Tarrantoceras Stephenson and Related Ammonoid Genera from Cenomanian (Upper Cretaceous) Rocks in Texas and the Western Interior of the United States

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Tarrantoceras Stephenson and Related Ammonoid Genera from Cenomanian (Upper Cretaceous) Rocks in Texas and the Western Interior of the United States

By WILLIAM A. COBBAN

U.S. GEOLOGICAL SURVEY PROFESSIONAL PAPER 1473

Ammonites of the genera
Tarrantoceras, Eucalycoceras, Pseudocalycoceras, Sumitomoceras, *and* Neocardioceras *are described and illustrated*

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TARRANTOCERAS STEPHENSON AND RELATED AMMONOID GENERA FROM CENOMANIAN (UPPER CRETACEOUS) ROCKS IN TEXAS AND THE WESTERN INTERIOR OF THE UNITED STATES

By WILLIAM A. COBBAN

ABSTRACT

Tarrantoceras, Eucalycoceras, Pseudocalycoceras, Sumitomoceras, and *Neocardioceras* are closely related genera of ammonites confined to rocks of middle and late Cenomanian age. *Tarrantoceras*, represented by *T. sellardsi* (Adkins) and *T. flexicostatum*, n. sp., was probably derived from *Calycoceras* (*Gentoniceras*) *leonense* (Adkins). *Eucalycoceras* appeared abruptly near the end of middle Cenomanian time and then disappeared until the middle of the late Cenomanian. The genus is represented by *E. templetonense*, n. sp., and *E. pentagonum* (Jukes-Browne). *Neocardioceras*, which was probably derived from *Tarrantoceras*, is known by the new species *N. uptonense* and *N. laevigatum* of early late Cenomanian age, *N. minutum*, n. sp. and *N.* sp. of middle late Cenomanian age, and *N. juddii* (Barrois and de Guerne) and *N. densicostatum*, n. sp., of late Cenomanian age. *Pseudocalycoceras* and *Sumitomoceras*, known only from the later part of middle late Cenomanian time, were probably derived from early forms of *Eucalycoceras pentagonum*. *Pseudocalycoceras* is represented by *P. angolaense* (Spath), and *Sumitomoceras* is known from *S. conlini* Wright and Kennedy and *S. bentonianum* (Cragin).

INTRODUCTION

Stephenson (1955, p. 59) proposed the genus *Tarrantoceras* for laterally compressed ammonites that have ribs which cross the flank and venter and bear umbilical, inner and outer ventrolateral, and siphonal tubercles. The genus was named for Tarrant County, Tex. As pointed out by Stephenson (1955, p. 59), the genus closely resembles the English genus *Eucalycoceras* Spath (1923, p. 144) in form and ornament, but the American genus has a simpler suture with a shallow lateral lobe. Other genera are closely related to *Tarrantoceras* and *Eucalycoceras*. *Pseudocalycoceras* Thomel (1969, p. 650) differs from *Tarrantoceras* and *Eucalycoceras* mainly in having conspicuous rursiradiate ribbing. *Neocardioceras* Spath (1926, p. 81) differs from the other genera discussed chiefly in having ribs that cross the venter as chevrons. *Sumitomoceras* Matsumoto (in Matsumoto and others, 1969, p. 280) loses its siphonal tubercles at an early growth stage.

All of these closely related genera are confined to rocks of middle and late Cenomanian age, and most are widely distributed over much of the world. One or more of the genera have been found in Mississippi, Texas, New Mexico, Arizona, Utah, Colorado, Oklahoma, Kansas, Wyoming, South Dakota, and Montana.

Species of these genera have very restricted time spans and provide a means for the correlation of thin rock units. This report was prepared to bring our knowledge of these genera in the United States up to date, to describe important new species, and to show the biostratigraphic sequence of species.

All specimens described and illustrated in this report are kept in the National Museum of Natural History in Washington, D.C., and have USNM catalog numbers. Plaster and plastic casts of the holotypes of new species as well as casts of some of the other figured specimens are in the reference collections of the U.S. Geological Survey at the Denver Federal Center in Lakewood, Colo. These casts were prepared by R.E. Burkholder and Robert O'Donnell of the U.S. Geological Survey, and Burkholder made all the photographs. The author made the drawings of the sutures.

LOCALITIES AT WHICH FOSSILS WERE COLLECTED

The fossils described in this report came from 67 localities in the Western Interior of the United States and from several localities in northeast Texas. Localities of collections from the Western Interior are shown on figure 1, and data concerning the locality number, names of collectors, year of collection, locality, and stratigraphic assignment are given in table 1. The prefix D indicates Denver Mesozoic locality numbers; the rest are Washington, D.C., Mesozoic locality numbers.

SYSTEMATIC DESCRIPTIONS

In the descriptions and illustrations of sutures, E stands for the external or siphonal lobe, L stands for the lateral lobe, and E/L stands for the saddle (first lateral saddle) that separates the external and lateral

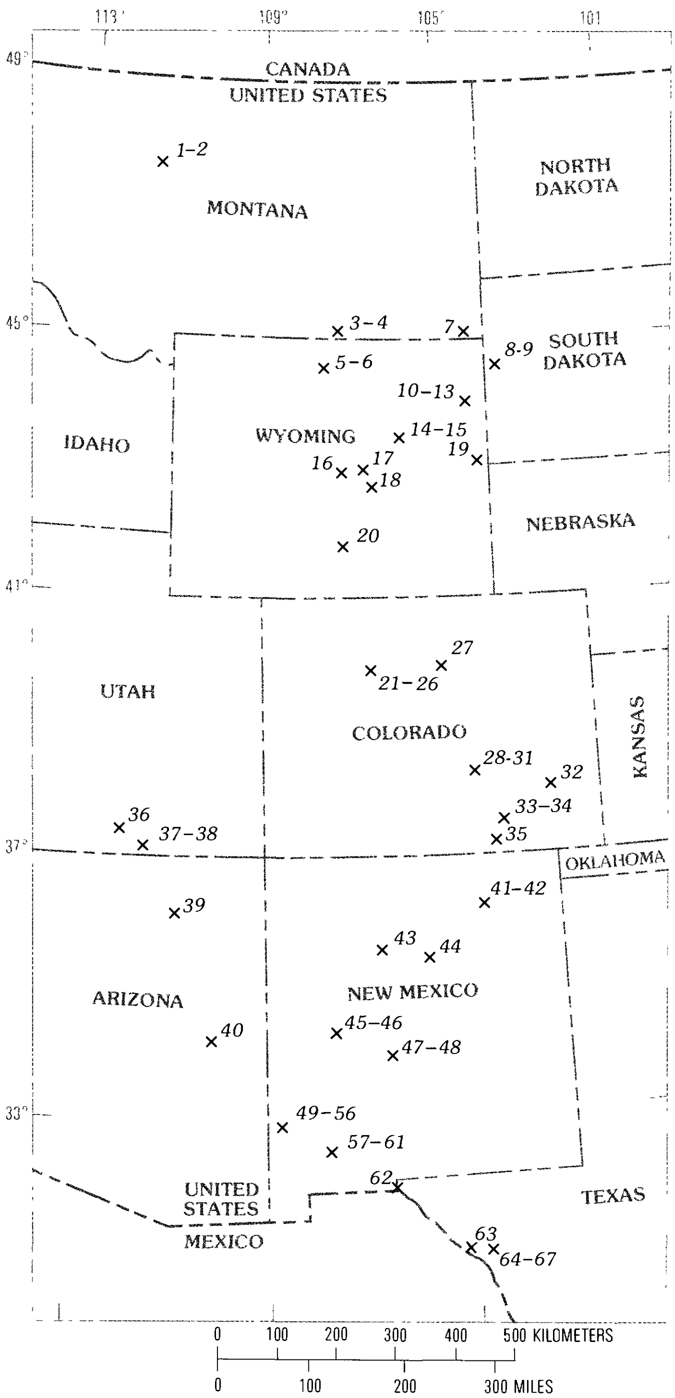


FIGURE 1.—Map of part of the Western Interior of the United States showing localities of fossil collections. Numbers refer to U.S. Geological Survey Mesozoic localities in table 1.

lobes. No further divisions of the sutures are described. In the drawings of sutures, the heavy straight line represents the middle of the venter, the evenly curved dashed line represents the umbilical shoulder, and the evenly curved solid line represents the umbilical seam.

Phylum MOLLUSCA
Class CEPHALOPODA
Order AMMONOIDEA
Suborder AMMONITINA
Superfamily ACANTHOCERATACEAE Grossouvre, 1894
Family ACANTHOCERATIDAE Grossouvre, 1894

Genus TARRANTOCERAS Stephenson, 1955, p. 59

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.—Small to medium-sized, somewhat evolute, compressed ammonites ornamented by dense, mostly rectiradiate, slightly flexuous primary and secondary ribs that cross the venter transversely and that, at most growth stages, bear small inner and outer ventrolateral and siphonal tubercles. Primary ribs arise from bullate to nodate tubercles located on the umbilical shoulder. Sutures are fairly simple and acanthoceratid with broad, bifid first lateral saddles and much smaller, shallow, bifid lateral lobes.

Remarks.—*Tarrantoceras* is closely related to *Eucalycoceras* Spath (1923, p. 144) from which it differs mainly in having a more simplified suture with a short lateral lobe instead of a long, narrow one. The narrow lobe of *Eucalycoceras* has been illustrated for several species from Madagascar (Collignon, 1937, pl. 4, fig. 3; pl. 8, fig. 5; pl. 9, figs. 3, 4) and for one from India (Kossmat, 1895, pl. 25, fig. 3c). In addition, some examples of *Eucalycoceras* have umbilical tubercles that project into the umbilicus (Kossmat, 1895, pl. 25, fig. 3a), a condition not observed in *Tarrantoceras*. *Ammonites pentagonus* Jukes-Browne (in Jukes-Browne and Hill, 1896, p. 156, pl. 5, figs. 1, 1a), the type species of *Eucalycoceras*, differs further from *Tarrantoceras* in having broad, flattened ribs with steep adoral faces on the last half of the body chamber. *Sumitomoceras* Matsumoto (in Matsumoto and others, 1969, p. 280), regarded as a subgenus of *Tarrantoceras* by Wright and Kennedy (1981, p. 38), differs from that genus in having siphonal tubercles on the innermost whorls and in losing the ventrolateral tubercles at a smaller diameter.

Occurrence.—*Tarrantoceras* is best known and best preserved in rocks of late middle to early late Cenomanian age in Texas, New Mexico, Colorado, and Wyoming. Crushed fragments occur in rocks of early late Cenomanian age in Montana, South Dakota, and Kansas. Outside the United States, the genus has been recorded from Mexico (Powell, 1965, p. 522), Colombia (Bürgl, 1957, p. 137), and Morocco (Collignon, 1966, p. 30–32, 59).

TABLE 1.—*Localities at which fossils were collected*

Locality (fig. 1)	U.S. Geological Survey Mesozoic locality	Collector, year of collection, description of locality, and stratigraphic assignment
1	D556	W.A. Cobban, 1955. SE¼ sec. 13, T. 22 N., R. 1 W., Teton County, Mont. Marias River Shale, from limestone concretions 4.2 m (14 ft) above base of Cone Member.
2	24615	W.A. Cobban, 1953. North side of Mill Coulee in the SE¼ sec. 21, T. 21 N., R. 1 W., Cascade County, Mont. Marias River Shale, from limestone concretions associated with a 1-m-thick bed of bentonite 4.2 m (14 ft) above base of Cone Member.
3	D8463	E.A. Merewether, 1972. SW¼ sec. 13, T. 9 S., R. 34 E., Big Horn County, Mont. Base of Greenhorn Calcareous Member of Cody Shale, from limestone concretions in bentonite bed M of Knechtel and Patterson (1956, p. 21).
4	21355	W.A. Cobban, 1948; E.A. Merewether and Cobban, 1983. SE¼ sec. 14, T. 9 S., R. 34 E., Big Horn County, Mont. Base of Greenhorn Calcareous Member of Cody Shale, from limestone concretions in bentonite bed M of Knechtel and Patterson (1956, p. 21).
5	D12630	N.H. James, 1962. Northeast of Greybull in the NW¼ T. 53 N., R. 92 W., Big Horn County, Wyo. Near top of Frontier Formation.
6	21850	J.B. Reeside, Jr., and D.A. Andrews, 1938. East of Herren Gulch in the SE¼ sec. 9, T. 53 N., R. 92 W., Big Horn County, Wyo. Cody Shale, from silty concretions 24.4 m (80 ft) above base.
7	12740	W.A. Rubey, 1924. NE¼ sec. 6, T. 9 S., R. 59 E., Carter County, Mont. Greenhorn Formation, from a limestone concretion in the lower part.
8	23060	J.B. Reeside, Jr., H.R. Christner, and W.A. Cobban, 1950. North of Belle Fourche in the E½ sec. 14, T. 9 N., R. 2 E., Butte County, S. Dak. Greenhorn Formation, from a thin layer of calcarenitic limestone.
9	23064	J.B. Reeside, Jr., H.R. Christner, and W.A. Cobban, 1950. Southeast side of peninsula in Belle Fourche Reservoir in W½ sec. 31, T. 9 N., R. 4 E., Butte County, S. Dak. Basal limestone bed of Greenhorn Formation.
10	D4462	W.A. Cobban, 1964. About 5.7 km (3½ mi) south-southeast of Upton in the NE¼ sec. 24, T. 47 N., R. 65 W., Weston County, Wyo. Greenhorn Formation, from a limestone concretion in the lower part.
11	D5940	W.A. Cobban, 1967. About 4 km (2½ mi) west of Upton in the NW¼ sec. 33, T. 48 N., R. 65 W., Weston County, Wyo. From an ironstone concretion in the Belle Fourche Shale.
12	D5947	W.A. Cobban, 1961. About 4.8 km (3 mi) south of Upton in the NW¼ sec. 14, T. 47 N., R. 65 W., Weston County, Wyo. Belle Fourche Shale, from a limestone concretion 19.8 m (65 ft) above a 0.6-m-thick bed of bentonite.
13	D11780	E.A. Merewether, 1964. About 8.8 km (5½ mi) northwest of Upton in the NE¼ sec. 13, T. 48 N., R. 66 W., Weston County, Wyo. Greenhorn Formation, from a ferruginous concretion in the concretionary facies.
14	D6962	W.A. Cobban, 1962. SW¼ sec. 30, T. 41 N., R. 80 W., Natrona County, Wyo. Frontier Formation, from a 2-m-thick bed of orange-brown-weathering sandstone in Belle Fourche Member.
15	D9798	E.A. Merewether, 1975. NW¼ sec. 1, T. 42 N., R. 82 W., Johnson County, Wyo. Frontier Formation, from Belle Fourche Member.
16	D8918	E.A. Merewether, 1973. Ervay Basin in the SW¼ sec. 19, T. 34 N., R. 88 W., Natrona County, Wyo. Frontier Formation, from upper part of Belle Fourche Member.
17	D9894	W.A. Cobban, 1976. SE¼ sec. 13, T. 35 N., R. 84 W., Natrona County, Wyo. Frontier Formation, from a limestone concretion 2.4 m (8 ft) below base of a middle Turonian sandstone bed.
18	D9337	E.A. Merewether and W.A. Cobban, 1974. Emigrant Gap Ridge in the NW¼ sec. 32, T. 34 N., R. 81 W., Natrona County, Wyo. Frontier Formation, from a lenticular bed of conglomerate in the upper part.
19	D5900	W.A. Cobban, 1967. Head of Elm Creek in the W½ sec. 14, T. 36 N., R. 62 W., Niobrara County, Wyo. Belle Fourche Shale, from limestone concretions 3.6 m (12 ft) below bentonite marker bed.
20	D7530	E.A. Merewether and W.A. Cobban, 1970. Olsen Basin in the NE¼ sec. 14, T. 23 N., R. 88 W., Carbon County, Wyo. Frontier Formation, from brown-weathering sandstone concretions above the lowest sandstone unit.
21	D7388	G.A. Izett, G.R. Scott, and W.A. Cobban, 1969. NE¼ sec. 31, T. 1 N., R. 81 W., Grand County, Colo. Benton Shale, 64.3 m (211 ft) below base of Juana Lopez Member.
22	D7389	G.A. Izett, 1969. Same locality as D7388. Benton Shale, 59.7 m (196 ft) below base of Juana Lopez Member.
23	D7390	G.A. Izett and W.A. Cobban, 1969. Same locality as D7388. Benton Shale, 58 m (191 ft) below base of Juana Lopez Member.
24	D7395	G.A. Izett, 1969. Same locality as D7388. Benton Shale, 38.4 m (126 ft) below base of Juana Lopez Member.
25	D7402	G.A. Izett and W.A. Cobban, 1969. Center of sec. 31, T. 1 N., R. 80 W., Grand County, Colo. Benton Shale, 62.5 m (205 ft) below base of Juana Lopez Member.
26	D7403	G.A. Izett and W.A. Cobban, 1969. Same locality as D7402. Benton Shale, 60.6 m (199 ft) below base of Juana Lopez Member.
27	D7410	G.R. Scott and G.A. Izett, 1970. South side of highway at east edge of Eldorado Springs in the SW¼ sec. 30, T. 1 S., R. 70 W., Boulder County, Colo. Greenhorn Limestone, from a shale bed underlying a 15-cm-thick bed of bentonite in the upper part of the Hartland Shale Member.

TABLE 1.—*Localities at which fossils were collected*—Continued

Locality (fig. 1)	U.S. Geological Survey Mesozoic locality	Collector, year of collection, description of locality, and stratigraphic assignment
28	D6472	W.H. Birchby, 1968. Boggs Creek in the NW¼ sec. 1, T. 21 S., R. 66 W., Pueblo County, Colo. Greenhorn Limestone, from lower part of Bridge Creek Member (Cobban and Scott, 1972, p. 24, bed 67).
29	D6998	W.H. Birchby, 1969. SW¼ sec. 30, T. 20 S., R. 65 W., Pueblo County, Colo. Greenhorn Limestone, from 3.6 m (12 ft) above base of Bridge Creek Member (Cobban and Scott, 1972, p. 23, bed 84).
30	D12558	W.A. Cobban, 1984. West of Pueblo in the SW¼ sec. 25, T. 20 S., R. 66 W., Pueblo County, Colo. Greenhorn Limestone, from Lincoln Member.
31	D12629	W.A. Cobban, 1985. West of Pueblo in the NW¼ sec. 25, T. 20 S., R. 66 W., Pueblo County, Colo. Greenhorn Limestone, from lower part of Bridge Creek Member (Cobban and Scott, 1972, p. 23, bed 79).
32	D12627	W.A. Cobban, 1985. Thompson Arroyo in the SW¼ sec. 5, T. 24 S., R. 54 W., Otero County, Colo. Greenhorn Limestone, float on lower part of Bridge Creek Member (probably from same bed as bed 84 of section at Pueblo, Colo., described by Cobban and Scott, 1972, p. 23).
33	18686	N.W. Bass, 1941, G.R. Scott and W.A. Cobban, 1966. E½ sec, 15, T. 30 S., R. 60 W., Las Animas County, Colo. Greenhorn Limestone, from basal bed of Bridge Creek Member.
34	22899	J.B. Reeside, Jr., H.R. Christner, and W.A. Cobban, 1950; G.R. Scott and Cobban, 1966. SW¼ sec. 12 and NW¼ sec. 13, T. 30 S., R. 60 W., Las Animas County, Colo. Greenhorn Limestone, from basal bed of Bridge Creek Member.
35	D12452	W.A. Cobban, 1984. NW¼ sec. 8, T. 33 S., R. 60 W., Las Animas County, Colo. Greenhorn Limestone, from lowest concretionary limestone bed in Bridge Creek Member.
36	D12493	F.B. Zelt, 1984. Northeast of Henrieville in the S½ sec. 14, T. 37 S., R. 2 W., Garfield County, Utah. Tropic Shale, from 7.5 m (24 ft) above base.
37	D5268	Fred Peterson, 1965. E½ sec. 11, T. 43 S., R. 2 E., Kane County, Utah. Tropic Shale, from 11 m (36 ft) above base.
38	D12356	F.B. Zelt, 1983. East of Wahweap Creek in the NW¼ sec. 2, T. 43 S., R. 2 E., Kane County, Utah. Tropic Shale, 5.5 m (18 ft) above base.
39	D11587	S.C. Hook, J.I. Kirkland, and W.A. Cobban, 1981. Ha Ho No Geh Canyon in the NW¼ sec. 25, T. 30 N., R. 13 E., Coconino County, Ariz. Mancos Shale, from gray limestone concretions 8.5 m (18 ft) above base.
40	D11584	S.C. Hook and W.A. Cobban, 1981. SW¼ sec. 17, T. 10 N., R. 21 E., Navajo County, Ariz. Unnamed Cretaceous sandstone.
41	D5848	G.R. Scott, 1967. Old railroad grade south of Taylor Springs in sec. 15, T. 24 N., R. 23 E., Colfax County, N. Mex. Greenhorn Limestone, from Lincoln Member.
42	D10734	S.C. Hook and J.R. Wright, 1979. Near Taylor Springs in the NW¼ sec. 22, T. 24 N., R. 23 E., Colfax County, N. Mex. Greenhorn Limestone, from Lincoln Member.
43	D5810	W.A. Cobban, 1967. Soda Spring on San Ysidro 15-minute quadrangle, Sandoval County, N. Mex. Mancos Shale, from sandstone bed in lower part.
44	D5309	W.A. Cobban, 1966. Near railroad cut at southeast edge of Lamy, Santa Fe County, N. Mex. Paguate Tongue of Dakota Sandstone.
45	D5784	E.R. Landis and W.A. Cobban, 1967. Southeast of Puertecito in the SE¼ sec. 33, T. 3 N., R. 5 W., Socorro County, N. Mex. Mancos Shale, 17 m (56 ft) above base.
46	D5795	W.A. Cobban, 1967. West of Riley in the SW¼ sec. 16 and NW¼ sec. 21, T. 2 N., R. 4 W., Socorro County, N. Mex. Mancos Shale, about 27 m (90 ft) above base.
47	D5776	W.A. Cobban, 1967. SE¼ sec. 8, T. 5 S., R. 2 E., Socorro County, N. Mex. Mancos Shale, 10.7 m (35 ft) above base.
48	D5777	E.R. Landis and W.A. Cobban, 1967. SE¼ sec. 8, T. 5 S., R. 2 E., Socorro County, N. Mex. Mancos Shale, from thin beds of very fine grained sandstone in lower part.
49	D9031	W.A. Cobban, 1970. Wild Horse Mesa in the center of the north line of sec. 11, T. 18 S., R. 17 W., Grant County, N. Mex. Colorado Formation, from a limestone concretion in lower part.
50	D10533	S.C. Hook and W.A. Cobban, 1978. South of center of north line of sec. 11, T. 18 S., R. 17 W., Grant County, N. Mex. Colorado Formation, from limestone concretions in lower part.
51	D10996	S.C. Hook and Gerald Stachura, 1976. Foxtail Creek in the SE¼ sec. 31, T. 17 S., R. 17 W., Grant County, N. Mex. Colorado Formation, from a limestone concretion in shale member.
52	D11004	S.C. Hook, 1976. Redrock Canyon in the NW¼ sec. 27, T. 18 S., R. 15 W., Grant County, N. Mex. Colorado Formation, from a limestone concretion in the shale member.
53	D11510	S.C. Hook, 1981. SE¼ sec. 31, T. 17 S., R. 17 W., Grant County, N. Mex. Colorado Formation, from a limestone concretion in the shale member.
54	D11529	S.C. Hook and W.A. Cobban, 1981. NE¼ sec. 11, T. 18 S., R. 18 W., Grant County, N. Mex. Colorado Formation, from limestone concretions in lower part.
55	D11533	S.C. Hook and W.A. Cobban, 1981. SE¼ sec. 5, T. 18 S., R. 16 W., Grant County, N. Mex. Colorado Formation, from a limestone concretion in the shale member.
56	D11538	S.C. Hook and W.A. Cobban, 1981. NE¼ sec. 11, T. 18 S., R. 18 W., Grant County, N. Mex. Colorado Formation, from shale member.
57	D6842	E.R. Landis and W.A. Cobban, 1968. NE¼ sec. 30, T. 20 S., R. 8 W., Luna County, N. Mex. Colorado Formation.

TABLE 1.—*Localities at which fossils were collected*—Continued

Locality (fig. 1)	U.S. Geological Survey Mesozoic locality	Collector, year of collection, description of locality, and stratigraphic assignment
58	D10112	S.C. Hook, 1976. NE¼ sec. 13, T. 21 S., R. 9 W., Luna County, N. Mex. Colorado Formation, from about 53 m (174 ft) above base.
59	D10114	S.C. Hook and W.A. Cobban, 1976. NE¼ sec. 13, T. 21 S., R. 9 W., Luna County, N. Mex. Colorado Formation, from limestone concretions near top of Bridge Creek Limestone Member (Hook and Cobban, 1981, fig. 3).
60	D10196	S.C. Hook and W.A. Cobban, 1976. NW¼ sec. 30, T. 20 S., R. 8 W., Luna County, N. Mex. Colorado Formation, from upper part of Bridge Creek Limestone Member.
61	D11483	W.A. Cobban, 1981. South of center of north line of sec. 30, T. 20 S., R. 8 W., Luna County, N. Mex. Colorado Formation, from Bridge Creek Limestone Member.
62	D10142	S.C. Hook, E.R. Landis, and W.A. Cobban, 1977. North of Sierra De Cristo Rey in the SW¼ sec. 9, T. 29 S., R. 4 E., Dona Ana County, N. Mex. Base of Boquillas Formation.
63	D10946	S.C. Hook and W.A. Cobban, 1979. About 0.6 km south of Love triangulation station on Eagle Mountains SW 7½-minute quadrangle, Hudspeth County, Tex. Chispa Summit Formation, 30 m (98 ft) above base.
64	D10741	W.A. Cobban, 1979. Chispa Summit, Jeff Davis County, Tex. Chispa Summit Formation, 1.5 m (5 ft) above base.
65	D10742	S.C. Hook and W.A. Cobban, 1979. Same locality as D10741. Chispa Summit Formation, 4.6 m (15 ft) above base.
66	D10746	S.C. Hook and W.A. Cobban, 1979. Same locality as D10741. Chispa Summit Formation, from a chalky limestone bed 39 m (128 ft) above base.
67	D10898	S.C. Hook and W.A. Cobban, 1979. About 1.4 km southwest of railroad cut at Chispa Summit, Jeff Davis County, Tex. Chispa Summit Formation, from yellowish, soft marl bed about 40 m (131 ft) above base.

Tarrantoceras sellardsi (Adkins)

Plate 1; plate 2, figures 1–22, 27, 28; text figure 4

1928. *Mantelliceras sellardsi* Adkins, p. 239, pl. 25, fig. 1; pl. 26, fig.4.
1942. *Mantelliceras sellardsi* Adkins. Moreman, p. 207.
1955. *Tarrantoceras rotatile* Stephenson, p. 59, pl. 5, figs. 1–10.
1955. *Tarrantoceras stantoni* Stephenson, p. 60, pl. 5, figs. 11–21.
1955. *Tarrantoceras lillianense* Stephenson, p. 60, pl. 5, figs. 22–27.
1955. *Tarrantoceras multicostatum* Stephenson, p. 61, pl. 6, figs. 21–23.
1971. *Eucalycoceras sellardsi* (Adkins). Kennedy, p. 84.
1972. *Tarrantoceras rotatile* Stephenson. Cobban and Scott, p. 64, pl. 10, figs. 1–11; text fig. 25.
1976 [1978]. *Utaticeras? sellardsi* (Adkins). Young and Powell, fig. 5.
1977. *Tarrantoceras rotatile* Stephenson. Cobban, p. 23, pl. 6, figs. 8–10, 28, 29; pl. 11, figs. 7, 8, 11–16; pl. 12, figs. 13, 14; text fig. 4.
1978. *Tarrantoceras rotatile* Stephenson. Cooper, p. 92, text fig. 20.
1984. *Tarrantoceras sellardsi* (Adkins). Cobban, p. 78.

Diagnosis.—A compressed, moderately evolute species that ranges from rather sparsely and strongly ornamented forms to more compressed and fairly densely ribbed forms. The species also ranges from forms that retain ventrolateral tubercles to the aperture (microconchs) to larger forms that lose the ventrolateral tubercles farther down on the body chamber (macroconchs).

Description.—The holotype, from the basal Eagle Ford Group of east-central Texas, is a large broken specimen that appears to be part of a body chamber and part of the last septate whorl (pl. 1, figs. 8, 9). The specimen was only briefly described by Adkins (1928, p. 239), who gave no dimensions other than the umbilical ratio. A plaster cast reveals half a whorl about 55.5 mm in diameter with an umbilical width of 13.5 mm and an umbilical ratio of 0.24. Offset against the half whorl is a fragment that probably is the older part of the body chamber. The half whorl and the fragment have high, narrow whorl sections with flattened flanks and venter. The umbilicus has a narrowly rounded shoulder and steep walls. Ornament consists of closely spaced, rectiradiate to rursiradiate, slightly flexuous ribs as wide as or a little wider than the interspaces and umbilical, ventrolateral, and siphonal tubercles. Ribs are mostly of alternate lengths; the longer ones begin from umbilical bullae on the umbilical shoulder, and the shorter ones arise at midflank or a little lower. The ribs on the fragment of the presumed body chamber have steeper adapical faces than adoral ones. Faint inner ventrolateral tubercles are present on the older part of the half whorl. Much stronger, clavate outer ventrolateral tubercles border the flattened venter, which is crossed transversely by the ribs. Each rib bears a weak, clavate siphonal tubercle. Part of the venter may have been concealed by matrix when Adkins described the specimen, because he mentioned that siphonal tubercles were absent (and, hence, his assignment to *Mantelliceras*). Adkins did not note the faint inner ventrolateral tubercles on the older part of the half whorl and mistook the outer ventrolateral and siphonal tubercles as "a pair of shoulder tubercles." The outer ventrolateral tubercles number about 22 per half whorl. According to Adkins, no sutures are preserved.

Specimens of *Tarrantoceras sellardsi* from northeastern Texas occur in silty limestone and tend to be fragmented and crushed. Farther north, in the Fort Worth–Dallas area (fig. 2), excellent specimens have been found in limestone concretions near the base of the Eagle Ford Group. At least four major finds have been made: one by T.W. Stanton on Walnut Creek northeast of Mansfield (fig. 2, loc. 11740), a second by W.J. Kennedy and J. M. Hancock from the same general area (fig. 2, loc. D12626), a third by the late J.P. Conlin near

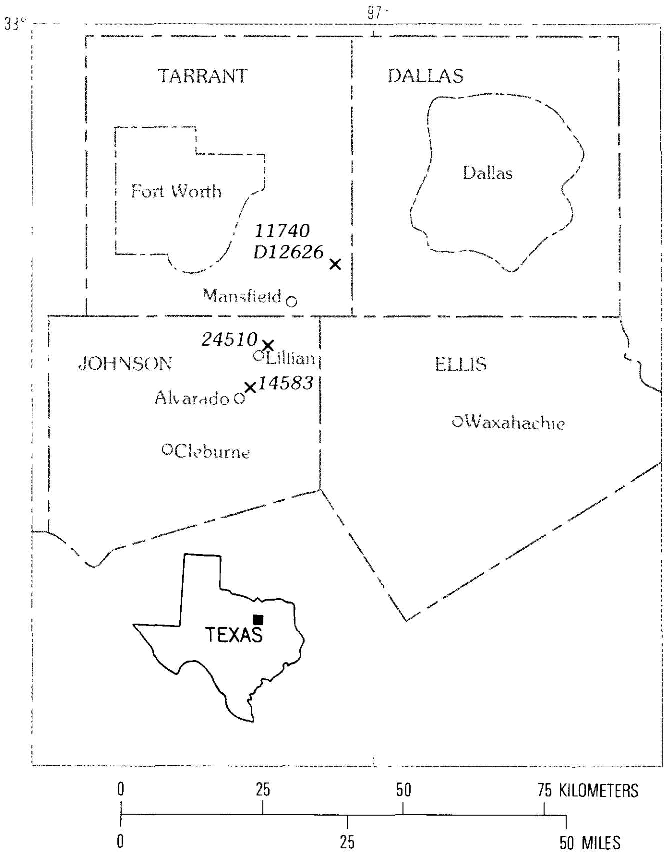


FIGURE 2.—Map of part of northeastern Texas showing localities (x) and their USGS locality numbers where *Tarrantoceras sellardsi* (Adkins) was collected from near the base of the Eagle Ford Group.

Lillian (fig. 2, loc. 24510), and a fourth by T.W. Stanton, L. W. Stephenson, and J.B. Reeside, Jr., near Alvarado (fig. 2, loc. 14583). All collections, except the recent one by Kennedy and Hancock, were made before 1955. Stephenson (1955) described as new species *Tarrantoceras rotatile, T. stantoni, T. lillianense*, and *T. multicostatum* from the concretions near Mansfield, Lillian, and Alvarado. Stephenson's forms were later interpreted as normal variants within a single species (Cobban and Scott, 1972, p. 64). These variants center about Stephenson's *T. lillianense*. His *T. rotatile* and *T. multicostatum* represent the slenderer and more weakly ornamented end of the variation series, and his *T. stantoni* represents the more robust and more strongly ornamented end.

The smallest complete whorl examined by me (pl. 2, figs. 18–20) has a diameter of 4.8 mm. At this size, the whorl section is broader than high, with flattened flanks and broadly rounded venter. Ornament consists of weak, prorsiradiate ribs and strong, nearly equal sized ventrolateral and siphonal tubercles. Nodate inner ventrolateral tubercles are already present at the beginning of this whorl at a diameter of about 2.2 mm. Outer ventrolateral and siphonal tubercles arise at a diameter of 3.5 mm. Larger growth stages have been well described by Stephenson (1955). In general, whorls become slenderer and more densely ribbed with growth (fig. 3), and the inner ventrolateral tubercles weaken with growth and disappear on the body chamber.

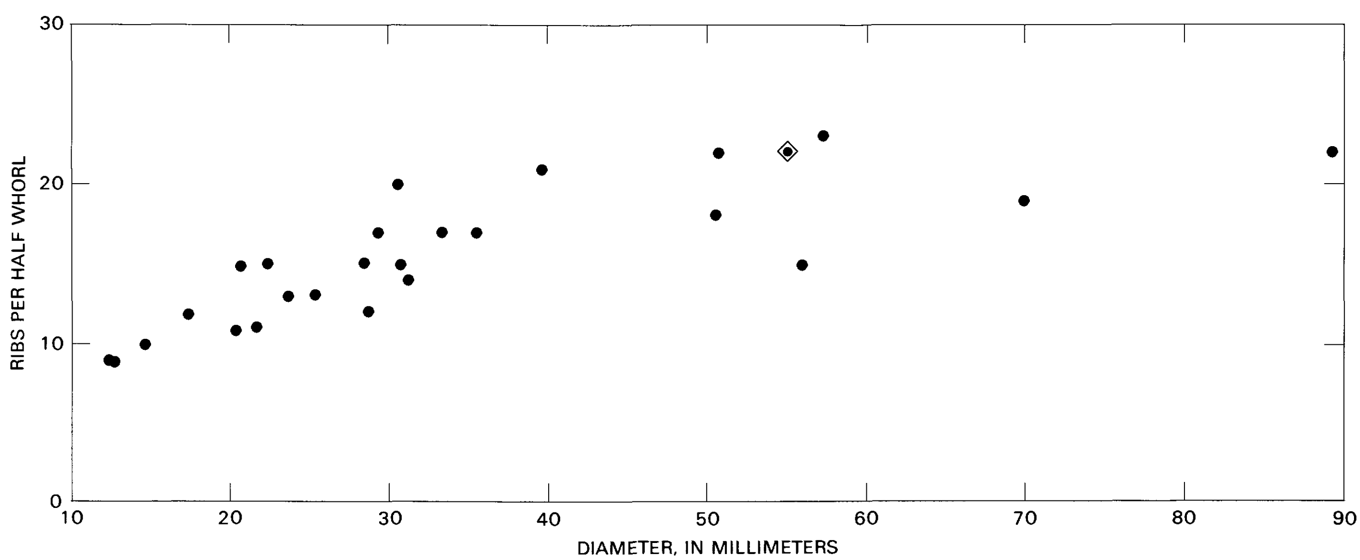


FIGURE 3.—Scatter diagram showing number of ribs per half whorl of 25 specimens of *Tarrantoceras sellardsi* (Adkins) from the Eagle Ford Group from USGS Mesozoic localities 11740, 14583, 24510, and D12626 in Tarrant and Johnson Counties, Tex. The diamond encloses the rib count of the holotype from Williamson County, Tex.

The species is dimorphic with adults ranging from about 40 to 90 mm in diameter. Smaller adults (microconchs) retain the flattened, tuberculated venter to the aperture (pl. 1, figs. 1–3; pl. 2, figs. 9–11), whereas the larger ones (macroconchs) lose the flattening and tuberculation (pl. 1, figs. 10–13; pl. 2, figs. 27, 28). The aperture is normal, and none of the specimens has crowded or reduced ribbing at the aperture. Body chambers occupy one-half to two-thirds of a whorl (pl. 1, figs. 2, 7, 11; pl. 2, figs. 8, 10, 22, 27).

The suture is fairly simple with deep, narrow external lobe, very broad bifid first lateral saddle, and much narrower and short bifid lateral lobe (fig. 4).

Occurrence.—The holotype is from the Tarrant Formation of the Eagle Ford Group near Round Rock, Williamson County, Tex. A fragment of *Acanthoceras amphibolum* Morrow is in the matrix. This ammonite also occurs with *Tarrantoceras sellardsi* in the collections from the limestone concretions in the Fort Worth–Dallas area (fig. 2). Other fossils in these concretions include *Inoceramus arvanus* Stephenson, *Pseudomelania*? *basicostata* Stephenson, *Lispodesthes lirata* Stephenson, *Puzosia* sp., *Desmoceras* (*Pseudouhligella*) aff. *D. japonicum* Yabe, *Acanthoceras johnsonanum* Stephenson, *Cunningtoniceras lonsdalei* (Adkins), *Borissiakoceras orbiculatum* Stephenson, *Anisoceras plicatile* (J. Sowerby), and *Turrilites acutus americanus* Cobban and Scott. *Tarrantoceras sellardsi* occurs farther west in Trans-Pecos Texas (fig. 1, locs. 63–65), where crushed fragments are present in the U.S. Geological Survey's collections from the lower part of the Chispa Summit Formation. A fragment of a very large specimen recorded as *Pseudocalycoceras* cf. *P. harpax* (Stoliczka) by Hook and Cobban (1983, p. 51) from the flaggy limestone member of the Boquillas Limestone is probably an unusually large *T. sellardsi*. In the El Paso area (fig. 1, loc. 62), the species occurs at the base of the Boquillas Formation, where *T. sellardsi* was reported as *T. rotatile* (Strain, 1976, p. 82). Here the species is associated with many of the same mollusks found in the Fort Worth–Dallas area and also with *Ostrea beloiti* Logan and *Pseudacompsoceras landisi* Cobban. *Tarrantoceras sellardsi*, recorded as *T. rotatile* (Cobban, 1977, p. 23), occurs at many localities in New Mexico, especially as flattened fragments in the Mancos Shale (fig. 1, locs. 45, 46) or in thin beds of calcarenitic limestone in the Mancos Shale (fig. 1, loc. 47). Better preserved specimens occur in limestone concretions in the Clay Mesa Tongue of the Mancos Shale and in sandy concretions in the Paguate Tongue of the Dakota Sandstone in west-central New Mexico (Cobban, 1977, pl. 6, figs. 8–10, 28, 29; pl. 11, figs. 7, 8, 11–16). In southeastern Colorado, *T. sellardsi* is found in skeletal limestone near the top of the Graneros Shale (Cobban and Scott, 1972, p. 7, 65, pl. 10, figs. 1–11; text fig. 25). Here the species, recorded as *T. rotatile*, is associated with *Inoceramus rutherfordi* Warren, *Ostrea beloiti* Logan, *Desmoceras* (*Pseudouhligella*) sp., *Acanthoceras amphibolum* Morrow, *Borissiakoceras* sp., and *Turrilites acutus americanus* Cobban and Scott. North of Colorado, *T. sellardsi* becomes scarce, and only an occasional specimen has been collected from limestone concretions near the top of the Belle Fourche Shale in eastern Wyoming (fig. 1, loc. 19).

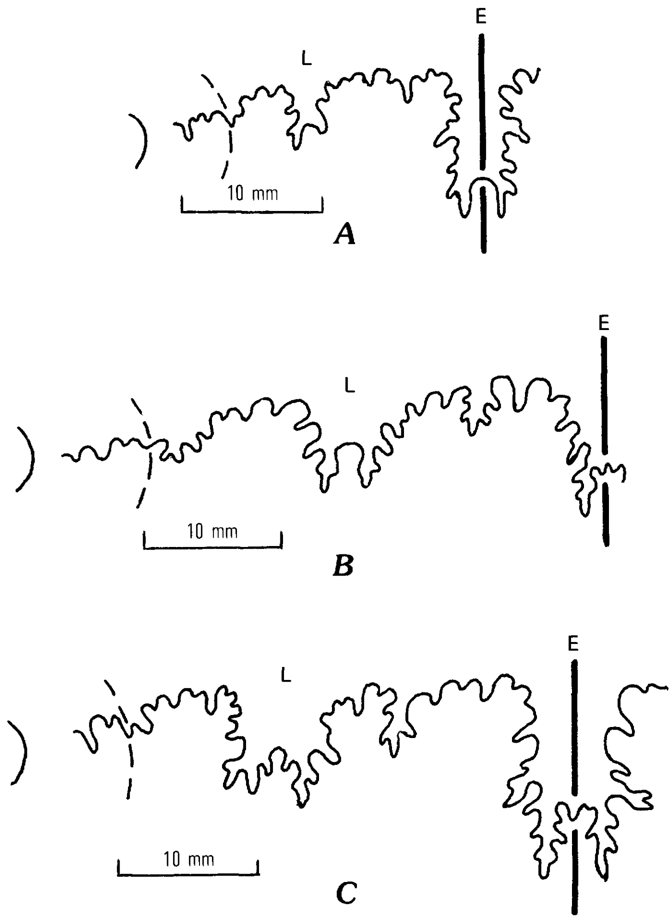


FIGURE 4.—External sutures of *Tarrantoceras sellardsi* (Adkins) from near the base of the Eagle Ford Group at USGS Mesozoic locality D12626 (fig. 2). *A*, Hypotype USNM 400771. *B*, Hypotype USNM 400772. *C*, Hypotype USNM 400760 (pl. 1, figs. 4–7).

Types.—Hypotypes USNM 400759–400772.

Tarrantoceras flexicostatum Cobban, n. sp.

Plate 2, figures 23–26; text figure 5

Diagnosis.—A medium-sized, very compressed, high-whorled species ornamented by closely spaced, narrow, flexuous ribs. Umbilical tubercles are conspicuous,

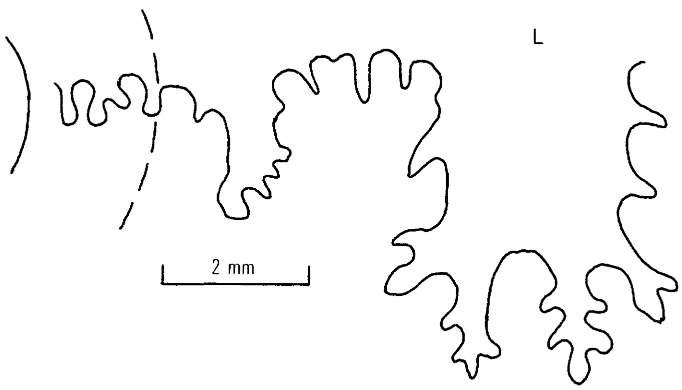


FIGURE 5.—Inner part of the seventh-from-last external suture at a diameter of about 31 mm of *Tarrantoceras flexicostatum* Cobban, n. sp., from the lower part of the Cody Shale at USGS Mesozoic locality 21850 in Big Horn County, Wyo. (fig. 1, loc. 6). Holotype USNM 400773 (pl. 2, figs. 25, 26).

whereas ventrolateral and siphonal tubercles are small and weak.

Description.—The holotype (pl. 2, figs. 25, 26) is a complete adult 80.8 mm in diameter with an umbilical width of 28.0 mm and an umbilical ratio of 0.35. Whorl is subrectangular in cross section, with the greatest width low on the flattened flank. The venter is narrow, flattened to rounded, and bordered to the aperture by small, clavate outer ventrolateral tubercles. A narrowly rounded umbilical shoulder merges evenly into a vertical umbilical wall. Inner whorls are crushed, whereas the body chamber, which occupies about three-fourths of a whorl, is undeformed. Ribs are numerous, flexuous, mostly prorsiradiate, and narrower than the interspaces. Longer or primary ribs rise singly or in pairs from nodate to bullate tubercles low on the umbilical shoulder. Shorter or secondary ribs arise at midflank or a little lower. Primary and secondary ribs tend to alternate, and all ribs curve forward a little on the ventrolateral shoulder to the position of the inner ventrolateral tubercle, where they straighten and cross the venter transversely. Forty-nine ribs are present on the last complete whorl. Faint inner ventrolateral tubercles disappear at the end of the phragmocone, but small, clavate outer ventrolateral tubercles and siphonal tubercles persist to the aperture. The shape of the aperture follows the form of the ribs. Only the inner part of the suture is visible; it has a broad, bifid lateral lobe (fig. 5) like that on most specimens of *Tarrantoceras sellardsi* (fig. 4).

The species is apparently dimorphic. A paratype has a diameter of only 60 mm (pl. 2, figs. 23, 24). Like the holotype, the body chamber is ornamented by numerous narrow, flexuous ribs that bear small outer ventrolateral and siphonal tubercles to the aperture. The younger half of the penultimate whorl is almost smooth, whereas it is well ribbed on the holotype.

Remarks.—*Tarrantoceras flexicostatum* differs from *T. sellardsi* chiefly in its more compressed whorls and in its more flexuous ribbing. *Eucalycoceras rowei* (Spath), as figured by Kennedy (1971, p. 83, pl. 49, figs. 2–7; pl. 50, figs. 3, 4a, b, 6a, b, 7a, b), resembles *T. flexicostatum* in its dense ribbing, some of which is flexuous, but the ribs on *E. rowei* do not curve forward on the ventrolateral shoulder, and the suture (Kennedy, 1971, pl. 49, figs. 4b, 6b) has the long, narrow lateral lobe typical of *Eucalycoceras.*

Occurrence.—The types are from silty limestone concretions in the lower part of the Cody Shale at USGS Mesozoic locality 21850 in the SE¼ sec. 9, T. 53 N., R. 92 W., Big Horn County, Wyo. (fig. 1, loc. 6). Associated fossils include *Inoceramus prefragilis stephensoni* Kauffman and Powell, *Dunveganoceras pondi* Haas, *Calycoceras canitaurinum* (Haas), *Metoicoceras praecox* Haas, and *Idiohamites* n. sp.

Tarrantoceras flexicostatum is an uncommon fossil. Some poorly preserved fragments from the base of the Greenhorn Formation in the Black Hills area of western South Dakota may represent this species (fig. 1, loc. 9).

Types.—Holotype USNM 400773, paratype USNM 400774.

Genus EUCALYCOCERAS Spath, 1923, p. 144

Type species.—*Ammonites pentagonus* Jukes-Browne (in Jukes-Browne and Hill, 1896, p. 156, pl. 5, figs. 1, 1a).

Diagnosis.—Medium-sized, generally compressed, somewhat evolute to somewhat involute ammonites that have, at most growth stages, flattened flanks and venter ornamented by dense tuberculate ribs that cross the venter transversely. Ribs tend to be alternately long and short. The long (primary) ribs originate from conspicuous tubercles located low on the umbilical shoulder or even projected into the umbilicus. At most growth stages, all ribs bear small inner and outer ventrolateral and siphonal tubercles. Ribs on the younger part of the body chamber may become flattened, have steep adoral faces and more sloping adapical faces, and lack all tubercles except the umbilical ones. Suture is characterized by a long, narrow lateral lobe and broad first lateral saddle (fig. 6).

Remarks.—According to Kennedy (1971, p. 81), the genus has its origin in a group of compressed middle Cenomanian *Calycoceras*. The few American specimens may be migrants from other regions.

Occurrence.—*Eucalycoceras* is widely distributed in rocks of middle to late Cenomanian age in Europe, Africa, Madagascar, North America, Japan, and India.

Eucalycoceras pentagonum (Jukes-Browne)

Plate 3; text figures 6, 7

1864. *Ammonites harpax* Stoliczka, p. 72 (*pars*), pl. 38, fig. 2, 2a.
1896. *Ammonites pentagonus* Jukes-Browne, in Jukes-Browne and Hill, p. 156, pl. 5, fig. 1, 1a.
1897. *Acanthoceras pentagonum* (Jukes-Browne). Kossmat, p. 14, pl. 4, fig. 3a–c.
1898. *Acanthoceras pentagonum* (Jukes-Browne and Hill). Choffat, p. 71, pl. 4, fig. 4a–c; pl. 6, figs. 3a, b, 4.
1907. *Acanthoceras pentagonum* (Jukes-Browne and Hill). Pervinquière, p. 271.
1923. *Eucalycoceras pentagonum* (Jukes-Browne). Spath, p. 144.
1925. *Acanthoceras pentagonum* (Jukes-Browne and Hill). Diener, p. 164.
1951. *Eucalycoceras pentagonum* (Jukes-Browne). Wright and Wright, p. 26.
1964. *Eucalycoceras pentagonum* (Jukes-Browne and Hill). Collignon, p. 138, pl. 370, figs. 1610, 1611.
1965. *Eucalycoceras* aff. *pentagonum* Jukes-Browne and Hill. Collignon, p. 12.
1970. *Eucalycoceras pentagonum* (Jukes-Browne). Il'in, p. 13, pl. 2, fig. 2a, b; pl. 3, fig. 1.
1971. *Eucalycoceras pentagonum* (Jukes-Browne). Kennedy, p. 81, pl. 48, figs. 1–6; pl. 49, fig. 1a–c.
1972. *Eucalycoceras* (*Eucalycoceras*) *pentagonum* (Jukes-Browne and Hill). Thomel, p. 83, pl. 28, figs. 1, 10.
1973. *Eucalycoceras pentagonum* (Jukes-Browne and Hill). Pop and Szász, p. 189, pl. 10, fig. 1a, b; pl. 11, fig. 1.
1975. *Eucalycoceras pentagonum* (Jukes-Browne). Matsumoto, p. 106, fig. 1a, b.
1976 [1978]. *Eucalycoceras pentagonum* (Jukes-Browne). Kennedy and Hancock, pl. 11, fig. 7a, b.
1981 [1983]. *Eucalycoceras pentagonum saharense* Collignon and Roman, p. 101, pl. 14, fig. 1a, b.

Diagnosis.—A large, compressed to stout species that has 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.

Description.—The species has been well described and illustrated by Kennedy (1971, p. 81) who 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 and Hill, 1896, p. 156) gave its diameter as 4 in. (102 mm). Kennedy noted that the holotype is moderately involute, that the whorl section of the phragmocone is compressed with flat sides and high, arched venter, and that the venter becomes 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 on two large specimens illustrated by Kennedy (1971, pl. 48, fig. 1b; 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).

A few incomplete specimens from the base of the Bridge Creek Member of the Greenhorn Limestone of

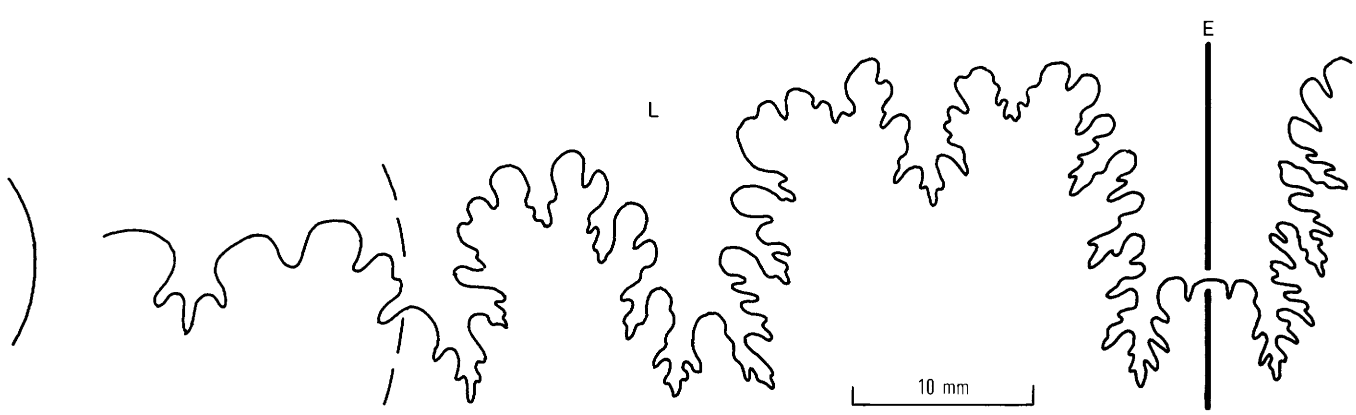


FIGURE 6.—Most of external suture of *Eucalycoceras pentagonum* (Jukes-Browne) at a diameter of about 80 mm from a phragmocone from bed C of the Cenomanian limestone at Whitlands along the Devon coast between Pinhay Bay and Humble Point, England. Hypotype USNM 400910. Specimen furnished by C.W. Wright and has his number 22430.

southeastern Colorado are probably referable to *Eucalycoceras pentagonum* (pl. 3, figs. 4, 5, 7, 8, 10–13). The Bridge Creek specimens have body chambers with broad, flattened ribs that have steep adoral faces and more sloping adapical ones. Conspicuous, clavate, nearly equal sized inner and outer ventrolateral tubercles and nodate siphonal tubercles are present on the older part of the body chambers. Primary ribs begin from bullate tubercles well down on the umbilical shoulder, and secondaries arise low on the flank. In most cases, long and short ribs alternate. Ventrolateral and siphonal tubercles weaken and disappear on the younger part of the body chamber, where the ribs become flattened and slablike. On one fragment, ribs become narrow and more closely spaced near the aperture (pl. 3, figs. 4, 5). The specimens from the Bridge Creek Member differ from the holotype in their smaller size and in their lack of conspicuous effaced ribbing at midflank. In their size and general appearance, the Greenhorn specimens resemble forms assigned to *E. pentagonum* by Il'in (1970, p. 13, pl. 2, fig. 2a, b; pl. 3, fig. 1) and by Collignon and Roman (1981, p. 101, pl. 14, fig. 1a, b).

Crushed fragments from a thin bed of calcarenitic limestone in the Greenhorn Formation in western South Dakota (fig. 1, loc. 8) are apparently referable to *E. pentagonum.* One of the larger specimens has effaced ribbing on the older part of the body chamber (pl. 3, fig. 6). Only part of the phragmocone is preserved, but it has a suture much like that of *E. pentagonum* (fig. 7*A*). Other fragments from this bed may represent microconchs of *E. pentagonum.* The younger parts of body chambers lack tubercles, and the ribs are flattened with steep adoral faces (pl. 3, fig. 9). Similar specimens occur at the base of the Bridge Creek Member of the Greenhorn Limestone in southeastern Colorado (pl. 3, figs. 7, 8). Small specimens from limestone concretions in the lower part of the Colorado Formation of southwestern New Mexico (fig. 1, loc. 61) may also be interpreted as microconchs (pl. 3, figs. 1–3). The last two septa of one specimen have an estimated diameter of 34.3 mm. Another specimen, which has an estimated diameter of 43 mm at the base of the body chamber, has flank ribbing effaced on the older part of the body chamber (pl. 3, fig. 3).

Occurrence.—The holotype of *Eucalycoceras pentagonum* came from the remanié phosphatic fauna of bed C of the Cenomanian limestone near Lyme Regis in Dorset, England (Kennedy, 1971, p. 81), from the *Calycoceras guerangeri* Zone of late Cenomanian age. The specimens compared to *E. pentagonum* from southeastern Colorado are from 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 (fig. 1,

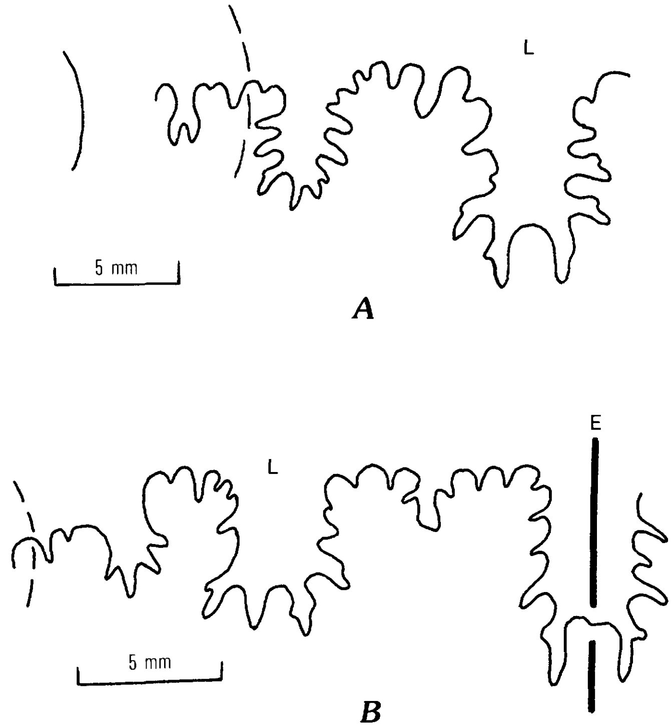


FIGURE 7.—External sutures of *Eucalycoceras pentagonum* (Jukes-Browne). *A*, Hypotype USNM 400778 (pl. 3, fig. 6) at a diameter of about 43 mm, from the Greenhorn Formation at USGS Mesozoic locality 23060 near Belle Fourche, S. Dak. (fig. 1, loc. 8). *B*, Hypotype USNM 400775 (pl. 3, figs. 1, 2) at a diameter of 32.3 mm, from the Bridge Creek Limestone Member of the Colorado Formation at USGS Mesozoic locality D11483 in the Cooke Range in southwestern New Mexico (fig. 1, loc. 61).

locs. 33, 34; Bass and others, 1947). A large collection of *Calycoceras naviculare* (Mantell) was described from this bed at this locality, as were specimens of *Moremanoceras scotti* (Moreman) and *Anisoceras plicatile* (J. Sowerby) (Cobban, 1971). Fragments of specimens referable to *E. pentagonum* from the Black Hills area came from the Greenhorn Formation at USGS Mesozoic locality 23060 (fig. 1, loc. 8). These fragments were not associated with other fossils. The specimens from southwestern New Mexico (fig. 1, loc. 61) were found with *Euomphaloceras* (*Euomphaloceras*) *euomphalum* (Sharpe), *Metoicoceras* sp., *Vascoceras diartianum* (d'Orbigny), and other small ammonites.

Types.—Hypotypes USNM 400775–400781, 400910.

Eucalycoceras templetonense Cobban, n. sp.

Plate 4; text figure 8

1975. *Eucalycoceras* sp. A. Hattin, Kansas Geological Survey Bulletin 209, pl. 2, figs. S–U.

Diagnosis.—A large, moderately robust species that has fairly sparse ribbing. Innermost whorls tend to have smooth or nearly smooth flanks.

Description.—The holotype (pl. 4, figs. 2–4) is a complete, uncrushed adult from the Templeton Member of the Woodbine Formation of north Texas. The specimen is 83 mm in diameter, the umbilical width is 25 mm, and the umbilical ratio is 0.30. Whorls are higher than wide with flattened flanks, narrow flattened to rounded venter, narrowly rounded umbilical shoulder, and vertical umbilical wall. The body chamber occupies three-fourths of a whorl. The parts of the inner whorls exposed are almost smooth except for small, closely spaced, nodate tubercles on the umbilical margin. Eighteen of these umbilical tubercles occur on the last whorl of the phragmocone and 12 are present on the three-fourths of a whorl of body chamber. Other ornament consists of primary and secondary ribs that have inner and outer ventrolateral and siphonal tubercles on all but the youngest part of the body chamber. Primary ribs originate singly or in pairs from the umbilical tubercles, and secondary ribs arise low on the flank. Most ribs alternate in length. On the last septate whorl, ribs are weak and prorsiradiate at first and then gradually become stronger, slightly flexuous, and rectiradiate. Each bears a weak, bullate inner ventrolateral tubercle; a much stronger, nodate outer ventrolateral tubercle that rises above and bounds the narrow, flat venter; and a weak, clavate siphonal tubercle. Ribs bend forward a little at the site of the inner ventrolateral tubercle and then cross the venter transversely. On the body chamber, ribs remain strong and, at midflank, they curve back to the position of the inner ventrolateral tubercle and then straighten slightly and cross the venter transversely. On the outer part of the flank and on the venter, the ribs become broad and flatten a little. There are 40 ribs on the last complete whorl. Inner ventrolateral tubercles disappear on the older part of the body chamber, and the outer and siphonal ones weaken and disappear about at the middle, where the venter becomes rounded. The aperture is normal. The suture has a deep, moderately narrow external lobe and a smaller, narrow, bifid lateral lobe (fig. 8). A much broader, asymmetrical saddle separates these lobes. In its general form and complexity, the suture is much like that of *E. pentagonum* (fig. 6).

Innermost whorls are best observed on a crushed paratype (pl. 4, fig. 10). At a diameter of 13.5 mm, the whorls are compressed with flat flanks, narrowly rounded umbilical shoulder, and vertical umbilical wall; the venter is not preserved. Ornament is absent except for conspicuous nodate tubercles low on the umbilical shoulder; these number eight per whorl.

Larger inner whorls can be seen on a phragmocone (pl. 4, figs. 5, 6) of 36 mm in diameter from almost the same locality. This specimen has an umbilical ratio of 0.33 and a whorl section slightly higher than wide, with

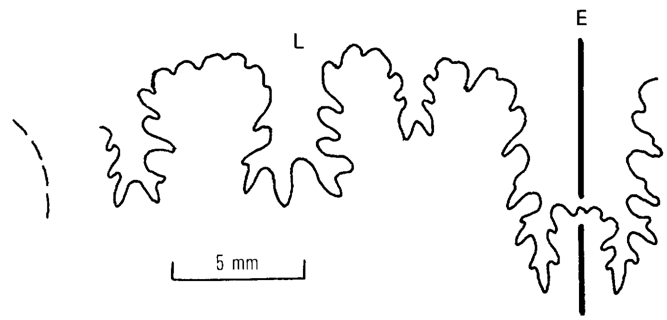


FIGURE 8.—Most of the fourth-from-last external suture at a diameter of about 40 mm of the holotype (USNM 400782) of *Eucalycoceras templetonense* Cobban, n. sp., from the Templeton Member of the Woodbine Formation at USGS Mesozoic locality 20314, along Templeton Branch of Cornelius Creek 2¾ mi north of Bells, Grayson County, Tex.

flat flanks and rounded venter. The ribs are straight, rectiradiate to prorsiradiate, number 31 per whorl, and cross the venter transversely. Umbilical tubercles are bullate to nodate and number 18 per whorl. Inner ventrolateral tubercles are nodate and somewhat smaller than the clavate outer ones. Siphonal clavi are smaller and lower than the outer ventrolateral ones on the older part of the outer whorl and about equal in size and height on the younger part.

The species attains a large size. Crushed specimens have diameters of 100–110 mm.

Remarks.—This form differs from other described species in its smooth-flanked inner whorls and in its thick ribs that cross the venter of the body chamber. A crushed fragment from eastern Wyoming (pl. 4, fig. 1) may have had spinose umbilical tubercles projected into the umbilicus like those of *E. gothicum* (Kossmat, 1895, p. 69, pl. 25, fig. 3a–c).

Occurrence.—The types are from silty limestone concretions 6.0–6.7 m (20–22 ft) above the base of the Templeton Member of the Woodbine Formation at USGS Mesozoic locality 20314 along Templeton Branch of Cornelius Creek 4.4 km (2¾ mi) north of the center of Bells, Grayson County, Tex. (Stephenson, 1952, p. 41, loc. 164; pl. 1, loc. 164). The holotype and a paratype (USNM 400788) were collected by Frank Crane, Fort Worth, Tex., who gave them to the late James P. Conlin of Fort Worth. Mr. Conlin kindly donated his remarkable collection of fossils to the U.S. Geological Survey. Stephenson described many molluscan fossils from the Templeton Branch locality and listed 29 species from there (Stephenson, 1952, locality 164 on unnumbered table in pocket). Ammonites described by Stephenson as *Mammites*? *bellsanus* and *Metoicoceras crassicostae* have their type localities here. Stephenson's *Mammites*? *bellsanus* is probably better assigned to *Plesiacanthoceras* owing to the resemblance of its phragmocone to that of *P. wyomingense* (Reagan). *Eucalycoceras templetonense* may also be present farther south in Dallas County, where a part of a body chamber (unfigured paratype 400911) that was at least 100 mm in diameter was found in the Six Flags Limestone Member of the Woodbine Formation of Norton (1965). This specimen, from the J.P. Conlin collections, has Conlin's catalog number 14988.

In the Western Interior region, crushed fragments of *E. templetonense* have been found in the Belle Fourche Shale on the west flank of the Black Hills uplift (fig. 1, loc. 11), in the Frontier Formation of east-central Wyoming (fig. 1, loc. 16) and south-central Wyoming (fig. 1, loc. 20), in the Lincoln Member of the Greenhorn Limestone of northeastern New Mexico (fig. 1, locs. 41, 42) and south-central Kansas (Hattin, 1975, pl. 2, figs. S–U), and in the lower part of the Mancos Shale in west-central New Mexico (fig. 1, loc. 43) and south-central New Mexico (fig. 1, loc. 48). *Inoceramus prefragilis* Stephenson is present at most of these localities. *Plesiacanthoceras wyomingense* (Reagan) occurs at locality 20 and *Dunveganoceras pondi* Haas at locality 11.

Types.—Holotype USNM 400782, paratypes USNM 400783–400788, 400911.

Genus PSEUDOCALYCOCERAS Thomel, 1969, p. 650

Type species.—By original designation, *Ammonites harpax* Stoliczka, 1864, p. 72 (part), pl. 39, fig. 1, 1a, 1b.

Diagnosis.—Stout, fairly evolute ammonites that have strong, thick ribs, which are usually conspicuously rursiradiate on the body chamber. Ribs generally alternate between long and short. Long ribs begin from strong, nodate tubercles or bullae low on the umbilical shoulder; shorter ones arise near midflank. All ribs cross the venter transversely, and all bear inner and outer ventrolateral and siphonal tubercles on the inner whorls and on the older part of the outer whorl. The suture is like that of *Eucalycoceras*. The scope of the genus has been treated in detail by Cobban and Scott (1972, p. 63). *Pseudocalycoceras* seems to have been derived from *Eucalycoceras*, from which it differs in its more robust shell, its sparser ribbing, and its conspicuous rursiradiate ribbing.

Remarks.—On the holotype of the type species, *Ammonites harpax* Stoliczka (1864, pl. 39, fig. 1, 1a, 1b), umbilical bullae on the younger part of the body chamber twist back initially and then curve forward before merging into ribs that bend forward on the lower and middle parts of the flank and finally bend back on the outer part of the flank. This results in a distinctive S shape for the ribs. Stoliczka's illustration is a good drawing, and Wright and Kennedy (1981, text fig. 14A, B) have recently shown good photographs of the type. Most American specimens of *Pseudocalycoceras* lack twisted umbilical bullae and have straighter ribs.

Occurrence.—The genus is known only from upper Cenomanian rocks. Wright and Kennedy (1981, p. 37) listed it from England, France, Spain, Romania, Syria, Israel, Madagascar, Angola, India, and the United States. In addition, the genus occurs in Tunisia and Japan.

Pseudocalycoceras angolaense (Spath)

Plate 5; plate 6, figures 1, 2, 13, 14, 18, 19; text figure 10

1920. *Acanthoceras rhotomagense* Brongniart. Taubenhaus, p. 12, pl. 1, fig. 3a, b.
1927. *Acanthoceras* sp. A. Moreman, p. 95, pl. 15, fig. 2.
1931. *Acanthoceras lyelli* (Deshayes) Leymerie. Douvillé, p. 31, pl. 1, fig. 1a, b; text fig. 1.
1931. *Protacanthoceras angolaense* Spath, p. 316.
1940. *Protacanthoceras angolaense* Spath. Basse, p. 448, pl. 6, fig. 3a, b.
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. 21.
1942. *Eucalycoceras lewisvillense* Moreman, p. 206, pl. 33, figs. 6, 7; text fig. 2n, u.
1959. *Eucalycoceras dentonense* Moreman. Matsumoto, p. 97, text fig. 51.
1959. *Eucalycoceras indianense* Moreman. Matsumoto, p. 98.
1962. *Protacanthoceras angolaense* Spath. Avnimelech and Shoresh, p. 531.
1963. *Eucalycoceras underwoodi* Powell, p. 315, pl. 31, fig. 17; text fig. 3e, g.
1969. *Pseudocalycoceras* (*Neocalycoceras*) *angolaense* (Spath). Thomel, p. 651.
1969. *Eucalycoceras* (*Proeucalycoceras*) *dentonense* Moreman. Thomel, p. 650.
1969. *Eucalycoceras* (*Proeucalycoceras*) *lewisvillense* Moreman. Thomel, p. 650.
1971. *"Protacanthoceras" angolaense* Spath. Kennedy, p. 115.
1972 [1973]. *Pseudocalycoceras dentonense* (Moreman). Cobban and Scott, p. 63, pl. 13, figs. 11–29; pl. 15, figs. 1–7, 10–13.
1972. *Pseudocalycoceras* (*Haugiceras*) *angolaense* (Spath). Thomel, p. 97.
1975. *Pseudocalycoceras* sp. aff. *P. dentonense* (Moreman). Matsumoto and Kawano, p. 13, pl. 1, fig. 1a–e; text fig. 3.
1975. *Pseudocalycoceras dentonense* (Moreman). Hattin, pl. 6, figs. F, G.
1976 [1978]. *Pseudocalycoceras angolaense* (Spath). Cooper, pl. 4, figs. i, j.
1977. *Pseudocalycoceras dentonense* (Moreman). Hattin, text fig. 5 (13).
1977. *Pseudocalycoceras dentonense* (Moreman). Kauffman, pl. 18, figs. 5, 6.
1978. *Pseudocalycoceras angolaense* (Spath). Cooper, p. 96, text figs. 4A–C, H–K, 6I, J, 10F, G, 14A, 18E, F, 19A, B, 23–25, 26F–K.
1978. *Pseudocalycoceras dentonense* (Moreman). Hattin and Siemers, text fig. 6 (13).
1981. *Pseudocalycoceras dentonense* (Moreman), Wright and Kennedy, p. 37, pl. 5, fig. 4a–c; pl. 6, figs. 3a–e, 6a, b, 7a, b; text figs. 15A, B, E–H, 19S, T.

Diagnosis.—A stout to moderately compressed, small to medium-sized, highly variable species that has straight to flexuous, usually rursiradiate ribs that have steeper adoral faces than adapical ones on the younger part of the body chambers. Outer ventrolateral tubercles are closer to the siphonal ones than to the inner ventrolateral ones.

Description.—The well-preserved specimen from the upper Cenomanian of Angola that was referred to *Acanthoceras lyelli* Leymerie by Douvillé (1931, p. 31, pl. 1, fig. 1a, b; text fig. 1) and then assigned to the new species *Protacanthoceras angolaense* by Spath (1931, p. 316) represents the sparsely ribbed, robust end of the variation series characteristic of this species. The specimen is a complete adult 75 mm in diameter with an umbilical width of 28 mm and an umbilical ratio of 0.37. Douvillé described the body chamber as having a circular section. Ribs on the body chamber are straight, slightly rursiradiate, barlike, but narrower than the interspaces; ribs are mostly long and number 12 on the last half whorl and 13 on the preceding half whorl. Longer ribs begin from umbilical tubercles, and all ribs cross the venter transversely as thickened ridges. Ribs on most of the outer whorl have small, nodate to clavate, inner ventrolateral tubercles and slightly larger, clavate outer ventrolateral and siphonal tubercles. Cooper (1978) illustrated several specimens that show the ornament on the inner whorls. Ribs are more numerous on some of these whorls, and they are flexuous on some whorls. The smallest whorls tend to be weakly ornamented or nearly smooth. The suture of *P. angolaense* has a broad, bifid first lateral saddle and a narrow, long, bifid lateral lobe (Douvillé, 1931, text fig. 1; Cooper, 1978, text fig. 25).

American specimens of *Pseudocalycoceras angolaense* are usually slenderer and more costate than the Douvillé's Angolan specimen. Cobban and Scott (1972, p. 63) combined as one variable species (*P. dentonense*) the forms described by Moreman (1942) as the new species *Eucalycoceras dentonense*, *E. indianense*, and *E. lewisvillense*. Larger collections now at hand and the investigations of Cooper (1978) reveal that all of Moreman's species can be referred to *P. angolaense.*

One of the best collections of *P. angolaense* is from limestone concretions in the Colorado Formation at USGS Mesozoic locality D11529 in southwestern New Mexico (fig. 1, loc. 54). Thirteen specimens are suitable for rib counts, which range from 10 to 20 per half whorl (fig. 9). Early whorls can be observed on several specimens. The innermost whorls of one specimen (pl. 5, figs. 8, 9) have ventral ornament at a diameter of only 3 mm. On some specimens, the outer ventrolateral tubercles appear first, but on others the inner and outer ventrolateral and siphonal tubercles arise together. Ventral ribs usually form a little later. One individual already had inner ventrolateral tubercles at a diameter of 5.5 mm, whereas the outer ones formed at 7.0 mm, the umbilical ones at 9.4 mm, and the siphonal tubercles and ventral ribs at 10.4 mm. As the shell enlarges, the ventral ribs and tubercles tend to occur in groups of three or four separated by smooth areas (pl. 5, figs. 3, 4, 12–15). 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 (pl. 5, figs. 10, 11, 16, 17) somewhat resembling *P. haugi* (Pervinquière, 1907, p. 270, pl. 14. fig. 1a, b) to finer and more densely ribbed forms (pl. 5, figs. 23, 24). The largest adult from southwest New

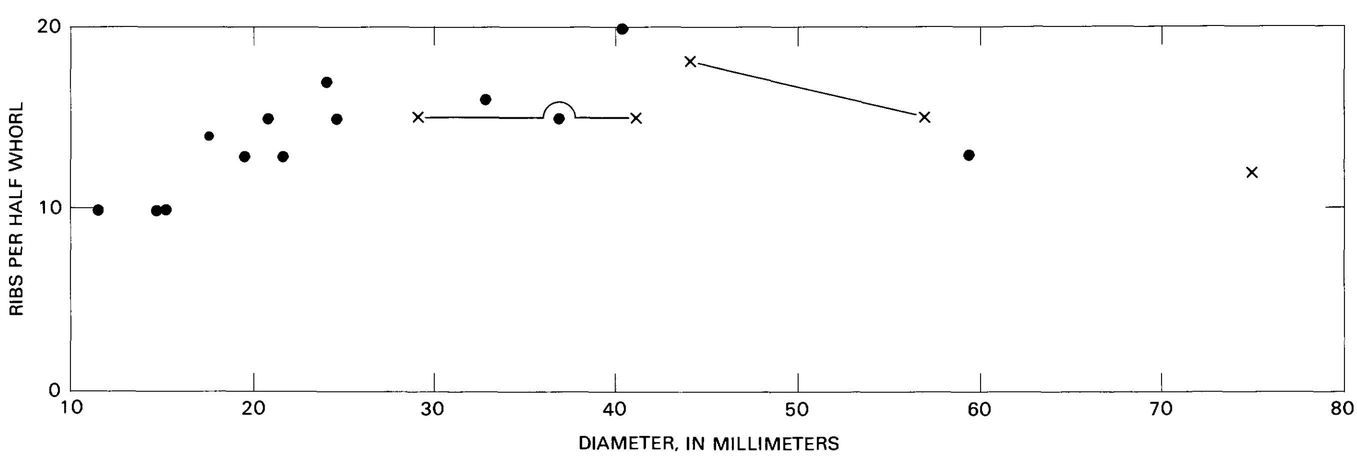


FIGURE 9.—Scatter diagram showing number of ribs per half whorl (.) of 13 specimens of *Pseudocalycoceras angolaense* (Spath) from a bed of limestone concretions in the Colorado Formation at USGS Mesozoic locality D11529 in southwestern New Mexico (fig. 1, loc. 54) as well as rib counts (X) on three examples of *P. angolaense* from Angola (Cooper, 1978, text figs. 23, 26). Lines connect counts on the same specimen.

Mexico has a diameter of 93.3 mm and an umbilical ratio of 0.32 (pl. 5, figs. 25–27). 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.

The suture (fig. 10) of specimens from southwestern New Mexico is fairly simple with broad, bifid E/L saddle, and narrower, bifid L. The holotype of *P. harpax* (Stoliczka, 1864, pl. 39, fig. 1, 1a, 1b), on which *Pseudocalycoceras* was based, has a little more digitate suture.

Pseudocalycoceras angolaense is dimorphic. Cobban and Scott (1972) illustrated several adults of different sizes. On all adults, ventrolateral and siphonal tubercles weaken and disappear on the younger part of the body chamber.

Occurrence.—In Angola, *Pseudocalycoceras angolaense* is associated with a varied ammonite fauna that includes *Calycoceras naviculare* (Mantell), *Euomphaloceras* (*Kanabiceras*) *septemseriatum* (Cragin), *Metoicoceras geslinianum* (d'Orbigny), and *Sciponoceras gracile* (Shumard). The same fossils are found with *P. angolaense* in southwestern New Mexico and in southeastern Colorado. In the Western Interior region, *P. angolaense* occurs in the basal part of the Bridge Creek Member of the Greenhorn Limestone in eastern Colorado, northeastern New Mexico, and southwestern Kansas; in the middle of the Hartland Member of the Greenhorn Limestone in central Kansas; in the Bridge Creek Limestone Beds in the lower part of the Mancos Shale in south-central New Mexico; in the Bridge Creek Limestone Member of the Colorado Formation in southwestern New Mexico; in the lower part of the Tropic Shale in southern Utah; and in the lower part of the Mancos Shale in northeastern Arizona. In northeastern Texas, *P. angolaense* occurs in the Britton Formation, and the species is found in the Boquillas Limestone in Terrell and Val Verde Counties in southwestern Texas. In Trans-Pecos Texas, *P. angolaense* was found in the lower part of the Chispa Summit Formation at Chispa Summit (fig. 1, loc. 66). Associated fossils include *Euomphaloceras* (*Kanabiceras*) *septemseriatum*, *Metoicoceras geslinianum*, *Sciponoceras gracile*, and *Worthoceras gibbosum* Moreman.

Types.—Hypotypes USNM 400789–400802.

Genus SUMITOMOCERAS Matsumoto, in Matsumoto and others, 1969, p. 280

Type species.—By original designation, *Sumitomoceras faustum* Matsumoto and Muramoto, in Matsumoto and others, 1969, p. 283, pl. 38, figs. 1–4; text fig. 8.

Diagnosis.—Small to moderate-sized, compressed, fairly evolute ammonites with long and short ribs that cross the venter transversely. Long ribs begin from umbilical tubercles; all ribs bear small inner and outer ventrolateral tubercles in most growth stages, but these disappear near the beginning of the adult body chamber. Weak siphonal tubercles are present on the earliest whorls. A few weak, shallow constrictions are present on the larger whorls. Sutures are like those of *Eucalycoceras* with long, narrow, bifid lateral lobes.

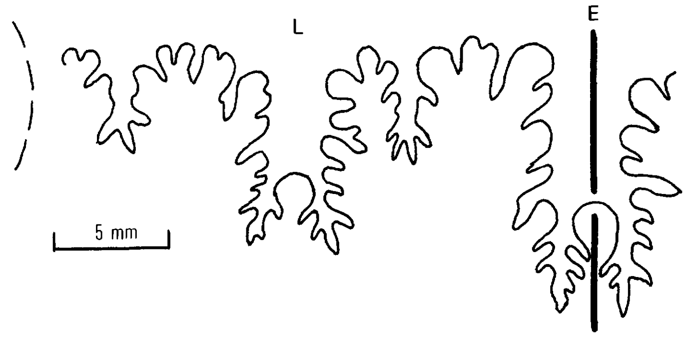


FIGURE 10.—External suture of *Pseudocalycoceras angolaense* (Spath) at a whorl height of 16.5 mm. Hypotype USNM 400792 from USGS Mesozoic locality D11529 (fig. 1, loc. 54) from the lower part of the Colorado Formation.

Remarks.—Cooper (1978, p. 93) considered *Sumitomoceras* to be a junior subjective synonym of *Tarrantoceras*. However, Wright and Kennedy (1981, p. 38) believed that enough differences were present to justify regarding *Sumitomoceras* as a subgenus of *Tarrantoceras*. The very early loss of siphonal tubercles, the presence of constrictions, and the *Eucalycoceras*-like suture easily distinguishes *Sumitomoceras* from *Tarrantoceras*; they are treated herein as separate genera.

Occurrence.—*Sumitomoceras* is known only from upper Cenomanian rocks of England, France, the United States, Japan, and possibly India. In the United States, the genus has been found in Texas, Colorado, and Arizona.

Sumitomoceras conlini Wright and Kennedy

Plate 7, figures 1–15, 26–28; text figure 11

1981. *Tarrantoceras* (*Sumitomoceras*) *conlini* Wright and Kennedy, p. 39, text fig. 16A.

Diagnosis.—A moderately large species that has whorls higher than wide with flattened flanks and numerous ribs.

Description.—The holotype (pl. 7, figs. 26–28) was described briefly by Wright and Kennedy (1981, p. 39), although no dimensions were given. The specimen is a well-preserved adult that consists of most of the body chamber and part of the phragmocone. Because the venter at the adoral end of the body chamber is missing, the diameter at that end of the specimen can only be estimated at 70 mm. Its umbilical width is 23.9 mm, and the umbilical ratio is 0.36. Whorls are much higher than wide with flattened flanks, well-rounded venter, narrowly rounded umbilical shoulder, and vertical umbilical wall; greatest width is at the umbilical shoulder. Ribs are mostly rectiradiate and cross the venter transversely. Long ribs arise singly or in pairs from sharp, nodate umbilical tubercles located well down on the umbilical shoulder or even projected slightly into the umbilicus. Shorter ribs arise at midflank or slightly lower. Ribs number 33 on the last half whorl of the phragmocone and 31 on half of a whorl of the body chamber. Each rib on the outer whorl of the phragmocone supports a small nodate inner ventrolateral tubercle and a similar-sized slightly clavate outer one. These tubercles weaken greatly on the older part of the body chamber, and the inner ones disappear there. The outer ones probably disappear on the younger part. Only part of the suture is visible, but it is much like that of a paratype of *Sumitomoceras faustum* Matsumoto and Muramoto (in Matsumoto and others, 1969, text fig. 8) in that the lateral lobe is long and narrow (fig. 11*B*).

Remarks.—*Sumitomoceras conlini* is an uncommon fossil. Most specimens are from southern Texas and southwestern New Mexico. The species seems to be dimorphic with the holotype representing the macroconch. The diameter at the base of the body chamber of the type is 46 mm. Microconchs are best represented by several specimens from southwestern New Mexico (pl. 7, figs. 5–8, 11–13). These have diameters at the base of the body chamber of less than 30 mm. At these small sizes, ventrolateral tubercles weaken and disappear on the older part of the body chamber.

Occurrence.—The holotype was collected by the late J.P. Conlin of Fort Worth, Tex., from the Britton Formation on the east bank of a creek 0.15 mi west of the old Britton-Midlothian road 4 km (2½ mi) south of Britton in Ellis County, Tex. Several specimens present in the collections of the U.S. Geological Survey are from the lower part of the Boquillas Limestone in Terrell and Val Verde Counties in southwest Texas (USGS D7443, D7466) and in Uvalde County farther east (USGS 15344). Associated ammonites include *Sciponoceras gracile* (Shumard), *Pseudocalycoceras angolaense* (Spath), and *Metoicoceras geslinianum* (d'Orbigny). In southwestern New Mexico, *S. conlini* occurs in limestone concretions in the Colorado Formation. The best locality (fig. 1, loc. 54) has a large variety of molluscan fossils that includes *Inoceramus pictus* J. de C. Sowerby, *Exogyra levis* Stephenson, *Sciponoceras gracile*

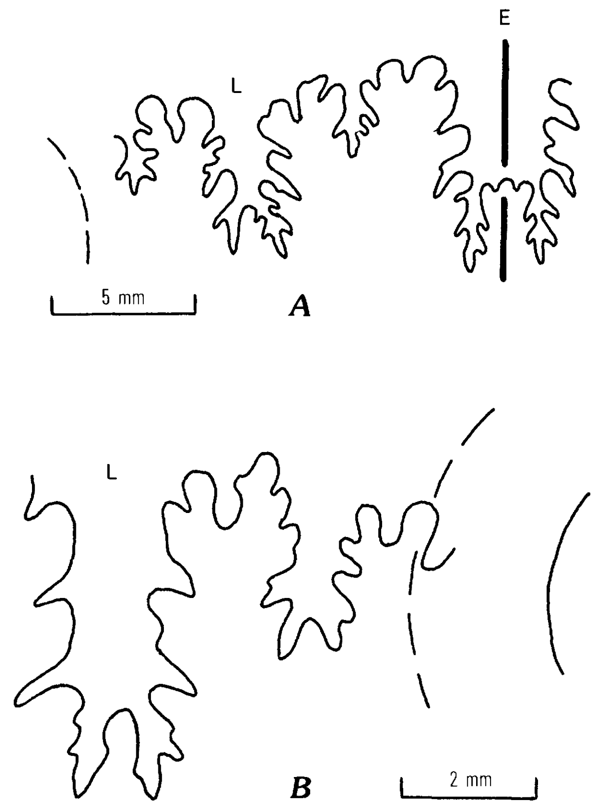


FIGURE 11.—External sutures of *Sumitomoceras conlini* Wright and Kennedy. *A*, Hypotype USNM 400807 (pl. 7, figs. 9, 10) at a whorl height of 11.5 mm, from the Bridge Creek Limestone Member of the Colorado Formation at USGS Mesozoic locality D10196 (fig. 1, loc. 60). *B*, Holotype USNM 400803 (pl. 7, figs. 26–28) at a diameter of 20 mm, from the Britton Formation 4 km (2½ mi) south of Britton, Ellis County, Tex.

(Shumard), *Worthoceras gibbosum* Moreman, *Euomphaloceras* (*Kanabiceras*) *septemseriatum* (Cragin), *Pseudocalycoceras dentonense* (Moreman), and *Metoicoceras geslinianum* (d'Orbigny). A few specimens of *S. conlini* have also been found in the lower part of the Bridge Creek Member of the Greenhorn Limestone in southeastern Colorado (fig. 1, locs. 28, 34).

Types.—Holotype USNM 400803, hypotypes USNM 400804–400809.

Sumitomoceras bentonianum (Cragin)

Plate 6, figures 3–12, 15–17; plate 7, figures 16–25; text figure 12

1893. *Pulchellia bentoniana* Cragin, p. 239.
1931. *Eucalycoceras bentonianum* (Cragin). Adkins, p. 63.
1932 [1933]. *Eucalycoceras bentonianum* (Cragin). Adkins, p. 408.
1942. *Eucalycoceras bentonianum* (Cragin). Moreman, p. 207, text fig. 2E.
1951. *Eucalycoceras bentonianum* (Cragin). Adkins and Lozo, pl. 6, figs. 9, 10.

1971. "*Eucalycoceras*" *bentonianum* (Cragin). Kennedy, p. 121.
1976 [1978]. *Eucalycoceras bentonianum* (Cragin). Young and Powell, fig. 2.
1978. *Tarrantoceras bentonianum* (Cragin). Cooper, p. 96.
1981. *Tarrantoceras (Sumitomoceras) bentonianum* (Cragin). Wright and Kennedy, p. 39.
1981. *Tarrantoceras* (*Tarrantoceras*) aff. *lilianense* (*sic*) Stephenson. Wright and Kennedy, p. 41, text fig. 15C, D.

Diagnosis.—A moderately evolute species that has whorls somewhat higher than wide with sharp, mostly rectiradiate ribs separated by wider interspaces.

Description.—The holotype (pl. 6, figs. 15-17) is almost half a whorl that appears to be about half living chamber and half phragmocone. Cragin (1893, p. 239) gave its diameter as about 57 mm. A plaster cast at hand has an umbilical ratio of 0.39. Inner whorls are not preserved. The half whorl has a subovate section with slightly flattened flanks, well-rounded venter, narrowly rounded umbilical shoulder, and steep umbilical wall. The greatest width is at the umbilical shoulder. Ribs, which number about 20 per half whorl, are rectiradiate, very narrow, sharp, and nearly straight. They are narrower than the interspaces and are both long and short. Long ribs begin from umbilical bullae or at the umbilical shoulder. Short ribs begin at midflank or lower. All ribs are highest where they cross the venter transversely. Ribs on the older end of the whorl have faint inner ventrolateral tubercles and stronger, nodate, outer ones. Siphonal tubercles are absent on the plaster cast and were not mentioned by Cragin. Moreman (1942, text fig. 2E) indicated the presence of siphonal tubercles in a cross-sectional drawing of the whorl, but this is probably an error.

Wright and Kennedy (1981, text fig. 15C, D) illustrated an interesting specimen assigned by them to *Tarrantoceras*. This specimen, from the Britton Formation in Ellis County, Tex., seems to me to be an aberrant form of *S. bentonianum*. The specimen consists of a complete adult body chamber 61.7 mm in diameter and most of the inner whorls. Umbilical width is 21.8 mm, and the umbilical ratio is 0.35. Diameter at the base of the body chamber is about 23 mm. All visible whorls are higher than wide with flattened flanks. Inner whorls have long and short ribs that are sparse, weak, and rectiradiate. The older half of the body chamber has strong, narrow, slightly flexuous, prorsiradiate ribs that are narrower than the interspaces. Long ribs begin from small, sharp bullae on the umbilical shoulder, and short ribs begin at midflank or lower. Most ribs have faint, bullate inner ventrolateral tubercles and larger, clavate outer ones. Ribs remain high and narrow where they cross the venter transversely. Ornament changes abruptly on the younger half of the body chamber. Here the ribs are flexuous, irregular in height, and nodeless; they are conspicuous only on the venter, where they are high, narrow, and flexed forward. The aperture is normal and follows the trend of the ribbing.

Several incomplete but well-preserved specimens have been found in southwestern New Mexico. One of the better specimens (pl. 6, figs. 3-5), from the Colorado Formation at USGS Mesozoic locality D6842 (fig. 1, loc. 57), has a diameter of 42 mm, an umbilical width of 14.5 mm, and an umbilical ratio of 0.35. The specimen consists of half a whorl of body chamber and most of the last septate whorl. The diameter at the base of the body chamber is 28.4 mm. Whorls are robust and about as high as they are wide with flattened flanks. The venter on the body chamber is high and arched. Ribs are strong, narrow, and rectiradiate to prorsiradiate. Most ribs are long and usually arise in pairs from pointed nodate umbilical tubercles. The few short ribs arise near midflank. Ribs are flexuous, bend forward a little on the ventrolateral shoulder, and arch forward upon crossing the venter. Ribs are flattened a little on the venter of the phragmocone but, on the venter of the body chamber, ribs become narrow or even sharp. Nodate inner and outer ventrolateral tubercles are conspicuous on the phragmocone. The outer ones weaken and disappear on the older part of the body chamber, whereas the inner ones disappear on some ribs and reappear on others. The complete external suture has a broad, bifid lateral saddle and long, narrow, bifid lateral lobe (fig. 12).

Occurrence.—The holotype came from "Hackberry creek, Dallas county, in clay-ironstone concretions of the Eagle Ford shales" (Cragin, 1893, p. 240). Rocks at this locality in northeastern Texas are now assigned to the Britton Formation. Cragin's locality may be the same as locality 11 or 15 of Moreman (1942, p. 197). In having sparse, thin ribs, *Sumitomoceras bentonianum* resembles *Calycoceras* (*Gentoniceras*) *leonense* (Adkins) from the older Tarrant Formation farther south in Texas. This may have led Young and Powell (1976,

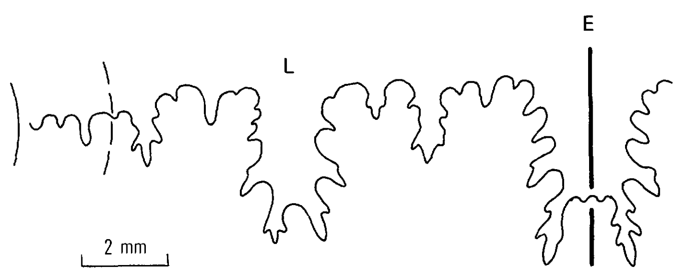


FIGURE 12.—Last external suture at a diameter of 28.6 mm of *Sumitomoceras bentonianum* (Cragin) from the Bridge Creek Limestone Member of the Colorado Formation at USGS Mesozoic locality D6842, Luna County, N. Mex. (fig. 1, loc. 57). Hypotype USNM 400810 (pl. 6, figs. 3-5).

p. XXV.15–XXV.23) to regard *S. bentonianum* (as *Eucalycoceras bentonianum*) as a guide to rocks of *C. leonense* age.

Specimens referable to *S. bentonianum* have been found at a few localities in the Western Interior region. The best localities are in southwestern New Mexico (fig. 1, locs. 57, 60), where the species occurs in limestone concretions in the lower part of the Colorado Formation. Associated fossils include *Sumitomoceras conlini, Euomphaloceras (Kanabiceras) septemseriatum*, and *Metoicoceras geslinianum*. In southeastern Colorado, *S. bentonianum* occurs sparsely in the lower part of the Bridge Creek Member of the Greenhorn Limestone (fig. 1, locs. 33, 35).

Types.—Hypotypes USNM 400810–400817.

Genus NEOCARDIOCERAS Spath, 1926, p. 81

Type species.—*Ammonites juddii* Barrois and de Guerne, 1878, p. 46, pl. 1, figs. 1a, b, 2a, b.

Diagnosis.—*Neocardioceras* is a fairly small, moderately evolute, generally compressed genus that usually has numerous rectiradiate to prorsiradiate, narrow ribs that bend forward at the ventrolateral shoulder and cross the venter as chevrons. Long ribs begin from umbilical tubercles or on the umbilical wall; short ribs begin farther out on the flank. All ribs support small inner and outer ventrolateral tubercles and siphonal clavi. The sutures of the European specimens have not been illustrated. American specimens have simple sutures with broad, bifid first lateral saddles and much smaller, shallow, bifid lateral lobes.

Remarks.—The cotypes of *Neocardioceras juddii* (Barrois and de Guerne, 1878, p. 46, pl. 1, figs. 1a, 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-Chevrières (Département de Ardennes, France).

Considerable confusion as to the scope of *Neocardioceras* followed the assignment of the Angolan ammonite *Prionotropis echinatus* Douvillé (1931, p. 34, pls. 3, 4) to *Neocardioceras* by Spath (1931, p. 316). The Angolan species is a typical *Euomphaloceras (Kanabiceras) septemseriatum* (Cragin), which is widely distributed in Texas and the Western Interior. Examples of the assignment of *E. septemseriatum* to *Neocardioceras* are Adkins (1932, p. 437), Moreman (1942, p. 213), and Cobban and Reeside (1952, p. 1017). Some specimens of *Kamerunoceras* were referred to *Neocardioceras* before that genus was established (Cobban and Reeside, 1952, p. 1018; Repenning and Page, 1956, p. 268).

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

Neocardioceras juddii (Barrois and de Guerne)

Plate 8; text figure 14

1875. *Ammonites neptuni* Geinitz, pl. 62, fig. 4a, b.
1878. *Ammonites juddii* Barrois and de Guerne, p. 46, pl. 1, figs. 1a, b, 2a, b.
1903. *Ammonites [Prionocyclus] neptuni* Geinitz. Jukes-Browne and Hill, p. 443, 449.
1926. *Neocardioceras juddi (sic)* (Barrois and Guerne). Spath, p. 81.
1927. *Gauthiericeras* aff. *bravaisi* (d'Orbigny). Moreman, p. 96, pl. 14, fig. 2.
1976 [1978]. *Neocardioceras juddi (sic)* (Barrois and Guerne). Kennedy and Hancock, p. V.17, pl. 15, fig. 2a, b, 6a, b only.
1981. *Neocardioceras juddii juddii* (Barrois and Guerne). Wright and Kennedy, p. 50, pl. 8, fig. 1a, b; pl. 9, figs. 4, 12–20; text fig. 19J, L.
1981. *Neocardioceras juddii* (Barrois and Guerne). Hook and Cobban, p. 9, pl. 1, figs. 6–8.

Diagnosis.—A variable species ranging from compressed forms with thin, fine ribs and sharp ventrolateral tubercles (*N. juddii juddii*) to more robust forms with fewer and more rounded ribs and blunter tubercles (*juddii barroisi*).

Description.—The cotypes of *Neocardioceras juddii*, which apparently were lost, were only 4 and 5 mm in diameter with umbilical ratios of 0.38 and 0.40, respectively (Barrois and de Guerne, 1878, p. 46, pl. 1, figs. 1a, b, 2a, b). Drawings of the specimens by Barrois indicate 18 to 23 ribs in half a whorl.

Wright and Kennedy (1981, p. 50) divided their English and French specimens of *N. juddii* into two groups—*N. juddii juddii* and *N. juddii barroisi* (n. subsp.). The eight examples of *N. juddii juddii* from England illustrated by Wright and Kennedy range in diameter from 13 to 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 and Kennedy's *N. juddii barroisi* differs from *N. juddii juddii* in having stouter whorls and broader and more rounded ribs that do not project as strongly where they cross the venter. Ribs are also fewer; the eight English specimens illustrated by Wright and Kennedy for which half-whorl rib counts can be made or estimated have counts that range from 14 to 22. The ammonite figured by Geinitz (1875, pl. 62, fig. 4a, b) as *Ammonites neptuni* and assigned to *N. juddii barroisi* by Wright and Kennedy combines the stoutness of that form with narrow and abundant ribs similar to those of *N. juddii juddii*.

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

The first 3½–4 whorls are very evolute and smooth, 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 have flattened 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 throughout ontogeny. On many specimens, single primary ribs arise from narrow, sharp umbilical bullae but, on 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 on the larger specimens and number 4–10 per half whorl. These tubercles are usually of irregular height (pl. 8, figs. 28, 36), but they may be more uniform and conspicuous on some individuals (pl. 8, fig. 25). 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 smaller nodate to clavate siphonal tubercle. Inner ventrolateral tubercles are nodate to bullate and usually of irregular height, with the larger ones located on the primary ribs. The body chamber occupies about half of a whorl (pl. 8, figs. 13, 33, 38). The largest adult has a diameter of 69 mm (pl. 8, figs. 37–39).

N. juddii is present in 11 fossil collections from southwestern New Mexico, and two collections have many specimens suitable for either rib and tubercule counts or determination of umbilical ratios. USGS Mesozoic locality D10533 (fig. 1, loc. 50) in the Big Burro Mountains has 28 specimens suitable for measurements, and USGS Mesozoic locality D10114 (fig. 1, loc. 59) in the Cooke Range has 17 measurable specimens. These measurements are shown on figure 13.

The suture of *N. juddii* is fairly simple (fig. 14). E is moderately wide and deep; the E/L saddle is broader than E and bifid; L is shallow and bifid and about half as wide as the E/L saddle; and the second lateral saddle is high, bifid and smaller than L.

Remarks.—Wright and Kennedy (1981, p. 119) listed the following ammonites that occur with *Neocardioceras juddii* in the *Neocardioceras* Pebble Bed in Devon, England: *Neocardioceras tenue* Wright and Kennedy, *Thomelites serotinus* Wright and Kennedy, *Thomasites* cf. *gongilensis lautus* (Barber), *Allocrioceras annulatum* (Shumard), and *Sciponoceras bohemicum anterius* Wright and Kennedy. At another locality in England (Haven Cliff), Wright and Kennedy also found *Spathites* (*Jeanrogericeras*) cf. *subconciliatus* (Choffat) and *Thomasites* cf. *rollandi* (Peron) with *N. juddii.*

In the United States, the ammonites associated with *N. juddii* represent other species. At Chispa Summit in Trans-Pecos Texas, *N. juddii* occurs with poorly preserved specimens of *Kamerunoceras* cf. *K. eschii* (Solger), *Thomelites* n. sp., *Pseudaspidoceras* sp., *Vascoceras* cf. *V. cauvini* Chudeau, and *V. silvanense* Choffat. In southwestern New Mexico, *N. juddii* is found with *Kamerunoceras* n. sp., *Pseudaspidoceras pseudonodosoides* (Choffat), *Vascoceras proprium* (Reyment), *Thomasites* sp., *Sciponoceras gracile* (Shumard), *Anisoceras plicatile* (J. Sowerby), and *Worthoceras vermiculus* (Shumard).

Occurrence.—Wright and Kennedy (1981, p. 49) recorded abundant *Neocardioceras juddii* from the *Neocardioceras* Pebble Bed at the base of the Middle Chalk along the Devon coast in southern England. These authors also recorded the species from France, Belgium, Germany, Czechoslovakia, and the United States. The American specimens are from Texas, New Mexico, Arizona, Colorado, Utah, and Montana. Texas records are based on crushed specimens in the Britton Formation in north Texas that were recorded as *Gauthiericeras* aff. *bravaisi* (d'Orbigny) by Moreman (1927, p. 96, pl. 14, fig. 2) and on uncrushed specimens in the collections of the U.S. Geological Survey from the lower part of the Chispa Summit Formation in Trans-Pecos Texas (fig. 1, loc. 67). New Mexico occurrences are in the southwestern part of the State, where the species is abundant near the top of the Bridge Creek Limestone Member of the Colorado Formation (Hook and Cobban, 1981, p. 8, 9, pl. 1, figs. 6–8). In Arizona, *N. juddii* is present in collections of the U.S. Geological Survey from the lower part of the Mancos Shale of the Black Mesa area (fig. 1, loc. 39) and from unnamed sandstone farther south in the Show Low area (fig. 1, loc. 40). Colorado occurrences are sparse. A few fragments have been found in a bed of limestone in the lower part of the Bridge Creek Member of the Greenhorn Limestone in the southeastern part of the State (fig. 1, locs. 29, 31, 32). In southern Utah, *N. juddii* occurs as impressions in the lower part of the Tropic Shale (fig. 1, locs. 36–38). Small specimens have been found in limestone concretions associated with a widespread bed of bentonite (bed M of Knechtel and Patterson, 1956, p. 21) in south-central and northwestern Montana (fig. 1, locs. 1–4).

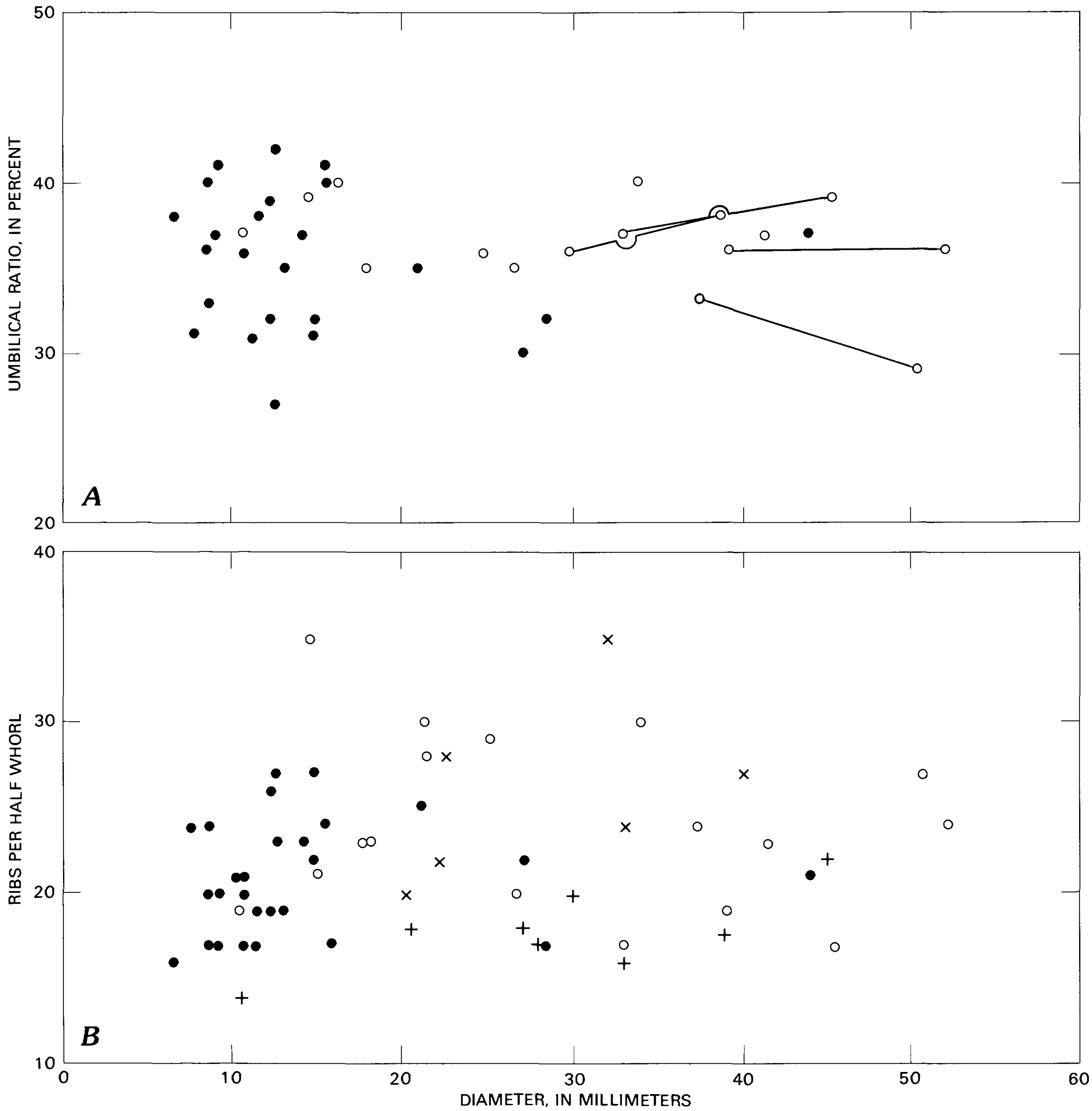


FIGURE 13.—Scatter diagrams of *Neocardioceras juddii* (Barrois and de Guerne) from USGS Mesozoic locality D10533 (closed circles) and USGS Mesozoic locality D10114 (open circles) plotted against diameter. Circles connected by lines represent measurements on a single specimen. *A*, Umbilical ratios in percentages. *B*, Number of ribs per half whorl of specimens of *N. juddii juddii* (x) and *N. juddii barroisi* (+) from England and France illustrated by Wright and Kennedy (1981, pl. 8, fig. 1b; pl. 9, figs. 1b, 2a, 4a, 5, 6, 9a, 10a, 12a, 14a, 16a, 17, 18, 19b).

Types.—Hypotypes USNM 307357, 356889, 400818-400831.

Neocardioceras densicostatum Cobban, n. sp.

Plate 9, figures 1-31

Diagnosis.—A densely ribbed species that has narrow, threadlike, flexuous ribs. Ventrolateral and siphonal tubercles are small and nodate and usually inconspicuous.

Description.—The type lot consists of flattened specimens from the Hartland Shale Member of the Greenhorn Limestone at USGS Mesozoic locality D7410 northwest of Denver, Colo. (fig. 1, loc. 27). At this locality, the strata are steeply inclined and the fossils are slightly distorted.

The holotype (pl. 9, fig. 23) is an adult 43.7 mm in

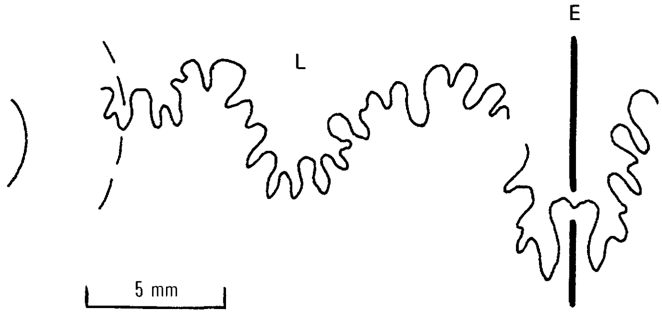


FIGURE 14.—External suture at a diameter of 28 mm of *Neocardioceras juddii* (Barrois and de Guerne) from the Colorado Formation at USGS Mesozoic locality D10533 (fig. 1, loc. 50). Hypotype USNM 400826 (pl. 8, figs. 23, 24).

diameter with an umbilical width of 13.2 mm and an umbilical ratio of 0.30. Only the lateral view of the specimen can be seen. Septa are not preserved and, accordingly, the diameter at the base of the body chamber could not be determined. All whorls down to a diameter of about 4 mm are densely ribbed. The ribs are narrow, prorsiradiate, and flexuous, and they number 75 on the last complete whorl. Long ribs begin singly or in pairs on the umbilical shoulder or from bullae on the shoulder. Long ribs are usually separated by a shorter rib that arises low on the flank. All ribs bend forward on the ventrolateral shoulder. Weak, nodate inner and outer ventrolateral tubercles are present on the older half of the outer whorl, but the inner ones weaken and disappear on the younger half. The aperture is normal and is preceded by a nearly smooth area that has a few closely spaced, faint ribs.

Details of the venter can be seen on some of the paratypes. Small, nodate siphonal tubercles seem to persist to the aperture (pl. 9, figs. 18, 20, 25, 27). Inner ventrolateral tubercles usually disappear on the last half whorl, but exceptions exist (pl. 9, figs. 18, 29). Both rows of ventrolateral tubercles disappear on some individuals (pl. 9, figs. 11, 28, 30).

Ribs per half whorl can be determined on 62 specimens in the type lot. Counts range from 19 to 48 and show great scatter (fig. 15).

The species is dimorphic. The smallest specimens on plate 9 are probably adults, and some a little larger (pl. 9, figs. 8, 18) are certainly adults. Fragments of much larger individuals (pl. 9, figs. 30, 31) indicate that the species attained diameters of at least 50 or 60 mm.

Remarks.—*Neocardioceras densicostatum* resembles *N. juddii* in its thin, flexuous ribs, but the sparser ribbing and persistence of tuberculation to the aperture of the latter separates the two species.

Occurrence.—The types are from the Hartland Shale

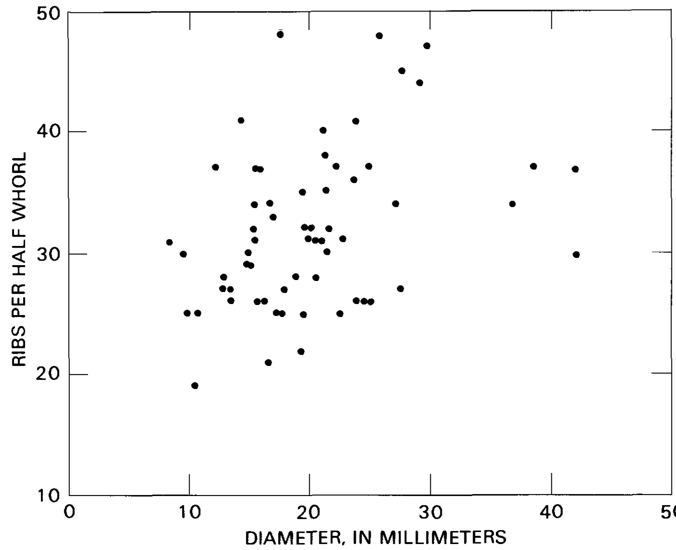


FIGURE 15.—Scatter diagram showing number of ribs per half whorl of *Neocardioceras densicostatum* Cobban, n. sp., from the Hartland Shale Member of the Greenhorn Limestone at USGS Mesozoic locality D7410 (fig. 1, loc. 27).

Member of the Greenhorn Limestone at USGS Mesozoic locality D7410 at Eldorado Springs, Colo. (fig. 1, loc. 27). Associated fossils include impressions of *Inoceramus* cf. *I. pictus* J. de C. Sowerby, *Worthoceras* sp., and *Anisoceras* sp.

Types.—Holotype USNM 400832, paratypes 400833-400862.

Neocardioceras uptonense Cobban, n. sp.

Plate 10, figures 36-70; text figure 17

1975. *Eucalycoceras* sp. B. Hattin, pl. 2, fig. K only.
1977. *Acanthoceras* group "B." Kauffman and Powell, p. 103, pl. 10, fig. 7 only.

Diagnosis.—A fairly small species characterized by effaced ribbing on the flank of the phragmocone and by conspicuous umbilical, ventrolateral, and siphonal tubercles.

Description.—The holotype (pl. 10, figs. 64-66) is a small adult 31.2 mm in diameter with an umbilical width of 9.5 mm and an umbilical ratio of 0.30. Intercostal whorl sections are a little higher than wide, with flat flanks and broadly rounded venter. The umbilicus has a narrowly rounded shoulder and vertical wall. Flanks on the phragmocone are smooth to faintly ribbed. The visible parts of the earliest whorls appear to be entirely smooth. Slightly bullate umbilical and nodate ventrolateral tubercles first appear near the beginning of the penultimate whorl at a diameter of about 6.5 mm. On the last complete whorl of the phragmocone, umbilical tubercles number 11 and ventrolateral tubercles number 22. Clavate siphonal tubercles are well developed on that whorl. On the younger half of that whorl, very prorsiradiate, weak ribs arise singly or in pairs from twisted, bullate umbilical tubercles or arise higher on the flank. All ribs rise into sharp, nodate inner ventrolateral tubercles and then bend forward and cross the venter as chevrons, where they support equal-sized nodate outer ventrolateral and clavate siphonal tubercles. The body chamber occupies about three-fourths of a whorl and has a diameter of 18.3 mm at its base. Ribs are more conspicuous on the body chamber and cross the entire flank. Umbilical tubercles are strong, closely spaced, nodate to bullate and are located on the shoulder. Bullate tubercles have flat, adoral faces. Inner ventrolateral tubercles are bullate on the body chamber and gradually weaken toward the aperture. Outer ventrolateral tubercles become clavate and, with the siphonal clavi, remain strong to the aperture. The last complete whorl of the holotype has 28 siphonal clavi.

The type lot is from a limestone concretion in the Belle Fourche Shale near Upton on the west flank of the Black Hills uplift in eastern Wyoming (fig. 1, loc. 12). Thirty-one specimens are suitable for measurements of diameter, umbilicus, and number of ribs per half whorl. The bulk of the specimens are 10–20 mm in diameter and have 9–16 ribs per half whorl (fig. 16). Diameters at the base of body chambers can be determined for 15 of the specimens. Although the holotype is the largest of these 15 specimens, fragments of 8 specimens exist that are as large as or larger than the type, which suggests that the species is dimorphic. Three of these specimens are shown (pl. 10, figs. 61–63). Diameters at the base of the body chambers of microconchs range from 10 to 16 mm, and those of macroconchs range from 18 mm to an estimated 25 mm. The holotype is a small macroconch.

Whorls less than 3 mm in diameter are smooth and have well-rounded venters and broadly rounded flanks. Nodate inner ventrolateral tubercles appear at some diameter between 3 and 4 mm. Siphonal clavi form by a diameter of 4 mm, and nodate umbilical tubercles arise between 5 and 6 mm. At a diameter of about 6 mm, flanks flatten, and ventral ribs and outer ventrolateral tubercles appear. On some individuals, ventral ornament occurs as groups of ribs and tubercles separated by smooth or weakly ornamented areas, and weak constrictions may separate some ribs. This condition may be present at diameters of as much as 10 or 11 mm (pl. 10, fig. 45). Umbilical, outer ventrolateral, and

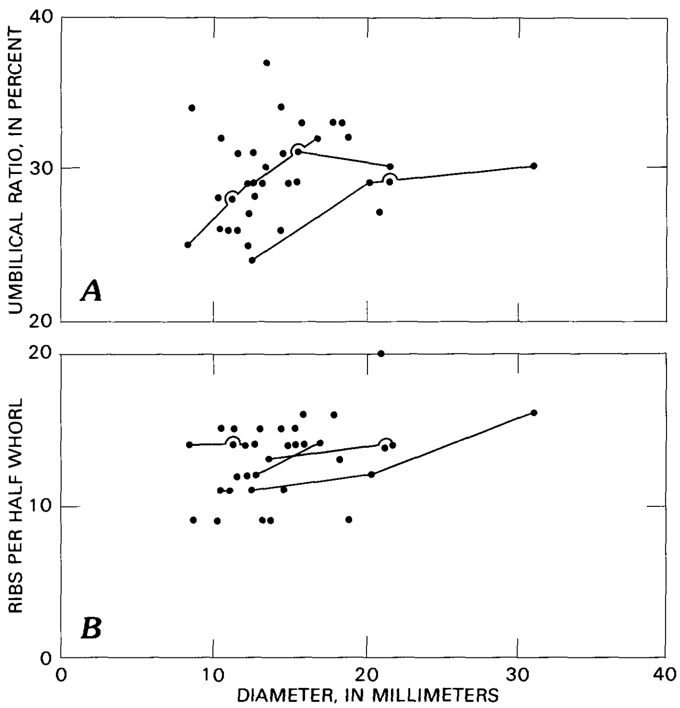


FIGURE 16.—Scatter diagrams of *Neocardioceras uptonense* Cobban, n. sp., from a concretion in the Belle Fourche Shale at USGS Mesozoic locality D5947 (fig. 1, loc. 12). *A*, Umbilical ratios. *B*, Ribs per half whorl. Lines connect measurements on single specimens.

siphonal tubercles usually persist to the aperture (pl. 10, fig. 57). Inner ventrolateral tubercles weaken on the body chamber and disappear near the aperture. Ventral ribbing is conspicuous on the body chamber and may be crowded at the adoral end (pl. 10, fig. 57). The aperture is normal and follows the form of the ribs. The suture is simple and characterized by a shallow, bifid lateral lobe (fig. 17).

Neocardioceras uptonense shows normal intraspecific variation of ammonites in that it ranges from compressed, finely ornamented specimens (pl. 10, figs. 48, 49) to robust, coarsely ornamented specimens (pl. 10, figs. 51–53). In addition, occasional specimens have ornament of irregular height (pl. 10, figs. 61, 67). A few large, crushed adults from the Benton Shale in north-central Colorado (fig. 1, loc. 25) reveal a loss of tuberculation on the younger part of the body chamber (pl. 10, figs. 68, 70).

Remarks.—*Neocardioceras uptonense* differs from *N. juddii* (Barrois and de Guerne) in its sparser ornament and in its effaced ribbing on the flank of the phragmocone. The effaced ribbing also distinguishes it from *N. tenue* Wright and Kennedy (1981, p. 50, pl. 8, figs. 2–6, 8).

Occurrence.—The types are from a limestone concretion in the Belle Fourche Shale at USGS Mesozoic

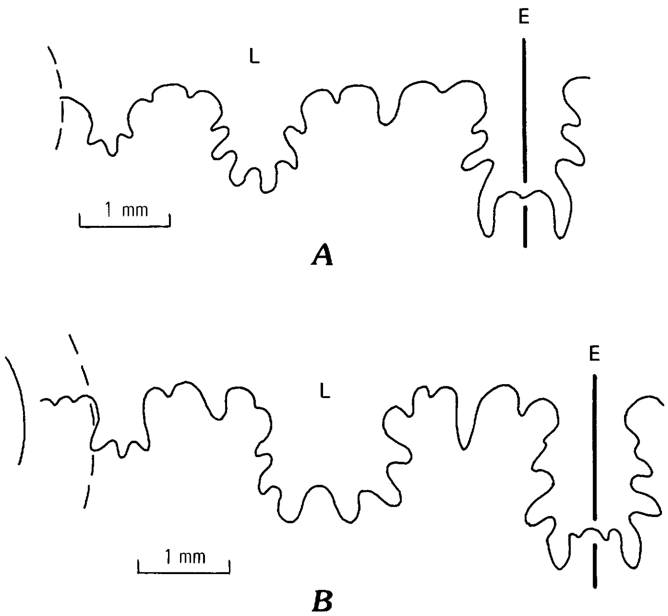


FIGURE 17.—External sutures of *Neocardioceras uptonense* Cobban, n. sp., from the Belle Fourche Shale at USGS Mesozoic locality D5947 (fig. 1, loc. 12). *A*, Paratype USNM 400876 at a diameter of 13 mm. *B*, Paratype USNM 400877 at a diameter of 12.4 mm.

locality D5947 near Upton in the NW¼ sec. 14, T. 47 N., R. 67 W., Weston County, Wyo. (fig. 1, loc. 12). Associated ammonites include *Moremanoceras* n. sp., *Metoicoceras* aff. *M. latoventer* Stephenson, *Borissiakoceras* aff. *B. orbiculatum* Stephenson, *Hamites simplex* d'Orbigny, and *Allocrioceras* sp. The collection is from 6.4 m (21 ft) above a 3.6-m-thick unit of shale that contains *Dunveganoceras pondi* Haas. A few fragments of *Neocardioceras uptonense* have been found in the Frontier Formation farther southwest near Casper, Wyo. (fig. 1, loc. 18), where they were found with a late form of *Calycoceras canitaurinum* (Haas), *Dunveganoceras problematicum* Cobban, and *Metoicoceras frontierense* Cobban. Specimens of *N. uptonense* also occur in the Frontier Formation farther north in Wyoming (fig. 1, loc. 15).

Neocardioceras uptonense occurs in the middle of the Lincoln Member of the Greenhorn Limestone in central Kansas (Hattin, 1975, pl. 2, fig. K) and near the base of the Hartland Shale Member in western Oklahoma (Kauffman and Powell, 1977, p. 103, pl. 10, fig. 7). The species also occurs in the Lincoln Member in the Pueblo area in southeastern Colorado (fig. 1, loc. 30) where it is associated with *Inoceramus prefragilis* Stephenson and *Calycoceras canitaurinum* (Haas). Impressions of *N. uptonense* are abundant in the Benton Shale 60–64 m (196–211 ft) below the base of the Juana Lopez Member in the Middle Park area in north-central Colorado (fig. 1, locs. 21, 22, 25, 26). Some of these impressions are shown on plate 10.

Types.—Holotype USNM 400863, paratypes USNM 400864–400888.

Neocardioceras laevigatum Cobban, n. sp.

Plate 9, figures 32–38; text figure 18

Name.—Latin *levigatus*, smooth, slippery; in reference to the smooth, polished appearance of the holotype.

Diagnosis.—A moderately involute, compressed form that has smooth or faintly ribbed flanks.

Description.—The holotype (pl. 9, figs. 35, 36) is an adult that consists of the uncrushed phragmocone and the older part of the crushed body chamber. The specimen has a diameter of 25.1 mm, an umbilical width of 5.5 mm, and an umbilical ratio of 0.22. The diameter at the base of the body chamber is 20.4 mm. Whorls are much higher than wide with the greatest width at the narrowly rounded umbilical shoulder. Flanks are flattened, and the narrow venter is rounded. Ornament on the last complete whorl of the phragmocone consists of eight conspicuous, nodate tubercles low on the umbilical shoulder; equal-sized, nodate to slightly clavate outer ventrolateral and siphonal tubercles located on low, chevronlike ventral ribs; a few flexuous striae of irregular strength; and, on the older half of the whorl, a few small, widely spaced, nodate inner ventrolateral tubercles. On the older part of the whorl, the outer ventrolateral and siphonal tubercles are in groups of twos or threes separated by smooth areas on the venter (pl. 9, fig. 36). Ornament on the preserved part of the body chamber consists of faint, closely spaced, flexuous ribs, and small, nodate, closely spaced inner ventrolateral tubercles. The venter on the body chamber is not preserved. The last two septa are approximated. The suture is characterized by a broad, shallow, bifid lateral lobe (fig. 18).

Remarks.—*Neocardioceras laevigatum* is a rare ammonite from the Black Hills area. The holotype was the only representative of this species in the concretion that produced the type lot of *N. uptonense*. In other areas, *N. laevigatum* is more common (pl. 9, fig. 38).

In its smooth or nearly smooth flanks, the subspecies resembles impressions of small ammonites from Oklahoma and Kansas referred to *Acanthoceras* group "B" by Kauffman and Powell (1977, p. 103, pl. 10, fig. 2 only) and to *Eucalycoceras* sp. B by Hattin (1975, pl. 2, fig. L only). However, specimens of *N. laevigatum* from the Black Hills and Colorado are more involute than are the ammonites from Oklahoma and Kansas.

Occurrence.—The holotype is from a limestone concretion in the Belle Fourche Shale 4.8 km (3 mi) south

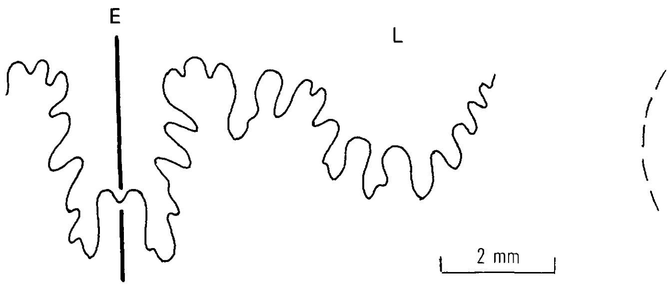


FIGURE 18.—Part of the third-from-last external suture of the holotype of *Neocardioceras laevigatum* Cobban, n. sp., at a diameter of 18.7 mm, from the Belle Fourche Shale near Upton, Wyo. (fig. 1, loc. 12). USNM 400889 (pl. 9, figs. 35, 36).

of Upton, Wyo., at USGS Mesozoic locality D5947 (fig. 1, loc. 12). Associated ammonites included *Neocardioceras uptonense, Metoicoceras* aff. *M. latoventer* Stephenson, *Moremanoceras* n. sp., *Borissiakoceras* aff. *B. orbiculatum* Stephenson, *Hamites simplex* d'Orbigny, and *Allocrioceras* sp. Parts of two specimens were found at another locality on the west flank of the Black Hills uplift (fig. 1, loc. 10). Impressions of *N. laevigatum* occur in the Benton Shale at several localities in the Middle Park area of north-central Colorado (fig. 1, locs. 23–25).

Types.—Holotype USNM 400889, paratypes USNM 400890–400893.

Neocardioceras minutum Cobban, n. sp.

Plate 10, figures 1-35; text figure 20

1984. *Neocardioceras* spp. Cobban, p. 19, pl. 4, figs. 3, 5.

Diagnosis.—A small, compressed, rather densely ribbed species that has ribs usually effaced on the middle of the flanks of the phragmocone.

Description.—The type lot, from a limestone concretion in the Greenhorn Formation at USGS Mesozoic locality D4462 near Upton, Wyo. (fig. 1, loc. 10), consists of 10 small, well-preserved specimens. The holotype (pl. 10, figs. 1, 2) is a complete adult 13.7 mm in diameter with an umbilicus of 3.4 mm and an umbilical ratio of 0.25. The whorl section is rectangular, higher than wide, with flat flanks, a broadly rounded to flattened venter, and a narrowly rounded umbilical shoulder. Considerable shell material is preserved on the specimen. The body chamber probably occupies the last two-thirds or three-fourths of the outer whorl. Ribs on the outer whorl number 32 and cross the venter as chevrons. Long ribs begin singly or in pairs from conspicuous bullae located on the umbilical shoulder. Short ribs arise at midflank. All ribs are greatly reduced at midflank, and all bend forward on the ventrolateral shoulder. Umbilical bullae number 14 on the last complete whorl, and each is twisted backward a little. On the older part of this whorl, nodate to bullate inner ventrolateral tubercles are about equal in size to nodate to clavate outer ones, but, on the younger part of the whorl, the inner ones weaken and disappear. The outer ventrolateral tubercles weaken and become elongated following the trend of the ribs and, near the aperture, the tubercles bound the narrow, flattened venter. Slightly smaller, nodate to somewhat clavate siphonal tubercles persist to the aperture. A faintly sinuous lateral outline and a conspicuous ventral lappet characterize the aperture.

A specimen 7.4 mm in diameter (paratype USNM 400907) was taken apart to observe the early whorls. Its first two or three whorls are wider than high with broad, rounded venter that merges evenly into rounded flanks. By a diameter of 4 mm, the whorl section has become squared with flattened flanks and slightly flattened venter. Other specimens show an increase in height over width as the shells enlarge beyond 4 mm in diameter.

The specimens of *Neocardioceras minutum* in the type lot are all small. Most have diameters of 6.6–7.8 mm at the base of the body chambers. The species ranges from compressed, rather densely and finely ornamented forms (such as the holotype) to forms that are more evolute, more robust, and more coarsely and sparsely ornamented (pl. 10, figs. 5–7, 32–35). Even within the compressed forms, rib density varies (fig. 19). One specimen (pl. 10, figs. 26, 27) has 27 ribs per half whorl in contrast to 18 at a comparable diameter on the holotype. Similar-sized robust forms have 11 to 15 ribs per half whorl.

Sutures are not visible on the holotype. A paratype (pl. 10, figs. 8, 9) has a simple pattern with a moderately broad, shallow lateral lobe (fig. 20).

Remarks.—*Neocardioceras minutum* was derived from *N. uptonense* by a reduction in size and by an increase in rib density. In addition, *N. minutum* shows a greater degree of variation. Some flattened specimens from Colorado (fig. 1, loc. 23) are larger than the types from the Black Hills and may be macroconchs (pl. 10, fig. 28).

Occurrence.—The type lot is from a limestone concretion in the concretionary facies of the Greenhorn Formation (Robinson and others, 1964, p. 62) on the west side of the Black Hills uplift near Upton, Wyo., at USGS Mesozoic locality D4462 (fig. 1, loc. 10). Associated ammonites include *Metoicoceras* aff. *M. latoventer* Stephenson, *Borissiakoceras* aff. *B. orbiculatum* Stephenson, and *Allocrioceras* sp. The specimens of *Metoicoceras* are slenderer than those occurring with *Neocardioceras uptonense. Neocardioceras minutum* also has been found in a ferruginous concretion at

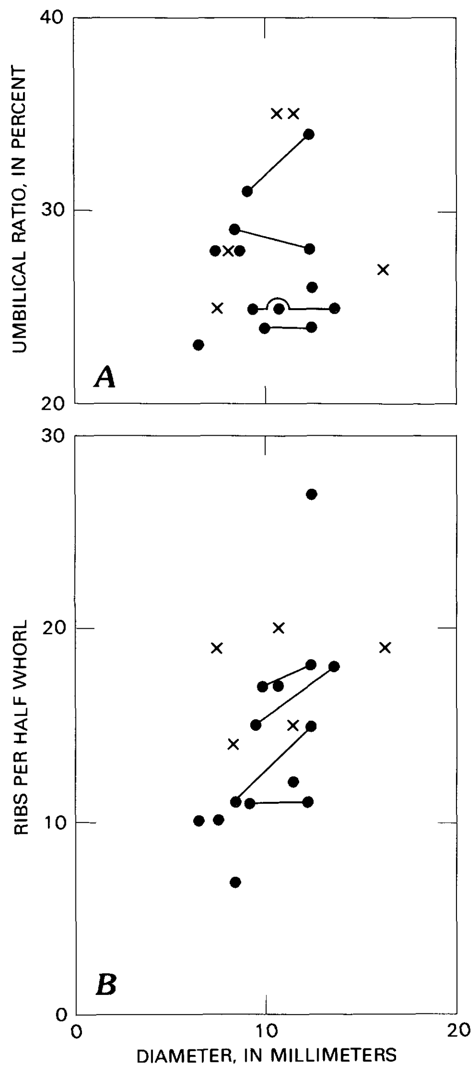


FIGURE 19.—Scatter diagrams of *Neocardioceras minutum* Cobban, n. sp., from the Greenhorn Formation at USGS Mesozoic localities D4462 (.) and 12740 (x). *A*, Umbilical ratios. *B*, Ribs per half whorl. Lines connect measurements on single specimens.

roughly the same stratigraphic level at a nearby locality (fig. 1, loc. 13). A little farther southeast, specimens were found in the lower part of the Greenhorn Formation in a borehole in the Osage oilfield (Cobban, 1984, p. 19, pl. 4, figs. 3, 5). On the northern flank of the Black Hills uplift, *N. minutum* was recorded from the Greenhorn Formation as "Ammonite, n. gen., sp. B" (Robinson and others, 1964, p. 63, loc. 12740). In north-central Colorado, *N. minutum* has been found as impressions in shale in the Benton Shale in the Middle Park area (fig. 1, loc. 23). Two small fragments that are probably *N. minutum* were found in the Frontier Formation in east-central Wyoming (fig. 1, loc. 17).

Types.—Holotype USNM 400894, paratypes 400895–400908.

Neocardioceras sp.

Plate 10, figures 71, 72; text figure 21

A phragmocone from the Frontier Formation of north-central Wyoming (fig. 1, loc. 14) reveals the presence of a large species of *Neocardioceras* in the upper part of the zone of *Metoicoceras mosbyense* (subzone of *Dunveganoceras conditum*). The specimen has a diameter of 45.5 mm, an umbilical width of 13.3 mm, and an umbilical ratio of 0.29. A bit of attached body chamber indicates that the diameter is also that of the base of the body chamber. The whorl section is rectangular and higher than wide with flattened flanks and venter. Ribs on the outer whorl are narrow, straight, and prorsiradiate; they tend to alternate in length and number 19 on the last half whorl. Ribs bend forward on the ventrolateral shoulder and cross the venter as chevrons. Long ribs begin from inconspicuous umbilical bullae. All ribs bear nodate inner and outer ventrolateral tubercles. Siphonal tubercles are small and clavate. Only part of the sutures are visible (fig. 21); they have a broad first lateral saddle and a narrower

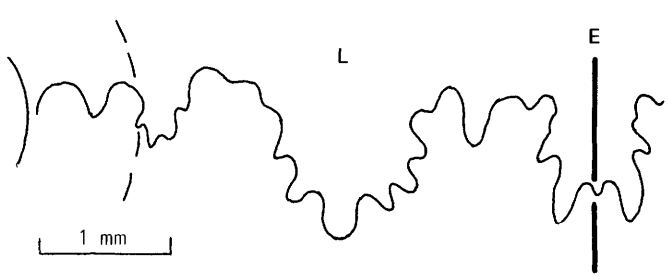


FIGURE 20.—Last external suture at a diameter of 7.3 mm of *Neocardioceras minutum* Cobban, n. sp., from the Greenhorn Formation at USGS Mesozoic locality D4462 near Upton, Wyo. (fig. 1, loc. 10). Paratype, USNM 400897.

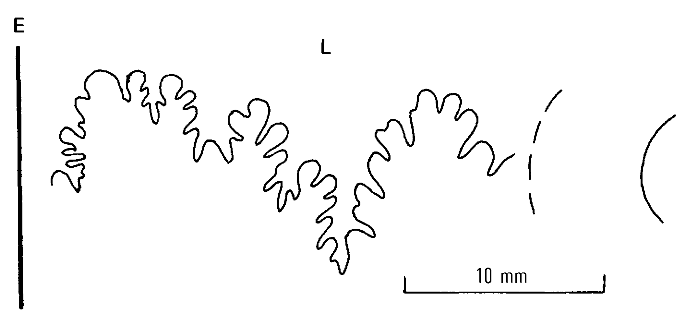


FIGURE 21.—Part of the second-from-last external suture at a diameter of 42 mm of *Neocardioceras* sp., from the Frontier Formation at USGS Mesozoic locality D6962 (fig. 1, loc. 14). Figured specimen USNM 400909 (pl. 10, figs. 71, 72).

bifid lateral lobe in which one branch is much longer than the other.

Remarks.—This specimen is the size of large individuals of *N. juddii* from southwestern New Mexico. However, the Wyoming specimen differs in its more robust shell and in its sparser ribbing.

Type.—Figured specimen USNM 400909.

ZONATION OF CENOMANIAN AMMONITES IN THE WESTERN INTERIOR

The sequence of ammonites of Cenomanian Age in the Western Interior of the United States has been recently summarized (Cobban, 1984), and newer data have been added (Cobban, in press). Zones and subzones now recognized are shown in table 2, which also shows the zonal position of the ammonites treated in this report.

At all localities where *Tarrantoceras sellardsi* occurs, *Acanthoceras amphibolum* is present. However, the younger part of the zone of *A. amphibolum* (subzone of *A. amphibolum fallense*) has not yielded any specimens of *T. sellardsi. Tarrantoceras flexicostatum* may be restricted to the zone of *Dunveganoceras pondi*, but specimens of *T. flexicostatum* are too few to establish this with certainty.

Eucalycoceras pentagonum is present throughout the zone of *Sciponoceras gracile*. The oldest specimens occur in the subzone of *Vascoceras diartianum* in southwestern New Mexico (fig. 1, loc. 61), and the youngest in the subzone of *Euomphaloceras* (*Kanabiceras*) *septemseriatum* in Colorado and South Dakota (fig. 1, locs. 8, 34). *Eucalycoceras templetonense* is found in Wyoming in the zones of *Plesiacanthoceras wyomingense* (fig. 1, loc. 20) and *Dunveganoceras pondi* (fig. 1, loc. 11).

Pseudocalycoceras angolaense seems to be confined to the upper part of the *Sciponoceras gracile* zone (subzone of *Euomphaloceras septemseriatum*). All specimens of *Sumitomoceras conlini* and *S. bentonianum* collected to date are from this subzone.

The types of *Neocardioceras uptonense* and *N. laevigatum* are from the zone of *Dunveganoceras pondi*, but these species of *Neocardioceras* range as high as the zone of *D. problematicum* in Wyoming (fig. 1, loc. 18). *Neocardioceras minutum* occurs still higher in Wyoming (fig. 1, loc. 17), probably in the lower part of the zone of *Metoicoceras mosbyense. Neocardioceras densicostatum* is probably from high in the zone of *M. mosbyense* because of its occurrence high in the Hartland Member of the Greenhorn Limestone.

ORIGIN OF *TARRANTOCERAS* AND RELATED GENERA

The oldest of the species treated herein, *Tarrantoceras sellardsi*, was probably derived from the slightly older ammonite described by Adkins (1928, p. 240, pl. 28, fig. 1; pl. 29, fig. 3) as *Eucalycoceras leonense*. Adkins' species is a robust, round-whorled form that seems best assigned to *Calycoceras* (Cobban and Scott, 1972, p. 60) and even to the subgenus *C.* (*Gentoniceras*) (Cobban, in press). *Calycoceras leonense* is similar to *T. sellardsi* in its size, umbilical ratio, suture, and ornament of conspicuous ribs and umbilical, inner and outer ventrolateral, and siphonal tubercles. The main difference between them is in the compressed whorls of *T. sellardsi*, with its denser and more flexuous ribbing. *Tarrantoceras flexicostatum* was apparently derived from *T. sellardsi* through further compression of the whorls and probably through a slight increase in rib density.

Eucalycoceras templetonense may be a migrant from outside North America. The species appears abruptly in the zone of *Plesiacanthoceras wyomingense* and ranges up into the zone of *Dunveganoceras pondi. Eucalycoceras* has not been found in the overlying zones of *Dunveganoceras problematicum* and *Metoicoceras mosbyense*, but the genus appears again as *E. pentagonum* in the zone of *Sciponoceras gracile*. No records of the genus are present in younger rocks.

American specimens of *Pseudocalycoceras angolaense* seem to be derived from American specimens of *Eucalycoceras pentagonum* by a change to sparser and rursiradiate ribbing. In addition, the ventral ornament on the early whorls changed from the uniform ribs and tubercles of *E. pentagonum* (Kennedy, 1971, pl. 48, figs. 4a, b) to one of ornamented areas separated by smooth areas (pl. 5, figs. 14, 15). *Pseudocalycoceras angolaense* is known only from the zone of *Sciponoceras gracile* and has no known descendents.

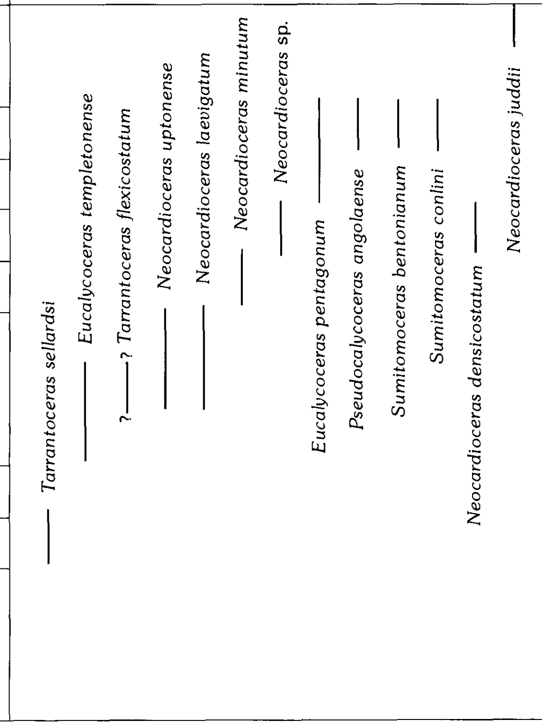
Sumitomoceras has been found only in the upper part of the zone of *Sciponoceras gracile* and has no known descendents. The genus may have been derived from an early form of *Eucalycoceras pentagonum* in the subzone of *Vascoceras diartianum* through early loss of siphonal tubercles.

Neocardioceras first appeared abruptly in the zone of *Dunveganoceras pondi*. The genus was probably derived from *Tarrantoceras* through a change in the ventral ribbing from a transverse style to one of forwardly inclined chevrons. *Neocardioceras uptonense*, the oldest species, ranges through the zones of *Dunveganoceras pondi* and *D. problematicum. Neocardioceras minutum*, which occurs in the lower part of the overlying zone of

TABLE 2.—*Zonation of Cenomanian ammonites in the Western Interior of the United States and ranges of species treated herein*

STAGE		ZONE	SUBZONE
CENOMANIAN (PART)	UPPER	*Neocardioceras juddii*	
		Vascoceras cauvini	
		Sciponoceras gracile	*Euomphaloceras (Kanabiceras) septemseriatum*
			Vascoceras diartianum
		Metoicoceras mosbyense	*Dunveganoceras conditum*
			Dunveganoceras albertense
		Dunveganoceras problematicum	
		Dunveganoceras pondi	
	MIDDLE	*Plesiacanthoceras wyomingense*	
		Acanthoceras amphibolum	*Acanthoceras amphibolum fallense*
			Acanthoceras amphibolum amphibolum
		Acanthoceras bellense	
		Acanthoceras muldoonense	
		Calycoceras (Conlinoceras) tarrantense	

AMMONITES IN THIS REPORT



Metoicoceras mosbyense (subzone of *Dunveganoceras albertense*), descended from *N. uptonense* through a reduction in size and an increase in rib density. Higher in the zone of *M. mosbyense, Neocardioceras* is scarce, but a phragmocone (pl. 10, figs. 71, 72) from the Frontier Formation of Wyoming indicates the presence of some large species that descended from *N. uptonense*. *Neocardioceras* has not been found in the younger zones of *Sciponoceras gracile* and *Vascoceras cauvini*, although large collections of fossils have been made at many localities in the Western Interior and in Texas from the zone of *S. gracile*. The sudden appearance of *N. juddii* in great numbers in rocks just above the zone of *V. cauvini* is puzzling. This species is probably a descendent of the *N. uptonense* stock.

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PLATES

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

PLATE 1

[All figures natural size. Arrows mark base of body chambers]

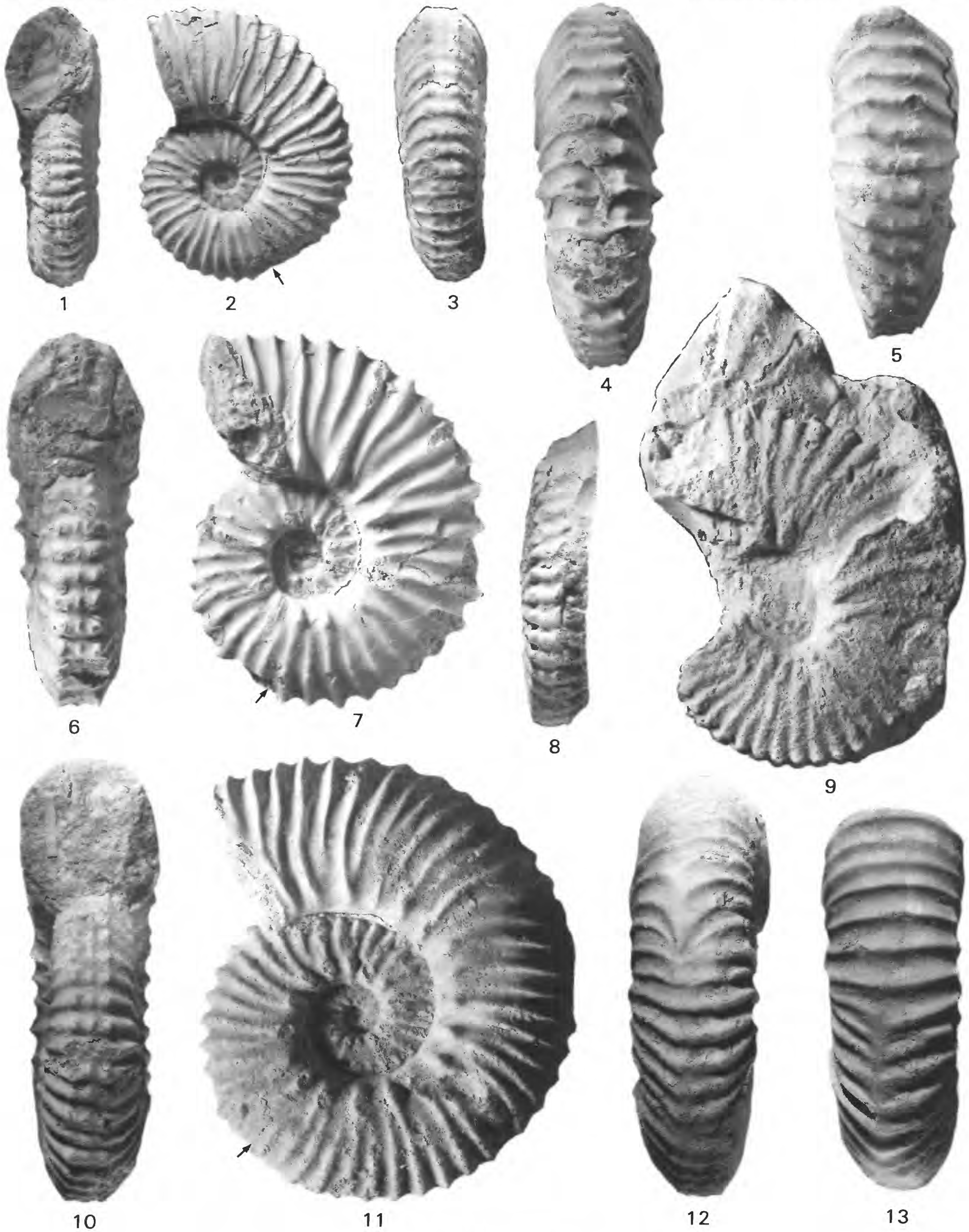
FIGURES 1–13. *Tarrantoceras sellardsi* (Adkins) (p. 5).

1–3. Front, side, and rear views of hypotype USNM 400759, from USGS Mesozoic locality 24510 (text fig. 2).

4–7. Rear, top, front, and side views of hypotype USNM 400760, from USGS Mesozoic locality D12626 (text fig. 2).

8, 9. Bottom and side views of a plaster cast of the holotype from Williamson County, Tex.

10–13. Front, side, rear, and top views of hypotype USNM 400761, from USGS Mesozoic locality D5309 (text fig. 1, loc. 44). Note the injured ventral area on figure 12 that was later healed (fig. 13).



TARRANTOCERAS

PLATE 2

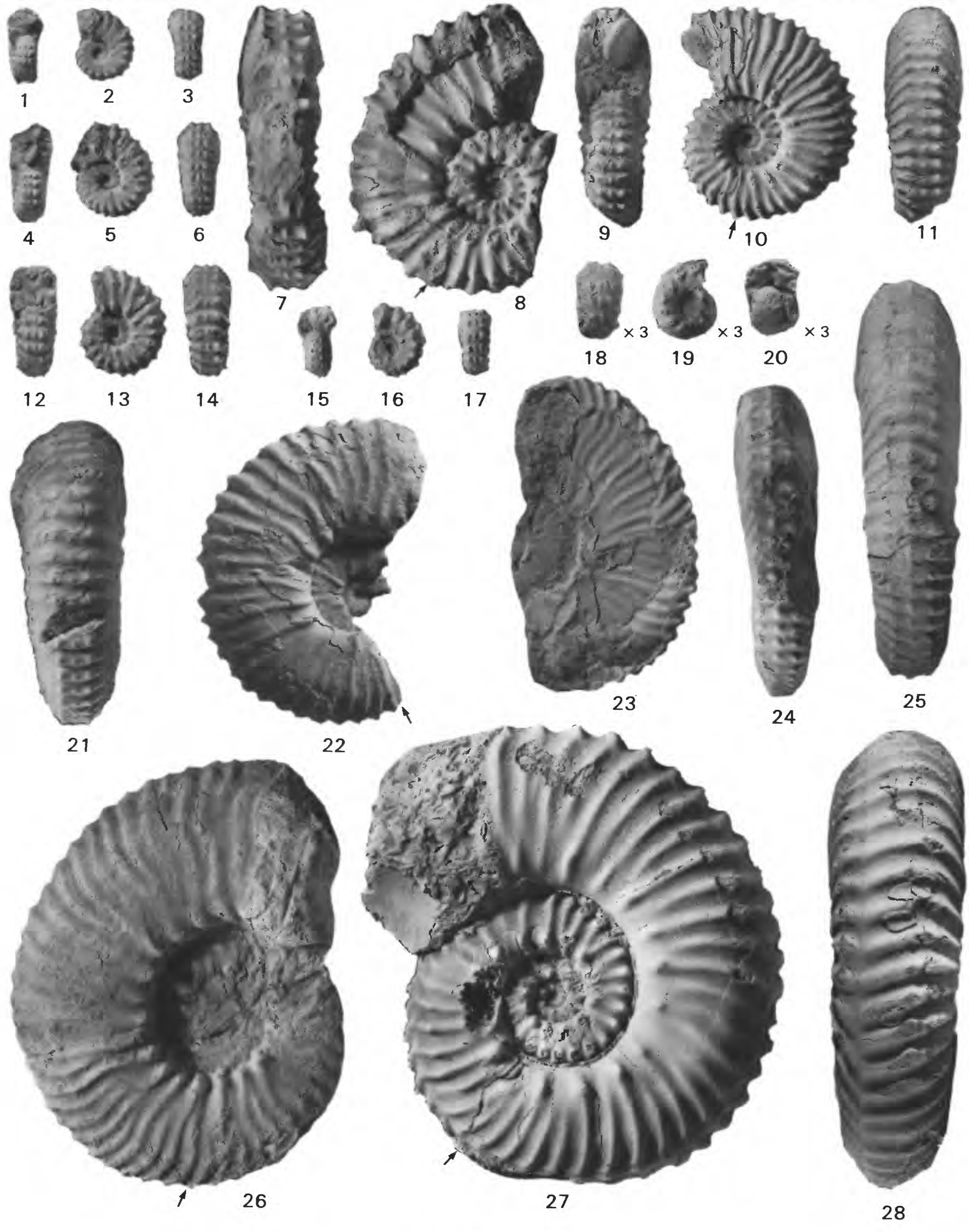
[All figures natural size except as indicated. Arrows mark base of body chambers]

FIGURES 1–22, 27, 28. *Tarrantoceras sellardsi* (Adkins) (p. 5).

1–3. Hypotype USNM 400762, from USGS Mesozoic locality D12626 (text fig. 2).
4–6. Hypotype USNM 400763, from USGS Mesozoic locality 24510 (text fig. 2).
7, 8. Hypotype USNM 400764, from USGS Mesozoic locality 24510 (text fig. 2).
9–11. Hypotype USNM 400765, from USGS Mesozoic locality 24510 (text fig. 2).
12–14. Hypotype USNM 400766, from USGS Mesozoic locality D12626 (text fig. 2).
15–17. Hypotype USNM 400767, from USGS Mesozoic locality D12626 (text fig. 2).
18–20. Hypotype USNM 400768, ×3, from USGS Mesozoic locality D12626 (text fig. 2).
21, 22. Hypotype USNM 400769, from USGS Mesozoic locality 24510 (text fig. 2).
27, 28. Hypotype USNM 400770, from USGS Mesozoic locality 24510 (text fig. 2). Note injury on venter (fig. 28).

23–26. *Tarrantoceras flexicostatum* Cobban, n. sp. (p. 7).

23, 24. Paratype USNM 400774, from USGS Mesozoic locality D12630 (text fig. 1, loc. 5).
25, 26. Holotype USNM 400773, from USGS Mesozoic locality 21850 (text fig. 1, loc. 6).



TARRANTOCERAS

PLATE 3

[All figures natural size. Arrows mark base of body chambers]

FIGURES 1–13. *Eucalycoceras pentagonum* (Jukes-Browne) (p. 9).

1, 2. Hypotype USNM 400775, from USGS Mesozoic locality D11483 (text fig. 1, loc. 61). See text figure 7*B* for suture.

3. Hypotype USNM 400776, from USGS Mesozoic locality D11483 (text fig. 1, loc. 61).

4, 5. Hypotype USNM 400777, from USGS Mesozoic locality 22899 (text fig. 1, loc. 34).

6. Hypotype USNM 400778, from USGS Mesozoic locality 23060 (text fig. 1, loc. 8).

7, 8. Hypotype USNM 400779, from USGS Mesozoic locality 22899 (text fig. 1, loc. 34).

9. Hypotype USNM 400780, from USGS Mesozoic locality 23060 (text fig. 1, loc. 8).

10–13. Bottom, top, rear, and side views of hypotype USNM 400781, from USGS Mesozoic locality 22899 (text fig. 1, loc. 34).

EUCALYCOCERAS

PLATE 4

[All figures natural size. Arrows mark base of body chambers]

FIGURES 1–13. *Eucalycoceras templetonense* Cobban, n. sp. (p. 10).

1. Paratype USNM 400783, from USGS Mesozoic locality D5940 (text fig. 1, loc. 11).

2–4. Holotype USNM 400782, from USGS Mesozoic locality 20314 on Templeton Branch northeast of Bells, Grayson County, Tex.

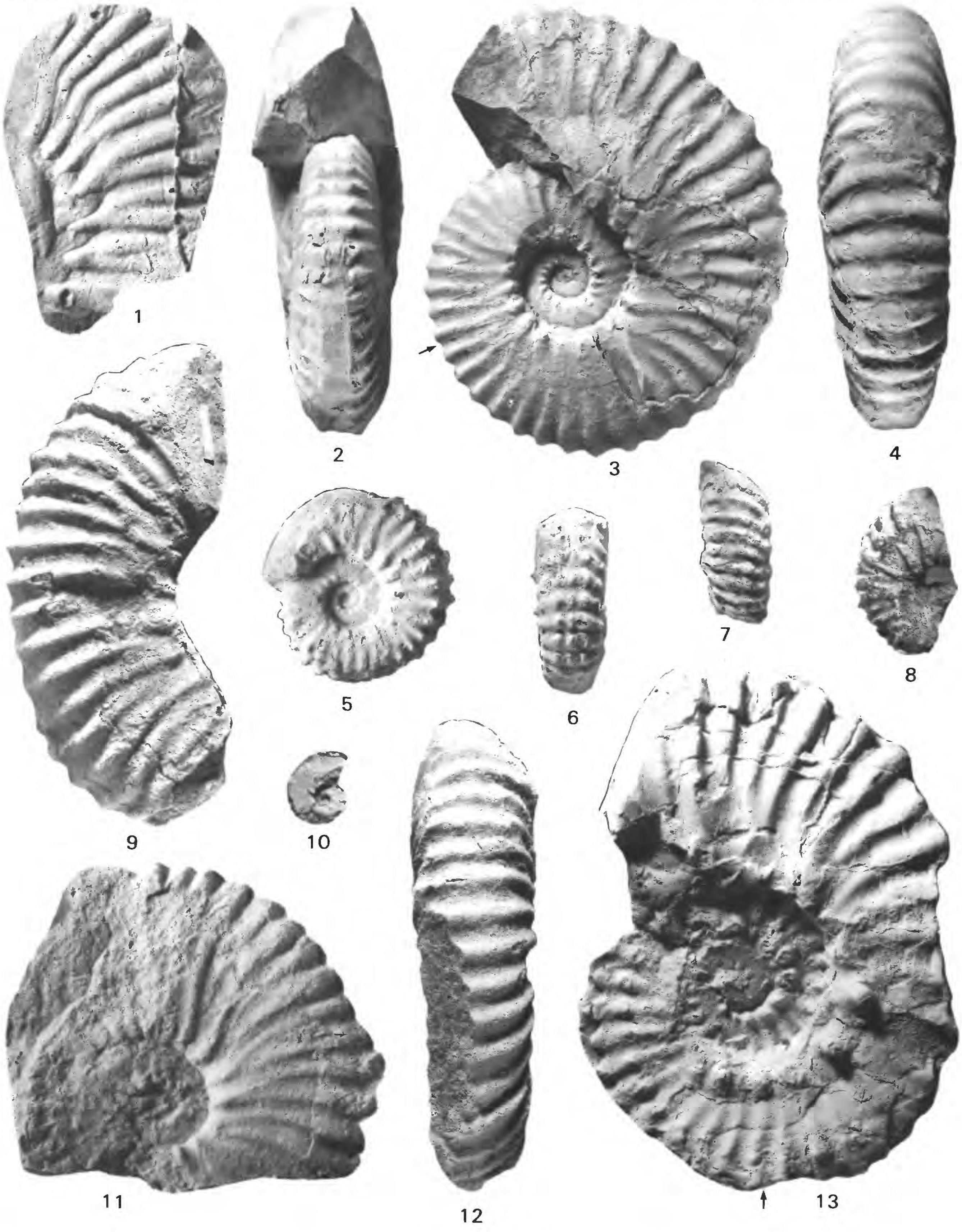
5, 6. Paratype USNM 400785, from the same locality as figs. 2–4.

7, 8. Paratype USNM 400786, from USGS Mesozoic locality D7530 (text fig. 1, loc. 20).

9, 12. Paratype USNM 400784, from USGS Mesozoic locality D7530 (text fig. 1, loc. 20).

10, 13. Paratype USNM 400788, from the same locality as figs. 2–4. Figure 10 is the innermost whorls of figure 13.

11. Paratype USNM 400787, from USGS Mesozoic locality D10734 (text fig. 1, loc. 42).



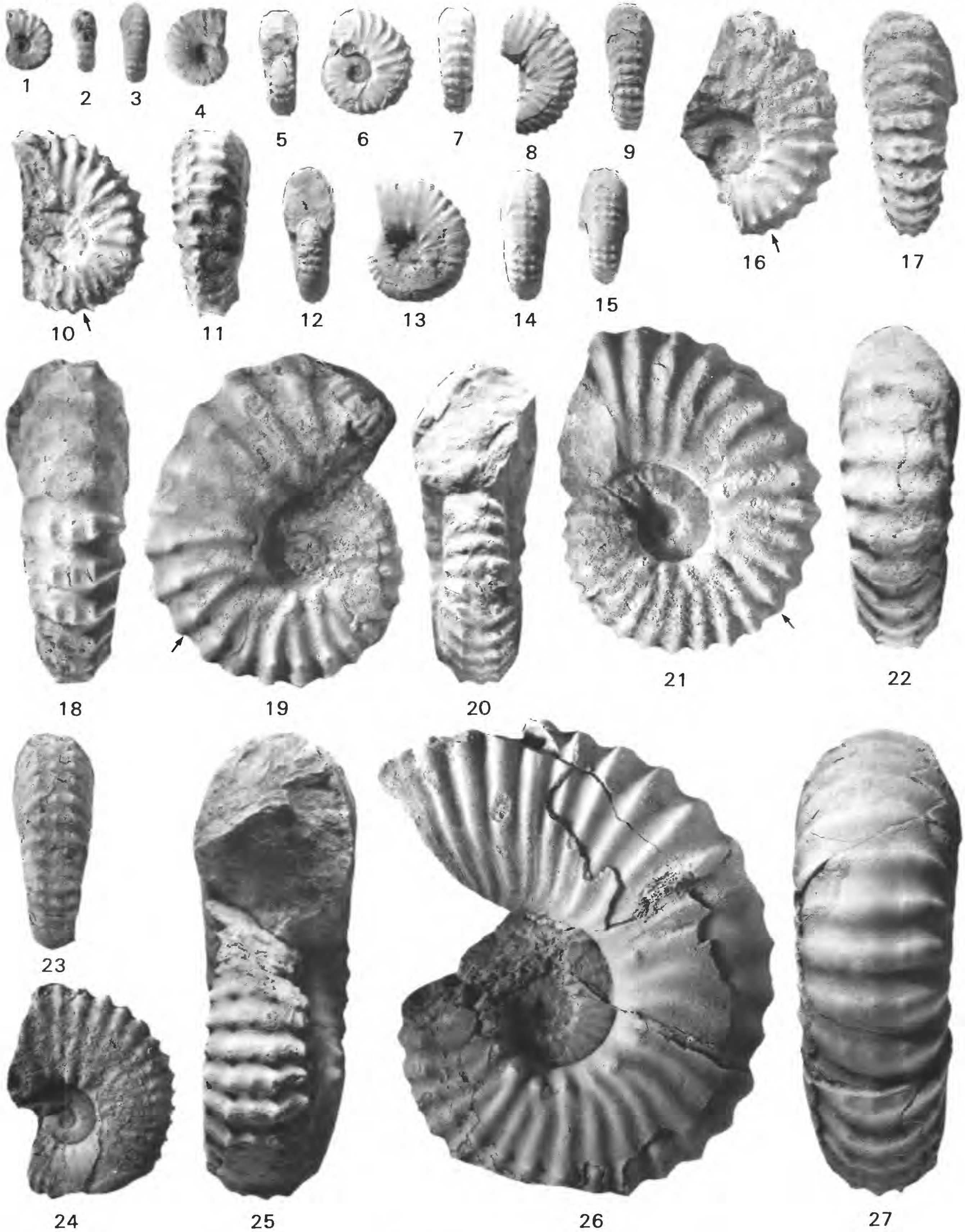
EUCALYCOCERAS

PLATE 5

[All figures natural size. Arrows mark base of body chambers]

FIGURES 1–27. *Pseudocalycoceras angolaense* (Spath) (p. 12).

1, 2. Hypotype USNM 400789, from USGS Mesozoic locality D11529 (text fig. 1, loc. 54).
3, 4. Hypotype USNM 400790, from the same locality.
5–7. Hypotype USNM 400791, from the same locality.
8, 9. Hypotype USNM 400792, from the same locality. See text figure 10 for the suture.
10, 11. Hypotype USNM 400793, from USGS Mesozoic locality D10196 (text fig. 1, loc. 60).
12–15. Front, side, rear, and bottom views of hypotype USNM 400794, from USGS Mesozoic locality D11538 (text fig. 1, loc. 56).
16, 17. Hypotype USNM 400795, from USGS Mesozoic locality D10112 (text fig. 1, loc. 58).
18, 19. Hypotype USNM 400796, from USGS Mesozoic locality D11529 (text fig. 1, loc. 54).
20–22. Hypotype USNM 400797, from USGS Mesozoic locality D10112 (text fig. 1, loc.58).
23, 24. Hypotype USNM 400798, from USGS Mesozoic locality D11529 (text fig. 1, loc. 54).
25–27. Hypotype USNM 400799, from USGS Mesozoic locality D10196 (text fig. 1, loc. 60).



PSEUDOCALYCOCERAS

PLATE 6

[All figures natural size. Arrows mark base of body chambers]

FIGURES 1, 2, 13, 14, 18, 19. *Pseudocalycoceras angolaense* (Spath) (p. 12).

1, 2. Hypotype USNM 400800, from the Britton Formation at the spillway of the Garza–Little Elm Reservoir, Denton County, Tex. (USGS Mesozoic loc. D9439).

13, 14. Hypotype USNM 400801, from USGS Mesozoic locality 18686 (text fig. 1, loc. 33).

18, 19. Hypotype USNM 400802, from the same locality.

3–12, 15–17. *Sumitomoceras bentonianum* (Cragin) (p. 15).

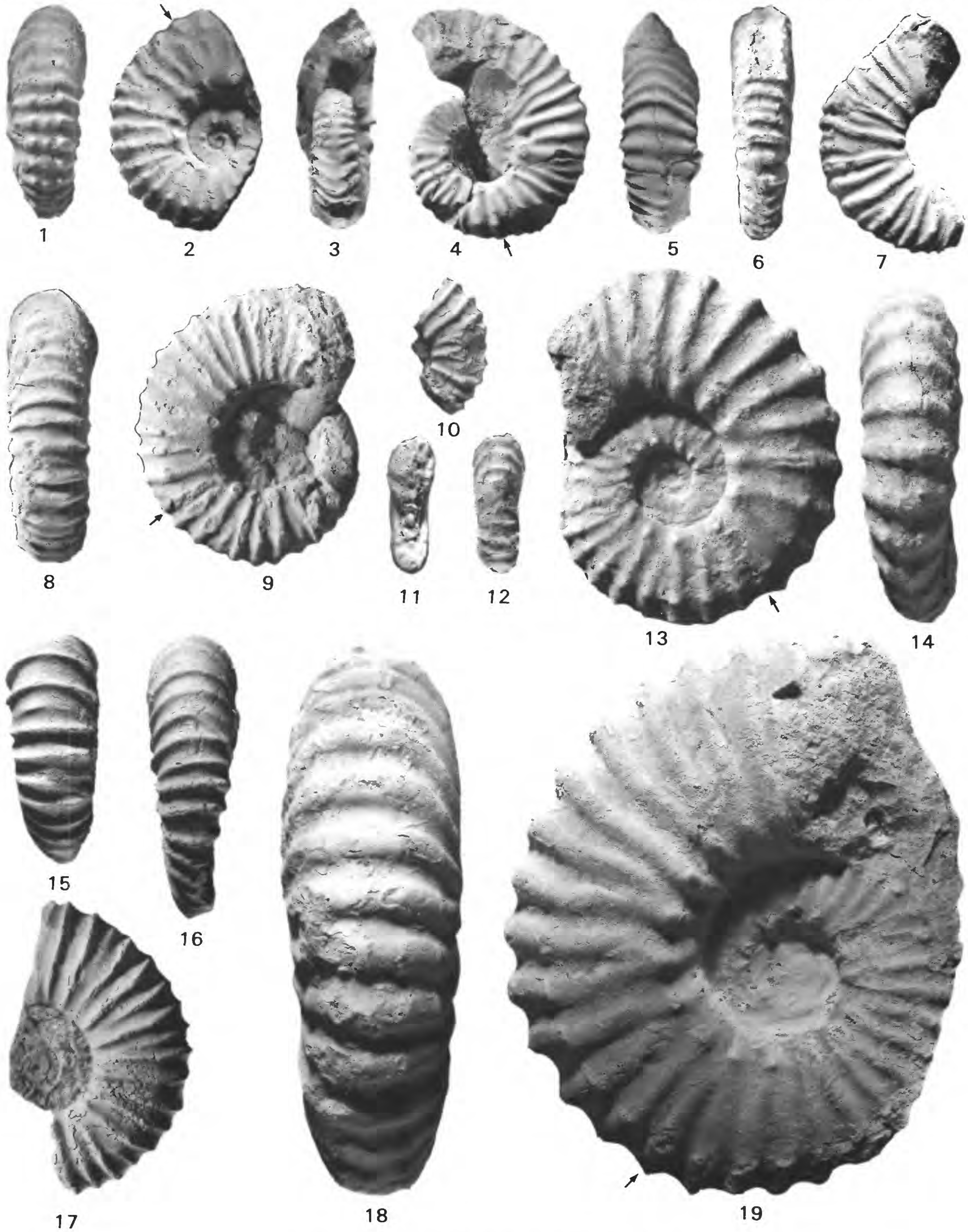
3–5. Hypotype USNM 400810, from USGS Mesozoic locality D6842 (text fig. 1, loc. 57). See text figure 12 for suture.

6, 7. Hypotype USNM 400811, from USGS Mesozoic locality 18686 (text fig. 1, loc. 33).

8, 9. Hypotype USNM 400812, from USGS Mesozoic locality D12452 (text fig. 1, loc. 35).

10–12. Hypotype USNM 400813, from USGS Mesozoic locality D10196 (text fig. 1, loc. 60).

15–17. Top, back, and side views of a plaster cast of the holotype from the Britton Formation at Hackberry Creek, Dallas County, Tex.



PSEUDOCALYCOCERAS AND *SUMITOMOCERAS*

PLATE 7

[All figures natural size except as indicated. Arrows mark base of body chambers]

FIGURES 1–15, 26–28. *Sumitomoceras conlini* Wright and Kennedy (p. 14).

1–4. Hypotype USNM 400804, ×1 and ×2, from USGS Mesozoic locality D11529 (text fig. 2, loc. 54).

5–7. Hypotype USNM 400805, from the same locality.

8. Hypotype USNM 400806, from the same locality.

9, 10. Hypotype USNM 400807, from USGS Mesozoic locality D10196 (text fig. 1, loc. 60). See text figure 11*A* for suture.

11–13. Hypotype USNM 400808, from USGS Mesozoic locality D11529 (text fig. 1, loc. 54).

14, 15. Hypotype USNM 400809, from the Boquillas Limestone at USGS Mesozoic locality D7466 along State Route 163 opposite entrance to Tom Brite road, Val Verde County, Tex.

26–28. Holotype USNM 400803 (J. P. Conlin 4500), from the Britton Formation 4 km (2½ mi) south of Britton, Ellis County, Tex. Figure 28 was taken after the older part of the body chamber was removed. See text figure 11*B* for the suture.

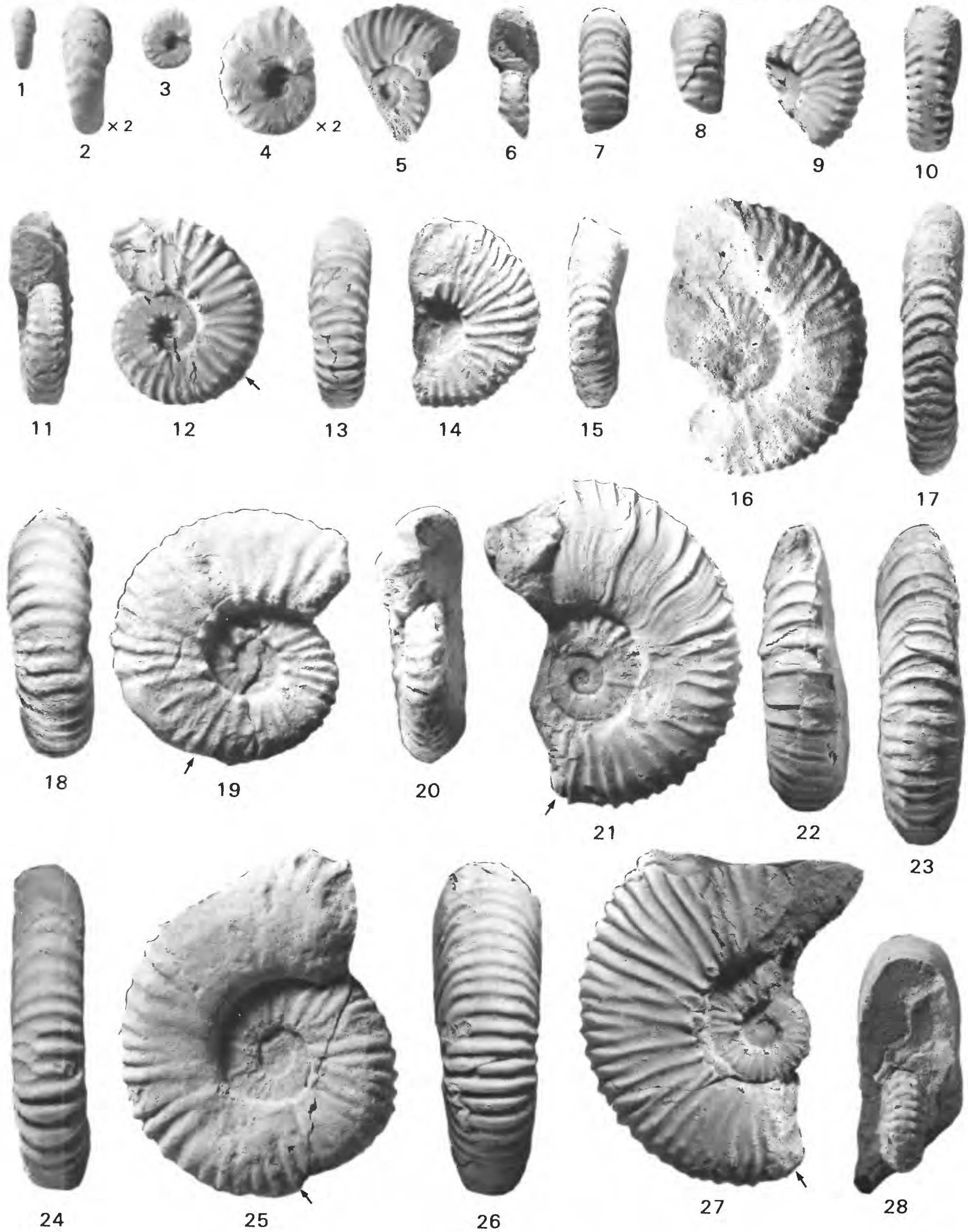
16–25. *Sumitomoceras bentonianum* (Cragin) (p. 15).

16, 17. Hypotype USNM 400814, from USGS Mesozoic locality 18686 (text fig. 1, loc. 33).

18–20. Hypotype USNM 400815, from the same locality as figs. 14, 15.

21–23. Side, top, and rear views of hypotype USNM 400816 (J.P. Conlin 4499), from the Britton Formation on a tributary to Newton Branch 6 km (3¾ mi) south of Britton, Ellis County, Tex.

24, 25. Hypotype USNM 400817, from the Boquillas Formation at USGS Mesozoic locality 15344 on the Nueces River 1 km upstream from the Southern Pacific Railway bridge, Uvalde County, Tex.



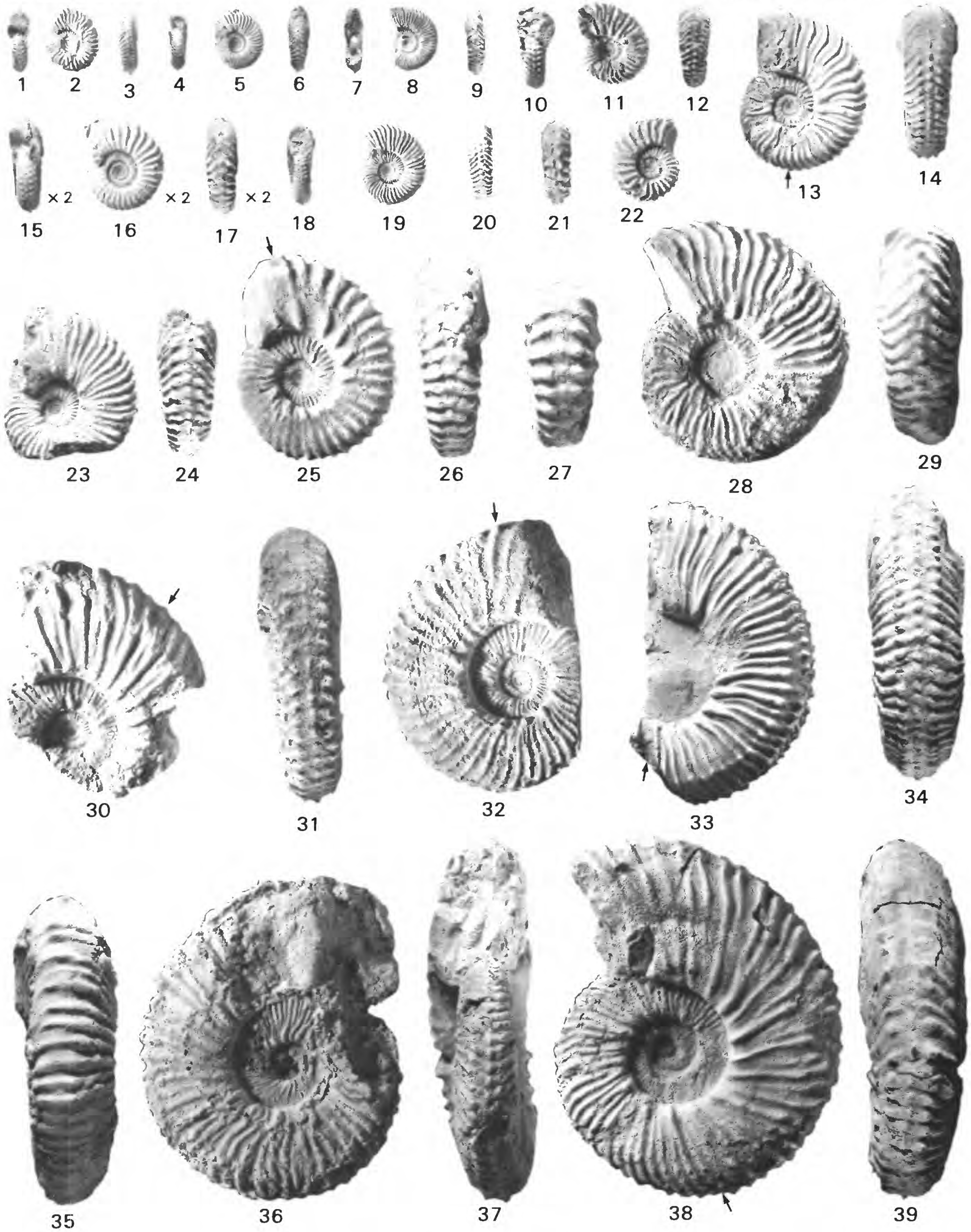
SUMITOMOCERAS

PLATE 8

[All figures natural size except as indicated. Arrows mark base of body chambers]

FIGURES 1–39. *Neocardioceras juddii* (Barrois and de Guerne) (p. 17).

1–3. Hypotype USNM 400818, from USGS Mesozoic locality D10533 (text fig. 1, loc. 50).
4–6. Hypotype USNM 400819, from the same locality.
7–9. Hypotype USNM 400820, from the same locality.
10–12. Hypotype USNM 400821, from USGS Mesozoic locality D9031 (text fig. 1, loc. 49).
13, 14. Hypotype USNM 400822, from USGS Mesozoic locality D10996 (text fig. 1, loc. 51).
15–17. Hypotype USNM 400823, ×2, from USGS Mesozoic locality D10533 (text fig. 1, loc. 50).
18–20. Hypotype USNM 400824, from the same locality.
21, 22. Hypotype USNM 400825, from USGS Mesozoic locality D11510 (text fig. 1, loc. 53).
23, 24. Hypotype USNM 400826, from USGS Mesozoic locality D10533 (text fig. 1, loc. 50). See text figure 14 for suture.
25–27. Side, rear, and top views of hypotype USNM 400827, from USGS Mesozoic locality D10114 (text fig. 1, loc. 59).
28, 29. Side and top views of hypotype USNM 356889, from the same locality.
30. Hypotype USNM 400828, from the same locality.
31, 32. Hypotype USNM 307357, from the same locality.
33, 34. Hypotype USNM 400829, from USGS Mesozoic locality D11004 (text fig. 1, loc. 52).
35, 36. Hypotype USNM 400830, from the same locality.
37–39. Hypotype USNM 400831, from USGS Mesozoic locality D11533 (text fig. 1, loc. 55).



NEOCARDIOCERAS

PLATE 9

[All figures natural size]

FIGURES 1–31. *Neocardioceras densicostatum* Cobban, n. sp. (p. 19).

From the Hartland Member of the Greenhorn Limestone at USGS Mesozoic locality D7410 (text fig. 1, loc. 27).

1. Paratype USNM 400833.
2. Paratype USNM 400834.
3. Paratype USNM 400835.
4. Paratype USNM 400836.
5. Paratype USNM 400837.
6. Paratype USNM 400838.
7. Paratype USNM 400839.
8. Paratype USNM 400840.
9. Paratype USNM 400841.
10. Paratype USNM 400842.
11. Paratype USNM 400843a, b.
12. Paratype USNM 400844.
13. Paratype USNM 400845a, b.
14. Paratype USNM 400846.
15. Paratype USNM 400847.
16. Paratype USNM 400848a, b.
17. Paratype USNM 400849.
18. Paratype USNM 400850.
19. Paratype USNM 400851.
20. Paratype USNM 400852.
21. Paratype USNM 400853.
22. Paratype USNM 400854.
23. Holotype USNM 400832.
24. Paratype USNM 400855.
25. Paratype USNM 400856.
26. Paratype USNM 400857.
27. Paratype USNM 400858.
28. Paratype USNM 400859.
29. Paratype USNM 400860.
30. Paratype USNM 400861.
31. Paratype USNM 400862a, b.

32–38. *Neocardioceras laevigatum* Cobban, n. sp. (p. 22).

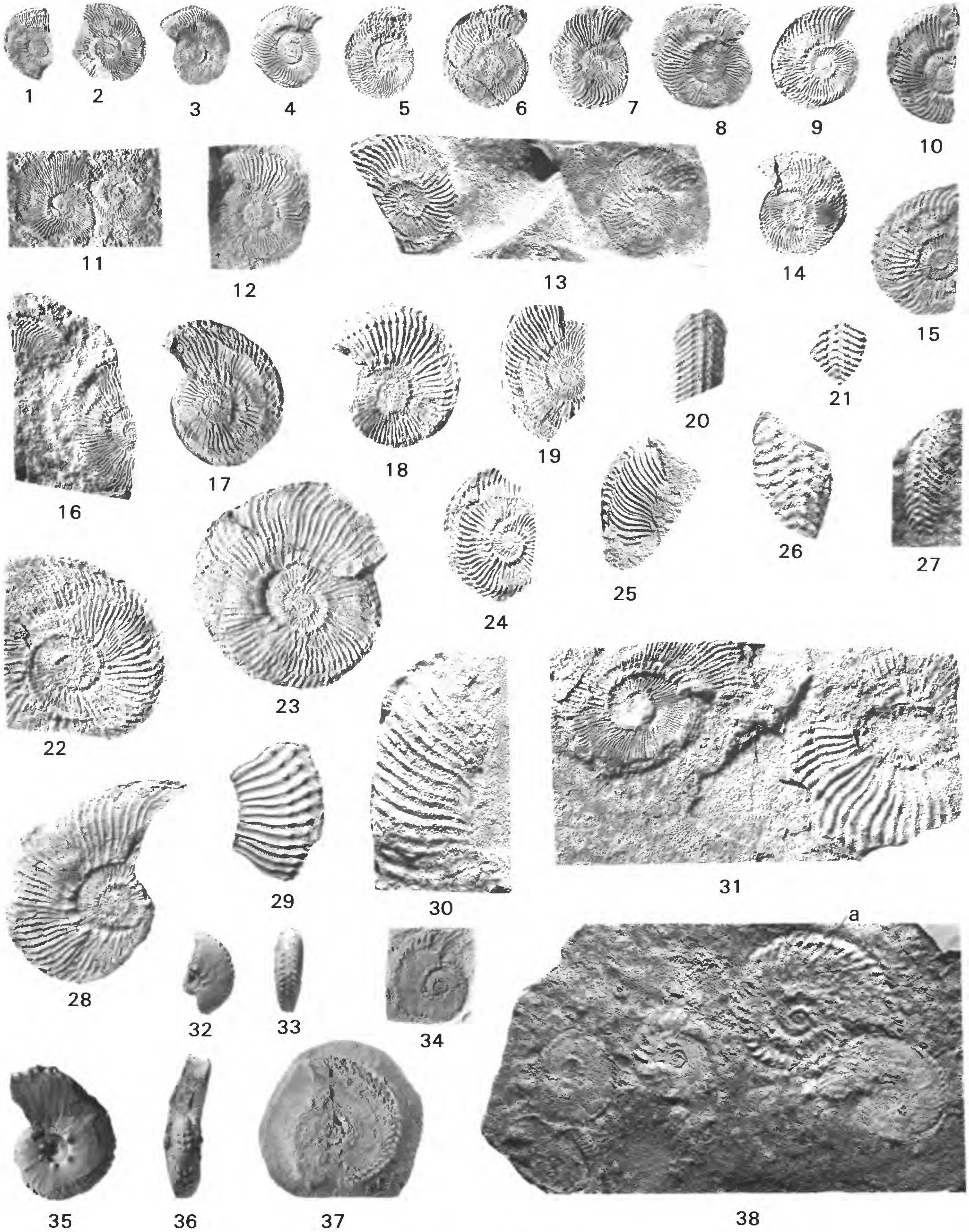
32, 33. Paratype USNM 400890, from USGS Mesozoic locality D4462 (text fig. 1, loc. 10).

34. Paratype USNM 400891, from USGS Mesozoic locality D7395 (text fig. 1, loc. 24).

35, 36. Holotype USNM 400889, from USGS Mesozoic locality D5947 (text fig. 1, loc. 12).

37. Paratype USNM 400892, from USGS Mesozoic locality D7390 (text fig. 1, loc. 23).

38. Paratype USNM 400893 (a) associated with impressions of *Neocardioceras uptonense* Cobban, n. sp., from USGS Mesozoic locality D7402 (text fig. 1, loc. 25).



NEOCARDIOCERAS

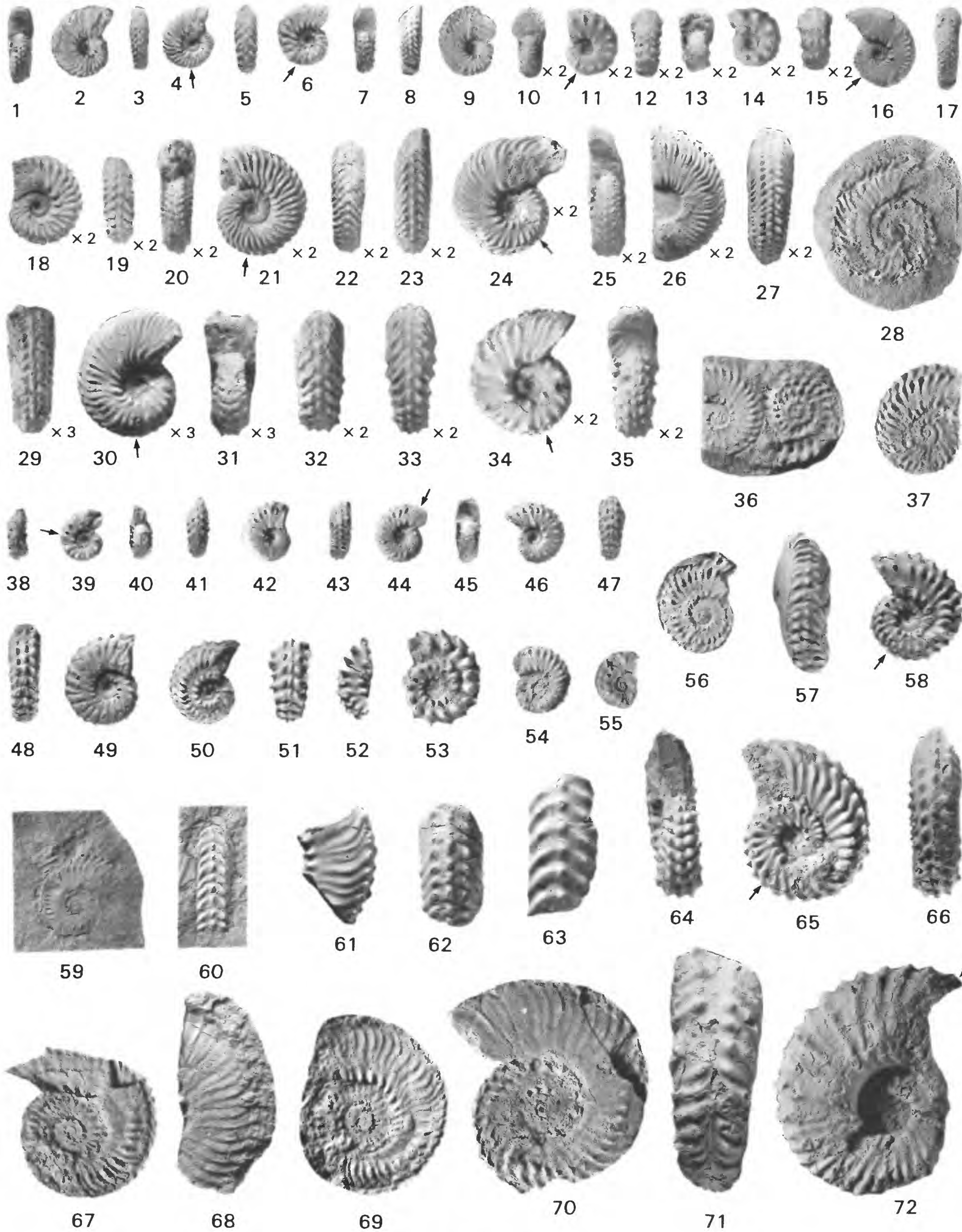
PLATE 10

[All figures natural size except as indicated. Arrows mark base of body chambers]

FIGURES 1–35. *Neocardioceras minutum* Cobban, n. sp. (p. 23).
- 1, 2. Holotype, USNM 400894, from USGS Mesozoic locality D4462 (text fig. 1, loc. 10).
- 3, 4. Paratype USNM 400895, from USGS Mesozoic locality 12740 (text fig. 1, loc. 7).
- 5–7. Paratype USNM 400896, from USGS Mesozoic locality D4462 (text fig. 1, loc. 10).
- 8, 9. Paratype USNM 400897, from the same locality as figures 5–7. See text figure 20 for suture.
- 10–12. Paratype USNM 400898, ×2, from the same locality.
- 13–15. Paratype USNM 400899, ×2, from the same locality.
- 16, 17. Paratype USNM 400900, from USGS Mesozoic locality 12740 (text fig. 1, loc. 7).
- 18, 19. Paratype USNM 400901, ×2, from the same locality as figures 16 and 17.
- 20–22. Paratype USNM 400902, ×2, from the same locality.
- 23–25. Paratype USNM 400903, ×2, from USGS Mesozoic locality D4462 (text fig. 1, loc. 10).
- 26, 27. Paratype USNM 400904, ×2, from the same locality as figures 23–25.
- 28. Paratype USNM 400908, from USGS Mesozoic locality D7390 (text fig. 1, loc. 23).
- 29–31. Paratype USNM 400905, ×3, from USGS Mesozoic locality 12740 (text fig. 1, loc. 7).
- 32–35. Top, rear, side, and front views of paratype USNM 400906, X2, from USGS Mesozoic locality D4462 (text fig. 1, loc. 10).

36–70. *Neocardioceras uptonense* Cobban, n. sp. (p. 20).
- 36. Paratype USNM 400881, from USGS Mesozoic locality D7402 (text fig. 1, loc. 25).
- 37. Paratype USNM 400882, from the same locality as figure 36.
- 38–40. Paratype USNM 400864, from USGS Mesozoic locality D5947 (text fig. 1, loc. 12).
- 41, 42. Paratype USNM 400865, from the same locality as figures 38–40.
- 43, 44. Paratype USNM 400866, from the same locality.
- 45–47. Paratype USNM 400867, from the same locality.
- 48, 49. Paratype USNM 400868, from the same locality.
- 50. Latex cast of paratype USNM 400869, from the same locality.
- 51, 52. Paratype USNM 400870, from the same locality.
- 53. Latex cast of paratype USNM 400871, from the same locality.
- 54. Latex cast of paratype USNM 400878, from USGS Mesozoic locality D7402 (text fig. 1, loc. 25).
- 55. Paratype USNM 400879, from the same locality as figure 54.
- 56. Latex cast of paratype USNM 400880, from the same locality.
- 57. Paratype USNM 400872, from USGS Mesozoic locality D5947 (text fig. 1, loc. 12).
- 58. Paratype USNM 400873, from the same locality as figure 57.
- 59. Paratype USNM 400883, from the same locality as figure 54.
- 60. Paratype USNM 400884, from the same locality as figure 54.
- 61, 62. Paratype USNM 400874, from the same locality as figure 57.
- 63. Paratype USNM 400875, from the same locality as figure 57.
- 64–66. Holotype USNM 400863, from the same locality.
- 67. Paratype USNM 400885, from the same locality as figure 54.
- 68. Latex cast of paratype USNM 400886, from the same locality as figure 54.
- 69. Latex cast of paratype USNM 400887, from the same locality.
- 70. Paratype USNM 400888, from the same locality.

71, 72. *Neocardioceras* sp. (p. 24).
Figured specimen USNM 400909, from USGS Mesozoic locality D6962 (text fig. 1, loc. 14).



NEOCARDIOCERAS

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