County, New Mexico. Paratypes USNM 425431, 425432.

Etymology—rotundus (Latin) = spherical, in reference to its shape.

Diagnosis—A globose species with very depressed whorls, large umbilical tubercles, and narrow ribs that bear weak inner and outer ventrolateral and siphonal tubercles.

Description—This species is represented by the holotype and a few fragments. The holotype (Fig. 94BB, CC) is an internal mold of adult that is missing part of the outer septate whorl and a piece of the adjoining body chamber. Its costal dimensions in millimeters are as follows: D = 80, U = 20 (0.25), Wb = 59.5, Wh = 37.0, Wb:Wh = 1.61. The umbilicus is small and deep, with vertical walls. Intercostal whorl section has broadly rounded flanks and venter and narrowly rounded umbilical shoulder. Ornament consists of very large, rounded umbilical tubercles that give rise to narrowly rounded, rectiradiate paired or single primary ribs separated by one or two secondaries. All ribs are narrower than the interspaces and trend straight across the flanks and venter. Each rib is accentuated at the position of the inner ventrolateral shoulder, and each supports a weak, bullate outer ventrolateral tubercle and a faint, bullate siphonal tubercle. Only three large umbilical tubercles are present on the outer part of the phragmocone and older part of the body chamber. The umbilical tubercles decrease in size and increase in number toward the aperture so that the last half whorl of body chamber has seven of these tubercles. Total number of ribs on the last complete whorl is estimated at 25. The suture is not preserved.

A fragment of a whorl (Fig. 92Z, AA) from the type locality of the species is probably representative of the inner whorls. This specimen has a depressed section and umbilical, inner and outer ventrolateral and siphonal tubercles that are mostly nodate. The whorl section of this specimen and a bit of its suture are shown in Fig. 58 along with the whorl section of the holotype. A similar part of a phragmocone (USNM 425432) that has inner and outer ventrolateral and siphonal tubercles was also found at this locality.

Occurrence—Known only from the zone of *Neocardioceras juddii* at loc. 41 in the Cookes Range.

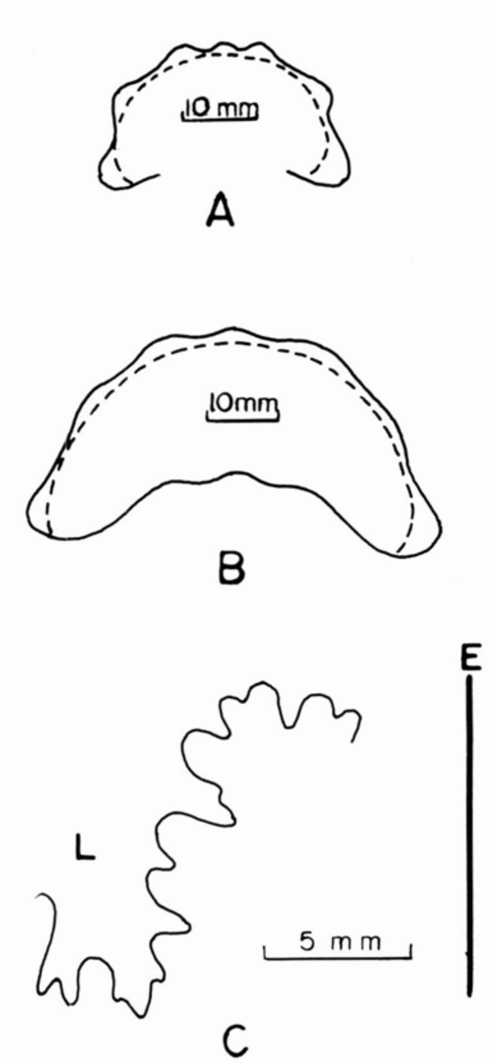

FIGURE 58—Whorl sections and part of external suture of *Rubroceras rotundum* gen. et sp. nov. from loc. 41 in the Cookes Range. A, paratype USNM 425431 (Fig. 94Z, AA). B. holotype USNM 425430 (Fig. 94BB, CC). C, paratype USNM 425431 (Fig. 94Z, AA).

Suborder ANCYLOCERATINA Wiedmann, 1966
Superfamily TURRJLITACEAE Gill, 1871
Family HAMITIDAE Gill, 1871
Genus *HAMITES* Parkinson, 1811

Type species—Hamites *attenuatus* J. Sowerby, 1814: 137, pl. 61, figs. 4, 5, by the subsequent designation of Diener, 1925: 65.

Diagnosis—Early whorls may be helical; in later growth stages the shell consists of three well-separated limbs that are parallel to subparallel. Ornament of fine to coarse ribs.

Occurrence—Widely distributed in rocks of early Albian to late Cenomanian age in Europe, Africa, India, Australia, and the United States (Texas, Oklahoma, New Mexico, Colorado, Wyoming, Montana, and South Dakota).

HAMITES cf. *SIMPLEX* d'Orbigny
Figs. 59, 92A–K

Compare:

1842. *Hamites simplex* d'Orbigny, p. 550, pl. 134, figs.12-15.
1951. *Hamites (Stomohamites) simplex* d'Orbigny: Wright & Wright, p. 14.
1956. *Hamites simplex* d'Orbigny: Somay, fiche 18.
1963. *Hamites (Stomohamites) simplex* d'Orbigny: Wright, p. 597, pl. 81, fig. la—c.
1971. *Stomohamites simplex* (d'Orbigny): Kennedy, p. 6, pl. 1, figs. 1-8 (with additional synonymy).

1973. *Stomohamites* **cf.** *S. simplex* **(d'Orbigny): Cobban & Scott, p. 44, pl. 13, figs. 5-10, pl. 17, figs. 3, 4.**
1975. *Stomohamites* **cf. S.** *simplex* **(d'Orbigny): Hattin, pl. 2, figs. I, J.**
1976. *Stomohamites simplex* **(d'Orbigny): Juignet & Kennedy, p. 51, pl. 1, figs. 8-10.**
1977. *Stomohamites* sp. cf. **S.** *simplex* **(d'Orbigny): Hattin, fig. 5(3).**
1977. *Stomohamites* **cf.** *S. simplex* **(d'Orbigny): Kauffman, pl. 17, figs., 8, 9.**
1978. *Stomohamites simplex* **(d'Orbigny): Kennedy & Hancock, pl. 9, fig. 5, 10-14.**
1979. *Stomohamites simplex* **(d'Orbigny): Kennedy, Chahida & Djafarian, p. 9, pl. 1, fig. 5.**
1983. *Hamites simplex* **d'Orbigny: Kennedy & Juignet, p. 13, figs. 15a—d, 17a—w, 36, 37v, w.**
1986. *Hamites* **cf.** *simplex* **d'Orbigny: Kennedy, Amedro & Collete, p. 210, fig. 4g.**

Types—Lectotype of *Hamites simplex,* **selected by Sornay (1956), is from the lower middle Cenomanian Craie de Rouen at Rouen (Seine Maritime), France. Figured specimens USNM 425433-425437, from the Colorado Formation in the Silver City Range and Big Burro Mountains.**

Diagnosis—This species has a stout elliptical section and ornament of four to six ribs on the venter in a distance equal to the whorl height (rib index).

Description—Kennedy & Juignet (1983) have refigured the lectotype and also illustrated six of d'Orbigny's syntypes from Rouen, France. The lectotype consists of a curved limb that has rectiradiate ribs with an index of 4.5-5. The syntypes have rib indices of 4 to 6, with most specimens having 5 or 6. Whorl sections are stoutly elliptical to subcircular (Kennedy & Juignet, 1983, fig. 15b-d).

A series of very small fragments (none exceeds 5 mm in whorl height) from the upper Cenomanian zones of *Calycoceras canitaurinum* **and** *Neocardioceras juddii* **in southwestern New Mexico are compared to** *H. simplex.* **None consists of more than two limbs connected by an elbow. Whorl sections are subcircular. Ribs on straight limbs are rectiradiate, whereas those on curved limbs are rursiradiate. Rib indices range from 4 to 6. Sutures are simple and characterized by bifid saddles that are wider than the lobes (Fig. 59). This pattern, which is quite different from the suture of a French specimen illustrated by Kennedy & Juignet (1983, fig. 15a), may be due to the small size of the New Mexican specimens in contrast to the larger French examples.**

Occurrence—D'Orbigny's types are from the lower part of the European middle Cenomanian zone of *Acanthoceras rhotomagense.* **The species has been recorded from high in the lower Cenomanian on up through the rest of the Cenomanian. In southwestern New Mexico** *H.* **cf.** *simplex* **is most common in the zone of** *Calycoceras canitaurinum* **(low in the upper Cenomanian) in the Cookes Range (locs. 29, 30, 33, 55) and Fort Bayard area (loc. 70). Specimens have been found higher in the Cenomanian in the zone of** *Metoicoceras mosbyense* **in the Virden area (loc. 159) and in the zone of** *Neocardioceras juddii* **in the Big Burro Mountains (locs. 110, 120, 121, 143, 146).**

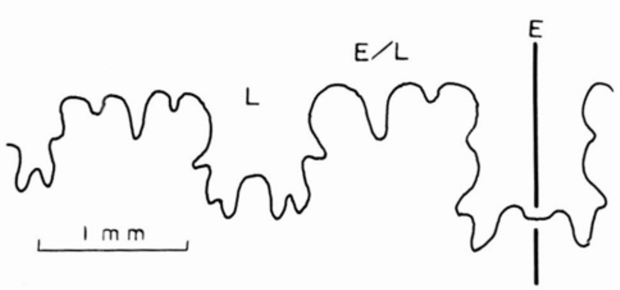

FIGURE 59—Most of the suture of *Hamites* cf. *simplex* d'Orbigny at a whorl height of 3.3 mm. USNM 425434 (Fig. 92C, D), from loc. 110 in the Big Burro Mountains.

HAMITES C1MARRONENSIS **(Kauffman & Powell)**
Fig. 96U

[977. *Stomohamites simplex cimarronensis* **Kauffman & Powell, p. 97, pl. 9, figs. 1, 3, 4, text-figs. 5,6.**
[988. *Hamites cimarronensis* **(Kauffman & Powell): Lucas et al., p. 156, fig. 9I.**

Holotype—USNM 167160, from the upper Cenomanian Hartland Shale Member of the Greenhorn Limestone at USGS Mesozoic loc. 30235 in Cimarron County, Oklahoma. Hypotype USNM 425442, from the Cookes Range.

Diagnosis—A densely ribbed hamitid that has a rib index of 7 or 8.

Description—A flattened specimen on a piece of shale consists of an elbow that connects two divergent straight limbs. The larger (younger) limb is 30 mm long and 6.3 mm high. Limbs and elbow have closely spaced, straight, prorsiradiate ribs with an index of 7 to 8.

Occurrence—Found in the flag member of the Colorado Formation at loc. 30 on the south side of the Cookes Range. Associated fossils include *Moremanoceras costatum* **sp. nov. and** *Calycoceras canitaurinum.*

HAMITES SALEBROSUS **sp. nov.**
Fig. 95BB, EE-II

Etymology—salebrosus **(Latin) = rough or rugged, in reference to the ornament.**

Types—Holotype USNM 425439, from the Twowells Sandstone Tongue of the Dakota Sandstone at locality D12069 in the NVV^1/4SW^1/4SW^1/4 sec. 30,T1ON, R30E, Apache County, Arizona. Paratypes USNM 425440, 425441 from east-central Montana and southwestern New Mexico.

Diagnosis—Compressed whorls and very coarse, sparse ornament distinguish *Hamites salebrosus* **from all other post-Albian** *Hamites.*

Description—The holotype (Fig. 95EE, FF) consists of two fragments of a nonseptate straight limb. The longest fragment is 60 mm long and has near its middle a costal height of 17.1 mm and a breadth of 12.9 mm (breadth to height ratio of 0.75). Whorl section is ovate, with the greatest width near midflank. Ribs are strong, coarse, narrowly rounded, rectiradiate and narrower than the interspaces; the ribs are slightly effaced on the dorsum and number four in a distance equal to the shell height. A smaller fragment, that represents a larger growth stage, has a costal whorl height of 21.3 mm.

A nonseptate paratype (Fig. 95BB), from loc. 159 near Virden, has five ribs at a costal height of 14.5 mm. A large, crushed body chamber (Fig. 95GG-II) from the Mosby Sandstone Member of the Belle Fourche Shale of east-central Montana (USGS Mesozoic loc. D10149 in the E^1/2 sec. 27, T13N, R25E) has a length of 85 mm and a rib index of 5.

Occurrence—Upper Cenomanian *Metoicoceras mosbyense* **zone of Montana, Arizona, and New Mexico. The holotype has a juvenile M.** *mosbyense* **embedded in it (Fig. 95EE). In southwestern New Mexico,** *H. salebrosus* **has been found only at loc. 159 near Virden.**

HAMITES PYGMAEUS **sp. nov.**
Figs. 60, 95CC

Etymology—pygmaeus (Latin) = dwarf.

Types—Holotype USNM 425443 from loc. 141 in the Big Burro Mountains.

Diagnosis—Small adult size alone distinguishes this finely ribbed species from all other described *Hamites.*

Description—The holotype (Fig. 95CC) consists of the U-shaped hook and part of the straight shaft of an adult. The preserved part has a length of 14.7 mm. The U-shaped hook represents the older part of the body chamber; heights of the body chamber whorl are 3.7 mm at the large end and 2.7 mm at the small end. Ribs are rectiradiate on the shaft

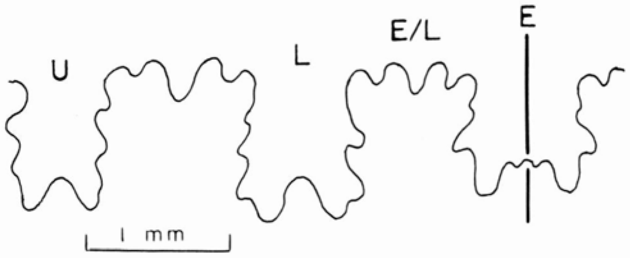

FIGURE 60—Most of the suture of *Hamites pygmaeus* sp. nov. at a whorl height of 2.5 mm. Holotype USNM 425443 (Fig. 95CC), from loc. 141 in the Big Burro Mountains.

where the index is 8; they are rursiradiate on the younger part of the hook where the index is 7. Squarish to rectangular, little incised, bifid lobes and saddles of nearly the same size characterize the suture (Fig. 60).

Occurrence-Known only from the upper Cenomanian *Burroceras clydense* zone at loc. 141 and from the *Neocardioceras juddii* zone at loc. 110, both in the Big Burro Mountains.

HAMITES? sp.
Fig. 96W

Material-Figured specimens USNM 425444, 425445, from the flag member of the Colorado Formation in the Cookes Range.

Description-Two curved limbs that form semicircles 16 and 18 mm in diameter may represent an unusually coarse-ribbed species of *Hamites*. Both have elliptical sections; heights are 4.0 and 4.5 mm. Ribs are rounded, prorsiradiate and as wide as the interspaces; their indices are 3.5 to 4. Sutures are not preserved.

Occurrence-Both limbs lie side by side in a limestone concretion from loc. 30. Associated fossils include *Calycoceras canitaurinum*.

Genus *METAPTYCHOCERAS* Spath, 1926a

Type *species-Ptychoceras smithi* Woods, 1896: 74, pl. 2, figs. 1, 2, from the upper Turonian Chalk Rock of England.

Diagnosis-A small genus that consists of an early coil followed by two slender, fairly straight, parallel shafts that form a U and then by a final parallel shaft pressed against the penultimate limb. Initial shaft is nearly smooth and has weak constrictions.

Occurrence-A rare genus known from England (upper Turonian) and the United States (upper Cenomanian of Texas, New Mexico, Oklahoma, Kansas, and Colorado; lower Turonian of South Dakota; middle and upper Turonian of Texas).

METAPTYCHOCERAS HIDALGOENSE sp. nov.
Fig. 95Z, AA, **DD**

Etymology-For Hidalgo County, New Mexico, where the types were found.

Types-Holotype USNM 425446, paratypes USNM 425447, 425448.

Diagnosis-A very small species that consists of a loose, open coil followed by two twisted shafts largely in contact.

Description-Several different growth stages characterize this species. An initial coil of one smooth whorl is followed by a very loose, planospiral coil that consists of a scarcely tapering, mostly smooth whorl. This whorl straightens, increases its expansion rate, and becomes ribbed as it forms the older limb of two somewhat parallel shafts. Ribbing becomes effaced on the elbow connecting the shafts, but then becomes conspicuous again on the younger shaft. The younger shaft may lie parallel and in contact with the older shaft or, in most cases, it twists upward and away from it or to the side, so that the aperture of the shell is at an angle to the earlier open planospire. Ribs are mostly rectiradiate and have indices of 4 or 5.

The holotype (Fig. 95AA) consists of two shafts partly in contact but both twisted to some degree. The older shaft is septate, but the younger one is a body chamber 12.5 mm in length that lies in contact for half its length with the septate shaft and then bends away from it at a low angle.

Both small and large specimens occur on the same slab (Fig. 95AA) and show the species to be markedly dimorphic.

Discussion-The twisted shafts are unlike in any described species. *Metaptychoceras reesidei* (Cobban & Scott, 1973: 45, pl. 17, figs. 7, 8) of the upper Cenomanian *Sciponoceras gracile* zone is more than twice the size of M. *hidalgoense* and has finer ribs with a conspicuous change in rib density between the two shafts. An undescribed species from the middle Turonian *Prionocyclus hyatti* zone of Trans-Pecos Texas is comparable in size to *M. hidalgoense* but has much coarser ribbing.

Occurrence-Known only from the upper Cenomanian *Metoicoceras mosbyense* zone at loc. 159 near Virden, in the NEI/4NW1/4 sec. 20, T18N, R2OW, Hidalgo County, New Mexico.

Family ANISOCERATIDAE Hyatt, 1900
Genus *ANISOCERAS* Pictet, 1854

Type species-By original designation, *Hamites saussureanus* Pictet, *in* Pictet & Roux, 1847: 374, pl. 13, figs. 1-4.

Diagnosis-Early whorls in a helical spire, later whorls in one or two straight shafts. Ornament of sharp to rounded ribs with lateral and ventral tubercles.

Occurrence-The genus has been recorded from rocks of late Albian through late Turonian age in Europe, Africa, Indian, Mexico, and Texas.

ANISOCERAS COLORADOENSE sp. nov.
Figs. 61, 94C-M, 95U-Y

1972. *Anisoceras plicatile* (J. Sowerby): Cobban, p. 4, pl. 1, figs. 4-7, text-fig. 2.

1988. *Anisoceras* sp. nov. aff. *plicatile* (J. Sowerby): Kennedy, p. 103, pl. 19, figs. 1, 2.

Etymology-For the type occurrence in Colorado.

Types-Holotype USNM 166338, the original of Cobban, 1972, pl. 1, figs. 4, 5, text-fig. 2B, from the base of the Bridge Creek Member of the Greenhorn Limestone at USGS Mesozoic locality 22899 in southeastern Colorado. Hypotypes USNM 425449-425457, from the *Neocardioceras juddii* zone in southwestern New Mexico.

Diagnosis-A large, compressed species that has the lateral tubercles high on the flank.

Description-This large species of *Anisoceras* has a compressed rectangular whorl section (whorl breadth to height ratio of 0.7). Rib index is as low as 5 in juveniles, but increases to 10-13 in adults. Ribs are strong, narrow and rounded; they are separated by equal or slightly wider interspaces. Ribs are transverse on the dorsum and slightly weaker than, or as strong as, those on the flank. Groups of up to three ribs are linked at a large rounded tubercle high on the flank. From this tubercle, ribs loop to a strong ventral clavus. The clavi, in turn, are connected across the venter by groups of two or three ribs. One to three ribs lie between the tuberculate groups on both the flank and venter.

The holotype consists of the elbow and part of a straight limb of a large internal mold 150 mm in length. Whorl height at its larger end is 54.5 mm.

Specimens from the Colorado Formation of southwestern New Mexico are smaller than the type and represent parts of several growth stages. The earliest growth stage preserved consists of an open spire of about one complete whorl (Fig. 94L, M). The older part of this whorl is smooth

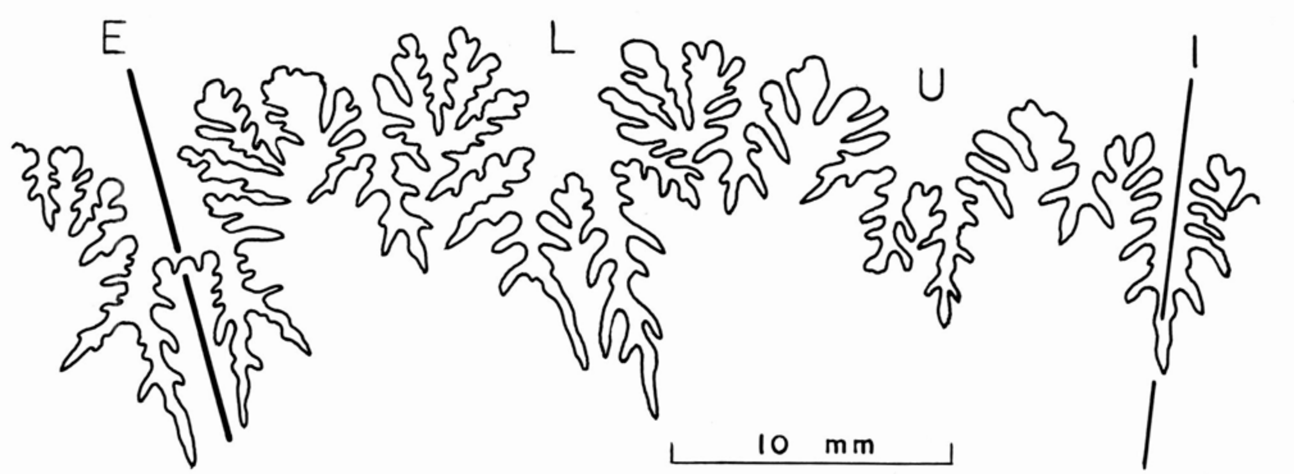

FIGURE 61—Entire suture of *Anisoceras coloradoense* sp. nov. at a whorl height of 21 mm (Fig. 95X, Y). Paratype USNM 425457, from loc. 110 in the Big Burro Mountains.

and has a very low angle of taper; the younger part is ribbed and has a greater taper. The spire continues through another whorl that has a pronounced increase in the angle of taper. Later whorls are represented by small fragments; none is large enough to represent the straight shaft of the type.

The suture is complex (Fig. 61). Lobes and saddles, other than the dorsal lobe, are deeply bifid and very digitate.

Discussion—Anisoceras coloradoense most closely resembles *A. plicatile* (J. Sowerby, 1819) (see Kennedy & Juignet, 1983: 25, figs. 16a–m, p, q, 19a–e, 341, m, for a recent review), from which it is distinguished by its greater size, compressed rather than circular whorl section, and a higher position of the flank tubercles.

Occurrence—The holotype came from the upper Cenomanian zone of *Sciponoceras gracile* of southeastern Colorado. All specimens from southwestern New Mexico are from the zone of *Neocardioceras juddii* in the Cookes Range (loc. 41), Little Burro Mountains (locs. 85, 95), east side of Big Burro Mountains (locs. 101, 103, 104, 105, 109, 110, 113), and west side of Big Burro Mountains (locs. 118, 120, 122, 126, 132, 134).

Genus *ALLOCRIOCERAS* Spath, 1926a

Type species—By original designation, *Crioceras ellipticum* Woods *(non Mantel!),* 1896: 84, pl. 3, fig. 9, 9a.

Diagnosis—Irregularly coiled in a plane or in a helix. Ornament of ribs and ventrolateral tubercles, the latter joined across the venter by a single rib.

Occurrence—Known from rocks of late Cenomanian into Coniacian age from western Europe, Nigeria, Zululand, Japan, Mexico, and the United States (Texas, New Mexico, Arizona, Utah, Colorado, Kansas, South Dakota, Wyoming, and Montana).

ALLOCRIOCERAS ANNULATUM (Shumard)
Fig. 96P

1860. *Ancyloceras annulatus* Shumard, p. 595.
1877. *Helicoceras pariense* White, p. 203, pl. 19, fig. 2a—d.
1894. *Exiteloceras pariense* (White): Hyatt, p. 577.
1933. *Allocrioceras pariense* (White): Adkins, p. 434, 437.
1942. *Allocrioceras annulatum* (Shumard): Moreman, p. 208.
1973. *Allocrioceras annulatum* (Shumard): Cobban & Scott, p. 51, pl. 20, figs. 1-14 (with full synonymy).
1975. *Allocrioceras annulatum* (Shumard): Hattin, pl. 5, figs. B, C.
1977. *Allocrioceras annulatum* (Shumard): Kauffman, pl, 19, figs. 1, 2.
1979. *Allocrioceras annulatum* (Shumard): Merewether, Cobban & Cavanaugh, pl. 2, figs. 18, 19.
1981. *Allocrioceras annulatum* (Shumard): Wright & Kennedy, p. 111, pl. 32, figs. 3-7 (with full synonymy).
1984b. *Allocrioceras annulatum* (Shumard): Cobban, pl. 2, fig. 4.
1988. *Allocrioceras annulatum* (Shumard): Kennedy, p. 104, pl. 19, figs. 3-12, 14, pl. 22, figs. 1, 2, pl. 24, fig. 2, text-fig. 36.

Types—Shumard's types are apparently lost. They came from beds now assigned to the Britton Formation at Shawnee Creek, Grayson County, Texas, that lie in the upper Cenomanian zone of *Sciponoceras gracile.* White's holotype of *Helicoceras pariense (= A. annulatum)* is from this zone in rocks now included in the Tropic Shale in southern Utah. Hypotypes from southwestern New Mexico are USNM 425458 and 425459.

Diagnosis—Early whorls with ribs only; later whorls with a ventral tubercle on each rib. Rib indices mostly 4 to 5.

Description—Only two fragments of this species were found in southwestern New Mexico. One specimen (USNM 425458) is a curved shaft 16.3 mm long, with a whorl height of 3.8 at the larger end. Ribs are strong, rounded and mostly rectiradiate, and have an index of 4. Tubercles are absent; Cobban & Scott (1973: 52) noted they may not arise until a height of 10 mm is attained. The other specimen (USNM 425459) is a fragment that has a whorl height of 11.0 mm and a rib index of 4.5. A nodate ventral tubercle is present on each rib.

Occurrence—Upper Cenomanian zone of *Metoicoceras geslinianum* in England and the correlative zone of *Sciponoceras gracile* in Mexico, Texas, and the Western Interior. Found in the shale member of the Colorado Formation at loc. 145 on the west side of the Big Burro Mountains in association with M. *geslinianum* and *S. gracile.*

Family TURRILITIDAE Gill, 1871
Subfamily TURRILITINAE Gill, 1871
Genus *TURRILITES* Lamarck, 1801

Type species—By original designation, *Turrilites costatus* Lamarck, 1801, p. 102.

Diagnosis—Turrilicones with a small apical angle and ornament of strong ribs with or without rows of tubercles on the lower part of the whorls that correspond to the ribs.

Occurrence—Widely distributed in rocks of early, middle, and late Cenomanian age.

TURRILITES sp.
Fig. 960

Material—Figured specimen USNM 425460, from the upper Cenomanian zone of *Calycoceras canitaurinum* in the Cookes Range.

Description—The specimen is 19.3 mm high and consists of an internal mold of five whorls with an apical angle of 10°. The whorls have a narrowly rounded upper shoulder and a more gently rounded lower shoulder; upper part of the flank is flattened and sloping, whereas the lower part is rounded. Ornament consists of about 17 ribs that occupy the middle part of the whorls. Each rib rises into a low bullate tubercle at midflank. The suture is not preserved.

Discussion-This specimen is nearest T. *costatus* Lamarck (1801: 102) that has ribs dominant over tubercles, but *T. costatus* has ribs that cross the entire upper half of the whorl and also a row of tubercles near the base of the whorl. The present specimen is probably an undescribed species.

Occurrence-From loc. 33 in the flag member of the Colorado Formation on the south side of the Cookes Range. Associated fossils include *Moremanoceras costatum* sp. nov., *Calycoceras canitaurinum,* and *Neostlingoceras kottlowskii.*

TURRILICONE sp. nov.
Fig. 96Q

Material-Figured specimen USNM 425461, from the zone of *Calycoceras canitaurinum* in the Cookes Range.

Description-An internal mold 14.3 mm high consists of two whorls that have an apical angle of 25°. Whorls slope with the greatest width at the lower shoulder. Both shoulders are narrowly rounded; flanks are flat to faintly depressed. Ornament consists of 30 short, closely spaced ribs per whorl, located on the lower whorl shoulder and lower one-third of the flank. These ribs seem to be interrupted in places to form two rows of incipient bullate tubercles. The suture is not preserved.

Discussion-The authors are not aware of anything like this.

Occurrence-From a limestone concretion in the flag member of the Colorado Formation at loc. 33 on the south side of the Cookes Range.

Genus *NEOSTLINGOCERAS* Klinger & Kennedy, 1978 Type *species-Turrilites carcitanensis* Matheron, 1842: 267, pl. 12, fig. 4.

Diagnosis-This genus includes tuberculate sinistral turrilicones that have ornament characterized by an upper row of nodate tubercles separated by a flat or slightly concave band from two or three rows of smaller and more numerous tubercles.

Occurrence-Widely distributed in the Northern Hemisphere in rocks of Cenomanian age.

NEOSTLINGOCERAS KOTTLOWSKII Cobban & Hook
Fig. 95A-F

1981. *Neostlingoceras kottlowskii* Cobban & Hook, p. 26, pl. 4, figs. 1-28.

1984b. *Neostlingoceras kottlowskii* Cobban & Hook: Cobban, p. 17, p1. 4, fig. 9.

Types-Holotype USNM 306777 and paratype USNM 306792 are from the Colorado Formation at USGS Mesozoic locality D10517 in sec. 13, T1OS, R8W, Sierra County, New Mexico. Paratypes USNM 306798 and 306801, and hypotype USNM 425462 are from the Colorado Formation in the Cookes Range.

Description-An acute apical angle and two rows of pointed tubercles characterize this species. A third row of bullate tubercles, which lies on the underside of the whorls, is not visible in side views.

The holotype (Fig. 95A, B) consists of four whorls in a length of 40 mm; its apical angle is 17°. Seventeen nodate tubercles per whorl are present in the upper row, and 23 smaller ones are present in the lower row. The third row, on the underside of the whorl, has still smaller bullate tubercles.

Occurrence-Upper Cenomanian *Calycoceras canitaurinum* zone in New Mexico, Colorado, and Wyoming. Crushed fragments of *N. kottlowskii* are fairly common in the shaly rocks in the lower part of the Colorado Formation in the Cookes Range. Occasional specimens from there have several whorls (Cobban & Hook, 1981, pl. 4, figs. 22, 26). Localities of *N. kottlowskii* in southwestern New Mexico listed by Cobban & Hook (1981, table 2) include 4, 5, 29, 31, 33, 34, 53, and 55 in the Cookes Range. The species has also been found in the Fort Bayard area (loc. 63), Silver City Range (loc. 71), and Little Burro Mountains (loc. 94).

NEOSTLINGOCERAS PROCERUM sp. nov.
Figs. 62, 95 0-Q, S

Types-Holotype USNM 425463, figured paratypes USNM 425464-425466, unfigured paratypes USNM 425467 and 425468, all from the zone of *Metoicoceras mosbyense* in the Virden area.

Etymology-procerus (Latin) = tall, slender, long.

Diagnosis-High, slender whorls with flat flanks, rounded upper shoulder, and angular lower shoulder that is separated from the base by a pronounced narrow, spiral groove. Very small tubercles on the lower shoulder of the whorls.

Description-The holotype (Fig. 95 0, P), a spire 23 mm high that has an apical angle of 10°, consists of eight whorls. Flanks are flat, with a well-rounded upper shoulder and an angular lower shoulder that supports about 30 tiny, rounded tubercles per whorl separated by much wider interspaces. A deep, narrow groove lies below this shoulder and separates it from the base of the whorl which is marked by another angular shoulder that is inset from the tuberculated one. This basal shoulder is smooth in the holotype, but in slightly larger paratypes the shoulder is faintly undulated into clavate tubercles. Part of an adult (Fig. 95Q) has more pronounced basal clavi as well as a few irregular, narrow, weak ribs on the flank. This is the only individual of the seven specimens at hand that has any trace of ribbing. Ornament in all the other specimens consists only of the minute tubercles on the lower shoulder. A paratype (USNM 425467) of four whorls, of about the size of the smaller ones of the holotype, has about 38 of these tubercles per whorl.

Only part of the suture (Fig. 62) is exposed on the flank of a paratype (USNM 425466). We interpret this as part of a rather simple, broad, bifid E/L saddle. The external lobe should lie near the lower shoulder of the whorl.

Occurrence-Known only from a high position in the zone of *Metoicoceras mosbyense at* loc. 159 in the Virden area.

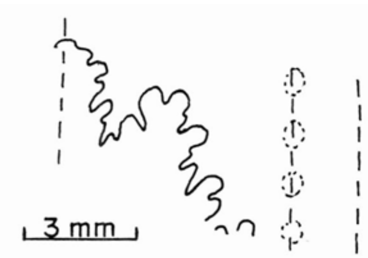

FIGURE 62—Part of the suture of a paratype USNM 425466 of *Neostlingoceras procerum* sp. nov., from loc. 159 near Virden. Straight dashed lines indicate the positions of the three shoulders. Circles are tubercles.

NEOSTLINGOCERAS BAYARDENSE sp. nov.
Fig. 95R, 96R

Types-Holotype USNM 425469, paratype USNM 425470, from the shale member of the Colorado Formation in the Fort Bayard area.

Etymology-For the type locality of the species, 1 mi southeast of Fort Bayard.

Diagnosis-Small apical angle and flat-sized whorls with weak ornament characterize this species.

Description-The holotype (Fig. 95R) is an internal mold 26.8 mm high that consists of six whorls with an apical angle of 11°. Upper and lower flank shoulders are narrowly rounded, and the flank is flattened with a faint spiral depression below midflank. Ornament consists of low, bullate tubercles just above midflank and two closely spaced rows of slightly stronger tubercles at the lower shoulder. Of these basal rows, the upper consists of rounded tubercles, and the lower consists of weaker bullate ones. The final complete whorl has 21 tubercles in each of the basal rows and 20 in the row above midflank. On the smaller whorls, the upper rows become very weak and even disappear in places. A paratype, USNM 425470, 15 mm high that has four whorls, has only the basal rows of tubercles and perfectly smooth flanks above. About 28 tubercles are present on the last whorl. Sutures are not preserved in either specimen.

Discussion—The species is nearest *N. procerum* of the younger zone of *Metoicoceras mosbyense. N. bayardense,* however, is more strongly ornamented and lacks the pronounced spiral furrow at the base of the whorls.

Occurrence—Known only by the holotype and paratype from a limestone concretion in the zone of *Calycoceras canitaurinum* at loc. 70 in the Fort Bayard area, and from one specimen in the same zone at loc. 33 in the Cookes Range.

NEOSTLINGOCERAS VIRDENENSE sp. nov.
Figs. 63, 95T

Types—Holotype USNM 425471 and paratype USNM 425472 from the zone of *Metoicoceras mosbyense* in the Virden area.

Etymology—For Virden, Hidalgo County, New Mexico, near the type locality.

Diagnosis—Large, rounded tubercles at midflank and twice as many much smaller ones at the base of the whorl characterize this species.

Description—This species is represented only by the holotype and three smaller paratypes. The holotype (Fig. 95T) consists of parts of five whorls with a total height of 26.7 mm and an apical angle of 25°. Whorls have well-defined angular shoulders, with the contact between whorls only slightly impressed. Lower half of the whorls is depressed into a low spiral groove, whereas the upper half is very broadly rounded and sloping. Ornament is dominated by large, nodate tubercles at midflank, which are estimated at 13 or 14 per whorl. A prominent shoulder at the base of the flank is notched into small, blunt, spirally elongated tubercles that are twice as numerous as those at midflank. Both upper and lower whorl faces are smooth. The suture (Fig. 63) is peculiar; it has a broad, poorly defined external lobe at midflank and moderately wide and bifid E/L saddle. The lateral lobe (L) is narrower than E/L and deeply bifid. The umbilical lobe (U) is also deeply bifid but unusually small.

A smaller paratype, USNM 425472, 17.5 mm high, consists of six whorls with an apical angle of 20°.

Discussion—This species resembles *N. kottlowskii* Cobban & Hook (1981: 26, pl. 4, figs. 1-28) in its apical angle and general appearance, but *N. virdenense* has only one row of small basal tubercles, and these are smaller and more numerous. The Virden species is probably a direct descendent of *N. kottlowskii.*

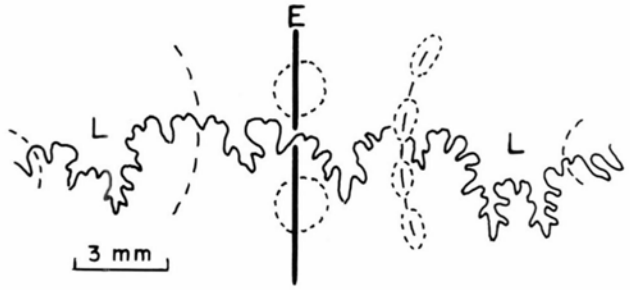

FIGURE 63—Most of the suture of the holotype (USNM 425471) of *Neostlingoceras virdenense* sp. nov., from loc. 159 near Virden. Heavy straight line marks the poorly defined external lobe. Broadly curved dashes mark the whorl shoulders; narrowly curved dashes mark the umbilical shoulders. Circles and ellipses are tubercles.

Occurrence—Known only from high in the zone of *Metoicoceras mosbyense* at loc. 159 near Virden.

NEOSTLINGOCERAS APICULATUM sp. nov.
Fig. 96D

Types—Holotype USNM 425458, from the Bridge Creek Limestone Member of the Colorado Formation in the Cookes Range.

Etymology—apiculus (Latin) = top or apex, for the occurrence at the top of its known lineage.

Diagnosis—A smooth species, apart from large, nodate tubercles above midflank.

Description—Known only from the holotype that consists of two whorls with a total height of 14.3 mm and an apical angle of 13°. Whorls have well-defined shoulders; lower half of flank is flat, and upper half is broadly rounded and sloping. Base of whorl is a low, narrowly rounded ridge devoid of tubercles. Rest of whorl is smooth except for 11 large, nodate tubercles per whorl that are located above midflank. The specimen is either part of a body chamber, or the sutures have not been preserved.

Discussion—This species differs from *N. virdenense* in its lack of the row of small, basal tubercles, and in its higher position of the flank tubercles.

Occurrence—Known only from loc. 15 in the Cookes Range. Associated fossils include *Metoicoceras geslinianum, Euomphaloceras septemseriatum, Calycoceras naviculare,* and other ammonites of the upper Cenomanian zone of *Sciponoceras gracile.*

Family BACULITIDAE Gill, 1871
Genus *SCIPONOCERAS* Hyatt, 1894

Type species—By original designation, *Hamites baculoide* Mantell, 1822, p. 123, pl. 23, figs. 6, 7.

Diagnosis—Initial coil of one whorl followed by a straight shaft that has prorsiradiate constrictions and an aperture directed at an angle to the shaft. Prorsiradiate ribs usually present on the venter and adjacent part of the flank.

Occurrence—Widely distributed in rocks of late Albian through late Turonian age. Most abundant in the Western Interior in the upper Cenomanian zone of *Sciponoceras gracile.*

SCIPONOCERAS GRACILE (Shumard)
Figs. 94A, B, 95G-N, 96A, B

1860. *Baculites gracilis* Shumard, p. 596.
1951. *Sciponoceras gracile* (Shumard): Cobban, p. 2185.
1981. *Sciponoceras gracile* (Shumard): Wright & Kennedy, p. 112, pl. 31, figs. 1-3, pl. 32, figs. 8, 11, text-fig. 38A—Q (with full synonymy).
1983. *Sciponoceras gracile* (Shumard): Kennedy & Juignet, p. 22, figs. 18a—d, 32i—p (with additional synonymy).
1984. *Sciponoceras gracile* (Shumard): Kennedy, Amédro, Badillet, Hancock & Wright, p. 41, figs. 2a—d.
1987. *Sciponoceras gracile* (Shumard): Hattin, fig. 8B.
1988. *Sciponoceras gracile* (Shumard): Kennedy, p. 108, pl. 20, figs. 1-14, 17-20, text-fig. 38.

Types—Shumard's types are lost; they are probably from rocks now included in the Britton Formation of north Texas. Hypotypes USNM 356913, 387358, 387360, and 425474-425476 from the shale member of the Colorado Formation in the Fort Bayard area and Big Burro Mountains.

Diagnosis—Subelliptical to nearly circular cross sections and constrictions spaced one or less for the shell diameter are typical of this species.

Description—Specimens at hand have diameters from 2 to 10 mm. Constrictions are internal and can only be seen on internal molds (Fig. 95J). The constrictions, spaced at 1 to 1.5 shell diameters, are strongest on the venter and lower part of the flank where they are prorsiradiate. In some individuals, constrictions completely encircle the internal molds and cross the dorsal side with faint forward arching. The suture is rather simple, with somewhat rectangular lobes and saddles.

Occurrence-Widely distributed in western Europe and the United States in upper Cenomanian rocks. Fairly common in the zone of *Sciponoceras gracile* in the Cookes Range (locs. 9, 10, 27), Fort Bayard area (locs. 62, 66, 67), and Big Burro Mountains (locs. 144, 145). The species also ranges up into the zone of *Burroceras clydense* in the Big Burro Mountains (locs. 136, 142) and on up into the zone of *Neocardioceras juddii* in these mountains (locs. 119, 120, 134).

Superfamily SCAPHITACEAE Gill, 1871
Family SCAPHITIDAE Gill, 1871
Subfamily OTOSCAPHITINAE Wright, 1953
Genus *WORTHOCERAS* Adkins, 1928

Type species-By original designation, *Macroscaphites platydorsus* Scott, 1924, p. 18, pls. 5, 6, pl. 9, fig. 6, from the upper Albian Duck Creek Limestone of Grayson County, Texas.

Diagnosis-A small genus that has a septate coil followed by a long, straight shaft and final hook. Markedly dimorphic; microconchs have a slender body chamber and lappeted aperture, macroconchs have a stout body chamber and a constricted aperture without lappets.

Occurrence-Upper Albian through middle Turonian; western Europe and the United States (Texas and Western Interior).

WORTHOCERAS VERMICULUS (Shumard)
Figs. 93D-F, 96E-N

1860. *Scaphites vermiculus* **Shumard, p. 419.**
1876. *Macroscaphites vermiculus* **(Shumard): Meek, p. 419.**
1942. *Worthoceras vermiculum* **(Shumard): Moreman, p. 214, pl. 34, figs. 12, 13, text-fig. 2p.**
1942. *Worthoceras gibbosum* **Moreman, p. 215, p1. 34, figs.** *7,* **8, text-fig. 2q.**
1988. *Worthoceras vermiculus* **(Shumard): Kennedy, p. 114, pl. 22, figs. 5, 10-15, pl. 24, figs. 22-33, text-fig. 39 (with full** synonymy).

Types-Neotype TMM 19827, designated by Moreman (1942: 214), from the upper Cenomanian zone of *Sciponoceras gracile* in Ellis County, Texas. Holotype, by monotypy, of W. *gibbosum* Moreman (= ***W. vermiculus)*** is TMM 19812, from the same locality as that of W. ***vermiculus.*** Hypotypes USNM 425477-425479, 429085, 429086 from the Colorado Formation.

Diagnosis-Microconchs with evolute septate coil and long, slender body chamber that has a slightly concave dorsum at the base of its straight shaft. Macroconchs with more involute coil and stouter body chamber that is more curved. Ornament lacking except for obscure growth lines and low, fold-like ribs.

Description-Specimens from southwestern New Mexico are typical of the species. An internal mold of a microconch with a length of 15 mm is shown in Fig. 93D-F. A small part of the terminal end is missing. Ornament is lacking. Macroconchs from the same locality (144) are shown in Fig. 96E-N. Very weak, irregular growth lines and obscure ribs are present on the septate parts.

Occurrence-Sciponoceras *gracile* zone in the Cookes Range (locs. 40, 90) and west side of the Big Burro Mountains (locs. 144, 145); *Burroceras clydense* zone in the Big Burro Mountains (loc. 142).

WORTHOCERAS sp. nov.
Fig. 93G

Material-Figured specimen USNM 425480, from the zone of *Neocardioceras iuddii* in the Big Burro Mountains.

Description-Small evolute coils from several localities in the zone of *N. juddii* may represent a new species. All are smooth and quite evolute. Slender-whorled coils up to 4.5 mm in diameter are probably from microconchs. More robust coils up to 6 mm in diameter are probably macroconchs. Sutures are not preserved.

Discussion-These coils are smaller than the septate coils of W. *vermiculus,* which has diameters up to 8 mm for microconchs and up to 11.5 mm for macroconchs. A similar diminutive form occurs in the lower Turonian zone of *Pseudaspidoceras flexuosum* in Trans-Pecos Texas (Kennedy, Wright & Hancock, 1987: 64, pl. 8, fig. 5).

Occurrence-Zone of *Neocardioceras juddii* in the Little Burro Mountains (locs. 85, 95) and Big Burro Mountains (locs. 101, 104, 113, 120, 121, 146).

Biostratigraphic summary

Cobban & Hook (1984) have shown that the Western Interior Cenomanian sea was transgressive across southwestern New Mexico, and that shorelines trended northwest-southeast. During the time of the middle Cenomanian zone of *Acanthoceras amphibolum* the shoreline was a little east of the Cookes Range, but by the end of the early late Cenomanian zone of *Calycoceras canitaurinum* the sea had transgressed in a southwesterly direction across all or most of the area included in the present study. Regressive conditions did not occur until the early Turonian, when at first silty noncalcareous shale was deposited and later thick beds of sandstone accumulated.

Zone of *Calycoceras canitaurinum*

This zone, which is considered earliest late Cenomanian in age (Cobban, 1984a), is the oldest one recognized in the Colorado Formation. Fossils indicative of this zone occur in the basal unit of sandstone in the Colorado Formation of the Cookes Range and in the overlying shaly beds and concretions of the flag member. Northwest of the Cookes Range fossils of this zone become sparse, and none has been determined with certainty west of the Silver City Range. It is possible that the sea never extended west of the Silver City area during this time.

Outcrops south of Rattlesnake Ridge on the south side of the Cookes Range have yielded the following ammonites: *Borissiakoceras* sp.
Moremanoceras costatum sp. nov.
Cunningtoniceras arizonense Kirkland & Cobban
Calycoceras (Proeucalycoceras) canitaurinum (Haas)
ammonite gen. indet.
Tarrantoceras cf. *sellardsi* (Adkins)
Tarrantoceras sp.
Metoicoceras praecox Haas
Metoicoceras frontierense Cobban
Hamites cf. *simplex* (d'Orbigny)
Hamites cimarronensis (Kauffman & Powell)
Hamites? sp.
Turrilites sp.
turrilicone indet.
Neostlingoceras kottlowskii Cobban & Hook
Neostlingoceras bayardense sp. nov.

In addition, there are some small, smooth, straight ammonites and at least one undescribed micromorph ammonite. Occasional limestone concretions in the flag member contain abundant ammonite nuclei that cannot be assigned to any genera at present.

Inoceramus prefragilis Stephenson is fairly abundant in the flag member, but other bivalves are rare. Several specimens of a plain exogyroid oyster were found in one limestone concretion. Other bivalves such as *Astarte* and *Lucina* are found occasionally. Small gastropods, scaphopods, fish scales, and shark teeth are present in places, and a single solitary coral was collected.

Zone of *Metoicoceras mosbyense*

This upper Cenomanian zone contains a great variety of ammonites in southwestern New Mexico. Most of the ammonites are from the upper part of the zone, from limestone concretions and thin beds of concretionary limestone in the basal part of the Bridge Creek Limestone Member of the Colorado Formation on the east side of the Cookes Range, and from the equivalent part of the shale member in the Virden area. The following species have been collected:

Moremanoceras scotti (Moreman)
Moremanoceras sp. nov.
Placenticeras sp.
Forbesiceras sp.
Cunningtoniceras novimexicanum sp. nov.
Cunningtoniceras cookense sp. nov.
Calycoceras (Calycoceras) inflatum sp. nov.
Calycoceras (Proeucalycoceras) guerangeri (Spath)
Calycoceras (Proeucalycoceras) sp. nov.
Calycoceras (Proeucalycoceras) sp.
Eucalycoceras pentagonum (Jukes-Browne)
Euomphaloceras euomphalum (Sharpe)
Euomphaloceras merewetheri sp. nov.
Metoicoceras mosbyense Cobban
Metoicoceras frontierense Cobban
Nannometoicoceras cf. *acceleratum* (Hyatt)
Vascoceras diartianum (d'Orbigny)
Hamites cf. *simplex* d'Orbigny
Hamites salebrosus sp. nov.
Metaptychoceras hidalgoense sp. nov.
Neostlingoceras procerum sp. nov.
Neostlingoceras virdenense sp. nov.

Other fossils are sparse. Inoceramids belong to the *pictus* group. An occasional *Astarte* is present as are small gastropods and rarely a scaphopod.

Zone of *Sciponoceras gracile*

Fossils of this zone are varied and abundant. The largest collections are from limestone concretions in the Bridge Creek Limestone Member of the Colorado Formation in the Cookes Range and from equivalent limestone concretions in the shale member on the west side of the Big Burro Mountains. Preservation is good everywhere. The following ammonites have been collected:

Moremanoceras scotti (Moreman)
Placenticeras (Karamaites) cumminsi Cragin
Calycoceras (Calycoceras) naviculare (Mantell)
Pseudocalycoceras angolaense (Spath)
Sumitomoceras bentonianum (Cragin)
Sumitomoceras conlini Wright & Kennedy
Euomphaloceras septemseriatum (Cragin)
Metoicoceras geslinianum (d'Orbigny)
Vascoceras diartianum (d'Orbigny)
Allocrioceras annulatum (Shumard)
Neostlingoceras apiculatum sp. nov.
Sciponoceras gracile (Shumard)
Worthoceras vermiculus (Shumard)

Other fossils include abundant *Pycnodonte newberryi* (Stanton) and *Exogyra levis* Stephenson, especially in the Cookes Range and in the Silver City–Bayard area. *Inoceramus* of the *pictus* group is fairly common. A large bivalve, *Plesiopinna,* is conspicuous in the Cookes Range and Fort Bayard area. Gastropods are uncommon but varied. At Clyde Canyon in the Big Burro Mountains, an extensive coral thicket is developed that consists of abundant branches of *Archohelia dartoni* Wells in a silty, limy matrix. Echinoids are represented by a small species in the Cookes Range.

Zone of *Burroceras clydense*

This zone was earlier referred to as the zone of *Vascoceras cauvini* by Cobban (1984a: 81). Ammonites from southwestern New Mexico that were considered as *V. cauvini* now seem better assigned to *V. barcoicense exile* subsp. nov.; Berthou, Chancellor & Lauverjat (1985: 72) noted that *V. cauvini* Chudeau, 1909, may well be a synonym of *V. barcoicense* Choffat, 1899. *Burroceras clydense* is herein selected as the guide fossil to this zone, inasmuch as *V. barcoicense exile* occurs both in this zone and in the overlying zone of *Neocardioceras juddii.*

Ammonites of this zone are only known with certainty from the Big Burro Mountains where the following species have been collected:

Placenticeras (Karamaites) cumminsi Cragin
Burroceras clydense sp. nov.
Paraburroceras minutum sp. nov.
Vascoceras cf. *gamai* Choffat
Vascoceras sp. A
Vascoceras sp. B
Vascoceras barcoicense exile subsp. nov.
Microdiphasoceras novimexicanum sp. nov.
Hamites pygmaeus sp. nov.
Sciponoceras gracile (Shumard)
Worthoceras vermiculus (Shumard)

Other fossils are scarce. Inoceramids are of the *pictus* group.

Zone of *Neocardioceras juddii*

A large and varied ammonoid fauna characterizes this very high Cenomanian zone which lies at the top of the Bridge Creek Limestone Member of the Colorado Formation in the Cookes Range and in the shale member farther west. Ammonites usually occur in limestone concretions or as free internal molds in the shale. *Neocardioceras juddii* and *Pseudaspidoceras pseudonodosoides* are abundant everywhere, but some species, such as *Vascoceras silvanense* Choffat and *V. hartti* Hyatt, have only been found in the Cookes Range. The known ammonoid fauna from this zone in southwestern New Mexico is as follows:

Placenticeras (Karamaites) cumminsi Cragin
Neocardioceras juddii (Barrois & de Guerne)
Neocardioceras woodwardi sp. nov.
ammonite indet. (gen. nov.?)
Watinoceras odonnelli sp. nov.
Euomphaloceras costatum sp. nov.
Euomphaloceras sp.
Burroceras irregulare sp. nov.
Burroceras transitorium sp. nov.
Pseudaspidoceras pseudonodosoides (Choffat)
Vascoceras cf. *gamai* Choffat
Vascoceras silvanense Choffat
Vascoceras sp. B
Vascoceras barcoicense exile subsp. nov.
Vascoceras hartti (Hyatt)
Fagesia catinus (Mantell)
Rubroceras alatum sp. nov.
Rubroceras burroense sp. nov.
Rubroceras rotundum sp. nov.
Hamites cf. *simplex* d'Orbigny
Anisoceras coloradoense sp. nov.
Sciponoceras gracile (Shumard)
Worthoceras sp. nov.

Pycnodonte newberryi (Stanton) extends up into this zone in the Cookes Range along with an occasional inoceramid of the *pictus* group. Other bivalves are scarce, but include *Phelopteria* and a small, simple oyster. Small gastropods, chiefly a *Drepanochilus*-like species, are abundant in limestone concretions in the Big Burro Mountains.

Zone of *Pseudaspidoceras flexuosum*

This poorly represented lowest Turonian zone comprises the lower part of the upper shale member of the Colorado Formation in the Cookes Range and the equivalent part of the shale member farther west. Fossils are fragmentary and poorly preserved. They are usually sparse impressions along bedding surfaces in thin beds of siltstone or very fine-grained sandstone. The few ammonites found are the following:

Watinoceras sp.
Quitmaniceras reaseri Powell
Pseudaspidoceras flexuosum Powell
Vascoceras sp.
Fagesia catinus (Mantell)

In addition, the bounce-mark of some fairly large evolute ammonite that has closely spaced, rounded umbilical tubercles was found; it could represent a large *Kamerunoceras*.

Mytiloides columbianus (Heinz) is a common bivalve especially in the Cookes Range, where it is accompanied by bivalves that seem to be *Solemya obscura* Stanton, *Lucina juvensis* Stanton, and a small, simple oyster.

Zone of *Vascoceras birchbyi*

This zone includes the lower part of the sandstone and shale member of the Colorado Formation in the Cookes Range and the basal part of the sandstone member farther west. Molluscan fossils in calcareous, sandstone concretions are usually uncrushed and well preserved. The best collections are from the Little Burro Mountains and Fort Bayard area where the following ammonites were collected:

Watinoceras sp.
Nigericeras cf. *scotti* Cobban
Vascoceras birchbyi Cobban & Scott
Vascoceras sp. C
Fagesia catinus (Mantell)
Fagesia sp.
Neoptychites cephalotus (Courtiller)
Thomasites adkinsi (Kummel & Decker)

The basal regressive sandstone bed of the sandstone member in the Little Burro Mountains contains abundant bivalves and gastropods of the genera *Modiolus, Pseudoptera, Mytiloides, Ostrea, Pleuriocardia, Cymbophora, Aphrodina, Corbula, Gyrodes, Cassiope, Rostellites,* and *Pugnellus*. We assign the *Mytiloides* to *M. columbianus* (Heinz).

Zone of *Mammites nodosoides*

This zone is known in the area only in the Cookes Range, where the uppermost marine sandstone bed in the sandstone and shale member of the Colorado Formation contains abundant molluscan fossils in sandstone concretions. The ammonite record is poor though, and only the following forms have been collected:

Watinoceras sp.
Mammites nodosoides (Schlüter)
Infabricaticeras lunaense sp. nov.
Thomasites? sp.

Bivalves and gastropods are abundant and consist mostly of the same genera noted in the sandstone of the *Vascoceras birchbyi* zone. The following genera were identified: *Modiolus, Phelopteria, Mytiloides, Ostrea, Pleuriocardia, Cymbophora, Aphrodina, Cyprimeria, Corbula, Gyrodes, Rostellites, Carota,* and *Pugnellus*. The *Mytiloides* is *M. mytiloides* (Mantell) of late early Turonian age.

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FIGURES 64-96

FIGURE 64

A-K, *Moremanoceras costatum* sp. nov.: A, B, paratype USNM 425134 from loc. 33. C, paratype USNM 425135 from loc. 33. D, E, holotype USNM 425133 from loc. 33. F, H, I, paratype USNM 423683 from the base of the Greenhorn Formation at USGS Mesozoic loc. 12740 in NE1/4 sec. 6, T9S, R59E, Carter County, Montana. G, paratype USNM 425136 from loc. 55. J, Latex cast of paratype USNM 425137 from loc. 31. K, paratype USNM 425138 from loc. 33.

L-Z, *Moremanoceras scotti* (Moreman): L, M, USNM 425126 from loc. 159, N, 0, USNM 425127 from loc. 159. P, W, X, USNM 425128 from loc. 20. Q, USNM 425129 from loc. 159. R-T, USNM 425130 from loc. 15. U, V, USNM 425131 from loc. 159. Y, Z, USNM 425132 from loc. 10.

All figures natural size.

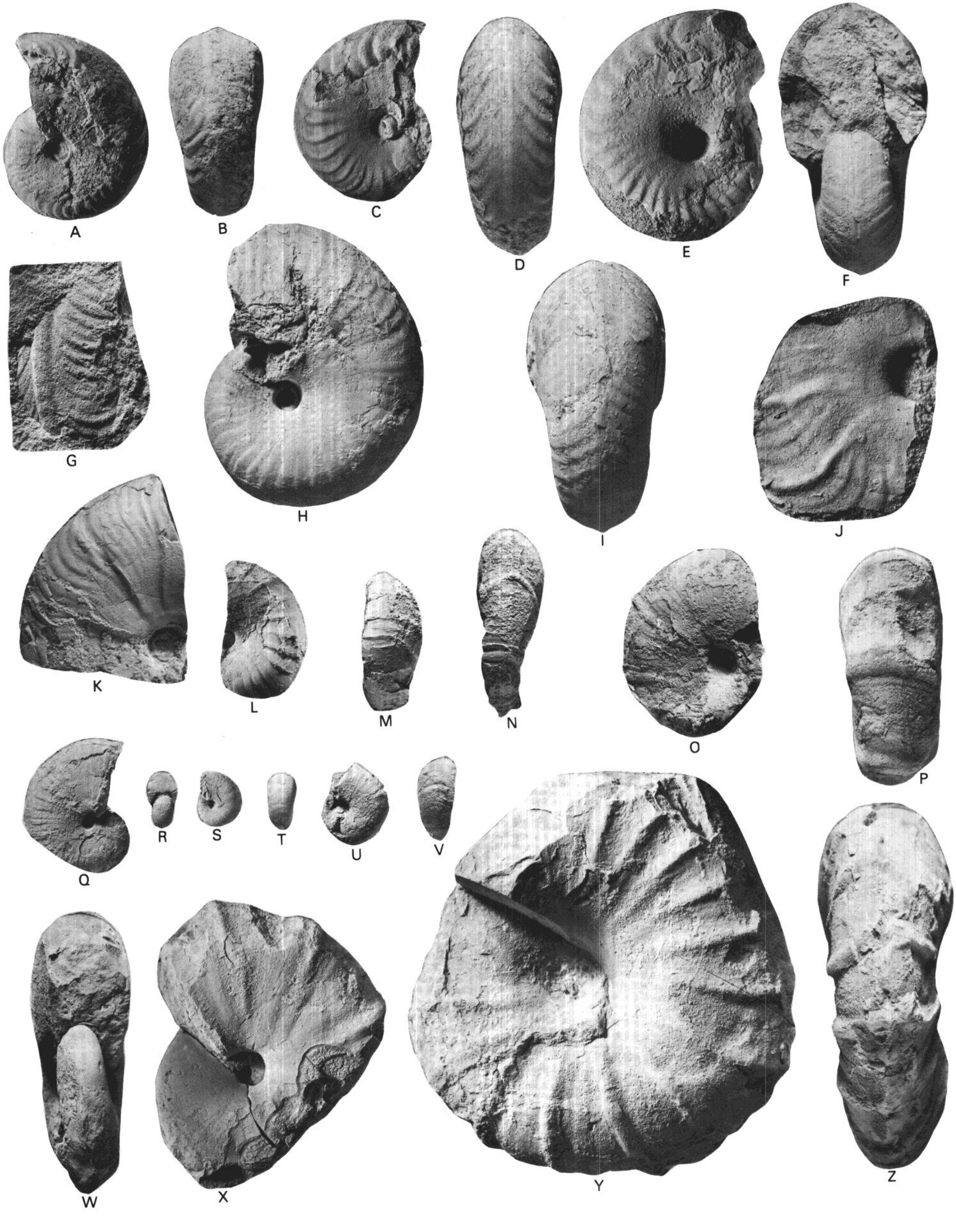
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FIGURE 65

A—D, G, H, *Moremanoceras costatum* sp. nov. from loc. 70: A, B, paratype USNM 425140. C, D, paratype USNM 425141. G, H, paratype USNM 425142.

E, F, *Cunningtoniceras cookense* sp. nov.: paratype USNM 425168 from loc. 14; see Fig. 25 for suture.

I, J, *Cunningtoniceras arizonense* Kirkland & Cobban: USNM 425161 from loc. 76; see Fig. 22 for whorl section.

I and J x 0.5, all other figures natural size.

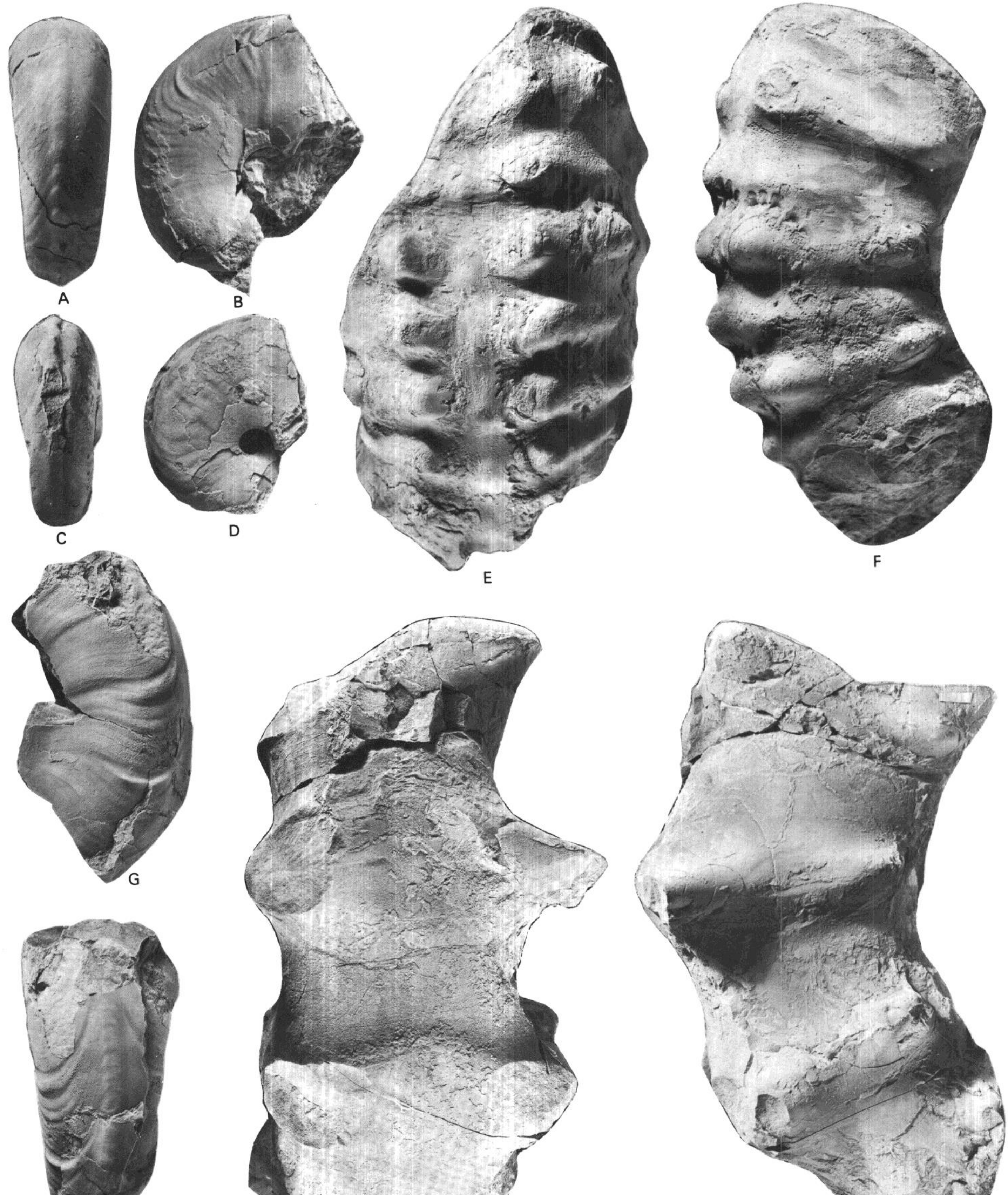
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FIGURE 66

Forbesiceras sp., USNM 425146 from loc. 6. Both A and B natural size.

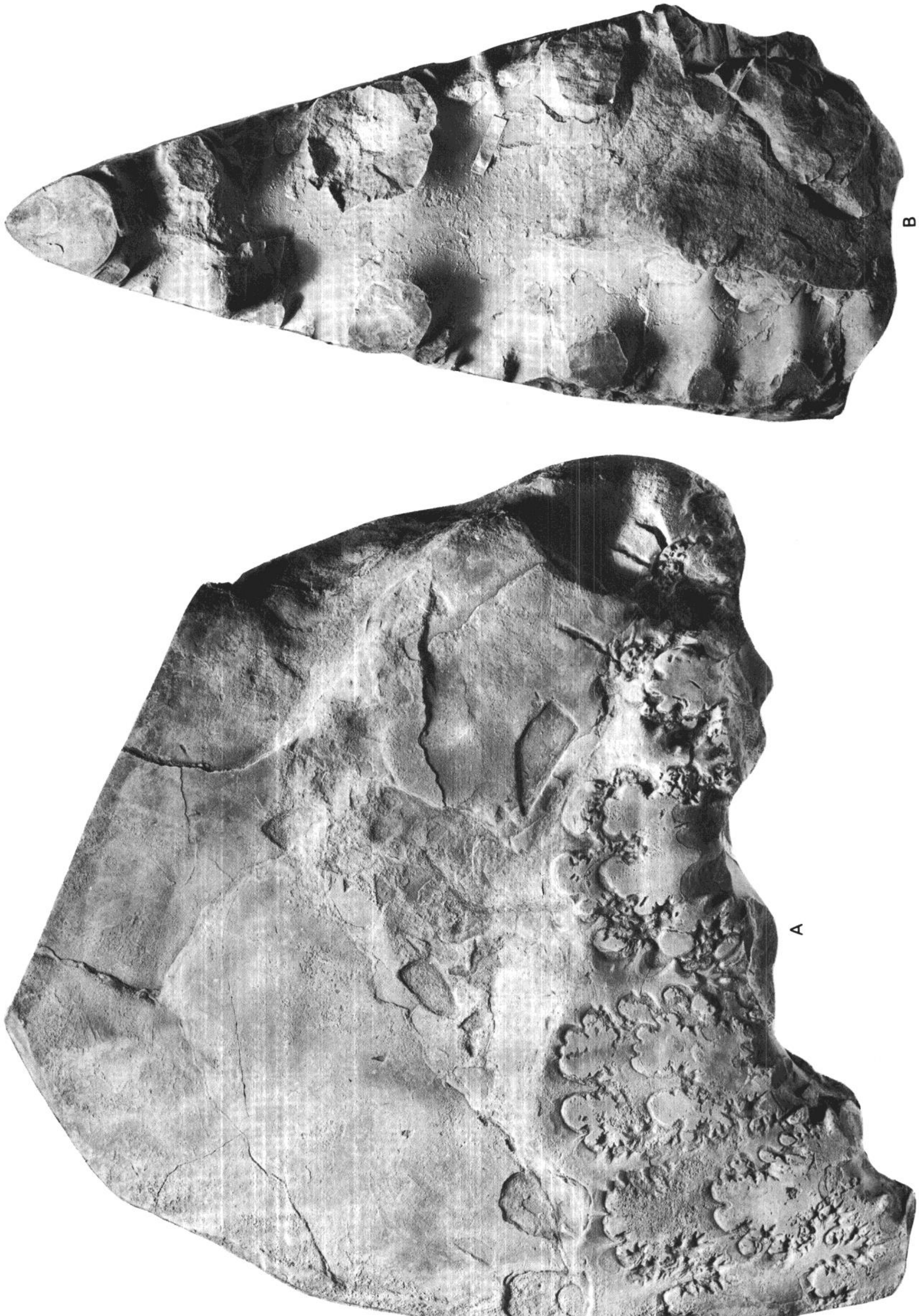
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FIGURE 67

Cunningtoniceras arizonense Kirkland & Cobban: A, Latex cast of USNM 425151 from loc. 53. B, USNM 425152 from loc. 30. C, USNM 425153 from loc. 33. D, G, USNM 425154 from loc. 33. E, F, USNM 425155 from loc. 33. H, USNM 425156 from loc. 53. I, USNM 425157 from loc. 33; see Fig. 23 for suture. J, Latex cast of USNM 425158 from loc. 53. K, USNM 425159 from loc. 53. L, USNM 425160 from loc. 53. All figures natural size.

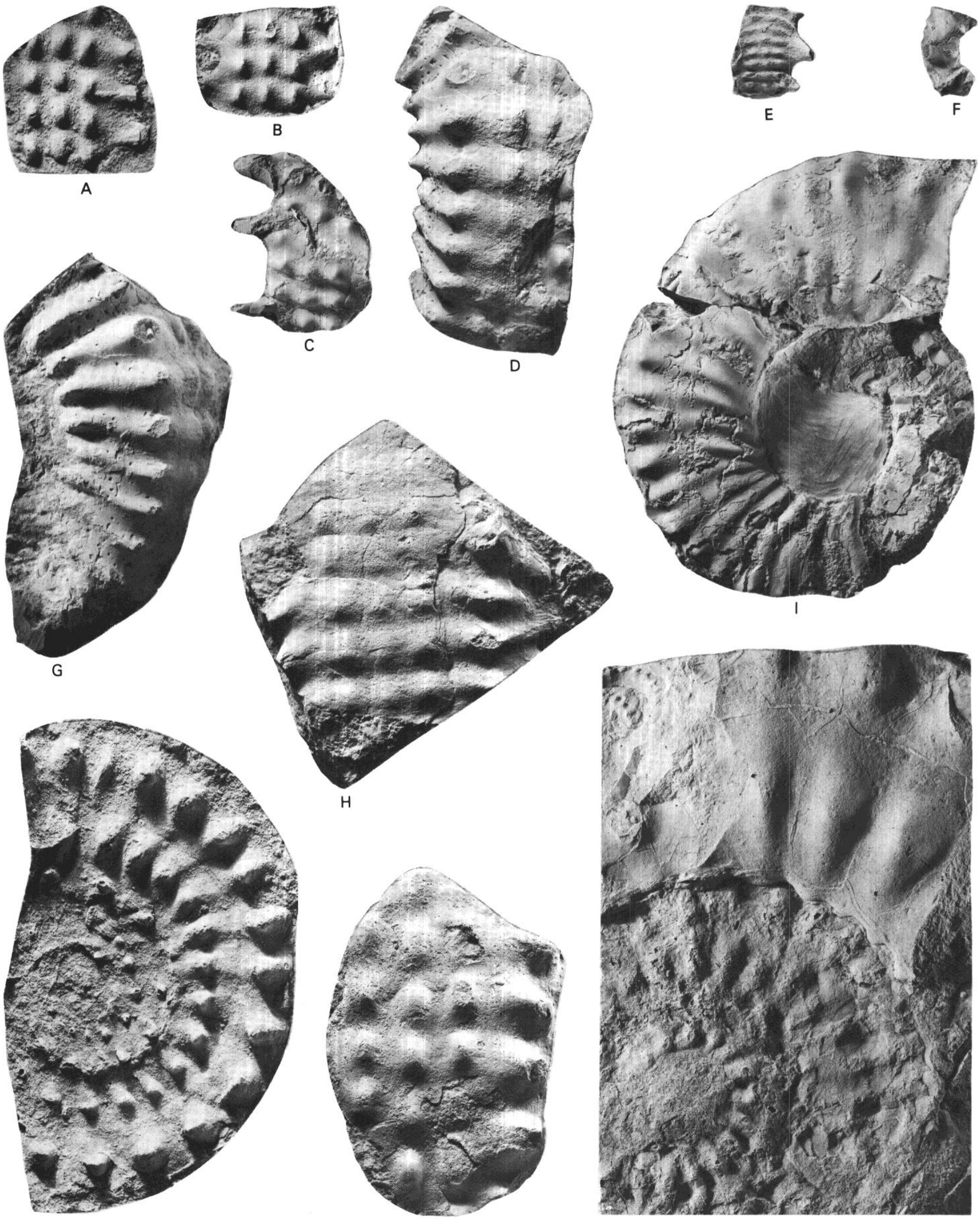
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FIGURE 68

A—E, H, *Tarrantoceras* cf. *sellardsi* (Adkins): A, Latex cast of USNM 425196 from loc. 53. B, Latex cast of USNM 425197 from loc. 53. C, Latex cast of USNM 425198 from loc. 34. D, Latex cast of USNM 425199 from loc. 31. E, Latex cast of USNM 425200 from loc. 72. H, Latex cast of USNM 425201 from loc. 31.

F, G, *Tarrantoceras* sp.: F. Latex cast of USNM 425202 from loc. 29. G, Latex cast of USNM 425203 from loc. 31.

I—K, *Cunningtoniceras novimexicanum* sp. nov.: I, J, holotype USNM 425162 from loc. 75. K, paratype USNM 425163 from loc. 75.

All figures natural size.

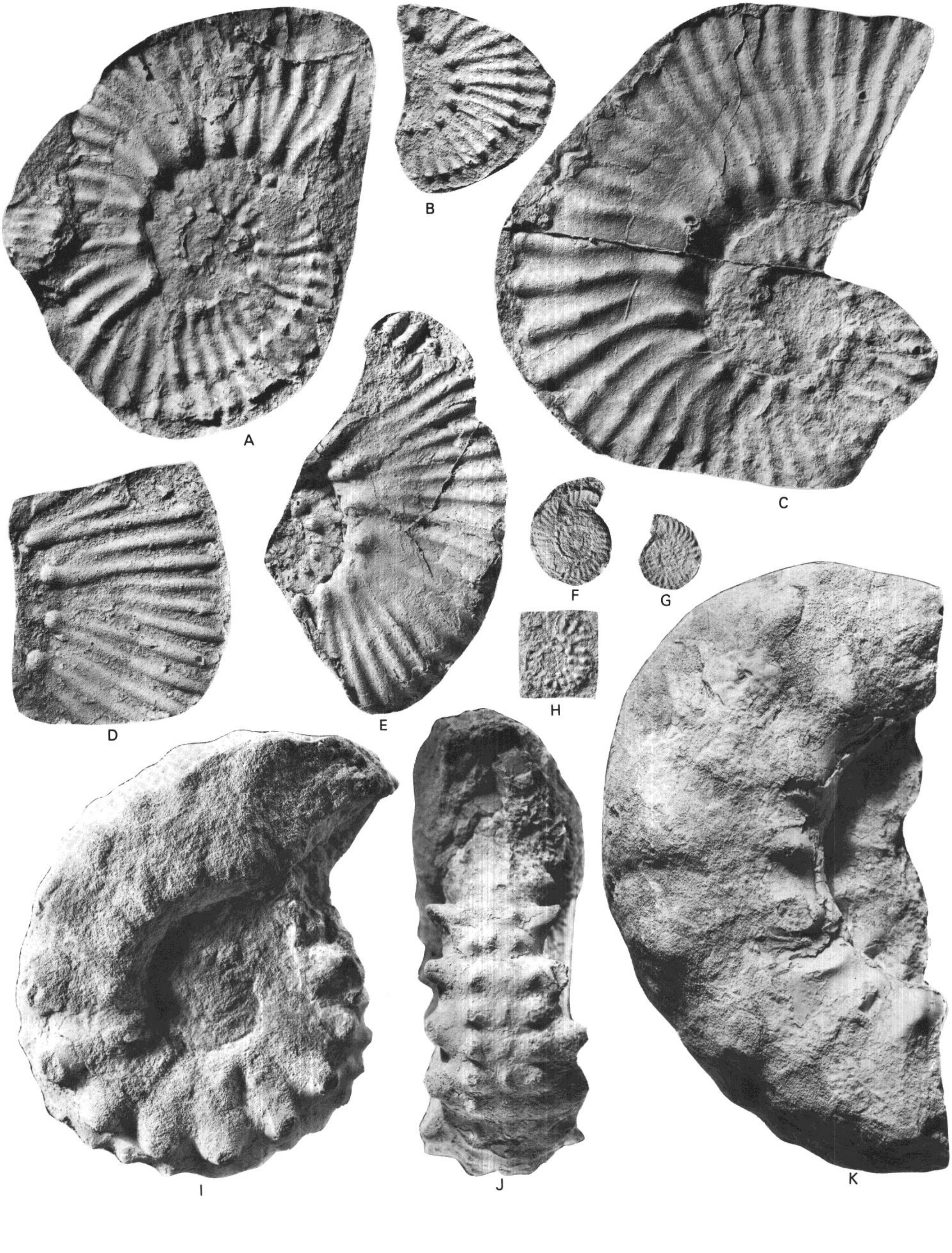
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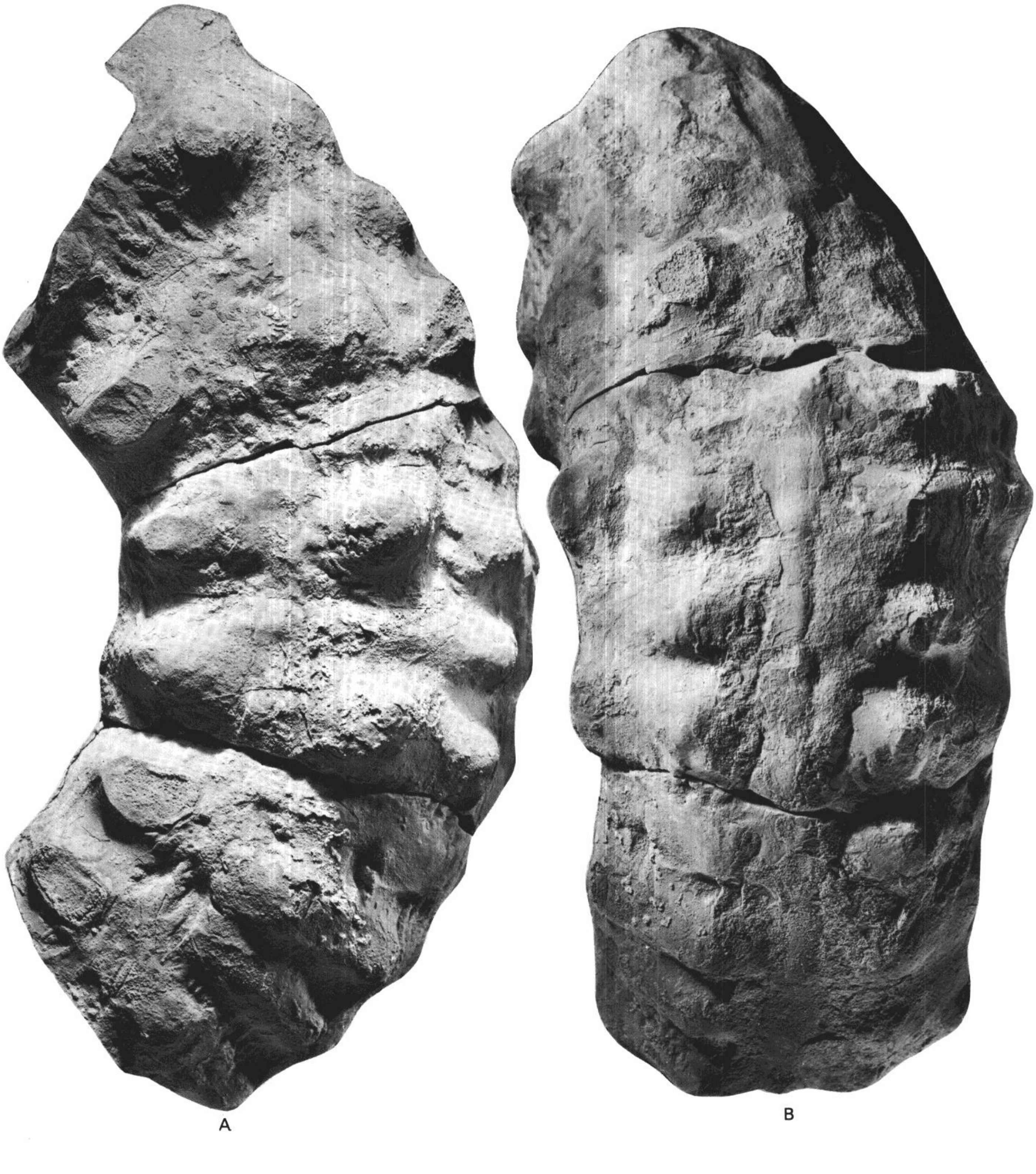
FIGURE 69

Cunningtoniceras cookense sp. nov.: Holotype USNM 425167 from loc. 14. Both A and B natural size.



A B

FIGURE 70

Calycoceras naviculare (Mantell): A—C, USNM 425170 from loc. 15. D—F, USNM 425171 from loc. 15. G—I, USNM 356897 from loc. 40, J, K, USNM 425172 from loc. 15. L, M, USNM 425173 from loc. 75. N, 0, USNM 425174 from loc. 36. P, USNM 425175 from loc. 38. Q, R, USNM 425176 from loc. 15. S, T, USNM 425177 from loc. 75. Figures A, C, and F x 2, all other figures natural size.

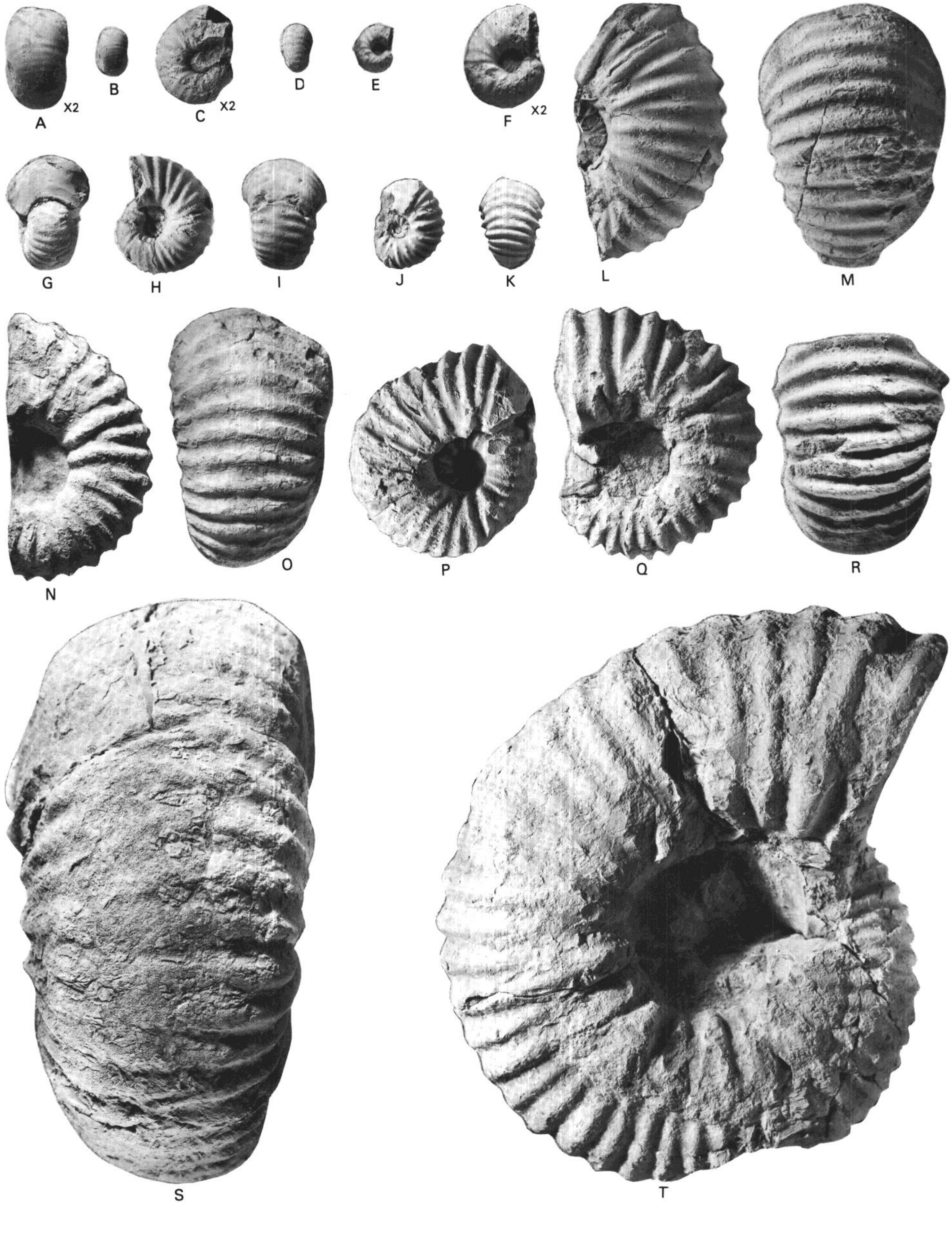

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FIGURE 71

A—F, *Calycoceras inflatum* sp. nov.: A, B, paratype USNM 425179 from loc. 75. C, D, paratype USNM 425180 from loc. 80. E, F, holotype USNM 425178 from loc. 75.

G, *Vascoceras birchbyi* Cobban & Scott, USNM 425364 from loc. 65.

All figures natural size.

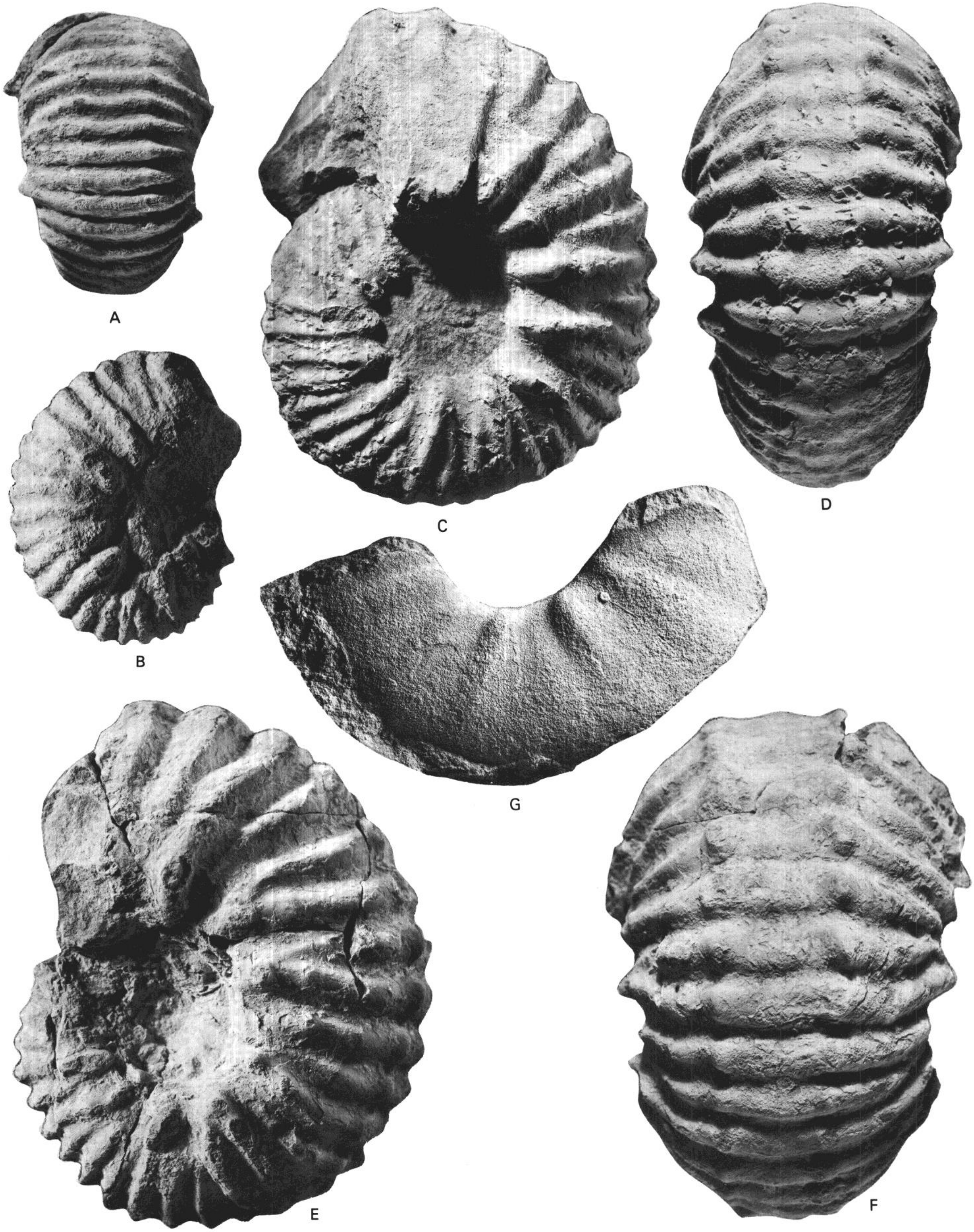
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FIGURE 72

A—J, *Sumitomoceras conlini* Wright & Kennedy: A, B, USNM 400806 from loc. 144. C—E, USNM 400805 from loc. 144. F, G, USNM 400807 from loc. 15; see Fig. 31 for suture. H—J, USNM 400808 from loc. 144.

K—M, *Sumitomoceras bentonianum* (Cragin), USNM 400810 from loc. 10; see Fig. 30 for suture.

N, 0, *Moremanoceras* sp. nov., USNM 423692 from loc. 159.

P—R, T, U, *Calycoceras (Proeucalycoceras) guerangeri* (Spath): P, T, U, USNM 425182 from loc. 20; P is latex cast of dorsum. Q, R, USNM 425181 from loc. 25.

S, *Tarrantoceras* cf. *sellardsi* (Adkins), USNM 425479 from loc. 29. All

figures natural size.


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FIGURE 73

A—D, *Eucalycoceras pentagon um* (Jukes-Browne): A, B, USNM 400775 from loc. 17; see Fig. 28 for suture. C, D, USNM 400776 from loc. 17.

E-O, *Pseudocalycoceras angolaense* (Spath) from loc. 144: E, F, USNM 400796. G, H, USNM 400798. I, J, USNM 400789. K, L, USNM 400790. M-O, USNM 400791.

P—X, *Calycoceras (Proeucalycoceras) canitaurium* (Haas): P, Q, USNM 425185 from loc. 70. R, Latex cast of USNM 425186 from loc. 72. S—U, USNM 425187 from loc. 33. V, USNM 425188 from loc. 30. W, X, USNM 425189 from loc. 70.

All figures natural size.

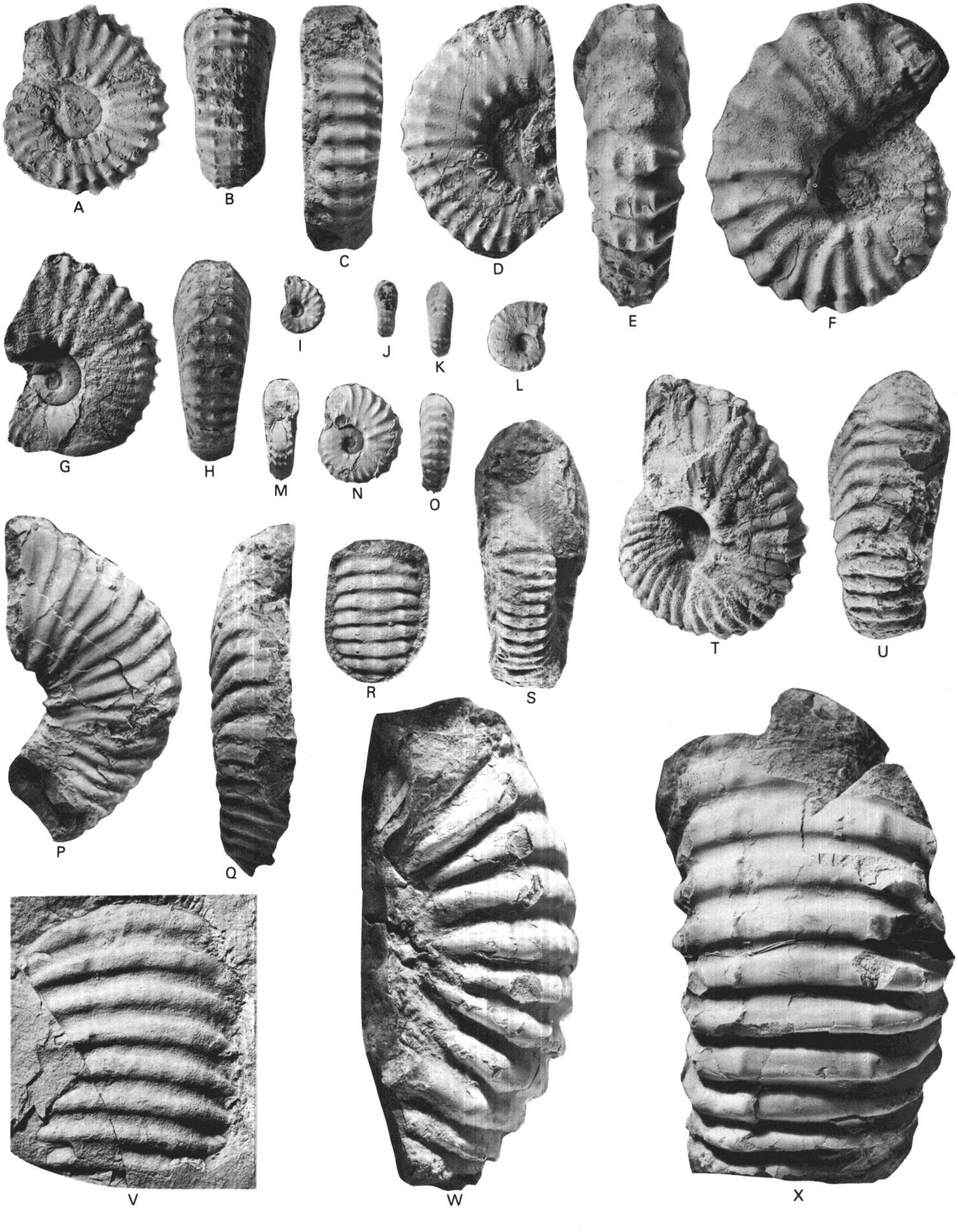
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FIGURE 74

A—G, *Pseudocalycoceras angolaense* (Spath): A, E, USNM 425204 from loc. 39. B—D, USNM 400799 from loc. 15. F, G, USNM 425205 from loc. 40.

H, Calycoceras (Proeucalycoceras) sp. nov., USNM 425192 from loc. 6.

I, Calycoceras (Proeucalycoceras) canitaurinum (Haas), USNM 425190 from loc. 33.

All figures natural size.

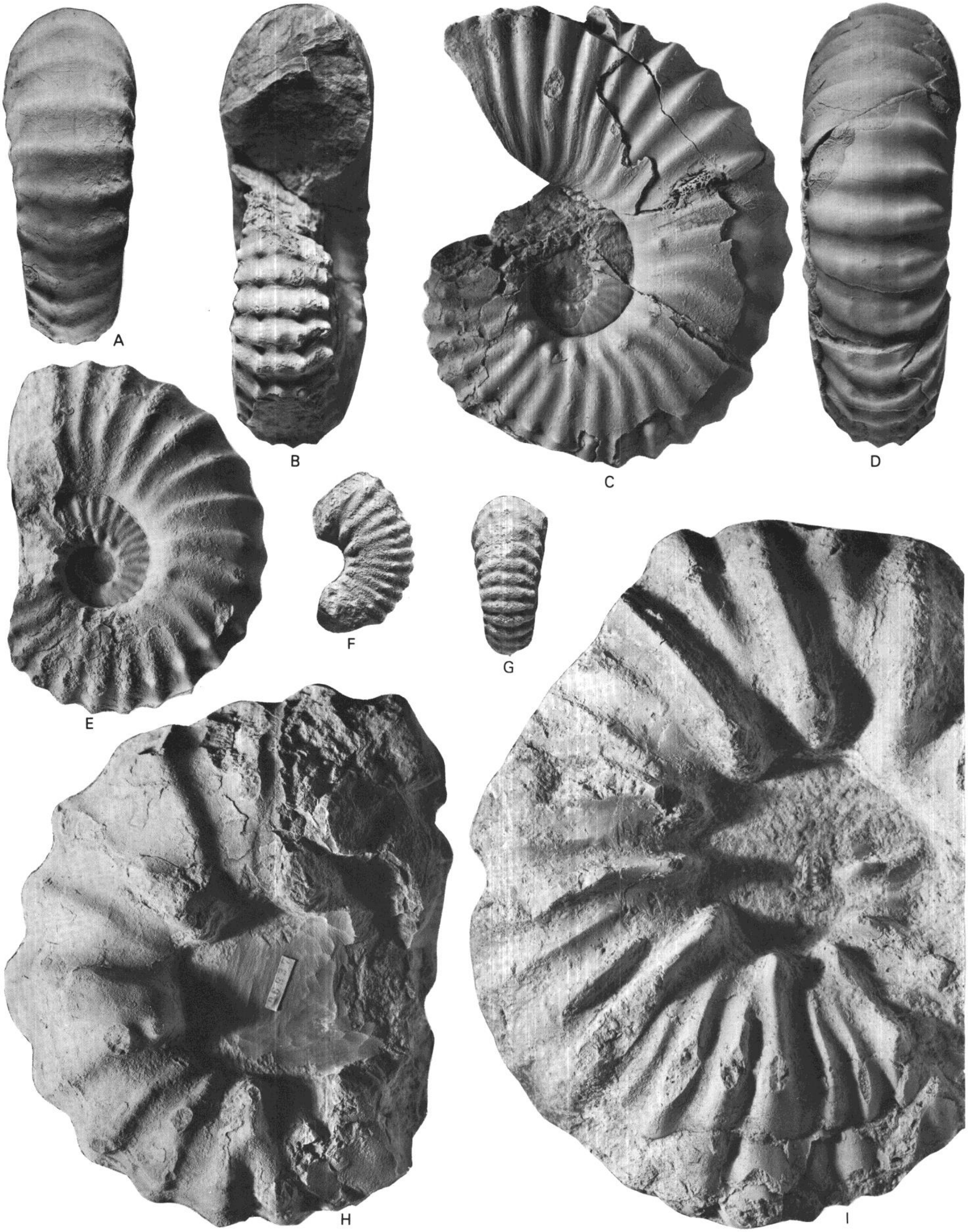
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FIGURE 75

A-E, *Placenticeras (Karamaites) cumminsi* Cragin: A-C, USNM 425144 from loc. 142. D, E, USNM 425145 from loc. 134.

F-DD, II-MM, *Neocardioceras juddii* (Barrois & de Guerne): F-H, USNM 400819 from loc. 110. I-K, USNM 400824 from loc. 110. L, USNM 425206 from loc. 110. M, N, USNM 356890 from loc. 113. 0, P, USNM 400825 from loc. 122. Q, R, USNM 400822 from loc. 110. S, U, USNM 400826 from loc. 110; see Fig. 33 for suture. T, USNM 425207 from loc. 110. V, W, USNM 400827 from loc. 41. X, Y, USNM 307357 from loc. 41. Z, AA, USNM 400829 from loc. 85. BB, CC, USNM 425208 from loc. 41. DD, USNM 400828 from loc. 41. II-KK, USNM 400831 from loc. 113.

EE-HH, *Quitmaniceras reaseri* Powell from loc. 123: EE, FF, USNM 425218. GG, USNM 425219. HH, USNM 425220.

LL, MM, *Nigericeras* cf. *scotti* Cobban, USNM 425221 from loc. 58.

L x 2, all other figures natural size. Arrows mark base of body chambers.

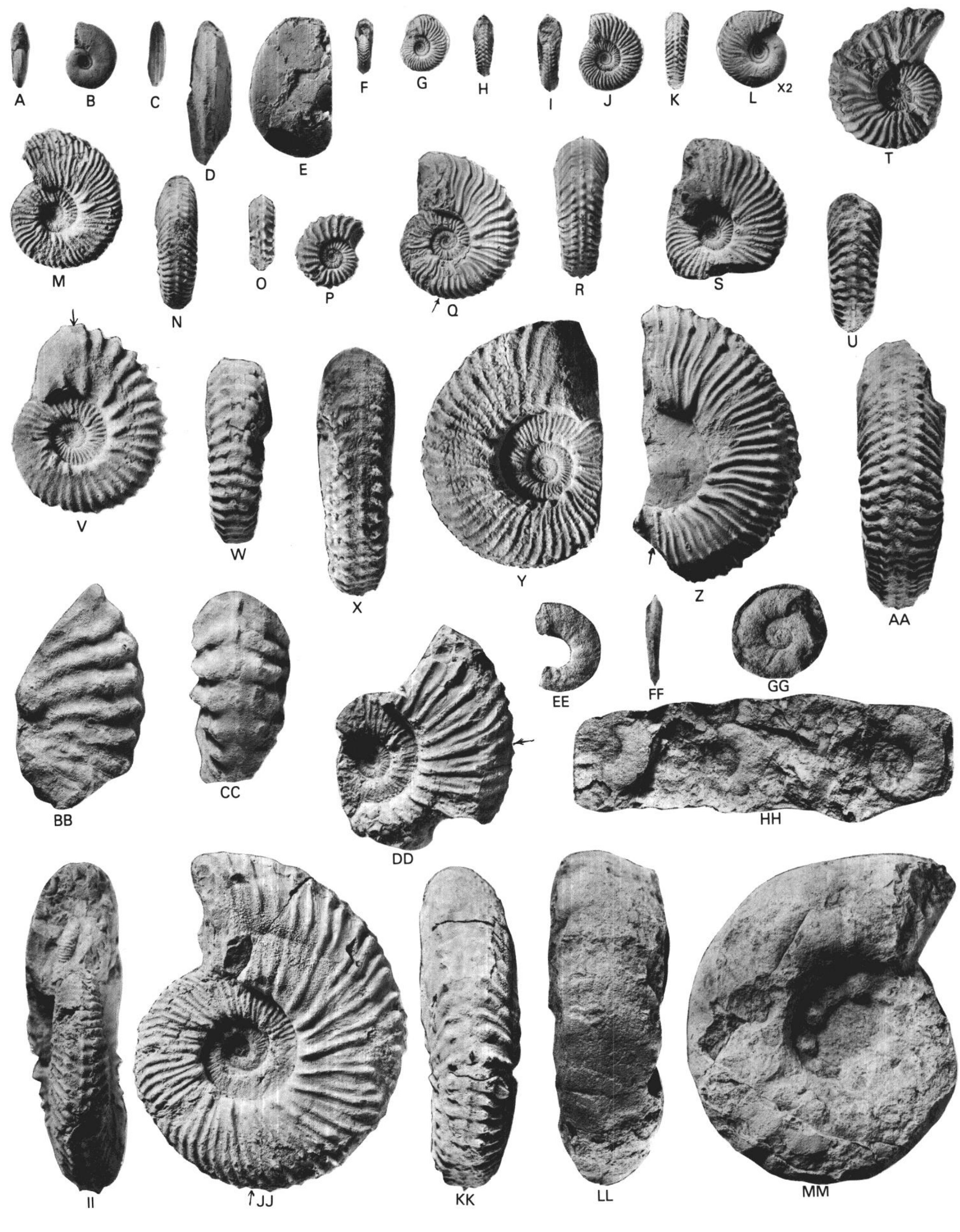
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FIGURE 76

A—C, *Neocardioceras woodwardi* sp. nov., holotype USNM 425209 from loc. 95.

D, E, *Neocardioceras* sp.: D, USNM 425210 from loc. 41. E, USNM 425211 from loc. 85. F—K, ammonite, new genus? F—I, USNM 425212 from loc. 95. J, K, USNM 425213 from loc. 118.

L—P, U, V, *Euomphaloceras euomphalum* (Sharpe) from loc. 17: L-0, USNM 425222. P, USNM 425223. U, USNM 425224; see Fig. 34 for suture. V, USNM 425225.

W—Y, GG, *Watinoceras* sp.: W, X, USNM 425215 from loc. 24. Y, USNM 425216 from loc. 47. GG, USNM 425217 from loc. 47.

Q—T, Z—FF, HH—PP, *Euomphaloceras septemseriatum* (Cragin): Q, R, USNM 425227 from loc. 10. S, 1', USNM 425228 from loc. 137. Z—BB, USNM 356910 from loc. 144. CC, DD, USNM 425229 from loc. 144. EE, II, JJ, USNM 425230 from loc. 10. FF, HH, USNM 425231 from loc. 144; see Fig. 35 for suture. KK, LL, USNM 425232 from loc. 10. MM, NN, USNM 425233 from loc. 10. 00, PP, USNM 425234 from loc. 38.

F—H, N, 0, S, T, W, and X x 2, all other figures natural size.

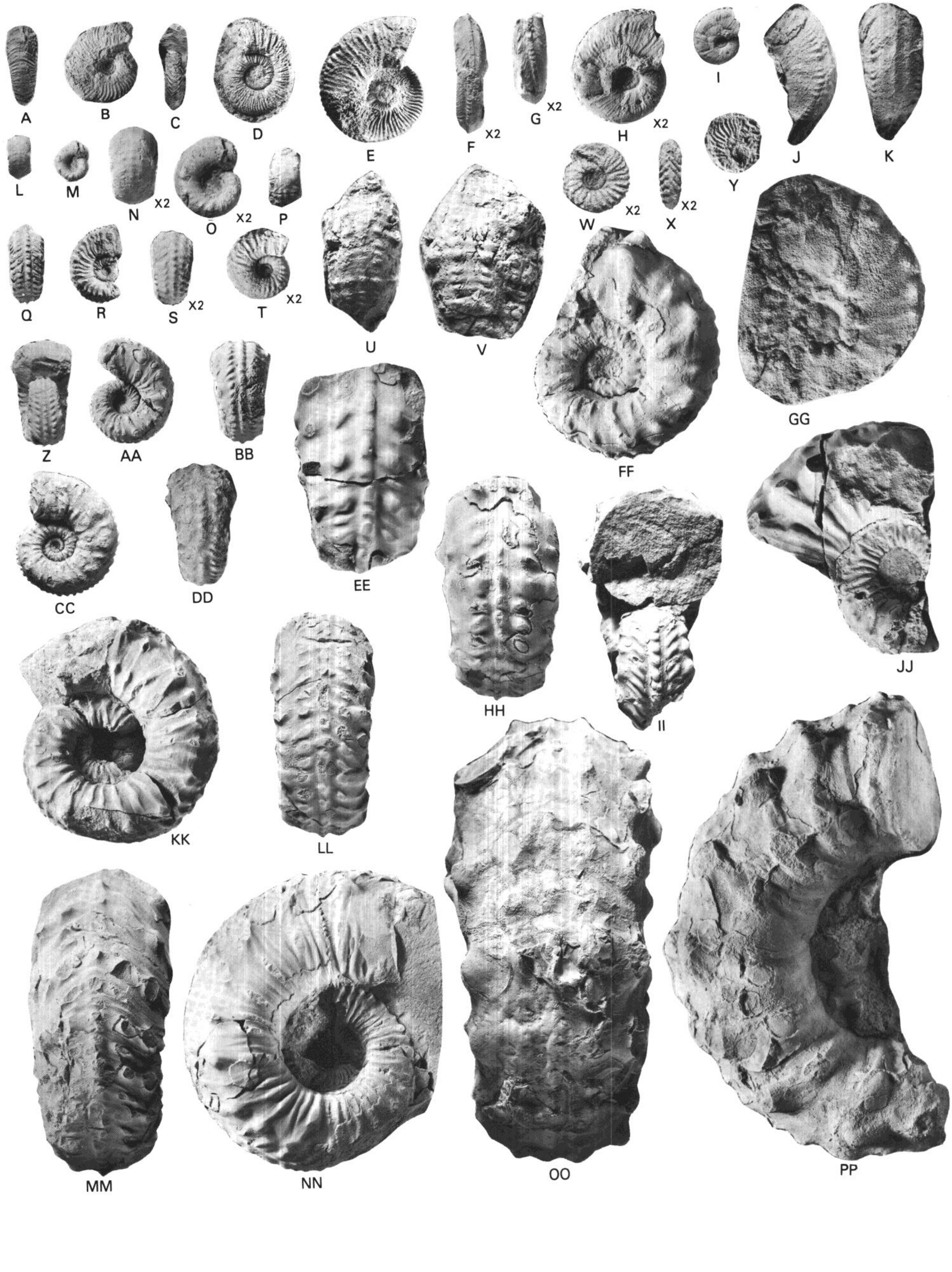
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FIGURE 77

A—R, *Euomphaloceras merewetheri* sp. nov: A—E, paratype USNM 425237 from loc. 159. F, G, paratype USNM 425238 from loc. 159. H,I, paratype USNM 425239 from loc. 159. **J,** paratype USNM 425240 from loc. 159. K, paratype USNM 425241 from loc. 159. L, paratype USNM 425242 from loc. 159. M, paratype USNM 425243 from loc. 159. N, 0, holotype USNM 425235 from USGS Mesozoic loc. D8314 in the NW 1/4 sec. 33, T50N, R66W, Crook County, Wyoming. P—R, paratype USNM 425236 from same locality as N, 0; see Fig. 36 for suture.

S—EE, *Euomphaloceras costatum* sp. nov.: S, T, paratype USNM 419968 from loc. 134. U, Latex cast of USNM 425244 from loc. 95. V—X, holotype USNM 419966 from loc. 41. Y, Z, paratype USNM 419972 from loc. 134. AA, Latex cast of paratype USNM 419967 from loc. 41. **BB,** CC, USNM 425245 from loc. 41. DD, EE, USNM 425246 from loc. 118; see Fig. 78C for apertural view.

D and E x 2, all other figures natural size.

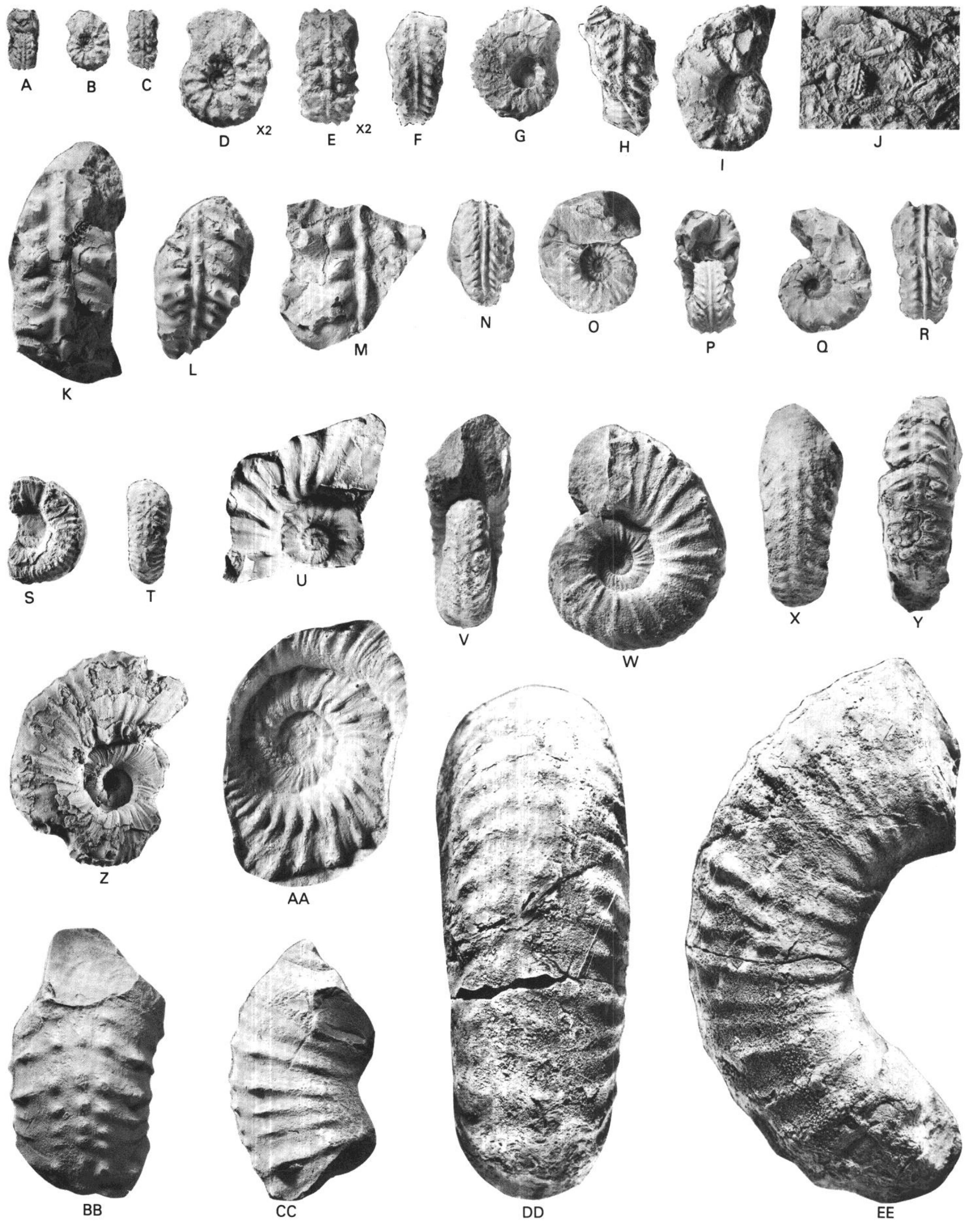
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FIGURE 78

Euomphaloceras costatum sp. nov.: A, B, paratype USNM 419970 from loc. 134. C, USNM 425246 from loc. 118; see Fig. 77DD, EE for other views. D, E, paratype USNM 419971 from loc. 151. F, paratype USNM 419973 from loc. 118. G, H, USNM 425247 from loc. 112. All figures natural size.


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FIGURE 79

A—C, *Burroceras transitorium* gen. et sp. nov., paratype USNM 424259 from loc. 121.

D—J, N—T, *Burroceras clydense* gen. et sp. nov.: D—F, paratype USNM 425250 from loc. 141. G, H, paratype USNM 425251 from loc. 142. I, J, paratype USNM 425252 from loc. 141. N, 0, paratype USNM 425253 from loc. 142. P, R, paratype USNM 425254 from loc. 141; see Fig. 38B for suture. Q, paratype USNM 425255 from loc. 142; see Fig. 38A for suture. S, T, holotype USNM 425249 from loc. 142.

K—M, *Paraburroceras minutum* gen. et sp. nov., holotype USNM 425267 from loc. 141. U, *Euomphaloceras* sp., USNM 425248 from loc. 121. All figures natural size.

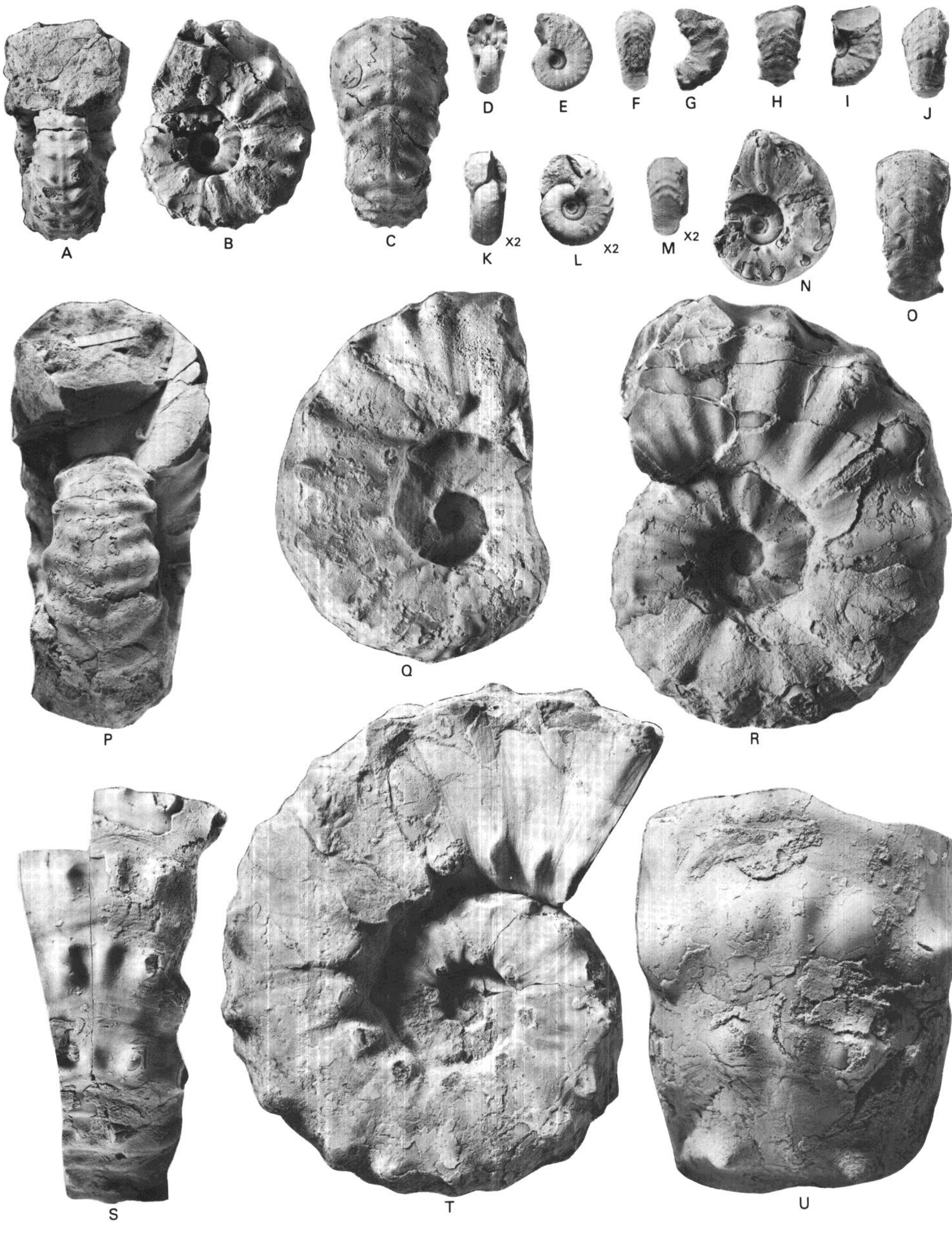
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FIGURE 80

A—C, *Paraburroceras minutum* gen. et sp. nov., paratype USNM 425268 from loc. 141.

D—R, *Burroceras transitorium* gen. et sp. nov.: D—F, paratype USNM 425260 from loc. 121. G—I, paratype USNM 425261 from loc. 121. J, K, paratype USNM 425262 from loc.110. L, M, paratype USNM 425263 from loc. 121. N—P, holotype USNM 425258 from loc. 121; see Fig. 40C for suture. Q, R, paratype USNM 425264 from loc. 121.

S—V, *Burroceras irregulare* gen. et sp. nov.: S, T, holotype USNM 425256 from loc. 95. U, V, paratype USNM 425257 from loc. 95; see Fig. 39 for suture. A and B x 2, all other figures natural size.

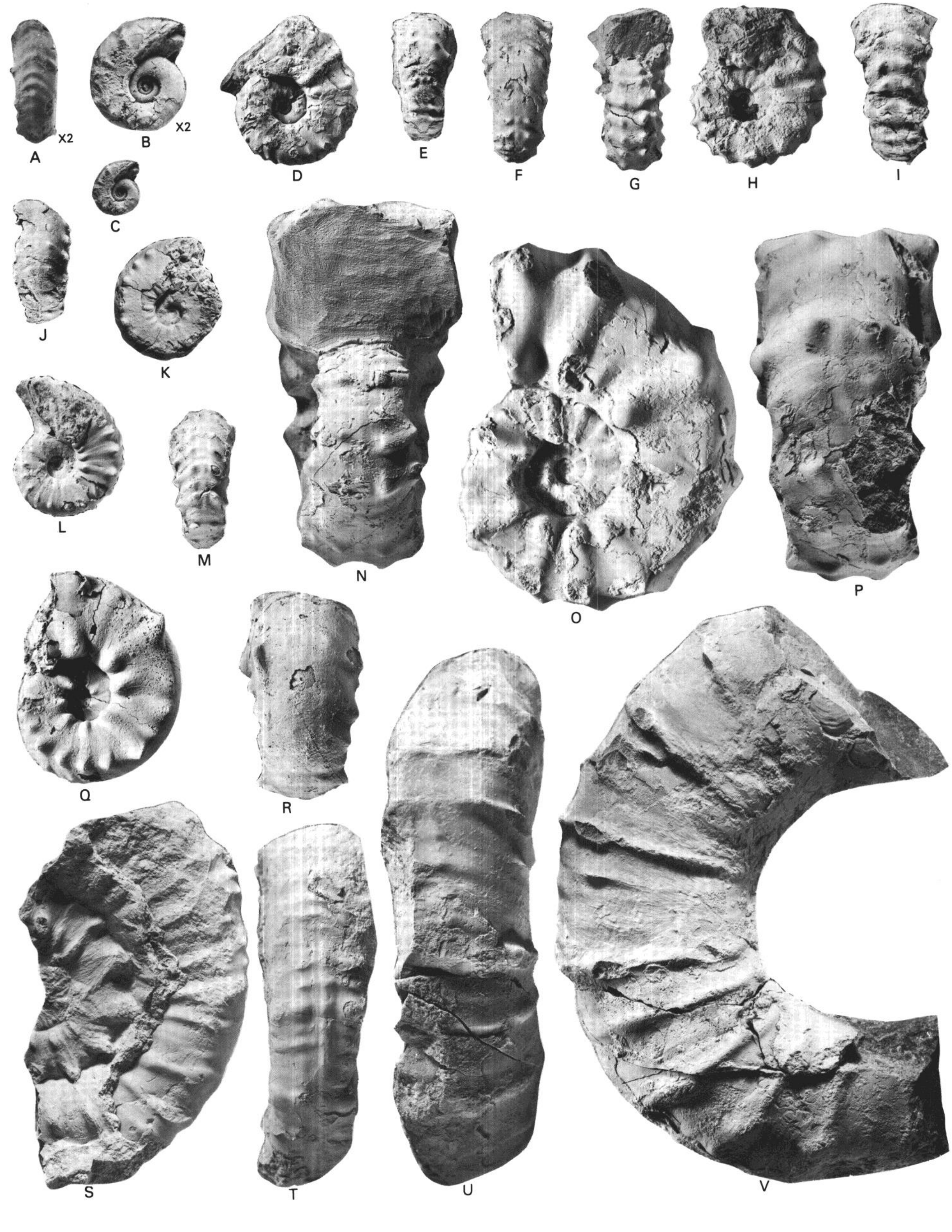
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FIGURE 82

Pseudaspidoceras pseudonodosoides (Choffat): A, B, USNM 425279 from loc. 113. C—E, USNM 425280 from loc. 41. F, G, USNM 425281 from loc. 101. **H,** I, USNM 425282 from loc. 41. J, K, USNM 425283 from loc. 41. L, M, USNM 425284 from loc. 41. N, 0, USNM 425285 from loc. 101. All figures natural size.

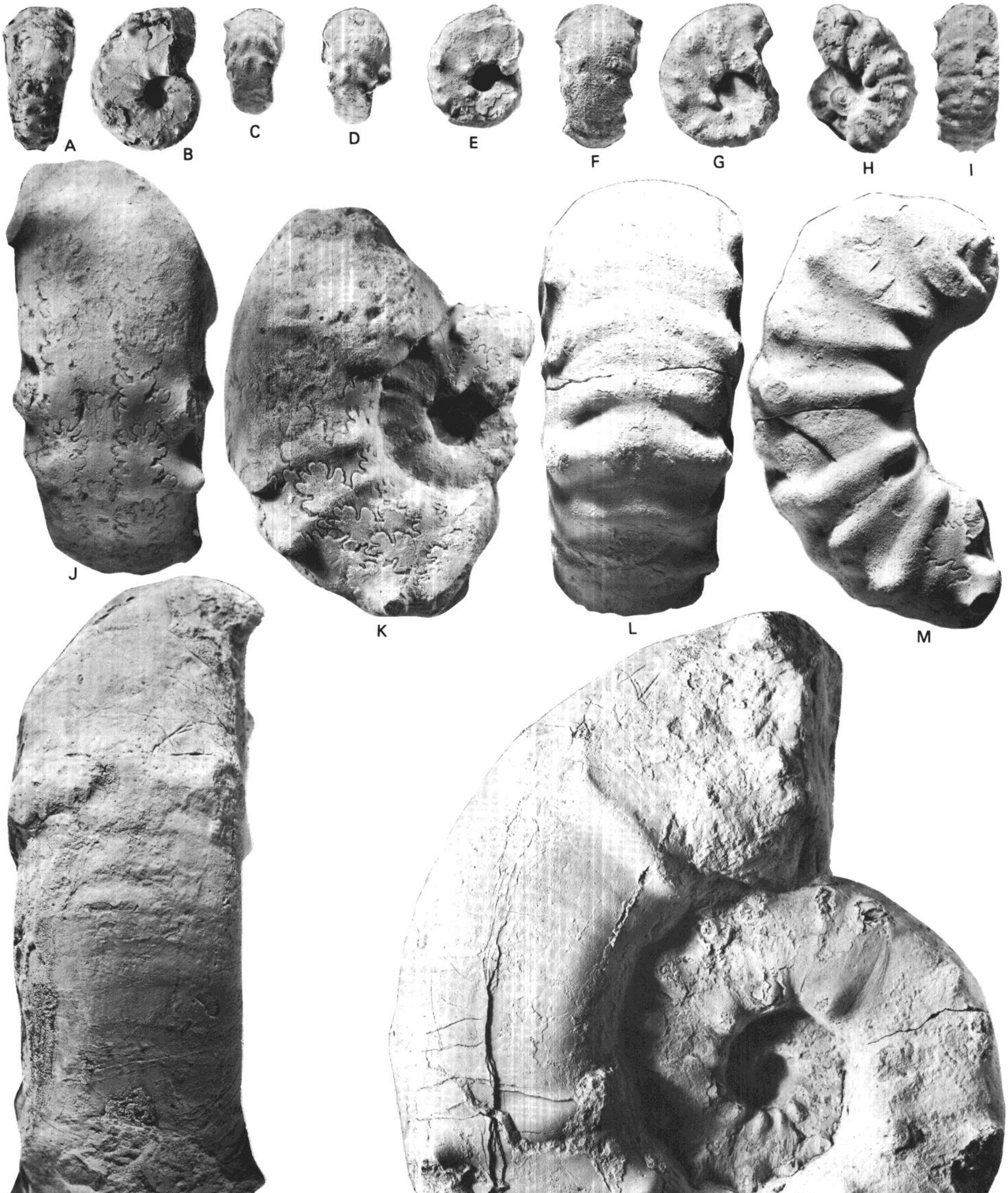
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FIGURE 83

Pseudaspidoceras pseudonodosoides (Choffat): A, B, USNM 425276 from loc. 41; see Fig. 81W for view of inner whorls. C—F, USNM 337428 from loc. 41. G, **H,** USNM 425286 from loc. 110. I, J, USNM 425287 from loc. 41. All figures natural size.

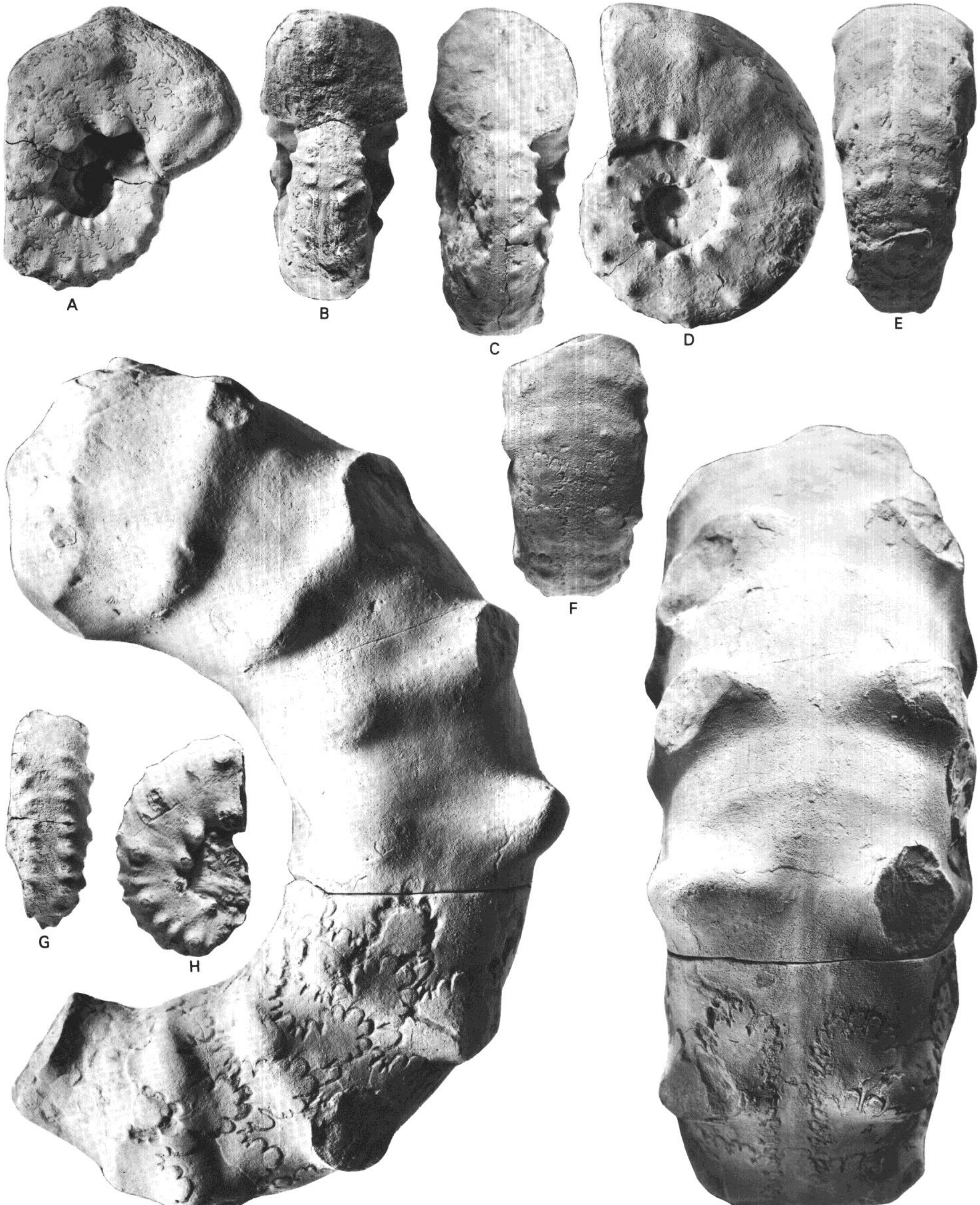
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FIGURE 84

A—W, AA, *Metoicoceras geslinianum* (d'Orbigny): A—C, USNM 425295 from loc. 144. D—F, USNM 425296 from loc. 144. G, H, USNM 425297 from loc. 15. I, J, USNM 425298 from loc. 144. K—M, USNM 425299 from loc. 144. N—P, USNM 425300 from loc. 144. Q, R, USNM 425301 from loc. 10. S, T, USNM 425302 from loc. 144. U—W, USNM 425303 from loc. 144. AA, USNM 425304 from loc. 10.

X—Z, *Metoicoceras frontierense* Cobban: X, USNM 425319 from loc. 53. Y, USNM 425320 from loc. 53. Z, USNM 421321 from loc. 72.

A, C—E x 2, all other figures natural size.

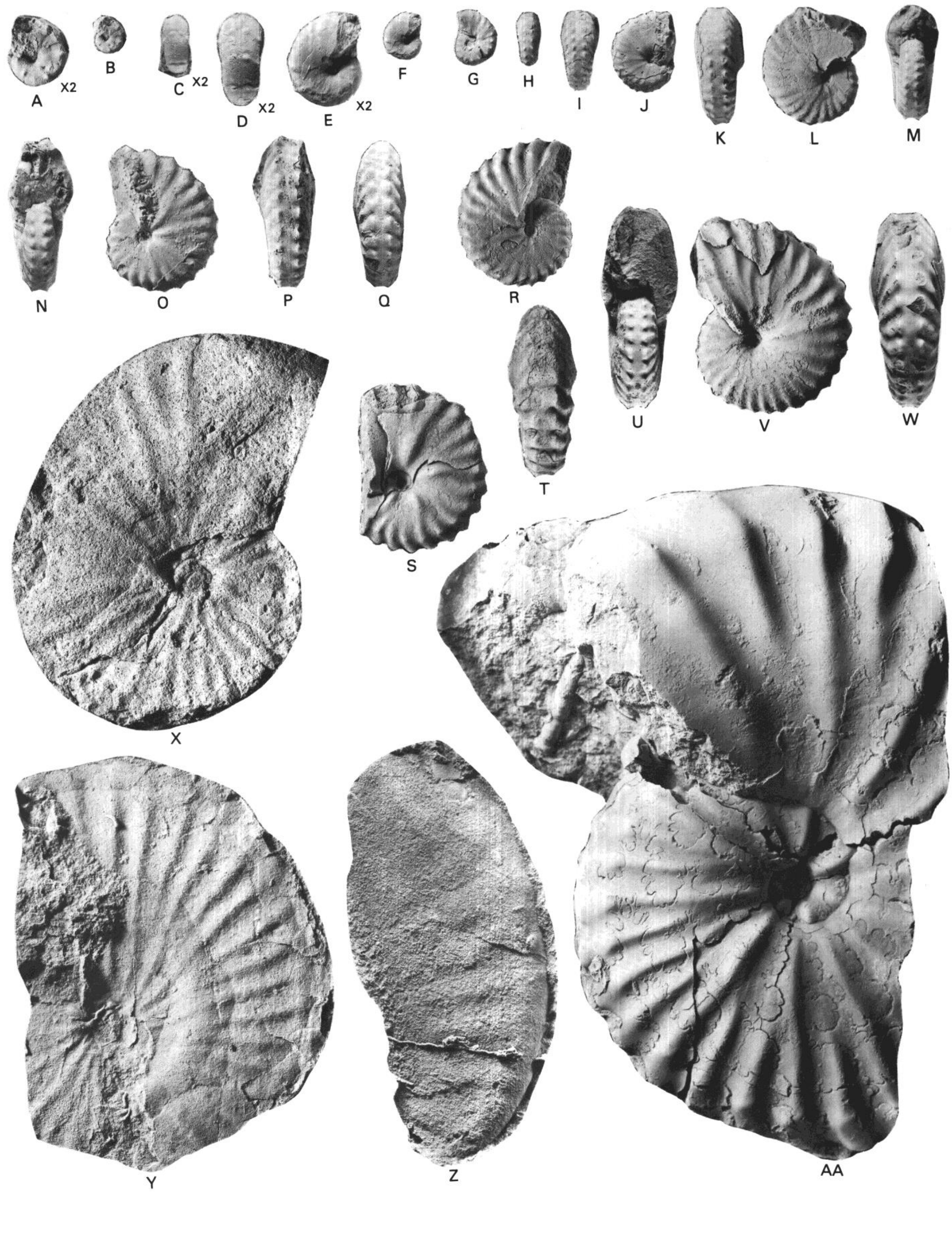
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FIGURE 85

A, B, *Metoicoceras praecox* Haas, USNM 425318 from loc. 70.

C—T, *Metoicoceras mosbyense* Cobban: C, D, USNM 425306 from loc. 159. E, F, USNM 425307 from loc. 159. G—I, USNM 425308 from loc. 159. J, K, USNM 425309 from loc. 159. L, M, USNM 425310 from loc. 159. N, 0, USNM 425311 from loc. 159. P, Q, USNM 425312 from loc. 6. R—T, USNM 425313 from loc. 75.

All figures natural size.

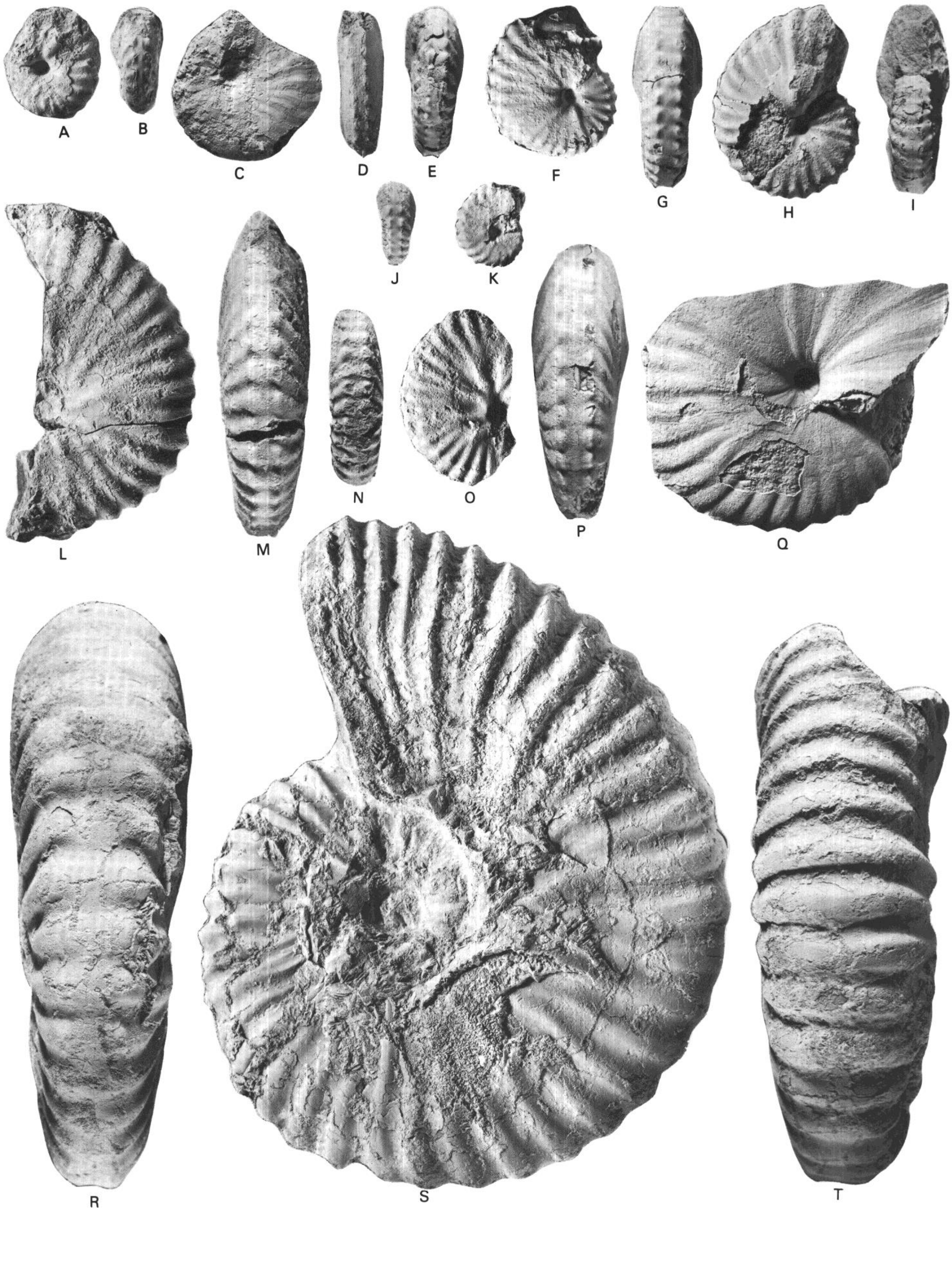
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FIGURE 86

A, B, *Thomasites adkinsi* (Kummel & Decker), USNM 425416 from loc. 90.

C—K, *Metoicoceras frontierense* Cobban: C, Latex cast of USNM 425322 from loc. 72. D, E, USNM 425323 from loc. 29. F, Latex cast of USNM 425324 from loc. 55. G, Latex cast of USNM 425325 from loc. 34. H, USNM 425326 from loc. 34; see Fig. 43 for suture. I, Latex cast of USNM 425327 from loc. 72. J, USNM 425328 from loc. 72. K, USNM 425329 from loc. 29.

L, M, *Metoicoceras mosbyense* Cobban: L, USNM 425314 from loc. 75. M, USNM 425315 from loc. 159.

N, 0, *Nannometoicoceras* cf. *acceleratum* (Hyatt), USNM 425330 from loc. 15. All

figures natural size.

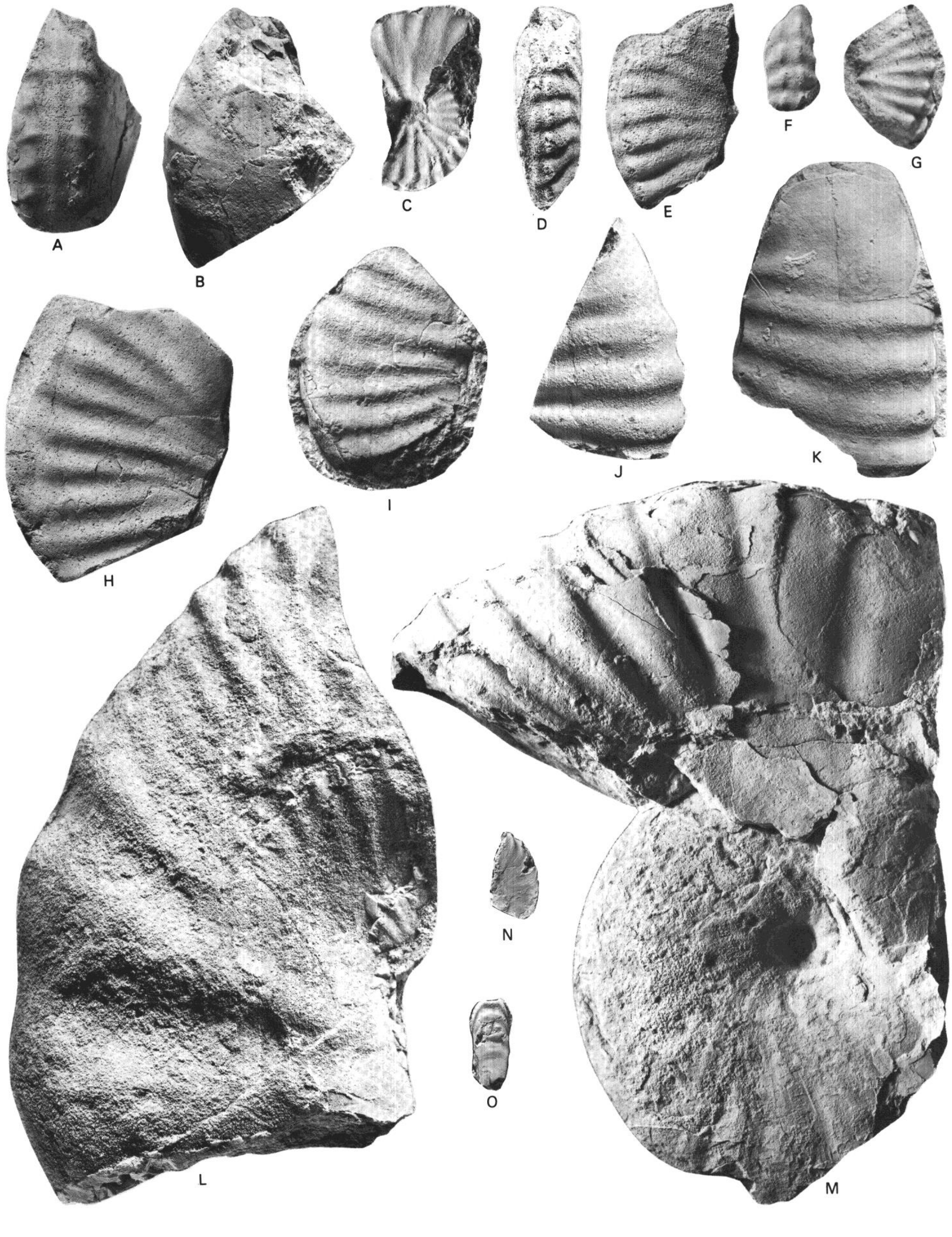
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FIGURE 87

A—P, T—V, *Microdiphasoceras novimexicanum* gen. et sp. nov.: A—C, holotype USNM 425405 from loc. 141. D—F, paratype USNM 425406 from loc. 141; see Fig. 55 for suture. G—I, paratype USNM 425407 from loc. 141. J—M, paratype USNM 425408 from loc. 142. N—P, paratype USNM 425409 from loc. 141. T—V, paratype USNM 425410 from loc. 141.

Q—S, *Vascoceras barcoicense exile* subsp. nov., paratype USNM 425438 from loc. 142.

W—AA, *Vascoceras* cf. *gamai* Choffat: W--Y, USNM 425331 from loc. 142. Z, AA, USNM 425332 from loc. 141. EE, FF, USNM 425333 from loc. 130. GG, HH, USNM 425334 from loc. 119. II—KK, USNM 356891 from loc. 100; see Fig. 44B for suture. LL—NN, USNM 425335 from loc. 141; see Fig. 44A for suture. 00, PP, USNM 425336 from loc. 141. QQ, RR, USNM 425337 from loc. 141.

BB—DD, *Vascoceras* sp. A, USNM 425338 from loc.

141. L—P x 2, all other figures natural size.

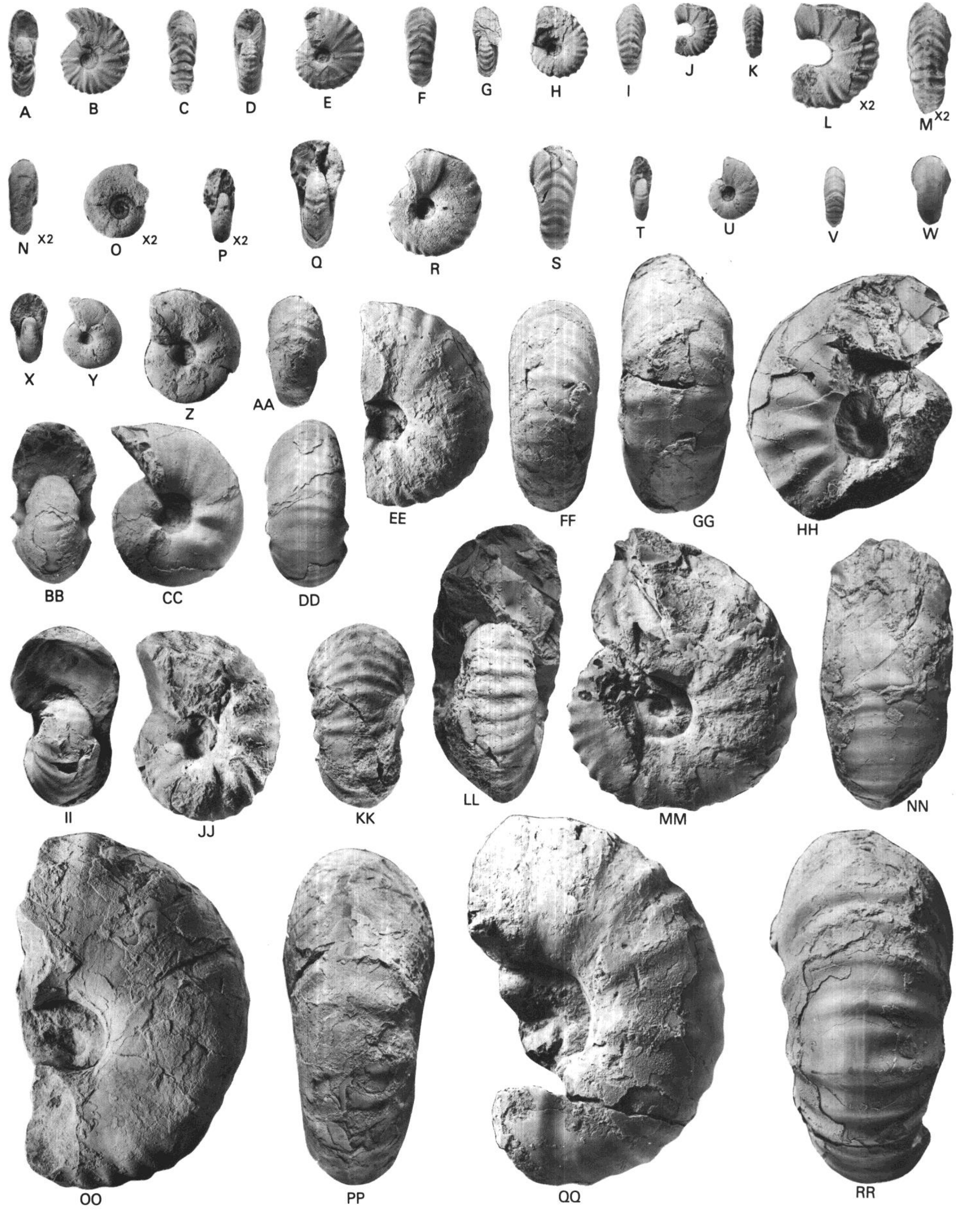
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FIGURE 88

A, B, *Vascoceras birchbyi* Cobban & Scott, USNM 425365 from loc. 48.

C—I, *Vascoceras silvanense* Choffat: C—F, USNM 425339 from loc. 118. G—I, USNM 425340 from loc. 118; see Fig. 45 for suture.

J—S, *Vascoceras* sp. B: J, K, USNM 425341 from loc. 142. L—N, USNM 425342 from loc. 41; see Fig. 46B for suture. 0, P, USNM 425343 from loc. 130. Q—S, USNM 425344 from loc. 141.

T—AA, *Vascoceras diartianum* (d'Orbigny): T—V, USNM 356892 from loc. 17. W—AA, USNM 356893 from loc. 17.

BB—FF, *Neoptychites cephalotus* (Courtiller): BB—DD, USNM 425403 from loc. 90. EE, FF, USNM 425404 from loc. 69.

E, F, Y, and Z x 2, all other figures natural size.

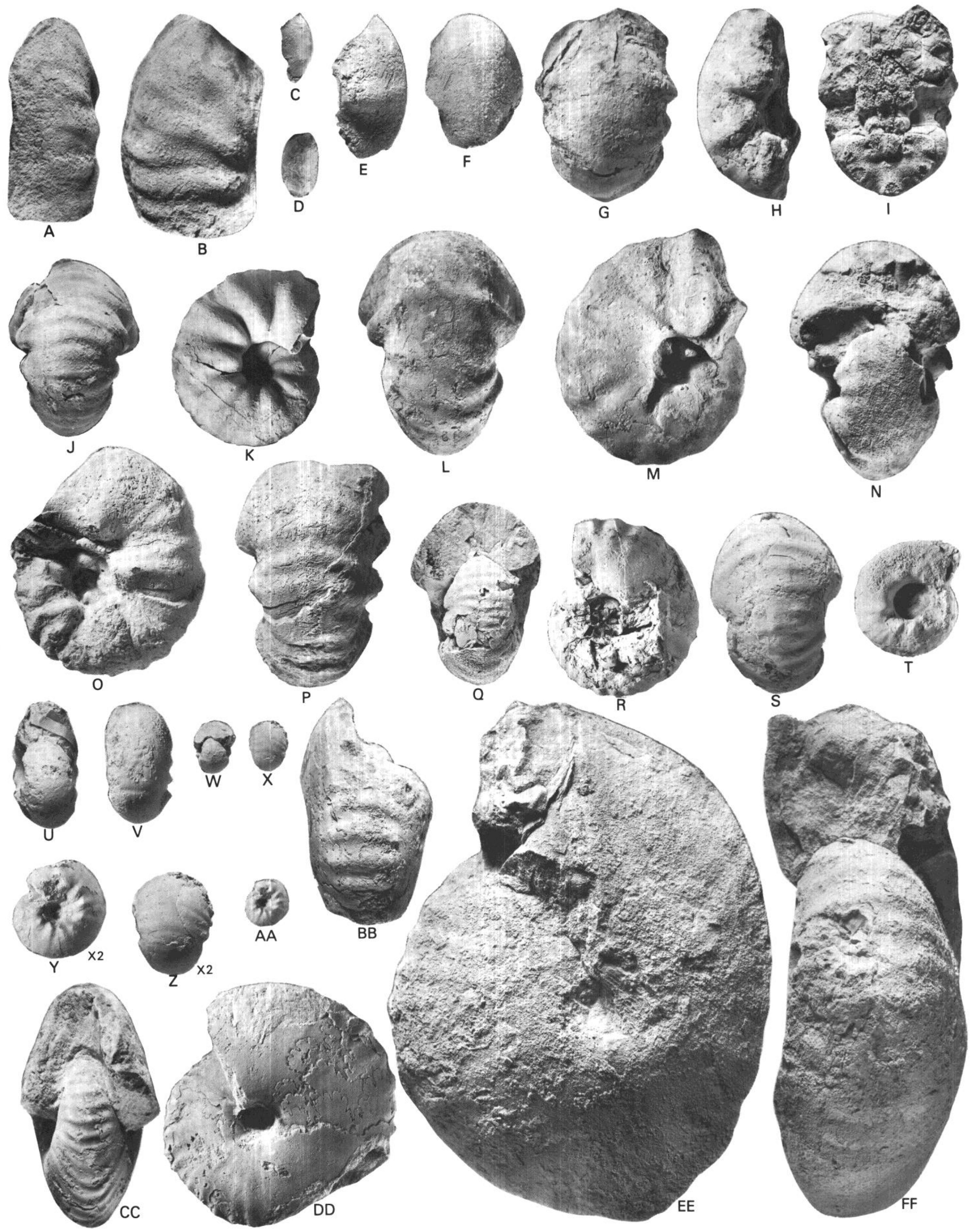
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FIGURE 89

A—L, *Vascoceras birchbyi* Cobban & Scott: A—C, USNM 425366 from loc. 96. D, E, USNM 425367 from loc. 90. F—H, USNM 425368 from loc. 87. I, J, USNM 425369 from loc. 88. K, L, USNM 425370 from loc. 65.

M—GG, *Vascoceras barcoicense exile* subsp. nov.: M-O, paratype USNM 425347 from loc. 141. P—R, paratype USNM 425348 from loc. 95. S—U, paratype USNM 425349 from loc. 141. V—X, paratype USNM 425350 from loc. 141. Y—AA, paratype USNM 425351 from loc. 141. BB, CC, paratype USNM 425352 from loc. 141. DD, EE, holotype USNM 425346 from loc. 121; see Fig. 47 for suture. FF, GG, paratype USNM 425361 from loc. 121.

All figures natural size.


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FIGURE 90

A—C, *Vascoceras* sp. C, USNM 425373 from loc. 65.

D—H, M, N, *Mammites nodosoides* (Schluter): D, USNM 425291 from loc. 24. E, F, USNM 425292 from loc. 51; see Fig. 42B for suture. G, H, USNM 425293 from loc. 24; see Fig. 42A for suture. M, N, USNM 425294 from loc. 51.

I—L, *Rubroceras alatum* gen. et sp. nov., holotype USNM 425417 from loc. 95; 1 is latex cast; see Fig. 56A for suture and Fig. 57B for whorl section.

All figures natural size.

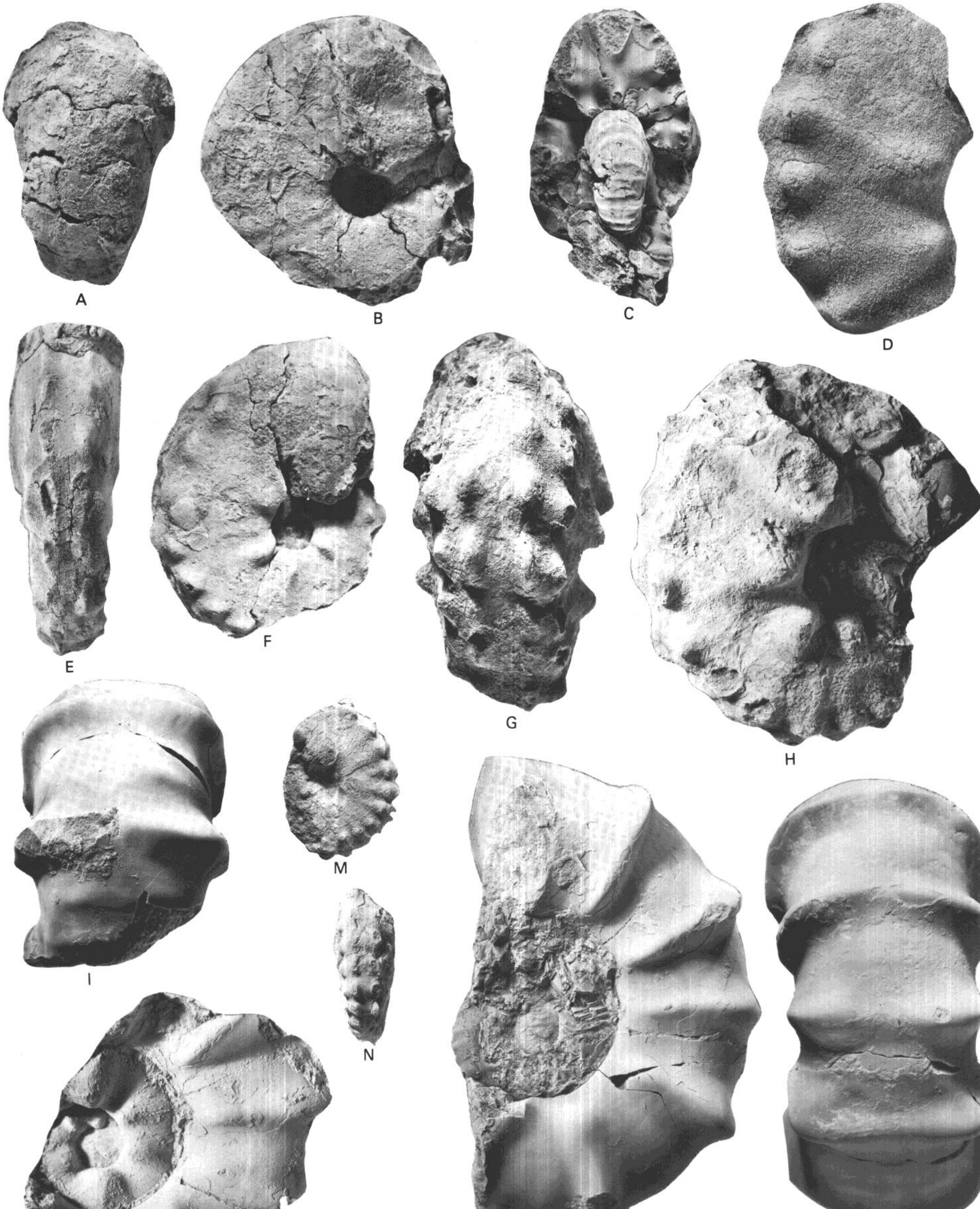

FIGURE 91

A—D, G—K, *Vascoceras hartti* (Hyatt) from loc. 41: A, B, USNM 425374; see Fig. 49A for suture. C, D, USNM 425375. G—I, USNM 425376; see Fig. 49C for suture. J, K, USNM 425377.

E, F, *Fagesia* sp., USNM 425392 from loc. 11.

L, *Pseudaspidoceras flexuosum* Powell, USNM 425290 from loc. 43. L

x 0.5, all other figures natural size.

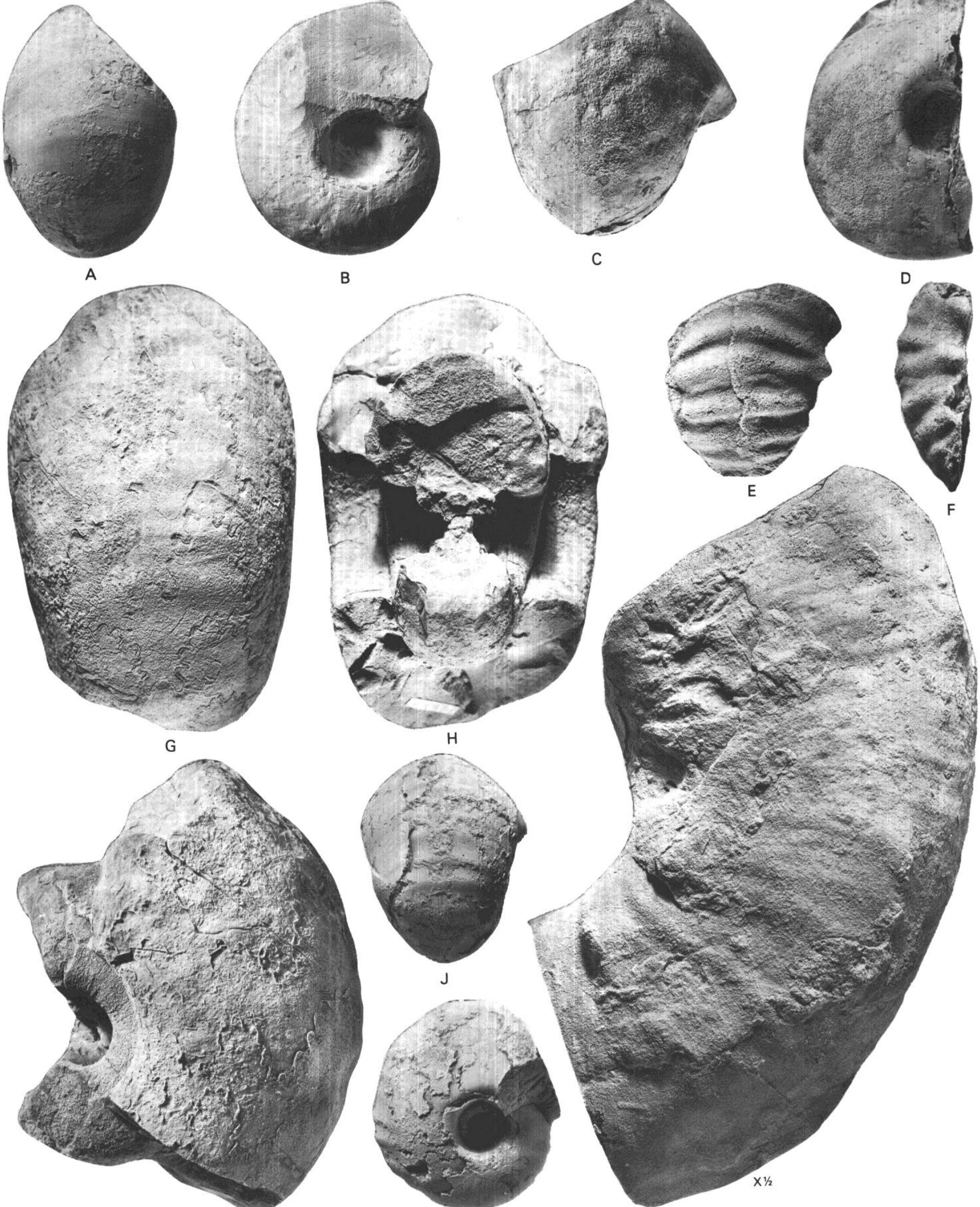
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FIGURE 92

A-K, *Hamites* cf. *simplex* d'Orbigny: A, B, USNM 425433 from loc. 120. C, D, USNM 425434 from loc. 110. E-G, USNM 425435 from loc. 146. H, I, USNM 425436 from loc. 70, J, K, USNM 425437 from loc. 70.

L-KK, *Fagesia catinus* (Mantell): L-N, USNM 425381 from loc. 88. O-Q, USNM 425382 from loc. 87. R-T, USNM 425383 from loc. 90. U-W, USNM 425384 from loc. 88. X-Z, USNM 425385 from loc. 88. AA-CC, USNM 425386 from loc. 90. DD-FF, USNM 425387 from loc. 90. GG, **HH,** USNM 425388 from loc. 90. II-KK, USNM 425389 from loc. 90; see Fig. 50A for suture.

All figures natural size.

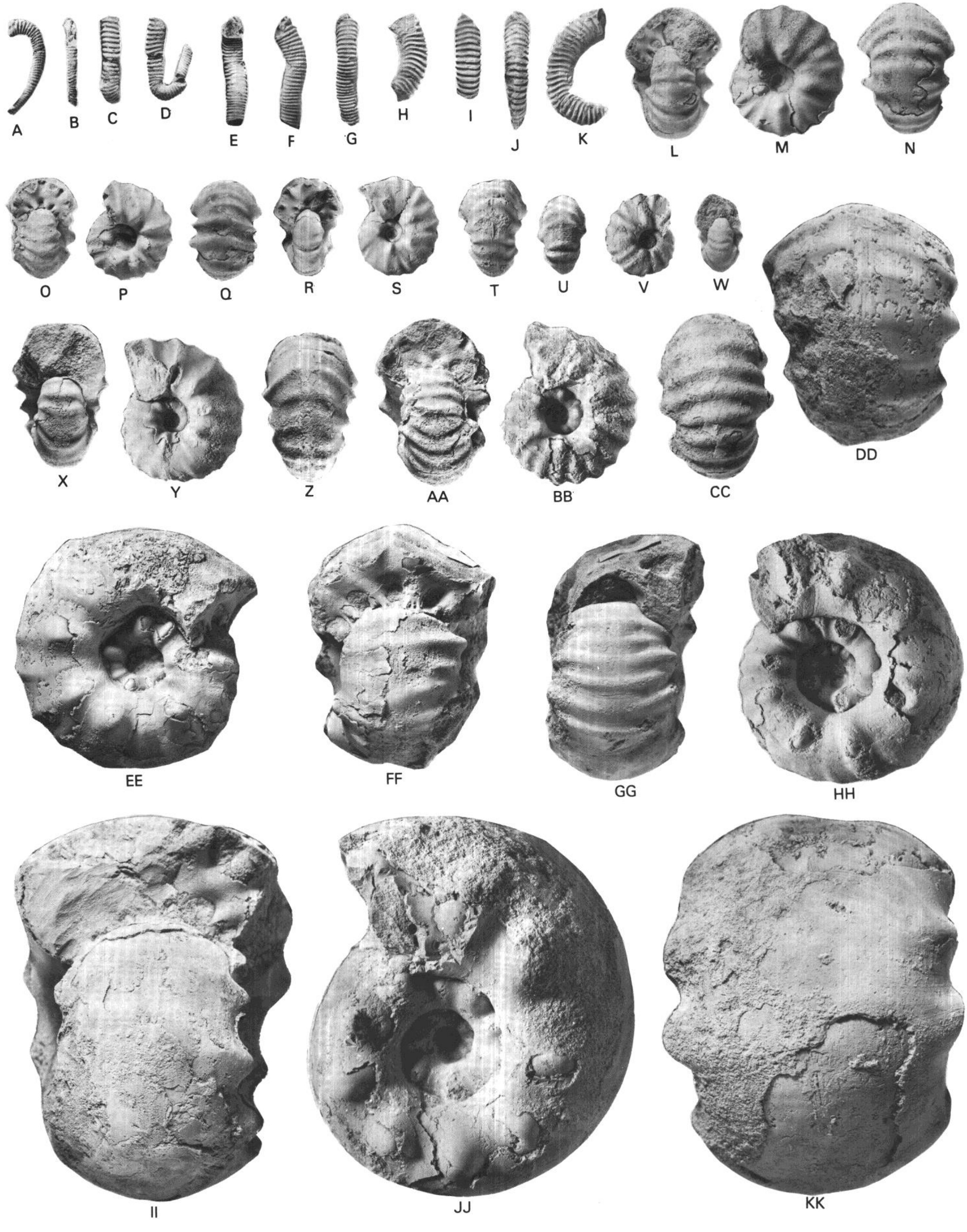
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FIGURE 93

A—C, *Rubroceras burroense* gen. et sp. nov., holotype USNM 425425 from loc. 110; C is latex cast of dorsum.

D—F, *Worthoceras vermiculus* (Shumard), USNM 425477 from loc. 144.

G, *Worthoceras* sp. nov. associated with *Neocardioceras juddii* (Barrois & de Guerne), USNM 425480 from loc. 101.

H, I, *Fagesia* sp., USNM 425393 from loc. 24.

J-O, *Infabricaticeras lunaense* gen. et sp. nov. from loc. 24: J, K, paratype USNM 425396. L, paratype USNM 425397. M, paratype USNM 425398. N, O., holotype USNM 425395; see Fig. 52A for whorl section.

All figures natural size.

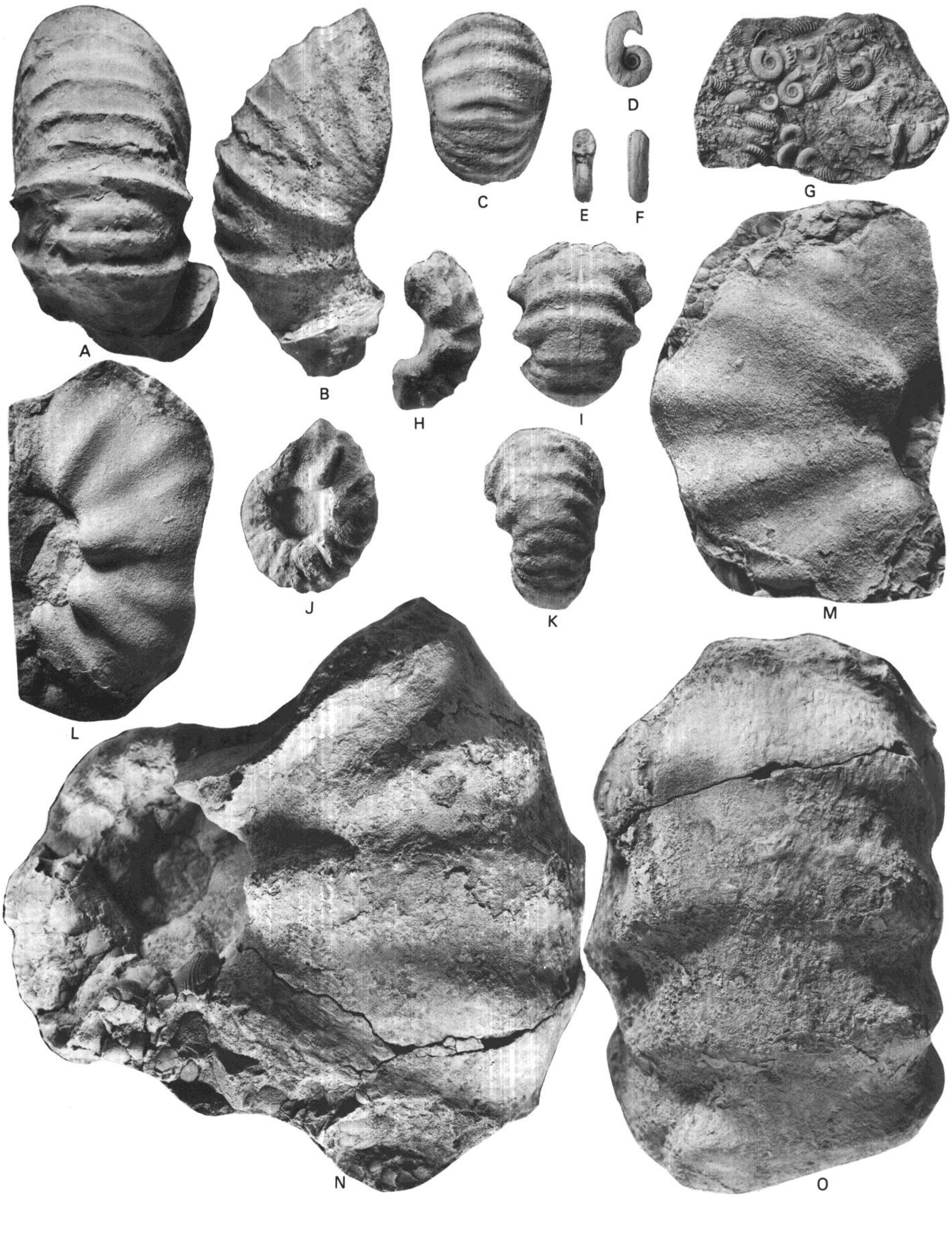
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FIGURE 94

A, B, *Sciponoceras gracile* (Shumard), USNM 425474 from loc. 144.

C—M, *Anisoceras coloradoense* sp. nov.: C, D, paratype USNM 425449 from loc. 104. E, F, paratype USNM 425450 from loc. 110. G—I, paratype USNM 425451 from loc. 134. J, K, paratype USNM 425452 from loc. 109; see Fig. 61 for suture. L, paratype USNM 425453 from loc. 126. M, paratype USNM 425454 from loc. 103.

N—P, T—Y, *Rubroceras alatum* gen. et sp. nov.: N, latex cast of the dorsum of paratype USNM 425418 from loc. 118. O, P, paratype USNM 425419 from loc. 83; see Fig. 56C for suture and Fig. 57A for whorl section. T, U, paratype USNM 425420 from loc. 95; see Fig. 56B for suture. V, W, paratype USNM 425421 from loc. 95; see fig. 56D for suture. X, Y, paratype USNM 425422 from loc. 41.

Q—S, *Rubroceras burroense* gen. et sp. nov., paratype USNM 425426 from loc. 118. Q is latex cast of dorsum.

Z—CC, *Rubroceras rotundum* gen. et sp. nov. from loc. 41: Z, AA, paratype USNM 425431; see Fig. 58A for whorl section and 58C for suture. BB, CC, holotype USNM 425430; see Fig. 58B for whorl section.

All figures natural size.

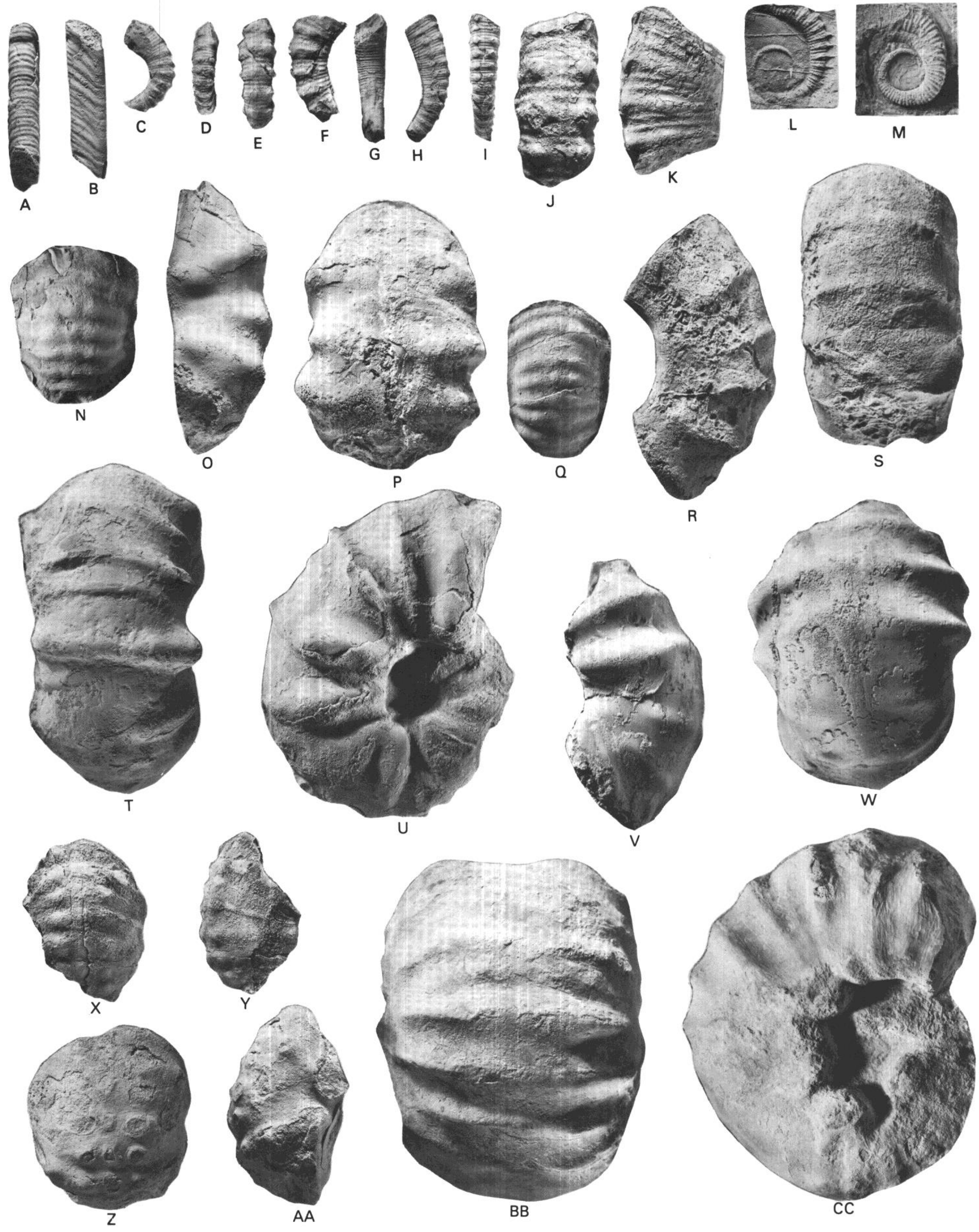
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FIGURE 95

A—F, *Neostlingoceras kottlowskii* Cobban & Hook: A, B, holotype USNM 306777 from USGS Mesozoic loc. D10517 in NE1/4NW1/4 sec. 13, T10S, R8W, Sierra County, New Mexico. C, paratype USNM 306798 from loc. 29. D, paratype USNM 306792 from same locality as that of the holotype. E, paratype USNM 306801 from loc. 31. F, USNM 425462 from loc. 31.

G—N, *Sciponoceras gracile* (Shumard): G, H, USNM 356913 from loc. 144. I, J, USNM 387358 from loc. 66. K, L, USNM 425475 from loc. 120. M, N, USNM 425476 from loc. 145.

O—Q, S, *Neostlingoceras procerum* sp. nov. from loc. 159: 0, P, holotype USNM 425463. Q, paratype USNM 425464. S, paratype USNM 425465.

R, Neostlingoceras bayardense sp. nov., holotype USNM 425469 from loc. 70.

T, *Neostlingoceras virdenense* sp. nov., holotype USNM 425471 from loc. 159.

U—Y, *Anisoceras coloradoense* sp. nov.: U, V, paratype USNM 425455 from loc. 105. W, paratype USNM 425456 from loc. 110. X, Y, paratype USNM 425457 from loc. 110; see Fig. 61 for suture.

Z, AA, DD, *Metaptychoceras hidalgoense* sp. nov. from loc. 159: Z, paratype USNM 425447. AA, holotype USNM 425446. DD, paratype USNM 425448.

CC, *Hamites pygmaeus* sp. nov., holotype USNM 425443 from loc. 141.

BB, EE—II, *Hamites salebrosus* sp. nov.: BB, paratype USNM 425440 from loc. 159. EE, FF, holotype 425439 from Twowells Tongue of Dakota Sandstone at USGS Mesozoic loc. D12069 in SW1/4SW1/4 sec. 30, T10N, R30E, Apache County, Arizona. GG—II, paratype USNM 425441 from Mosby Sandstone Member of Belle Fourche Shale at USGS Mesozoic loc. D10149 in E1/2 sec. 27, T31N, R25E, Petroleum County, Montana.

P, Z, and DD x 2, all other figures natural size.

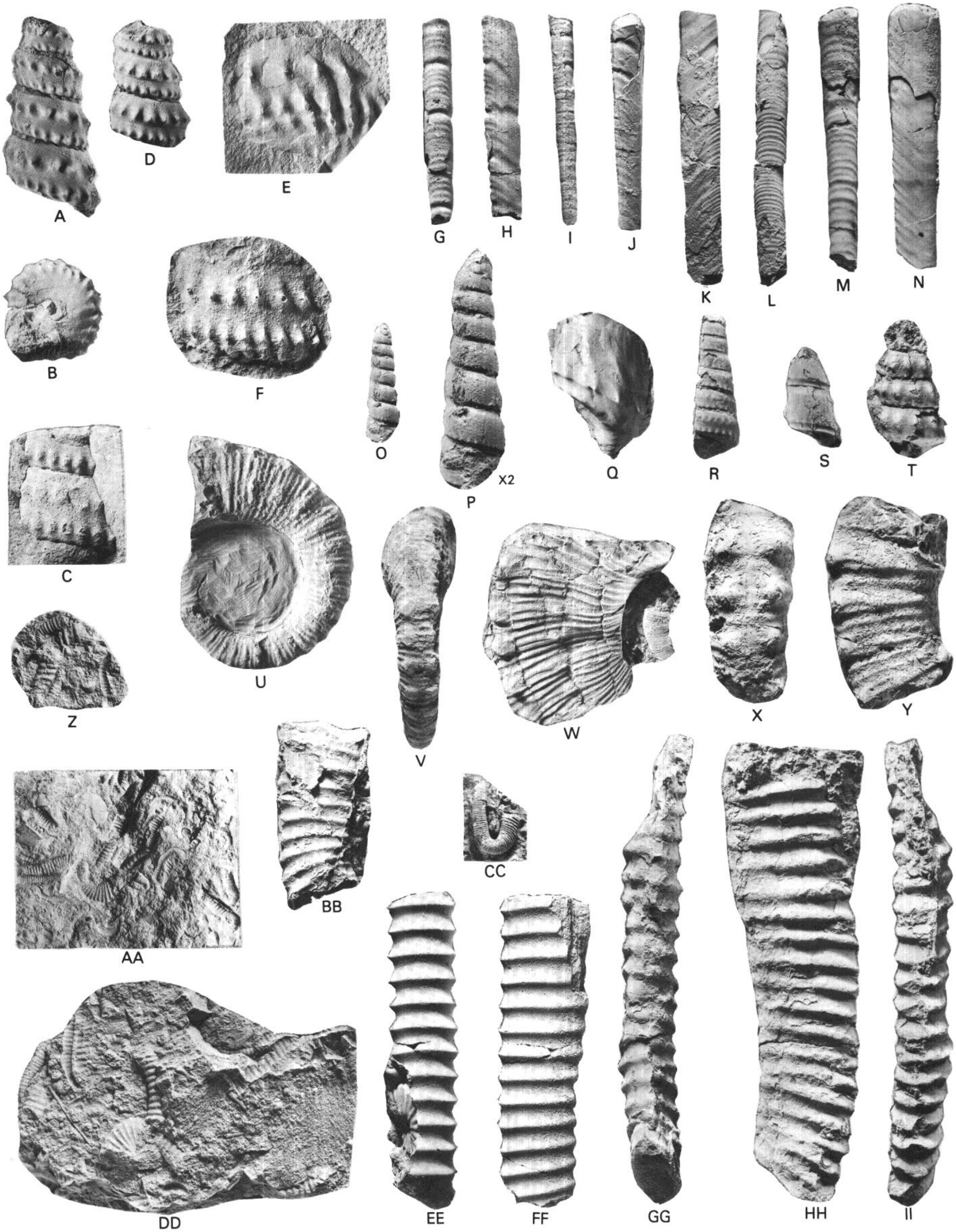
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FIGURE 96

A, B, *Sciponoceras gracile* (Shumard), USNM 387360 from loc. 144.

C, Borissiakoceras sp., latex cast of USNM 425125 from loc. 53.

D, Neostlingoceras apiculatum sp. nov., holotype USNM 425458 from loc. 145.

E—N, *Worthoceras vermiculus* (Shumard): E—G, USNM 425478 from loc. 144. H, USNM 425479 from loc. 142. I—K, USNM 429085 from loc. 144. L—N, USNM 429086 from loc. 144.

0, *Turrilites* sp., USNM 425460 from loc. 33.

P, Allocrioceras annulatum (Shumard), USNM 425458 from loc. 145.

Q, turrilicone sp. nov., USNM 425461 from loc. 33.

R, Neostlingoceras bayardense sp. nov., paratype USNM 425470 from loc. 70.

S, T, *Fagesia catinus* (Mantell), USNM 425391 from loc. 41.

U, Hamites cimarronensis (Kauffman & Powell), USNM 425442 from loc. 30.

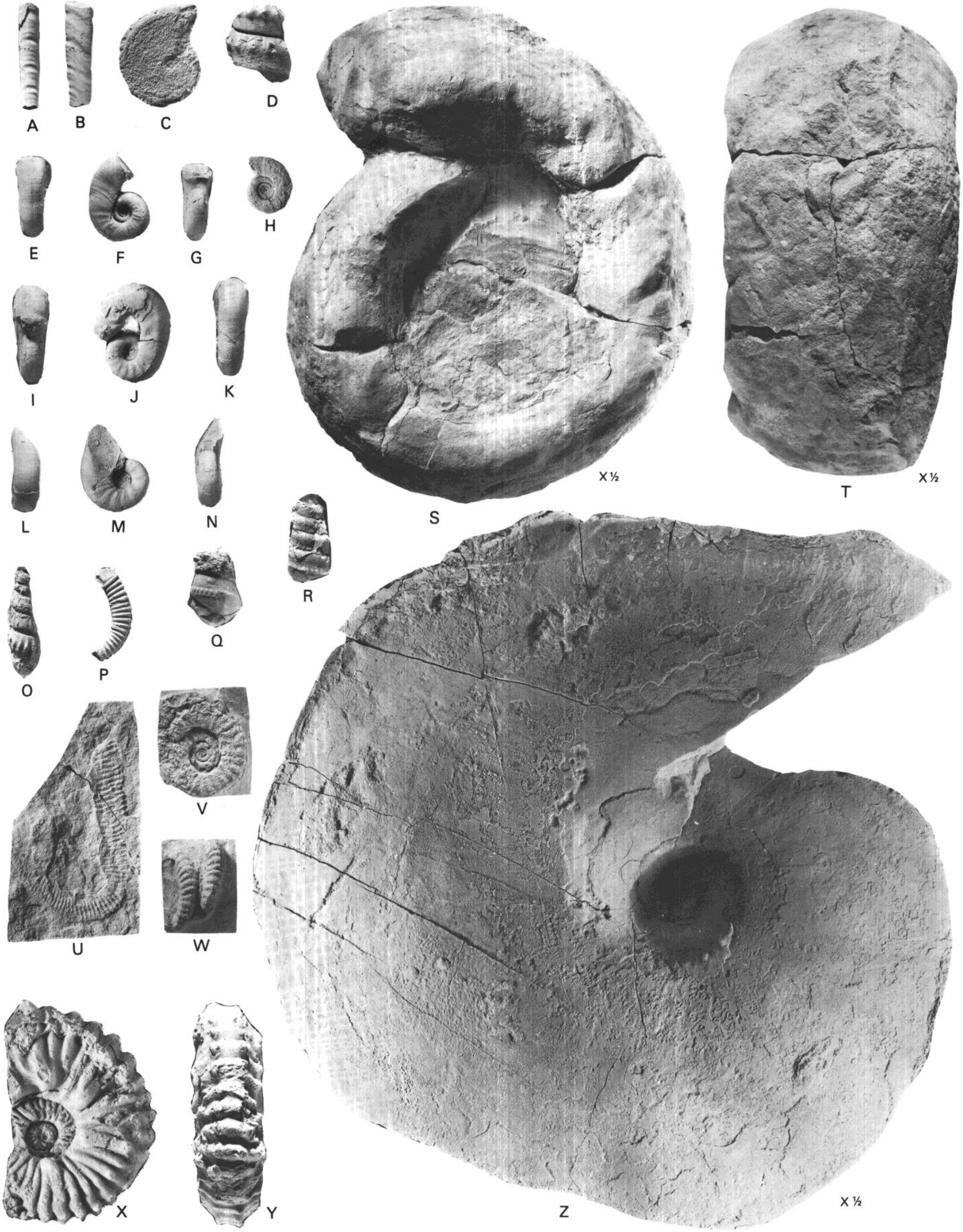
V, ammonite undetermined, USNM 425169 from loc. 30.

W, Hamites? sp., USNM 425444 and 425445 from loc. 30.

X, Y, Watinoceras odonnelli sp. nov., holotype USNM 425214 from loc. 131.

Z, *Placenticeras (Karamaites) cumminsi* Cragin, USNM 425143 from loc. 2. S, T,

and Z x 0.5, all other figures natural size.


A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
X ½
T
X ½
U
V
W
X
Y
Z
X ½

Selected conversion factors*

TO CONVERT	MULTIPLY BY	TO OBTAIN
Length		
inches, in	2.540	centimeters, cm
feet, ft	3.048×10^{-1}	meters, m
yards, yds	9.144×10^{-1}	m
statute miles, mi	1.609	kilometers, km
fathoms	1.829	m
angstroms, Å	1.0×10^{-8}	cm
Å	1.0×10^{-4}	micrometers, μm
Area		
in^2	6.452	cm^2
ft^2	9.29×10^{-2}	m^2
yds^2	8.361×10^{-1}	m^2
mi^2	2.590	km^2
acres	4.047×10^{3}	m^2
acres	4.047×10^{-1}	hectares, ha
Volume (wet and dry)		
in^3	1.639×10^{1}	cm^3
ft^3	2.832×10^{-2}	m^3
yds^3	7.646×10^{-1}	m^3
fluid ounces	2.957×10^{-2}	liters, l *or* L
quarts	9.463×10^{-1}	l
U.S. gallons, gal	3.785	l
U.S. gal	3.785×10^{-3}	m^3
acre-ft	1.234×10^{3}	m^3
barrels (oil), bbl	1.589×10^{-1}	m^3
Weight, mass		
ounces avoirdupois, avdp	2.8349×10^{1}	grams, gr
troy ounces, oz	3.1103×10^{1}	gr
pounds, lb	4.536×10^{-1}	kilograms, kg
long tons	1.016	metric tons, mt
short tons	9.078×10^{-1}	mt
oz mt^{-1}	3.43×10^{1}	parts per million, ppm
Velocity		
ft sec^{-1} (= ft/sec)	3.048×10^{-1}	m sec^{-1} (= m/sec)
mi hr^{-1}	1.6093	km hr^{-1}
mi hr^{-1}	4.470×10^{-1}	m sec^{-1}

TO CONVERT	MULTIPLY BY	TO OBTAIN
Pressure, stress		
lb in^{-2} (= lb/in^2), psi	7.03×10^{-2}	kg cm^{-2} (= kg/cm^2)
lb in^{-2}	6.804×10^{-2}	atmospheres, atm
lb in^{-2}	6.895×10^{3}	newtons $(N)/m^2$, N m^{-2}
atm	1.0333	kg cm^{-2}
atm	7.6×10^{2}	mm of Hg (at 0° C)
inches of Hg (at 0° C)	3.453×10^{-2}	kg cm^{-2}
bars, b	1.020	kg cm^{-2}
b	1.0×10^{6}	dynes cm^{-2}
b	9.869×10^{-1}	atm
b	1.0×10^{-1}	megapascals, MPa
Density		
lb in^{-3} (= lb/in^3)	2.768×10^{1}	gr cm^{-3} (= gr/cm^3)
Viscosity		
poises	1.0	gr cm^{-1} sec^{-1} *or* dynes cm^{-2}
Discharge		
U.S. gal min^{-1}, gpm	6.308×10^{-2}	l sec^{-1}
gpm	6.308×10^{-5}	m^3 sec^{-1}
ft^3 sec^{-1}	2.832×10^{-2}	m^3 sec^{-1}
Hydraulic conductivity		
U.S. gal day^{-1} ft^{-2}	4.720×10^{-7}	m sec^{-1}
Permeability		
darcies	9.870×10^{-13}	m^2
Transmissivity		
U.S. gal day^{-1} ft^{-1}	1.438×10^{-7}	m^2 sec^{-1}
U.S. gal min^{-1} ft^{-1}	2.072×10^{-1}	l sec^{-1} m^{-1}
Magnetic field intensity		
gausses	1.0×10^{5}	gammas
Energy, heat		
British thermal units, BTU	2.52×10^{-1}	calories, cal
BTU	1.0758×10^{2}	kilogram-meters, kgm
BTU lb^{-1}	5.56×10^{-1}	cal kg^{-1}
Temperature		
°C + 273	1.0	°K (Kelvin)
°C + 17.78	1.8	°F (Fahrenheit)
°F − 32	5/9	°C (Celsius)

**Divide by* the factor number to reverse conversions.
Exponents: for example 4.047×10^{3} (see acres) = 4,047; 9.29×10^{-2} (see ft^2) = 0.0929.

Editor: Jiri Zidek

Type face: Palatino

Presswork: Miehle Single Color Offset
Harris Single Color Offset

Binding: Smyth sewn with softbound *cover*

Paper: Cover on 17-pt. Kivar
Text on 70-lb white matte

Ink: Cover—PMS 320
Text—Black

Quantity: 1000