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Contributions to Late Cretaceous paleontology and stratigraphy of New Mexico
Part II

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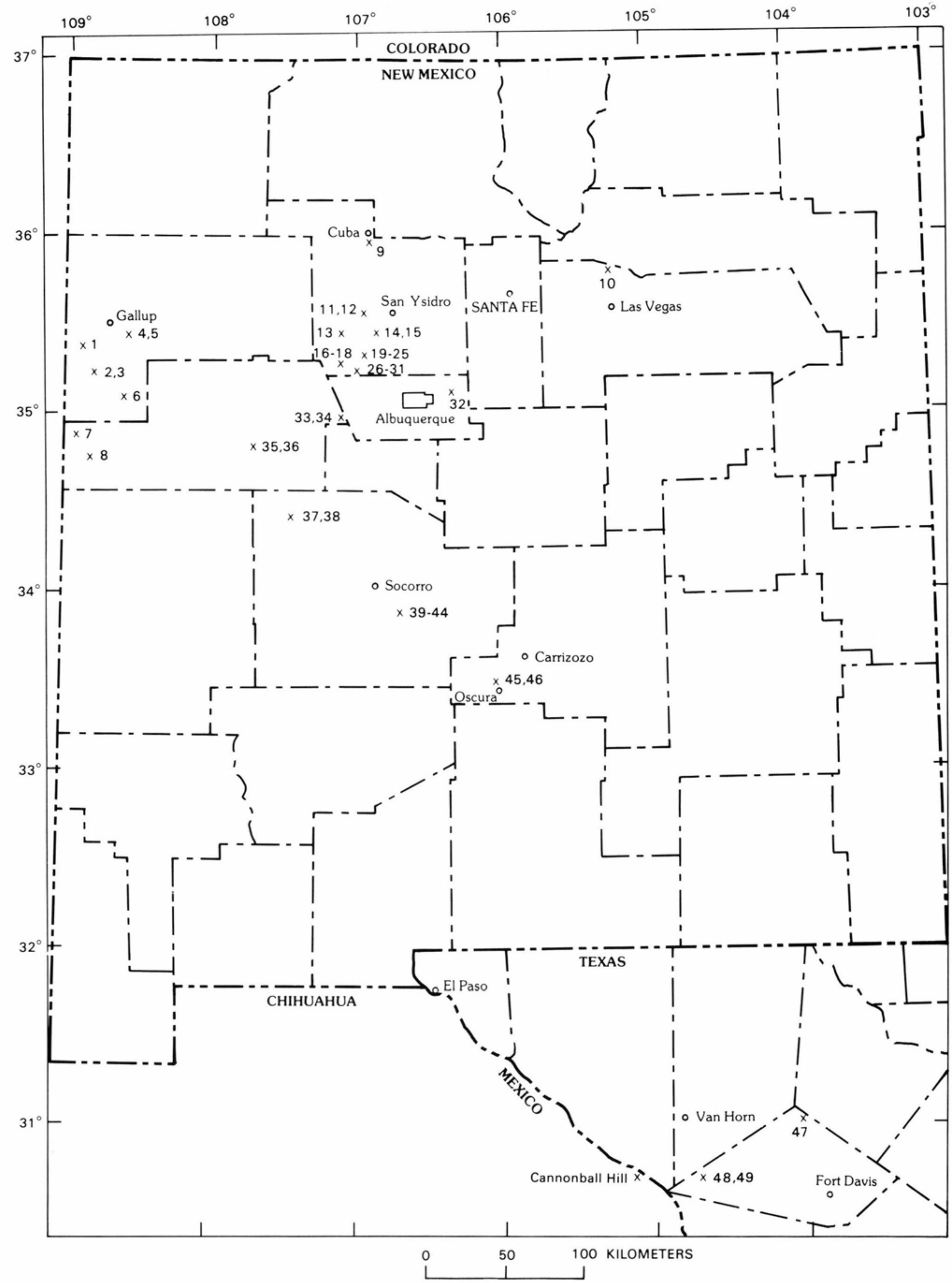


FIGURE 1—Map of New Mexico and part of Trans-Pecos Texas showing localities of *Spathites* referred to in the text and in Table 1.

The Late Cretaceous ammonite *Spathites* Kummel & Decker in New Mexico and Trans-Pecos Texas

W. A. Cobban

U.S. Geological Survey, Mail Stop 919, Box 25046, Federal Center, Denver, Colorado 80225, U.S.A.

Abstract—Spathites was established for S. *chispaensis* Kummel & Decker, 1954, which is a synonym of *Pseudotissotia? coahuilaensis* Jones, 1938. *Spathites* is known in the United States only from rocks of middle Turonian age in New Mexico and western Texas. At least three chronologic species are present, from oldest to youngest S. *rioensis* Powell, S. *coahuilaensis* (Jones), and S. *puercoensis* (Herrick & Johnson). The first two have subpseudoceratitic sutures, whereas *S. puercoensis* has a decidedly pseudoceratitic suture. *Spathites rioensis* occurs in the subzone of *Collignoniceras woollgari woollgari* (Mantell), and *S. coahuilaensis* is found in the younger subzone of *C. woollgari regulare* (Haas). *Spathites puercoensis* occurs still higher in the zone of *Prionocyclus hyatti.* Rare inner whorls from two localities in New Mexico suggest the possibility of a fourth species that may lie between the zones of *C. woollgari* and *P. hyatti.*

Introduction

The genus *Spathites* was proposed by Kummel & Decker (1954) for medium-sized, stout, involute ammonites that have inner whorls ornamented by ribs and tubercles (umbilical and inner and outer ventrolateral) and outer whorls with reduced ornament. The suture is simplified. Kummel & Decker based their genus on S. *chispaensis,* which they described as a new species from Trans-Pecos Texas and Chihuahua, Mexico.

Kennedy, Wright & Hancock (1980a) dealt extensively with the genus and noted that it had a time span of latest Cenomanian to middle Turonian and a geographic range from North America to Europe, northern Africa, and east across southern U.S.S.R. to southern India. Those authors recognized the following species: *Spathites (Spathites) chispaensis* Kummel & Decker, S. (S.) *rioensis* Powell, S. *(S.) puercoensis* (Herrick & Johnson), S. *(S.) sulcatus* (Wiedmann), *S. (Jeanrogericeras) reveliereanus* (Courtiller), and S. *(J.) subconciliatus* (Choffat).

Spathites is locally abundant in west-central and western New Mexico, where three chronologic species are known, from oldest to youngest *S. rioensis, S. coahuilaensis* (Jones), and *S. puercoensis.* The last species is especially common in the Semilla Sandstone Member of the Mancos Shale in the Rio Puerco valley northwest of Albuquerque.

The present study was undertaken to more fully document the presence of *Spathites* in New Mexico and Trans-Pecos Texas. Collections on which this study was based were made by many geologists of the U.S. Geological Survey and the New Mexico Bureau of Mines & Mineral Resources. The largest collections were made by W. T. Lee in 1905, T. W. Stanton and **J.** G. Walthers in 1906, C. B. Hunt and assistants in 1930-31, C. H. Dane in 1963, and S. C. Hook, E. A. Merewether, N.A. La Fon, and me in 1978. All photographs were made by Robert E. Burkholder of the U.S. Geological Survey. Drawings of sutures were made by me.

Geographic distribution

Spathites is present in 49 collections of fossils in the U.S. Geological Survey's collections from New Mexico and Trans-Pecos Texas. These localities are shown in Fig. 1, and data concerning the localities are given in Table 1. Prefix D indicates Denver Mesozoic locality numbers; the rest are Washington, D.C., Mesozoic locality numbers.

Sequence of species

The oldest known species of *Spathites* in North America is *S. rioensis* Powell, which occurs in the lower part of the middle Turonian zone of *Collignoniceras woollgari* (Mantell). This zone was divided into a lower subzone of *C. woollgari woollgari* (Mantell) and an upper one of *C. woollgari regulare* (Haas) (Cobban & Hook, 1979). An early form of S. *rioensis* was found at the base of the subzone of C. *woollgari woollgari* in western New Mexico (Fig. 1, locs. 6, 7). Specimens of this early form were assigned to *Spathites aff. subconciliatus* (Choffat) (Cobban & Hook, 1983: 6), but in the present report they are better reassigned to *S. rioensis.*

Spathites coahuilaensis (Jones) has been found in the subzone of *Collignoniceras woollgari regulare* in west-central and western New Mexico. At locality D11450 (Fig. 1, loc. 32), S. *coahuilaensis* was collected 7.3 m above beds that contain C. *woollgari woollgari.*

Spathites puercoensis (Herrick & Johnson) has been found only in the youngest middle Turonian zone of *Prionocyclus hyatti* (Stanton). Among the ammonites associated with *S. puercoensis* are the forms illustrated by Kennedy, Wright & Hancock (1980b, text fig. 2, pl. 45, figs. 1, 2) as *Shuparoceras* sp. nov. (Fig. 1, loc. 17) and *Romaniceras (R.) kallesi* (Zázvorka) (Fig. 1, loc. 16), both of which are herein reassigned to *Romaniceras (R.) mexicanum* Jones, 1938.

None of the American species of *Spathites* is known from Europe, where the genus also seems to be confined to the middle Turonian. In the type region of the Turonian, Saumurois and Touraine in northwestern France, two species, S. (J*eanrogericeras) reveliereanum* (Courtiller) and S. *(J.) com-besi* (Sornay), are present in the Tuffeau de Saumur at the same stratigraphic level as the ammonites *Lewesiceras peramplum* (Mantell), *Fagesia rudra* (Stoliczka), *Neoptychites cephalotus* (Courtiller), *N. xetriformis* Pervinquiere, *Kamerunoceras turoniense* (d'Orbigny), *Romaniceras kallesi* Zazvorka (basal part of range), *Tragodesmoceras courtilleri* Amédro & Badillet,

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	D11264	S. C. Hook and W. A. Cobban, 1980, SW1/4 sec. 34, T14N, R20W, McKinley County, New Mexico. Mancos Shale, about 45 m below Gallup Sandstone.
2	D6153	E. R. Landis and W. A. Cobban, 1967. North side of Whitewater Arroyo in the SE1/4 sec. 9, T12N, R19W, McKinley County, New Mexico. Mancos Shale, from unit of dark shale with olive-gray shaly siltstone and orange-brown weathering limestone concretions.
3	D10606	S. C. Hook, 1978. NW1/4 sec. 15, T12N, R19W, McKinley County, New Mexico. Rio Salado Tongue of Mancos Shale, float from a silty concretion in upper 7 or 8 m.
4	D2078	W. A. Cobban, 1959. About 6.5 km east-southeast of Gallup, McKinley County, New Mexico. Mancos Shale, from olive-gray shaly siltstone about 30 m below the Gallup Sandstone (Hook et al., 1983, sheet 1).
5	D7075	Molenaar, C. M., Landis, E. R., and Cobban, W. A., 1972, SE1/4 sec. 33, T15N, R17W, McKinley County, New Mexico. Mancos Shale, from olive-gray sandy beds about 80 m above Twowells Tongue of Dakota Sandstone.
6	D11140	S. C. Hook and W. A. Cobban, 1980. Rio Pescado in the NE1/4 sec. 5, T10N, R17W, McKinley County, New Mexico. Near top of Rio Salado Tongue of Mancos Shale (Hook et al., 1983, sheet 1).
7	D11559	Orin Anderson and W. A. Cobban, 1981. Yellowrock Canyon in the SE1/4 sec. 8 and SW1/4 sec. 9, T7N, R20W, Cibola County, New Mexico. About 14 m below top of Rio Salado Tongue of Mancos Shale.
8	D11708	S. C. Hook and W. A. Cobban, 1980; O. J. Anderson and Cobban, 1983. E1/2 sec. 6, T6N, R19W, Cibola County, New Mexico. 7 m below top of Rio Salado Tongue of Mancos Shale (Cobban & Hook, 1983: 6).
9	D10309	S. C. Hook, 1977. NE1/4 sec. 11, T20N, R1W, Sandoval County, New Mexico. Mancos Shale.
10	D10769	S. C. Hook, 1979. About 244 m east of old Sapello cemetery in the southwest part of the Lake Isabel 71/2′ quadrangle, San Miguel County, New Mexico. Upper part of Codell Sandstone Member of Carlile Shale.
11	D4020	C. H. Dane, E. R. Landis, and W. A. Cobban, 1963. 1 mi southwest of Ojito Spring, Ojo del Espiritu Santo Grant, Sandoval County, New Mexico. Mancos Shale, from limestone concretions about 2 m above base of Semilla Sandstone Member.
12	D4021	C. H. Dane, 1963. Near center of N1/2 N1/2 sec. 7, T15N, R1W [unsurveyed], Sandoval County, New Mexico. Mancos Shale, near base of Semilla Sandstone Member.
13	7992	W. T. Lee and T. W. Stanton, 1912. "About 31/2 miles south of Casa Salazar" [sec. 11, T14N, R3W, Sandoval County, New Mexico]. Mancos Shale, from limestone concretions about 180–222 m above base (Lee, 1917: 195).
14	16114	C. B. Hunt and J. W. Wyckoff, 1931. NW1/4 NW1/4 sec. 5, T14N, R1E, Sandoval County, New Mexico. Mancos Shale.
15	D10575	L. F. Gunther and W. A. Cobban, 1965. N1/2 sec. 6, T14N, R1E, Sandoval County, New Mexico. Lower part of Semilla Sandstone Member of Mancos Shale.
16	15925	C. B. Hunt and J. W. Wyckoff, 1931. "Agua Salada Grant, 900 feet north of south line and 3,000 feet west of east line, Sandoval County, N. Mex." [probably in the SE1/4 sec. 12, T12N, R3W]. Mancos Shale.
17	15947	C. B. Hunt, H. R. Joesting, J. W. Wyckoff, G. F. Taylor, and R.C. Becker, 1931; S. C. Hook and S. J. Frost, 1978. "Agua Salada Grant, 1,000 feet north of south line and 5,000 feet west of east line, Sandoval County, N. Mex." Mancos Shale.
18	D10508	Neal La Fon, 1977–1978; S. C. Hook and W. A. Cobban, 1978. NE1/4 NW1/4 sec. 7, T12N, R2W (unsurveyed), Agua Salada Grant, Sandoval County, New Mexico. Mancos Shale, from just beneath Semilla Sandstone Member.
19	7191	W. T. Lee, 1911. "Three-fourths mile [1.2 km] west of San Francisco, Sandoval County, N. Mex." Mancos Shale (Lee, 1917: 197).
20	7204	W. T. Lee, 1911. "About 3 miles north of San Francisco and east of the Rio Puerco, Bernabe M. Montano Grant, Sandoval County, N. Mex." Mancos Shale, from limestone concretions (Lee, 1917: 197).
21	7983	W. T. Lee and T. W. Stanton, 1912. "Arroyo south of road from Albuquerque to Casa Salazar and 2 1/2 miles east of west boundary of Albuquerque quadrangle" [possibly in areas of localities 7204 and 15795]. Mancos Shale (Lee, 1917: 198).
22	15792	C. B. Hunt, 1930. "Northeast quarter of Bernabe M. Montano Grant" [probably in sec. 28, T13N, R1W, unsurveyed, Sandoval County, N. Mex.]. Mancos Shale.
23	15795	C. B. Hunt, 1931. "Bernabe M. Montano Grant, 1,000 feet west of east line and 9,000 feet south of north line, Sandoval County, N. Mex." Mancos Shale.

TABLE 1—(continued)

Locality (Fig. 1)	U.S. Geological Survey Mesozoic locality	Collector, year of collection, description of locality, and stratigraphic assignment
24	15906	C. B. Hunt and others, 1931. "Bernabe M. Montano Grant, 13,000 ft south of north line and 8,000 ft west of east line, Sandoval County, N. Mex." Mancos Shale.
25	15909	C. B. Hunt, 1931. "Bernabe M. Montano Grant, 13,000 feet south of north line and 8,000 feet west of east line, Sandoval County, N. Mex." Mancos Shale.
26	3520	W. T. Lee, 1905. "Rio Puerco valley about 4 miles north of San Ignacio, Sandoval County, N. Mex." Mancos Shale, from limestone concretions (Lee, 1917: 196).
27	3672	T. W. Stanton and J. G. Walthers, 1906. "Rio Puerco, 5 miles above San Ignacio." Sandoval County, New Mexico. Mancos Shale.
28	15797	C. B. Hunt and others, 1931. "Bernabe M. Montano Grant, 13,000 feet west of east line and 31,000 feet north of south line, Sandoval County, N. Mex." Mancos Shale.
29	15799	C. B. Hunt, 1931. NE1/4 NE1/4 sec. 15, T12N, R2W [unsurveyed], Sandoval County, New Mexico. Mancos Shale.
30	D10469	S. C. Hook, E. A. Merewether, and W. A. Cobban, 1978. Bernabe M. Montano Grant, about 4,500 ft west of southeast corner of Puerto Dam quadrangle, Sandoval County, New Mexico. Mancos Shale.
31	D11476	S. C. Hook, 1981. SE1/4 sec. 22, T12N, R2W (unsurveyed), Sandoval County, New Mexico. Mancos Shale.
32	D7324	G. R. Scott and Juanita Scott, 1970. Arroyo San Antonio in the SW1/4 sec. 36, T11N, R5E, Bernalillo County, New Mexico. Mancos Shale, from limestone concretions in olive-gray silty shale.
33	D11450	S. C. Hook, 1981. About 0.6 km south of intersection of Interstate 40 and Canoncito School road, Antonio Sedillo Grant, Cibola County, New Mexico. Rio Salado Tongue of Mancos Shale.
34	D11475	S. C. Hook, 1981. About 2.4 km south of intersection of Interstate 40 and Canoncito School road, Antonio Sedillo Grant, Cibola County, New Mexico. Rio Salado Tongue of Mancos Shale.
35	D6804	W. A. Cobban, 1968. SE1/4 sec. 18, T7N, R8W, Cibola County, New Mexico. Rio Salado Tongue of Mancos Shale, from olive-gray siltstone concretions in upper part.
36	D10320	S. C. Hook, 1977; Hook and N. A. La Fon, 1978. NW1/4 sec. 23, T7N, R8W, Cibola County, New Mexico. Basal part of Tres Hermanos Formation.
37	D10258	S. C. Hook, 1977. NE1/4 sec. 33, T3N, R6W, Socorro County, New Mexico. Upper part of Rio Salado Tongue of Mancos Shale (Hook et al., 1983: 25 and sheet 1).
38	D10472	S. C. Hook, E. A. Merewether, and W. A. Cobban, 1978. SW1/4 sec. 34, T3N, R6W, Socorro County, New Mexico. Upper part of Rio Salado Tongue of Mancos Shale.
39	D9154	W. A. Cobban, 1974. SW1/4 sec. 10, T5S, R2E, Socorro County, New Mexico. Basal part of Atarque Sandstone Member of Tres Hermanos Formation.
40	D10240	G. Stachura and T. L. Wallace, 1976. SE1/4 sec. 8, T5S, R2E, Socorro County, New Mexico. Basal part of Atarque Sandstone Member of Tres Hermanos Formation.
41	D10241	G. Stachura, 1976. SW1/4 sec. 9, T5S, R2E, Socorro County, New Mexico. Basal part of Atarque Sandstone Member of Tres Hermanos Formation (Hook et al., 1983: 18 and sheet 1).
42	D10244	J. R. Wright, 1977. NW1/4 sec. 10, T5S, R2E, Socorro County, New Mexico. Basal part of Atarque Sandstone Member of Tres Hermanos Formation.
43	D10246	J. R. Wright, 1977. SE1/4 sec. 8 and SW1/4 sec. 9, T5S, R2E, Socorro County, New Mexico. Mancos Shale, from septarian limestone concretions a little below the Tres Hermanos Formation (Hook et al., 1983, sheet 1).
44	D10465	S. C. Hook and S. McLafferty, 1978. SW1/4 sec. 10, T5S, R2E, Socorro County, New Mexico. Basal part of Atarque Sandstone Member of Tres Hermanos Formation.
45	D10643	S. C. Hook and J. R. Wright, 1979. SW1/4 sec. 24, T9S, R8E, Lincoln County, New Mexico. Mancos Shale, from a unit of calcareous sandstone concretions in a thin bed of sandstone just below the Tres Hermanos Formation.
46	D12681	Brian Arkell, 1985. NW1/4 sec. 19, T9S, R9E, Lincoln County, New Mexico. Mancos Shale, from same stratigraphic level as D10643.
47	D11193	S. C. Hook and R. E. Burkholder, 1980. Gold Hill, 2.15 km N53°E of Gomez Peak, Jeff Davis County, Texas. Boquillas Limestone, from a 20 cm thick bed of chalky limestone 20 m above base.
48	D10750	S. C. Hook and W. A. Cobban, 1979. About 0.3 km southeast of Needle Peak on the Ninetysix Ranch 71/2′ quadrangle, Jeff Davis County, Texas. Chispa Summit Formation.
49	D10751	S. C. Hook, 1979. About 0.5 km west-southwest of Needle Peak on the Ninetysix Ranch 71/2′ quadrangle, Jeff Davis County, Texas. Chispa Summit Formation.

Collignoniceras woollgari (Mantell), *C. carolinum* (d'Orbigny), and *Lecointriceras costatum* Kennedy, Wright & Hancock (Amédro & Badillet, 1982, fig. 5).

Systematic paleontology

The specimens illustrated in this report are stored in the National Museum of Natural History in Washington, D.C., where they have USNM catalog numbers.

In the descriptions and illustrations of sutures, E stands for the external lobe, L stands for the lateral lobe, E/L stands for the saddle that separates the external and lateral lobes, U stands for the umbilical lobe (with U, and U2 as divisions), and I stands for the internal lobe. In the drawings of sutures, the heavy straight line marks the middle of the venter, the lighter straight line marks the middle of the dorsum, the dashed line marks the umbilical shoulder, and the evenly curved solid line marks the umbilical seam.

All dimensions are in millimeters. Figures in parentheses after the umbilical width represent percentage of the total diameter of the shell.

Family ACANTHOCERATIDAE de Grossouvre, 1893 [1894] Subfamily MAMMITINAE Hyatt, 1900

Genus *SPATHITES* Kummel & Decker, 1954
(= *Spathitoides* Wiedmann, 1960)

Type species-By original designation, *Spathites chispaensis* Kummel & Decker, 1954, from the lower Turonian of Chihuahua, Mexico; = *Pseudotissotia? coahuilaensis* Jones, 1938, from the lower Turonian of Coahuila, Mexico.

Diagnosis-Medium-sized, involute, stout to compressed ammonites that have inner whorls with ribs and tubercles (umbilical and inner and outer ventrolateral) and later whorls with reduced ornament or even loss of ornament. Venter flat or concave. Suture simple with broad bifid E/L and narrow to moderate L that is either poorly bifid or denticulate; sutures of some specimens pseudoceratitic.

Remarks-Kummel & Decker (1954: 312) noted that their species, *S. chispaensis,* the type species of *Spathites,* could be conspecific with the ammonite from Mexico described as *Pseudotissotia? coahuilaensis* Jones (1938: 123, pl. 9, figs. 1, 3, 8). A comparison of a plaster cast of Jones' holotype to topotypes of S. *chispaensis* reveals no specific differences, and Kummel & Decker's species is herein considered a junior synonym of *S. coahuilaensis.*

Kennedy, Wright & Hancock (1980a) recognized two subgenera of *Spathites, Spathites (S.)* with *S. chispaensis* as the type and *S. (Jeanrogericeras)* with *Ammonites reveliereanus* Courtiller, 1860, as the type. *Spathites (S.)* includes forms that have smooth adult body chambers with sharp ventral shoulders, and S. *(J.)* includes forms that retain ribs and tubercles on the outer whorls. *Spathites (Jeanrogericeras)* (Wiedmann, 1959: 740) is the older form and presumably gave rise to *S. (Spathites)* (Kennedy et al., 1980a: 833-835, fig. 9). *Spathites puercoensis,* the youngest of the American species, retains ornament on the adult whorls and in this respect resembles *Jeanrogericeras.* However, *S. puercoensis* is younger than *S. chispaensis [coahuilaensis],* the type of *Spathites (S.),* and has a broader venter, narrower umbilicus, and more pseudoceratitic suture than *Jeanrogericeras.* Until more is known about the relationship of *Jeanrogericeras* to *Spathites,* no attempt is made in the present study to assign the American species to subgenera of *Spathites.*

SPATHITES COAHUILAENSIS (Jones)
Figs. 2A-N, 3P-Y, 4

1931. *Pseudotissotia(?)* n.sp. Adkins, p. 58, pl. 2, fig. 5, pl. 4, figs. 3, 6.
1938. *Pseudotissotia(?) coahuilaensis* Jones, p. 123, pl. 9, figs. 1, 3,
1938. *Pseudotissotia(?) kellyi* Jones, p. 124, pl. 9, figs. 2, 7, pl. 10, fig. 9 (not pl. 8, fig. 3).
1954. *Spathites chispaensis* Kummel & Decker, p. 311, p1. 30, figs. 1, 2, pl. 31, figs. 1-15, text-fig. 1.
1954. *Spathites coahuilaensis* (Jones): Kummel & Decker, pp. 311, 312.
1954. *Spathites kellyi* (Jones): Kummel & Decker, pp. 311, 312. 1980a. *Spathites chispaensis* Kummel & Decker: Kennedy, Wright & Hancock, p. 822, text-figs. la, b, **8B.**

Types-Holotype University of Michigan 16822, from Coahuila, Mexico (locality and stratigraphic position unknown). Hypotypes: USNM 404344 from the Chispa Summit Formation at Sobaco, Chihuahua, Mexico; USNM 404336, 404339, 404341, and 404343 from the Chispa Summit Formation in Jeff Davis County, Texas; USNM 404337 and 404338 from the Tres Hermanos Formation in Cibola County, New Mexico; and USNM 404340 and 404342 from the Rio Salado Tongue of the Mancos Shale in Cibola and McKinley Counties, New Mexico.

Description-Spathites *coahuilaensis* is characterized by its adult body chamber that has smooth, flattened flanks; sharply defined ventrolateral shoulder; and broad, flat venter crossed transversely by broad, low folds.

The holotype is a well-preserved internal mold of a stout adult that consists of the phragmocone and about half of the body chamber. Jones (1938: 123) gave its diameter as 89 mm and its umbilicus as 9 mm. Whorls are higher than wide with flattened flanks, well-defined ventrolateral shoulder, and broad, flattened venter. Greatest width is a little below the middle of the flank. Ornament is lacking on the outer whorl of the phragmocone and on the body chamber except for prorsiradiate striae on the body chamber and broad, low, transverse folds on the venter. These folds are narrower than the interspaces and number about 20 per whorl. Most of the external suture is preserved (Fig. 4A). Only bits of the external lobe (E) are visible, and the drawing by Jones (1938, pl. 9, fig. 1) of that lobe is restored and too generalized. The lateral lobe (L) and the umbilical lobes (U_2 and U,) are narrow and little divided. Saddles that separate these lobes as well as the E/L saddle are very broad, bifid, and little divided.

Remarks-Spathites *coahuilaensis* is present in small numbers in the Chispa Summit Formation in Trans-Pecos Texas. The specimens occur in septarian limestone concretions and in unusual hiatus concretions (Kennedy et al., 1977). Specimens in the septarian concretions usually have fairly good early whorls, but the later septate whorls and body chambers are broken and distorted. Specimens in the hiatus concretions are mostly undistorted body chambers. Most specimens closely resemble the holotype as well as the specimens illustrated by Kummel & Decker (1954) as *S. chispaensis.* A fragment of a body chamber from one of the hiatus concretions is larger than any described specimen and has a venter 33 mm wide (Fig. 2I-K). Inasmuch as this fragment indicates an adult about twice as large as the smallest adult (Fig. 2A, B) from the hiatus concretions, sexual dimorphism is suggested.

Spathites coahuilaensis occurs sparingly in the Mancos Shale in west-central and western New Mexico (Fig. 1, locs. 2, 3, 6, 33). Two specimens, that have diameters of 48 and 91 mm, are especially noteworthy in that they further suggest dimorphism. The smaller one (Fig. 3R, S) has nearly three-fourths of a whorl of body chamber that has a diameter of about 32 mm at its base. Ribs disappear and umbilical tubercles weaken greatly at the beginning of the body chamber. Ventrolateral tubercles, although weakened, are still present on the youngest preserved part of the body chamber, which also has low transverse ventral ribs. The larger specimen (Fig. 2L-N) consists of a phragmocone and a little less than one-half whorl of body chamber, which has a diameter of 66 mm at its base. This specimen (macroconch)

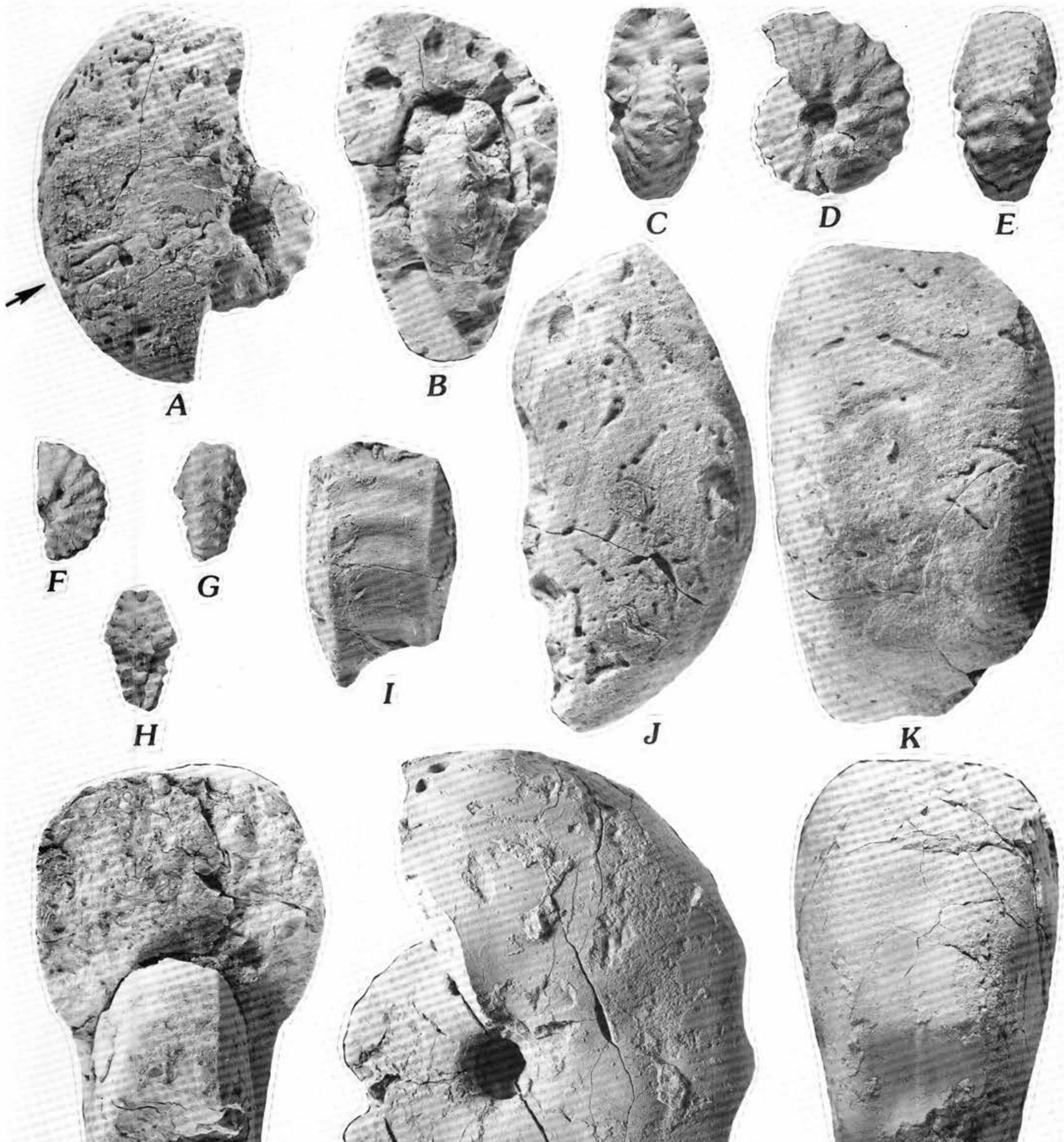
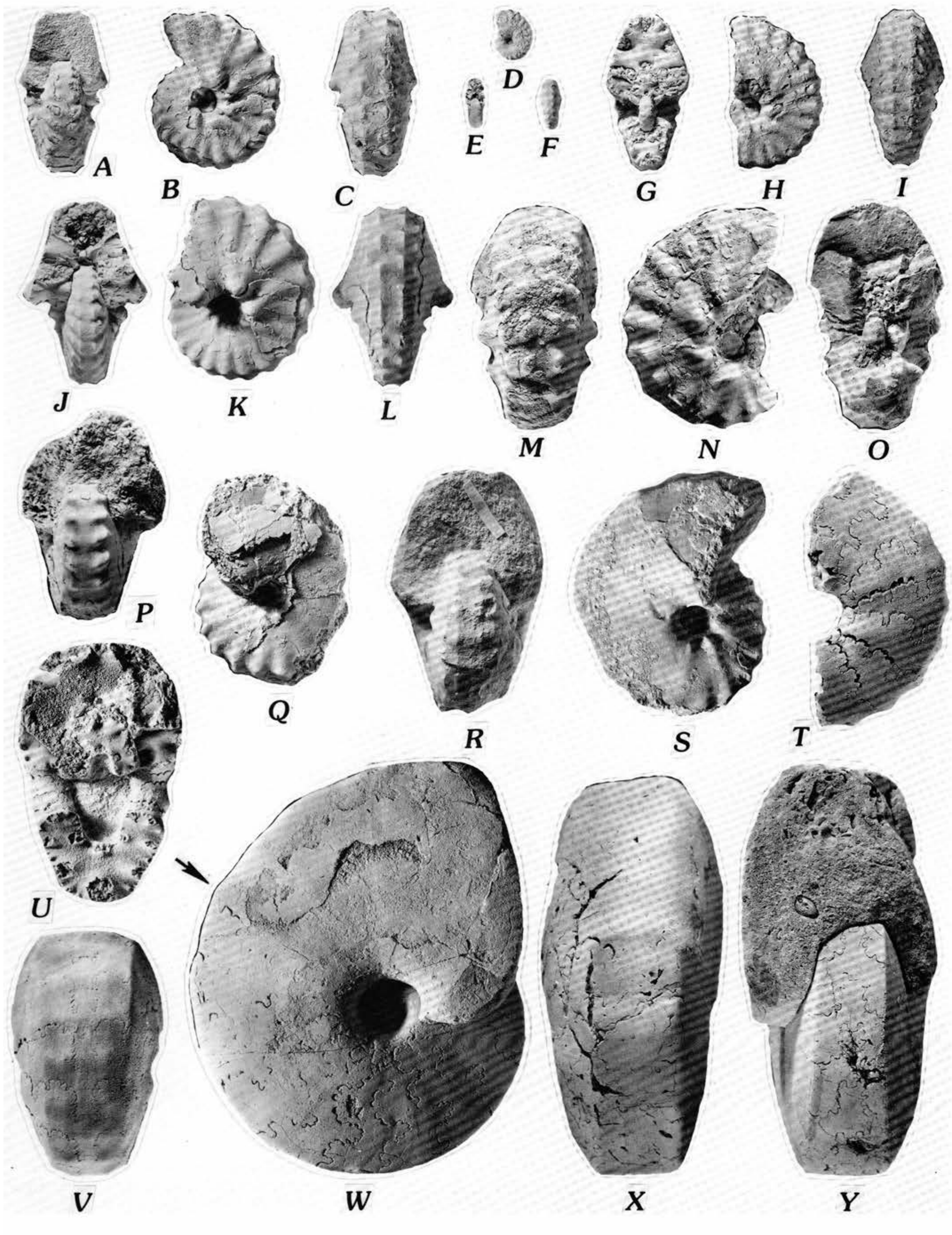


FIGURE 2—*Spathites coahuilaensis* (Jones): **A, B,** USNM 404336 from a hiatus concretion (Kennedy et al., 1977) in the Chispa Summit Formation at USGS Mesozoic locality D10751 in Trans-Pecos Texas (Fig. 1, loc. 49). The specimen consists of most of an extensively bored body chamber and part of the inner whorls. **C–E,** USNM 404337 from the basal part of the Tres Hermanos Formation at USGS Mesozoic locality D10320 (Fig. 1, loc. 36). **F–H,** USNM 404338 from the same locality as the specimen in C–E. **I–K,** USNM 404339 from the same locality as the specimen in A, B; I is a latex cast of impression of the venter of the next inner whorl. **L, M,** USNM 404340 from the Rio Salado Tongue of Mancos Shale at USGS Mesozoic locality D11450 (Fig. 1, loc. 33). All figures natural size. Arrows mark base of body chambers.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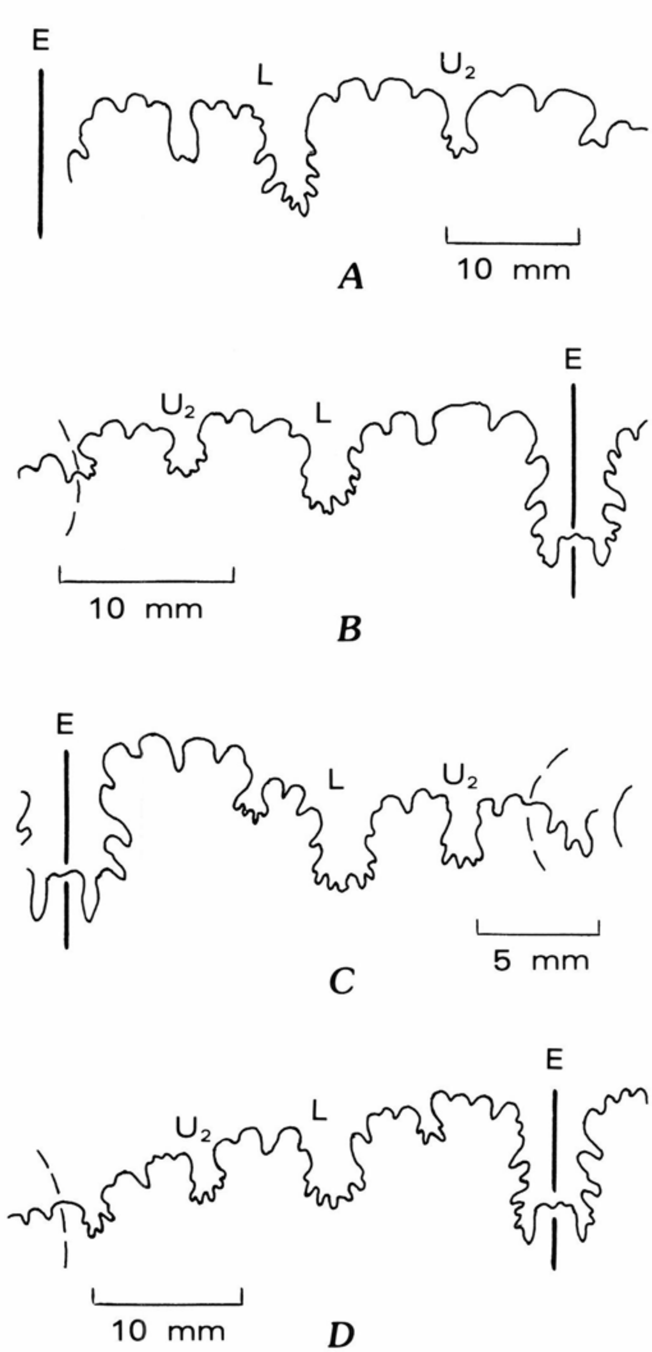

FIGURE 4—External sutures of *Spathites coahuilaensis* (Jones): **A,** Holotype UM 16822 from Coahuila, Mexico; composite suture drawn from last few sutures of plaster cast of the holotype. **B,** USNM 404344 (Fig. 3W–Y) from the Chispa Summit Formation at the type locality of *S. chispaensis* Kummel & Decker at Sobaco, Chihuahua, Mexico; tenth from last suture. **C,** USNM 404342 (Fig. 3R, S) from the upper part of the Rio Salado Tongue of Mancos Shale at USGS Mesozoic locality D10606 (Fig. 1, loc. 3); last suture at a diameter of about 32 mm. **D,** USNM 404343 (Fig. 3T–V) from the Chispa Summit Formation at USGS Mesozoic locality D10750 (Fig. 1, loc. 48); suture at a whorl height of 26 mm.

is twice as large as the smaller one (microconch). All ornament, except for broad transverse ventral folds, has disappeared before the beginning of the last complete whorl on the larger specimen.

Sutures of *S. coahuilaensis* from Trans-Pecos Texas (Fig. 4D) and New Mexico (Fig. 4C) resemble that of the holotype (Fig. 4A) and that of a topotype (Fig. 4B) of *S. chispaensis* Kummel & Decker *[coahuilaensis]* in their general form and simplicity. The lateral lobe (L) is fairly narrow, poorly bifid, and little divided. Umbilical lobes (U, and U_2) are small and quite simple. The E/L saddle is broad and bifid, and other saddles are bifid and tend to be broad.

Occurrence-Spathites *coahuilaensis* occurs in Trans-Pecos Texas in the Chispa Summit Formation at USGS Mesozoic localities D10750 and D10751 (Fig. 1, locs. 48, 49), where the ammonite is associated with *Collignoniceras woollgari* (Mantell), *Tragodesmoceras* sp., and *Romaniceras* sp. In west-central New Mexico, S. *coahuilaensis* has been found in the upper part of the Rio Salado Tongue of Mancos Shale and in the basal part of the Tres Hermanos Formation at USGS Mesozoic localities D6153, D10606, D11450, D11475, D6804, and D10320 (Fig. 1, locs. 2, 3, 33-36), and questionably at D11264 (Fig. 1, loc. 1).

SPATHITES RIOENSIS Powell
Figs. 3M-O, 5A-L, 6A-N, 8

1963. *Spathites rioensis* Powell, p. 1228, pl. 169, fig. 2, pl. 170, figs. 1-3, 6, 7, text-figs. 5j, 6c-e.

1979. *Spathites rioensis* Powell: Cobban & Hook, p. 18, pl. 2, figs. 1-4, p1. 5, figs. 11, 12, p1. 8, figs. 8-13, p1. 11, figs. 1-9, pl. 12, figs. 4-6, text-fig. 9.

1980a. *Spathites (Spathites) rioensis* Powell: Kennedy, Wright & Hancock, p. 833, text-fig. 8A.

1986. *Spathites rioensis* Powell: Cobban, p. 81, fig. 3L, M, R-U.

Types-Holotype UT 30954 and hypotype USNM 404345 from the Ojinaga Formation at Cannonball Hill east of Cieneguilla, Chihuahua, Mexico (Fig. 1). Hypotypes USNM 403199, 404346-404355 from the upper part of the Rio Salado Tongue of Mancos Shale and basal part of the overlying Tres Hermanos Formation in central New Mexico.

Description-This species is characterized by its adult body chamber that has a concave to flattened venter, rounded ventrolateral shoulder, and smooth or nearly smooth, flattened flanks.

The holotype (Powell, 1963, p1. 170, figs. 1, 6, text-fig. 6c) is an internal mold of a fairly large adult 130 mm in diameter, with an umbilical ratio of 0.15. More than one-half of the outer whorl is body chamber, which has a normal aperture. Ribs and tubercles are greatly weakened on the last part of the phragmocone, and only faint umbilical and ventrolateral swellings are present on the older part of the body chamber. The simple suture inked on the holotype (Powell, 1963, pl. 170, fig. 6) is typical of the genus. Lateral and umbilical lobes are fairly narrow and little divided, and the saddles that separate the lobes are broad and bifid with few incisions.

Early whorls of *S. rioensis,* illustrated by Powell (1963, pl. 170, figs. 2, 3, text-fig. 6d) are robust and have whorl sections about as high as wide. Ornament consists of strong, nodate umbilical tubercles that give rise to low, broad, rec-

FIGURE 3—**A–L,** *Spathites puercoensis* (Herrick & Johnson): **A–C,** USNM 404356 from the Semilla Sandstone Member of the Mancos Shale at USGS Mesozoic locality D4020 (Fig. 1, loc. 11). **D–F,** USNM 404357 from the same locality. **G–I,** USNM 404358 from the Mancos Shale at USGS Mesozoic locality 15909 (Fig. 1, loc. 25). **J–L,** USNM 404359 from the Mancos Shale at USGS Mesozoic locality 16114 (Fig. 1, loc. 14). **M–O,** *Spathites rioensis* Powell, USNM 404345 from the Ojinaga Formation at Cannonball Hill east of Cieneguilla, Chihuahua, Mexico. **P–Y,** *Spathites coahuilaensis* (Jones): **P, Q,** USNM 404341 from the Chispa Summit Formation at USGS Mesozoic locality D10750 (Fig. 1, loc. 48). **R, S,** USNM 404342 from the Rio Salado Tongue of the Mancos Shale at USGS Mesozoic locality D10606 (Fig. 1, loc. 3); see Fig. 4C for the suture. **T–V,** USNM 404343 from the same locality as the specimen in P, Q; see Fig. 4D for the suture. **W–Y,** USNM 404344 from the Chispa Summit Formation at Sabaco, Chihuahua, Mexico; see Fig. 4B for the suture. All figures natural size. Arrows mark base of body chambers.

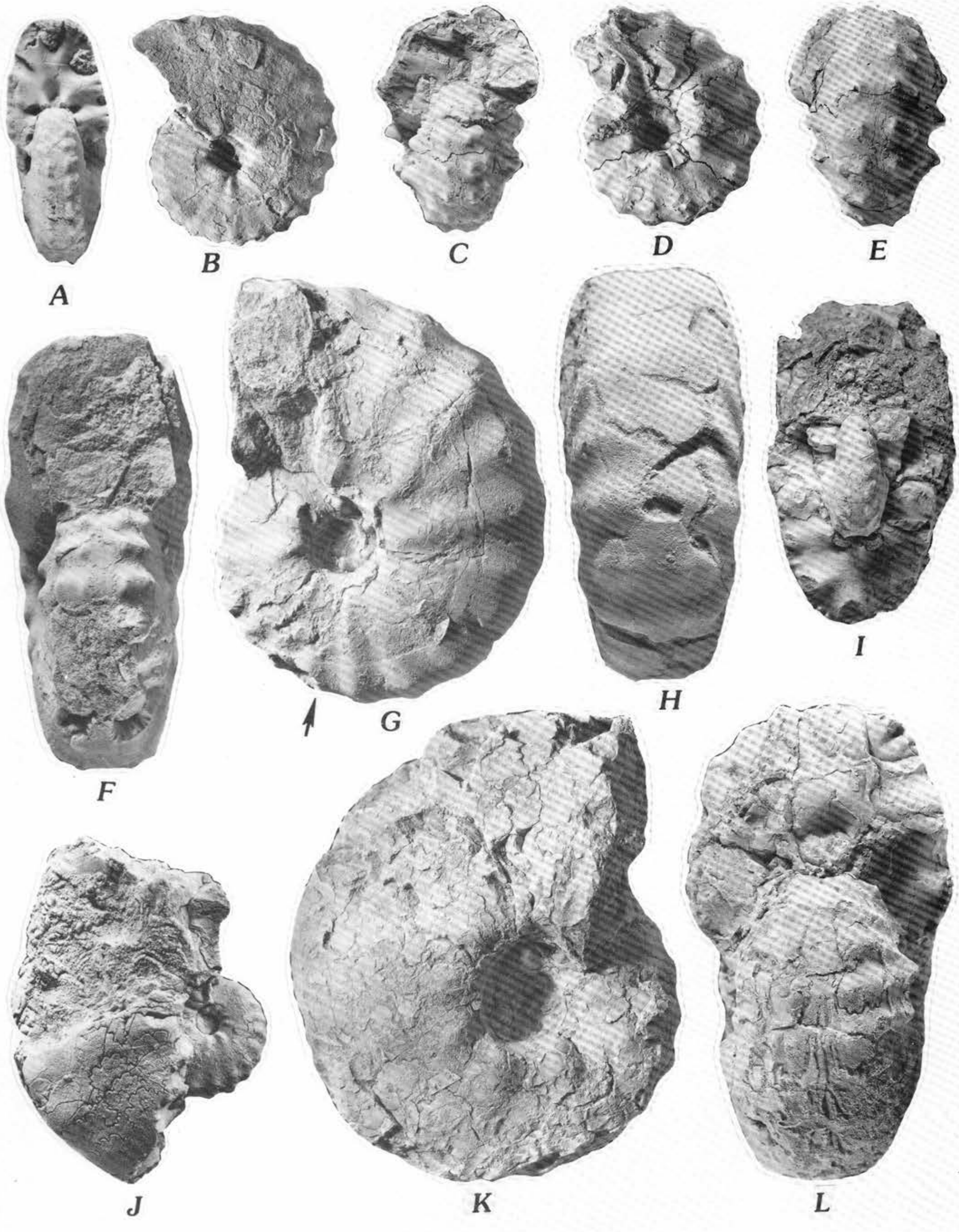

FIGURE 5—*Spathites rioensis* Powell: **A, B,** USNM 404346 from the upper part of the Rio Salado Tongue of the Mancos Shale at USGS Mesozoic locality D11708 (Fig. 1, loc. 8); inner whorls of the slender form of the species. **C–E,** USNM 404347 from the upper part of the Rio Salado Tongue of the Mancos Shale at USGS Mesozoic locality D11559 (Fig. 1, loc. 7); inner whorls of the robust form of the species; see Fig. 8C for the suture. **F–H,** USNM 404348 from the same locality as the specimen in A, B; a complete small adult (microconch). **I, J,** USNM 404349 from the same locality as the specimen in C–E; see Fig. 8A for the suture. **K, L,** USNM 404350 from the same locality as the specimen in C–E. All figures natural size. Arrow marks base of body chamber.

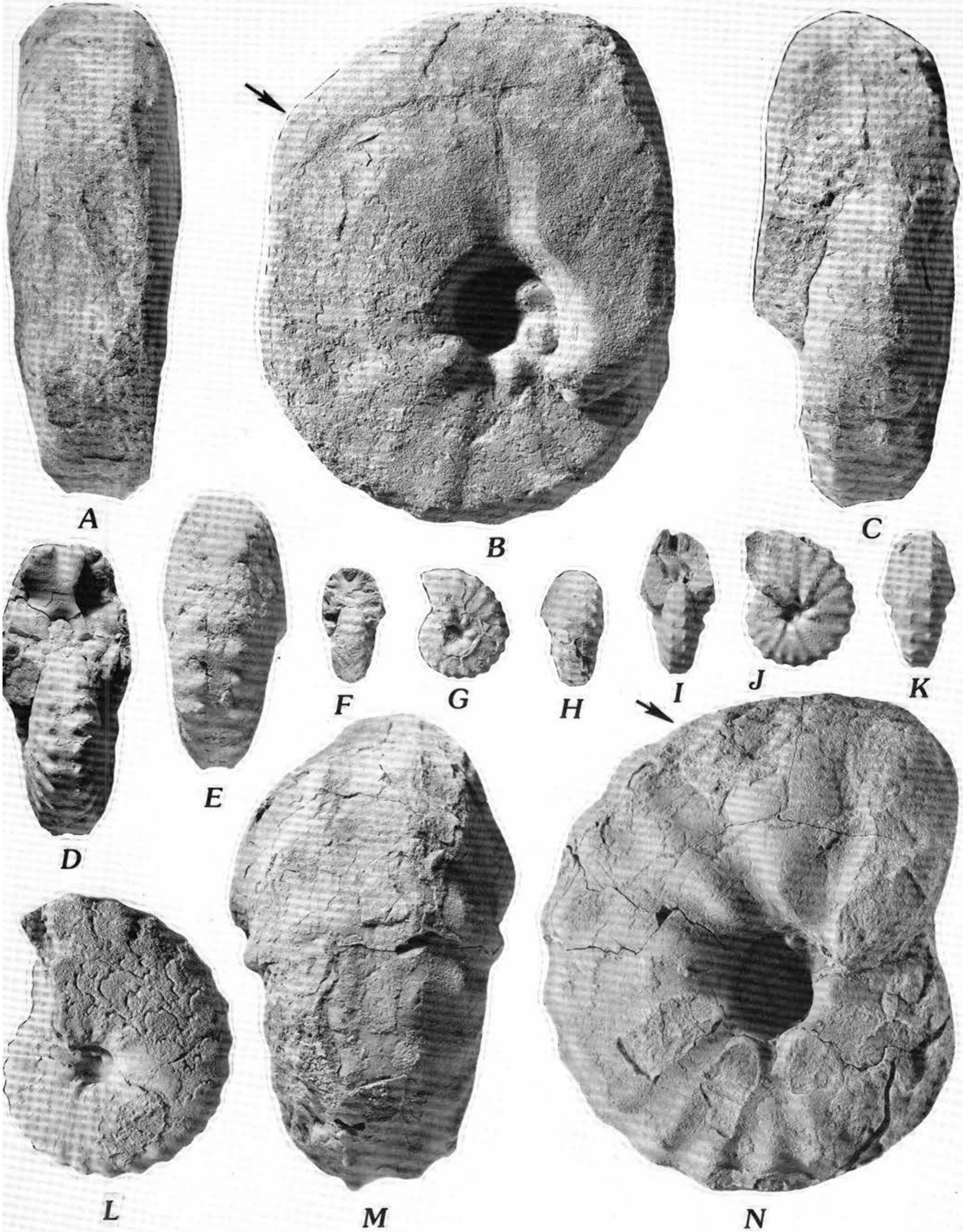

FIGURE 6—*Spathites rioensis* Powell: **A–C,** USNM 404351 from the Mancos Shale at USGS Mesozoic locality D12681 (Fig. 1, loc. 46); an unusually slender adult. **D, E, L,** USNM 404352 from the upper part of the Rio Salado Tongue of the Mancos Shale at USGS Mesozoic locality D11559 (Fig. 1, loc. 7); inner whorls of a slender specimen. **F–H,** USNM 404353 from the same locality. **I–K,** USNM 404354 from the basal part of the Tres Hermanos Formation at USGS Mesozoic locality D10240 (Fig. 1, loc. 40). **M, N,** USNM 403199 from the Mancos Shale at USGS Mesozoic locality D10643 (Fig. 1, loc. 45); most of a large, moderately robust specimen. All figures natural size. Arrows mark base of body chambers.

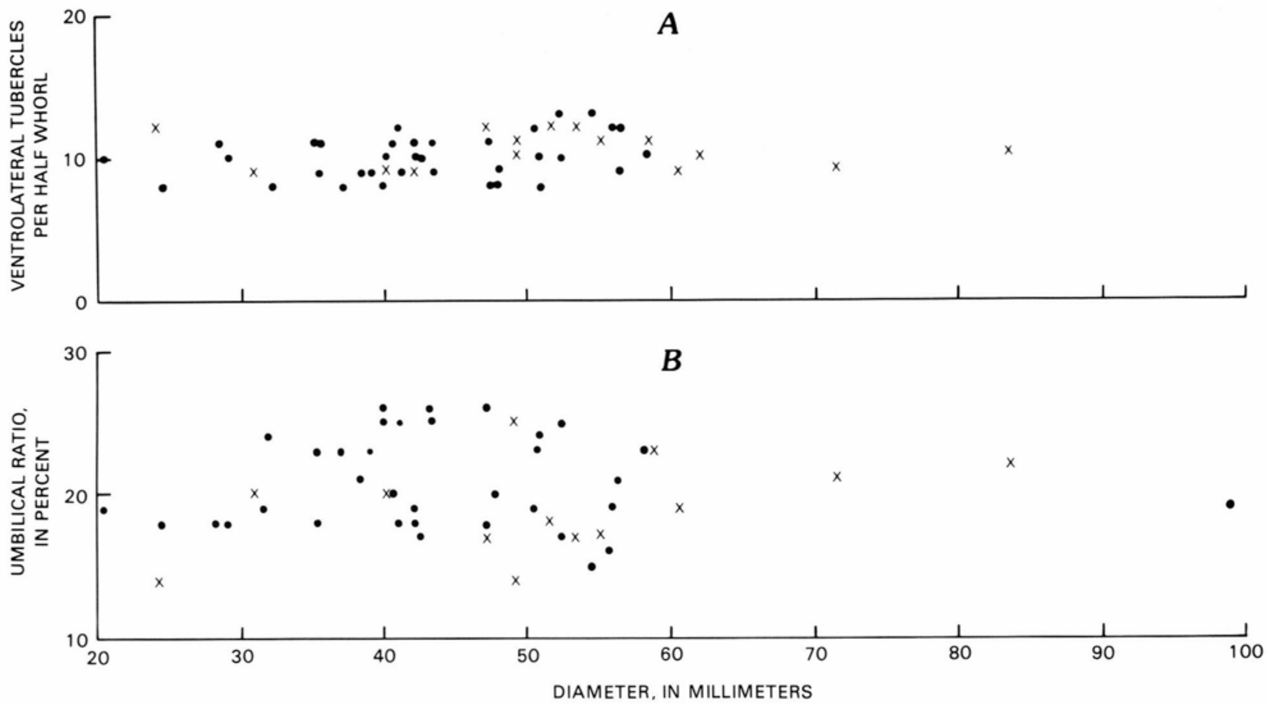

FIGURE 7—Scatter diagrams showing ventrolateral tubercles per half-whorl (**A**) and umbilical ratios (**B**) of *Spathites rioensis* Powell from near the top of the Rio Salado Tongue of Mancos Shale at USGS Mesozoic localities D11559 (•) and D11708 (×) (Fig. 1, locs. 7, 8).

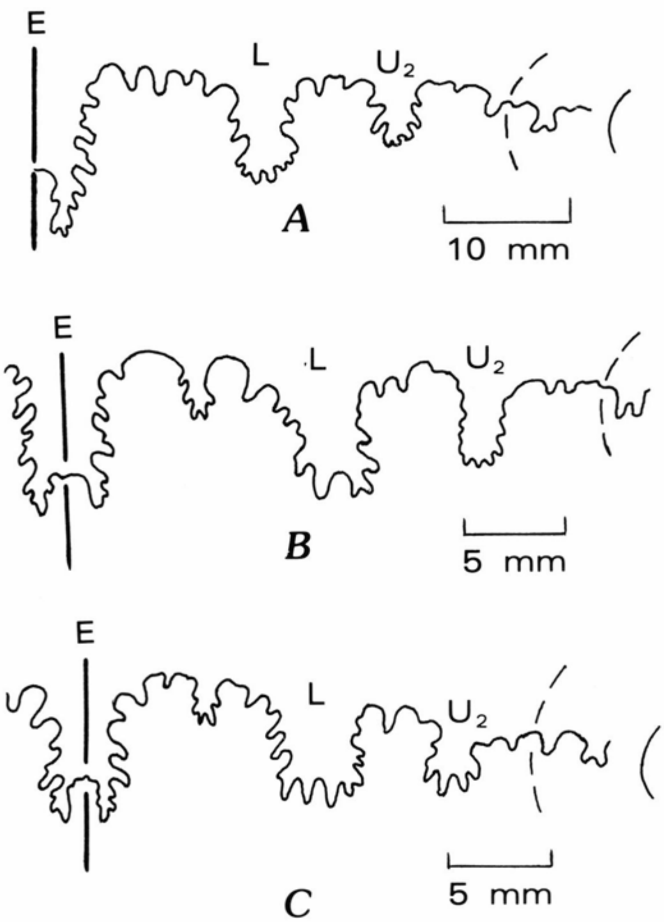

FIGURE 8—External sutures of three specimens of *Spathites rioensis* Powell from the upper part of the Rio Salado Tongue of Mancos Shale at USGS Mesozoic locality D11559 (Fig. 1, loc. 7). **A,** USNM 404349 (Fig. 5I, J) at a whorl height of 29.4 mm. **B,** USNM 404355 at a diameter of 40.4 mm. **C,** USNM 404347 (Fig. 5C–E) at a diameter of 38.4 mm.

tiradiate to prorsiradiate ribs. These ribs are separated by one or two secondaries that arise at midflank or higher. All ribs bear nodate to clavate inner ventrolateral tubercles and similar-sized outer ones and then weaken as they cross the venter transversely. On the few specimens at hand from the type locality (Cannonball Hill), all ventrolateral tubercles become clavate near the end of the phragmocone, and the outer ones are slightly stronger and bound a narrow, depressed venter.

A very large phragomocone (Powell, 1963, pl. 169, fig. 2) from the type locality suggests dimorphism in this species. Powell did not give its dimensions, but his illustration indicates a specimen still septate at a diameter of about 110 mm. In contrast, the holotype appears to have a diameter of about 65 mm at the base of the body chamber.

Spathites rioensis has been collected at several localities in New Mexico. The largest collections are from USGS Mesozoic localities D11559 and D11708 in Cibola County and D10643 in Lincoln County (Fig. 1, locs. 7, 8, 45). Locality D11559 has 38 specimens, mostly inner whorls, suitable for measurements of diameter, umbilicus, and number of tubercles. The inner whorls range from slender, involute, weakly to moderately ornamented forms (Fig. 5I J) to robust, less involute, strongly ornamented ones (Fig. 5C—E). In general, the more slender forms have umbilical ratios of 0.14-0.18, and the more robust ones have ratios of 0.190.26 (Fig. 7B). Ribs tend to be weak, straight, rectiradiate, to slighly prorsiradiate. Umbilical tubercles are usually no-date and strong and number 3-7 per half-whorl, averaging 4. Inner ventrolateral tubercles are usually nodate, whereas the outer ones are clavate and slightly stronger. Ventrolateral tubercles number 8-13 per half-whorl, averaging 10. Body chambers are crushed and incomplete. Diameters at the base of body chambers could be determined for only eight specimens; these measurements in millimeters (rounded) are 52, 53, 56, 56, 57, 58, 65, and 99.

USGS locality D11708 has 18 specimens suitable for measurements, which are much like those from locality D11559. Diameters at the base of body chambers are mostly 50-60 mm. One larger specimen has a measurement of 96 mm.

Only nine specimens are in the collection from locality D10643, but all represent fairly large adults. Diameters in mm (rounded) at the base of body chambers, which can be measured on only four of the specimens, are 84, 92, 94, and 98 mm. These adults range from robust forms (Fig. 6M, N) that have trapezoidal whorl sections to slender forms that have rectangular sections.

Sutures of *S. rioensis* (Fig. 8) resemble those of S. *coahuilaensis* except that the lobes and saddles are a little more incised.

Occurrence—Spathites *rioensis* is abundant at the type locality at Cannonball Hill in Chihuahua, Mexico, where Powell (1963: 1228) recorded 75 specimens from 433 m above the base of the Ojinaga Formation. Other ammonites illustrated by Powell from this locality include *Selwynoceras mexicanum* (Bose) *[Collignoniceras woollgari* (Mantell)], *Mammites [Morrowites] depressus* Powell, *Neoptychites xetriformis* Pervinquiere, *N. gourguechoni* Pervinquiere, and *Coilopoceras* sp.

Spathites rioensis is present in only one USGS collection (Fig. 1, loc. 47) from Trans-Pecos Texas. Here the species was found with *Collignoiceras woollgari* and *Neoptychites* sp. high in the Boquillas Limestone (Hook & Cobban, 1983: 49).

In west-central and western New Mexico, S. *rioensis is* found in concretions of siltstone and very fine-grained sandstone in the basal part of the Tres Hermanos Formation and in septarian limestone concretions in the upper part of the underlying Rio Salado Tongue of Mancos Shale (Fig. 1, locs. 6-8, 37-46). Associated ammonites include *Morrowites depressus* (Powell), *Collignoniceras woollgari woollgari* (Man-tell), *Placenticeras cumminsi* Cragin, and *Baculites yokoyamai* Tokunaga & Shimizu. In some localities a varied bivalve and gastropod fauna may also be present (Hook et al., 1983: 17). *Mytiloides subhercynicus* (Seitz) and M. *hercynicus* (Petrascheck) may be present.

SPATHITES PUERCOENSIS (Herrick & Johnson)
Figs. 3A-L, 9A-C, G-M, 10A-L, 11A-F, 14

1900a. *Buchiceras swallovi* Shumard: Herrick & Johnson, p. 39, pl. 1, figs. 1, 2.
1900a. *Buchiceras swallovi* var. *puercoensis* Herrick & Johnson, p. 39, pl. 1, figs. 3, 4.
1900b. *Buchiceras swallovi* Shumard: Herrick & Johnson, p. 213, pl. 27, figs. 1, 2.
1900b. *Buchiceras swallovi* var. *puercoensis* Herrick & Johnson, p. 213, pl. 27, figs. 3, 4.
1917. *Metoicoceras puercense* [sic] (Herrick & Johnson): Stanton *in* Lee, p. 176.
1968. *Spathites puercoensis* (Herrick & Johnson): Dane, Kauffman & Cobban, p. 7.
1980a. *Spathites (Spathites) puercoensis* (Herrick & Johnson): Kennedy, Wright & Hancock, p. 834, pl. 104, figs. 1-5, pl. 106, fig. 3, text-fig. 8C.
1982. *Spathites puercoensis* (Herrick & Johnson): Hook & Cobban, p. 37, figs. 2-4.

Types—Holotype (Herrick & Johnson, 1900a, pl. 1, figs. 3, 4; 1900b, pl. 27, figs. 3, 4) from the Mancos Shale of the Rio Puerco valley northwest of Albuquerque, New Mexico. Hypotypes USNM 404356-404378 from the Mancos Shale and Semilla Sandstone Member of the Mancos in the Rio Puerco valley, Sandoval County, New Mexico.

Remarks—The holotype was apparently housed in the Hadley Laboratory at the University of New Mexico in Albuquerque. The laboratory burned to the ground on May 23, 1910, and all of Herrick & Johnson's material was destroyed (Northrop, 1966: 20).

The holotype was defined as a variety of *Buchiceras swallovi* (Shumard) (originally *Ammonites swallovii* Shumard, 1860: 591) that was more compressed, smoother, and lacked umbilical tubercles. Specimens that Herrick & Johnson (1900a, p1. 1, figs. 1, 2) regarded as *B. swallovi* occur in the Rio Puerco valley in great abundance with the variety *puercoensis.* These authors also observed that some specimens of their variety possessed faint umbilical tubercles and were transitional to *B. swallovi.* Shumard's *Ammonites swallovii* was later designated as the type species of *Metoicoceras* (Shimer & Shrock, 1944: 591).

Description—In addition to retaining ornament on the adult body chamber, S. *puercoensis* is a highly variable species that ranges from slender, weakly ornamented forms to robust, strongly ornamented ones. The description by Herrick & Johnson (1900a: 39) is as follows:

> This beautiful species occurs in vast numbers in septaria concretions of the so-called cephalopod shales in the Rio Puerco valley where it is associated with Sphenodiscus lenticularis, Placenticeras placenta, Pholadomya subventricosa, and other lower Fox Hills species. The typical form as described by Shumard is abundant and is accompanied by a variety or possibly a distinct species characterized by the absence of nodes about the umbilicus, the greater lateral compression of the shell and the almost complete absence of the ribs. The paired dorsal nodes, though present, are inconspicuous. The sutural pattern is the same except that the serration of the lobes is less marked. Individuals with more prominent ribs and slight development of the umbilical nodes indicate the possibility of a transition to the type. The variety may be known as var. puercoensis. Plate I, Figs. 3, 4. It would seem that the two forms occur together wherever the species occurs.

Inasmuch as the holotype was not described separately, its features depend entirely on the sketch by Herrick & Johnson (reproduced by Hook & Cobban, 1982, fig. 2). The drawing reveals an internal mold of slender adult that had about one-quarter of a whorl of body chamber preserved. The specimen apparently had a diameter of about 92 mm and an umbilicus of 9 mm (0.10). Whorl section of the body chamber is much higher than wide, with divergent flattened flanks and slightly concave venter. Low, clavate ventrolateral tubercles bound the venter on the phragmocone and older part of the body chamber. Umbilical tubercles are lacking.

The large collections from the Rio Puerco valley verify that Herrick & Johnson's *Buchiceras swallovi* and variety *puercoensis* represent a variable population of one species that ranges from compressed, poorly ornamented forms to robust, strongly ornamented ones. Specimens that closely resemble the drawing of the holotype of *S. puercoensis* in lacking umbilical tubercles on the outer whorl are rare (Fig. 9H-J). Almost all adults have umbilical tubercles on the outer whorl, although they may be faint on the more slender, weakly ornamented individuals.

The largest collection from the Rio Puerco valley, USGS Mesozoic locality D4020 (Fig. 1, loc. 11), contains 70 specimens that consist of complete outer whorls suitable for the determination of two or more of the following measurements: diameter, umbilicus (and ratio to diameter), whorl breadth (and ratio to diameter), diameter at base of body chamber, and number of umbilical and ventrolateral tubercles per whorl.The specimens range in diameter from 30 to 114 mm and have umbilical ratios of 0.09-0.17 (Fig. 12B). Body chambers, which are present on many specimens, occupy about two-thirds of a whorl (Fig. 10J, K). Diameters at the base of these body chambers range from 49.5 to 88.8 mm (Fig. 13).

An adult that has a diameter of 66.2 mm at the base of the body chamber was taken apart and the inner whorl at a diameter of 9.7 mm was examined (Fig. 3D-F). This small whorl has an umbilical ratio of 0.14 and a breadth to diameter ratio of 0.43. The smaller end of the whorl is higher

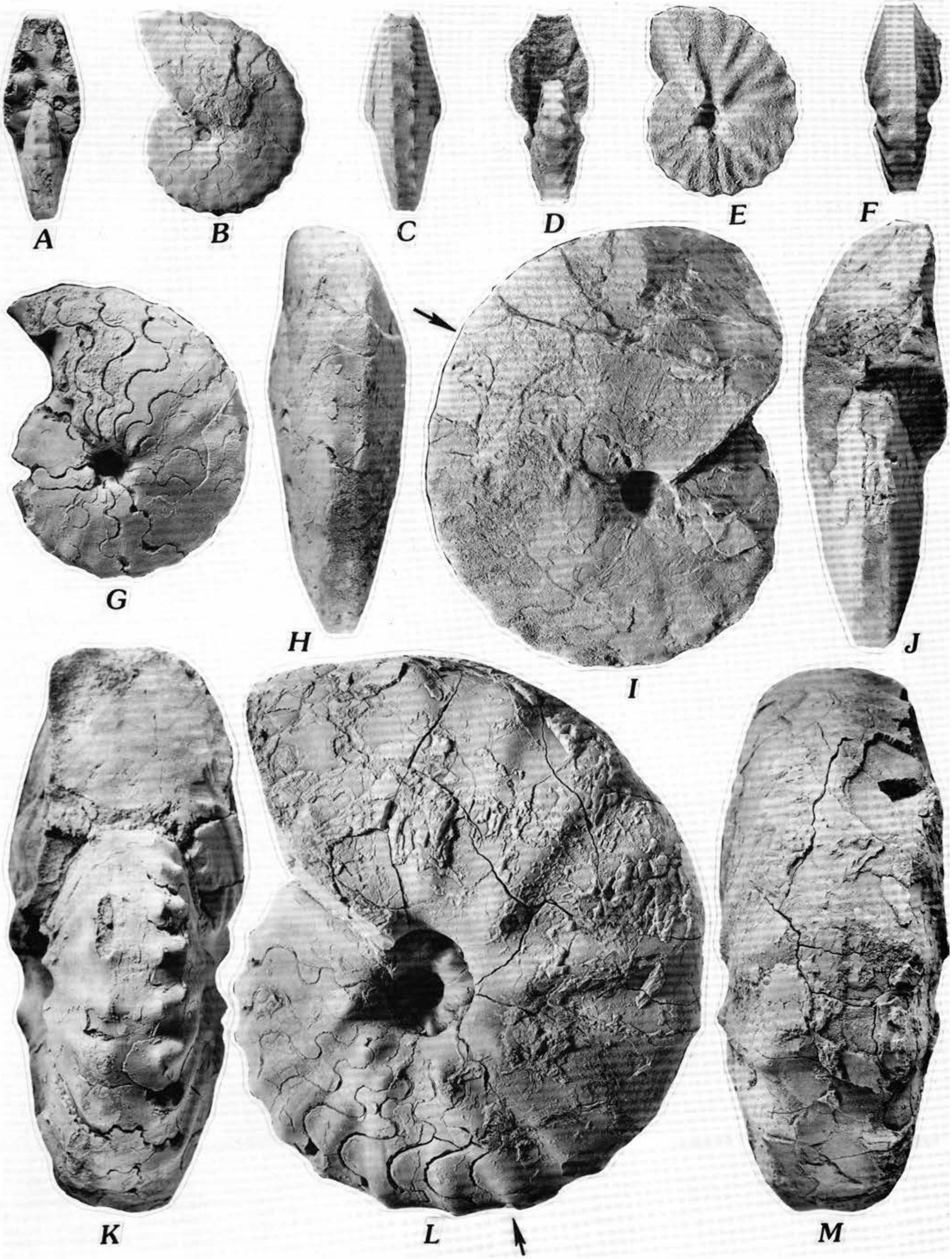

FIGURE 9—**A–C, G–M,** *Spathites puercoensis* (Herrick & Johnson): **A–C,** USNM 404360 from the Mancos Shale at USGS Mesozoic locality 15947 (Fig. 1, loc. 17). **G,** USNM 404361 from the Semilla Sandstone Member of the Mancos Shale at USGS Mesozoic locality D4020 (Fig. 1, loc. 11); a phragmocone that has an unusually pseudoceratitic suture. **H–J,** USNM 404362 from the Mancos Shale at USGS Mesozoic locality D10508 (Fig. 1, loc. 18); a slender form of the species that closely resembles the holotype. **K–M,** USNM 404363 from the Mancos Shale at USGS Mesozoic locality 3520 (Fig. 1, loc. 26); a complete adult that has an unusually pseudoceratitic suture. **D–F,** *Spathites* sp., USNM 404377 from the Codell Sandstone Member of the Carlile Shale at USGS Mesozoic locality D10769 (Fig. 1, loc. 10). All figures natural size. Arrows mark base of body chambers.

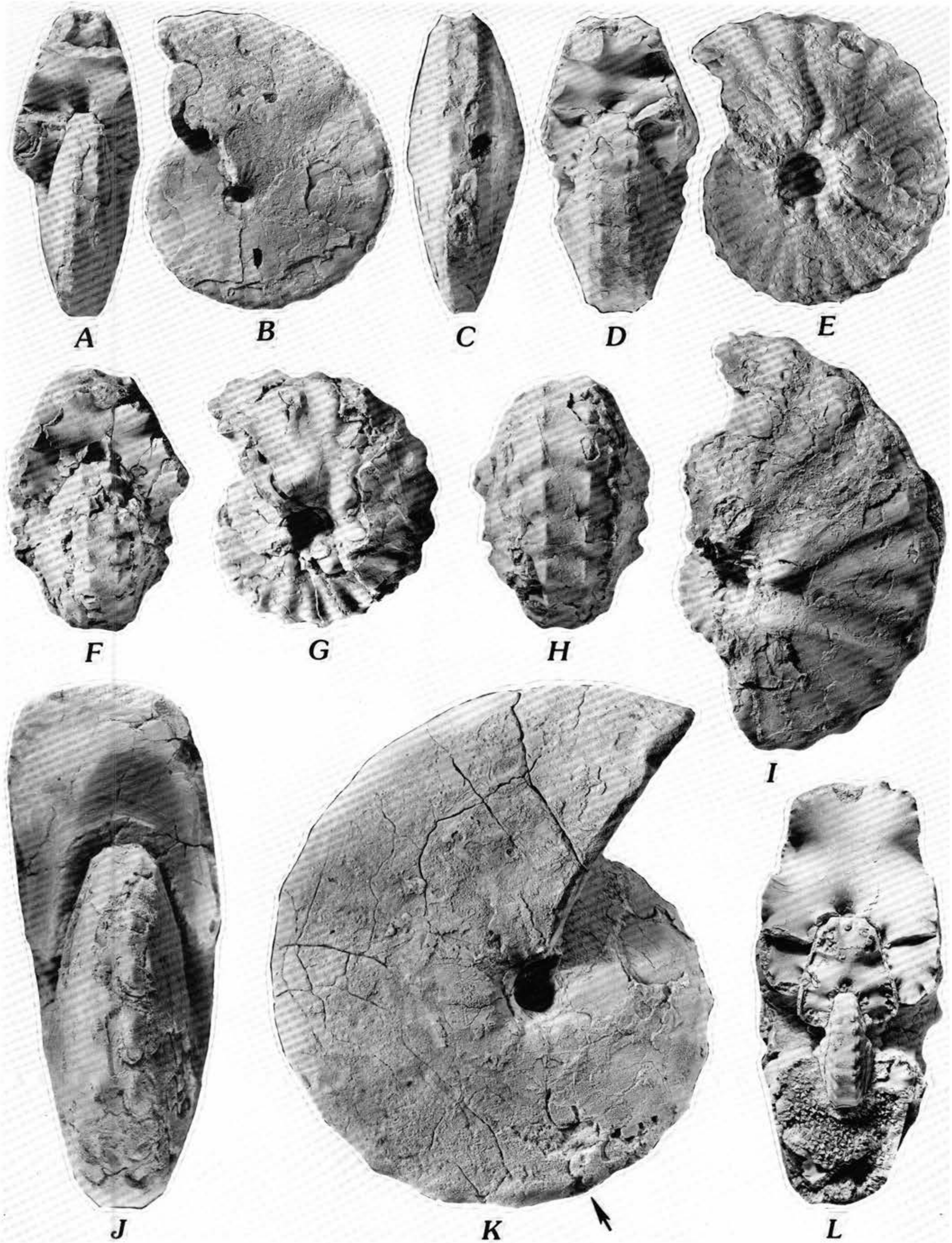

FIGURE 10—*Spathites puercoensis* (Herrick & Johnson): **A–C,** USNM 404364 from the Mancos Shale at USGS Mesozoic locality 15909 (Fig. 1, loc. 25); inner whorls of the slender form of the species. **D, E,** USNM 404365 from the same locality; inner whorls of a moderately robust form. **F–H,** USNM 404366 from the Mancos Shale at USGS Mesozoic locality 3672 (Fig. 1, loc. 27); inner whorls of a very robust form. **I, L,** USNM 404367 from the Mancos Shale at USGS Mesozoic locality 3520 (Fig. 1, loc. 26); broken phragmocone of the slender form of the species. **J, K,** USNM 404368 from the Semilla Sandstone Member of the Mancos Shale at USGS Mesozoic locality D4020 (Fig. 1, loc. 11); complete adult of the slender form of the species. All figures natural size. Arrow marks base of body chamber.

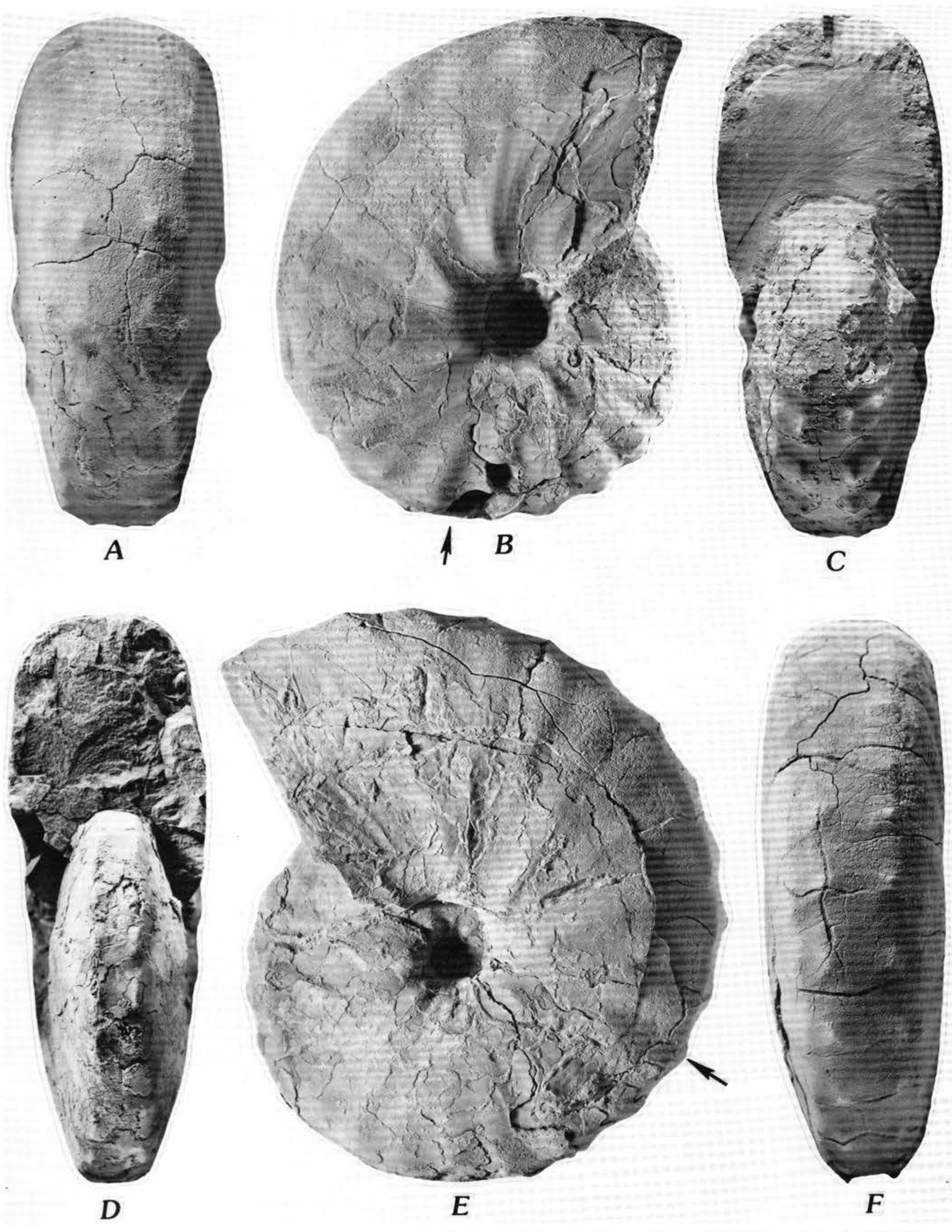

FIGURE 11—*Spathites puercoensis* (Herrick & Johnson): **A–C,** USNM 404369 from the Mancos Shale at USGS Mesozoic locality 3520 (Fig. 1, loc. 26); complete adult of the moderate form of the species. **D–F,** USNM 404370 from the Mancos Shale at USGS Mesozoic locality 3672 (Fig. 1, loc. 27); complete adult of the slender form of the species. All figures natural size. Arrows mark base of body chambers.

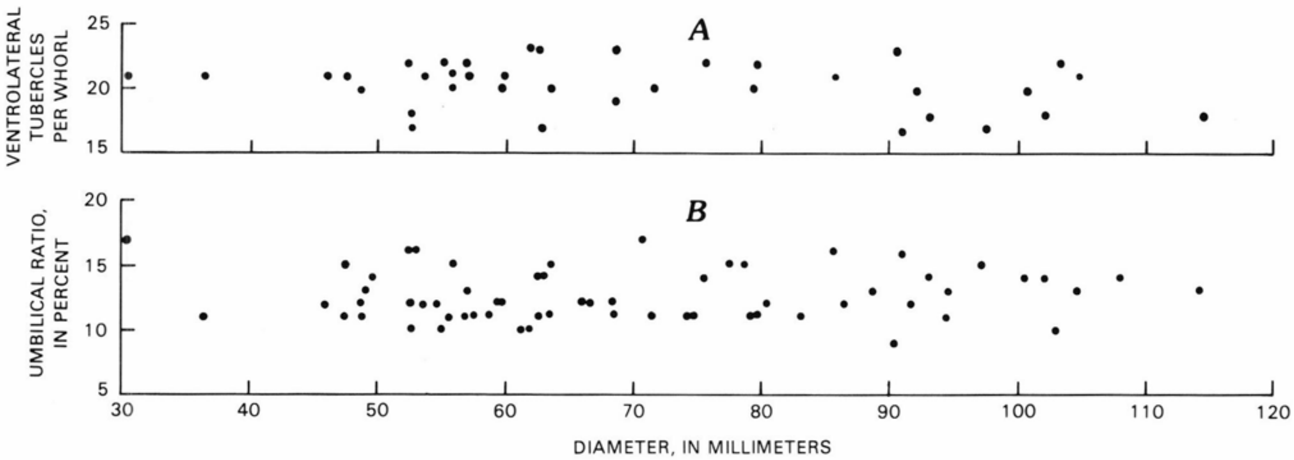

FIGURE 12—Scatter diagrams showing number of ventrolateral tubercles per whorl (**A**) and umbilical ratios (**B**) of *Spathites puercoensis* (Herrick & Johnson) from the Mancos Shale at USGS Mesozoic locality D4020 (Fig. 1, loc. 11).

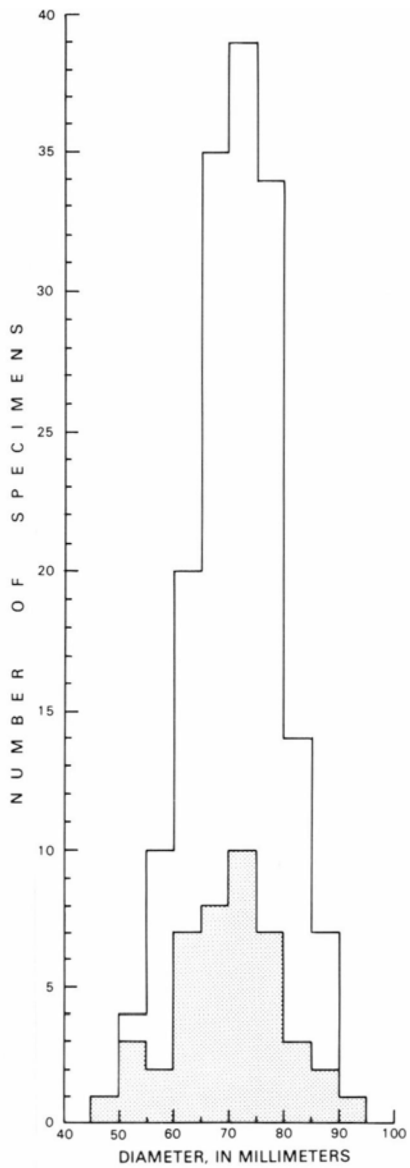

FIGURE 13—Histogram showing diameter at base of body chambers of *Spathites puercoensis* (Herrick & Johnson) from the Mancos Shale at USGS Mesozoic localities D4040, 7992, 16114, D10575, 15947, D10508, 7191, 7204, 7983, 15792, 15909, 3520, 3672, 15797, 15799, and D10469 (Fig. 1, locs. 11, 13–15, 17–22, 25–30). Shaded area represents specimens from D4020.

than wide, with rounded venter and slightly flattened flanks. The larger end of the whorl has a subrectangular section with flattened flanks and narrow, flat venter. Greatest width of the whorl is at the umbilical shoulder. Very weak umbilical and ventrolateral tubercles and poorly defined faint ribs arise at the small end of the whorl and rapidly become distinct at the larger end.

Later growth stages of the phragmocone can be seen in many specimens from locality D4020 (Fig. 3A—C). Whorls have a trapezoidal section that is usually higher than wide, with the greatest width at the umbilical shoulder. Flanks and venter are flattened. The specimens range from slender and weakly ornamented to robust and strongly ornamented. Slender specimens tend to be a little more involute than robust ones. Umbilical tubercles, which number 5-9 per whorl, are strong and nodate on robust specimens and weak and bullate on slender ones. Ventrolateral tubercles are clavate; the inner ones are a little weaker than the outer ones. The ventrolateral tubercles number 17-23 per whorl (Fig. 12A) and persist beyond the larger end of the phragmocone. Ribs are broad, flattened, and weak; they arise either from umbilical tubercles or on the outer half of the flank. On robust phragmocones, ribs may cross the venter transversely as low, broad swellings.

Body chambers of specimens from locality D4020 have flattened venters, truncated ventrolateral shoulders, and flattened flanks. The umbilicus is narrow and deep, with steep wall and narrowly rounded shoulder; the degree of curvature decreases noticeably toward the aperture. Slender specimens have weak umbilical bullae or none; low, faint inner ventrolateral tubercles or none; and low, outer ventrolateral clavi that may weaken and disappear before reaching the aperture. Robust specimens have conspicuous nodate umbilical tubercles that persist to the aperture; the last one or two usually weaken. Inner and outer ventrolateral tubercles are distinct on the older part of the body chamber, but on the younger part the inner tubercles weaken and disappear, and the outer ones may or may not persist to the aperture. On some robust individuals, inner and outer tubercles merge into low ventrolateral swellings before disappearing on the younger part of the whorl. Ribs are sparse, broad, and faint on the robust body chambers.

Apertures at the end of adult body chambers are preserved on many specimens and are nearly all normal (Fig. 10J, K). An exception is one adult 95 mm in diameter that has a slightly flared aperture preceded by a shallow constriction.

Sutures of *Spathites puercoensis* are distinctly pseudoceratitic in that lobes tend to be minutely denticulate and saddies little divided (Fig. 14). External lobes of some specimens are fairly short (Fig. 14F).

Only one specimen out of the 300 at hand is pathologic. This individual (hypotype USNM 400378) has only one row of ventrolateral tubercles, which are centered at or near the middle of the venter.

Occurrence—Spathites *puercoensis* has not been found in Trans-Pecos Texas. The species is abundant only in the Rio Puerco valley northwest of Albuquerque, New Mexico (Fig. 1, locs. 9, 11-31), where the species occurs in sandy calcareous concretions in the Semilla Sandstone Member of the Mancos Shale (Dane et al., 1968: 7, 12; La Fon, 1981: 710) and in septarian limestone concretions in silty shale transitional into the underlying shale. The fossils occur in such an abundance that the beds containing them were referred to as the "Cephalopod zone" (Herrick, 1900: 338; Herrick & Johnson, 1900a: 15; Lee, 1917: 195-198) or as the "Cephalopod Shale" (Herrick & Johnson, 1900a: 26, 39, 41). Associated ammonites include *Hoplitoides sandovalensis* Cobban & Hook, *Herrickiceras costatum* (Herrick & Johnson), and *Prionocyclus hyatti* (Stanton). A recent addition to the fauna is a fossil crab described by Kues (1980). Some fragments

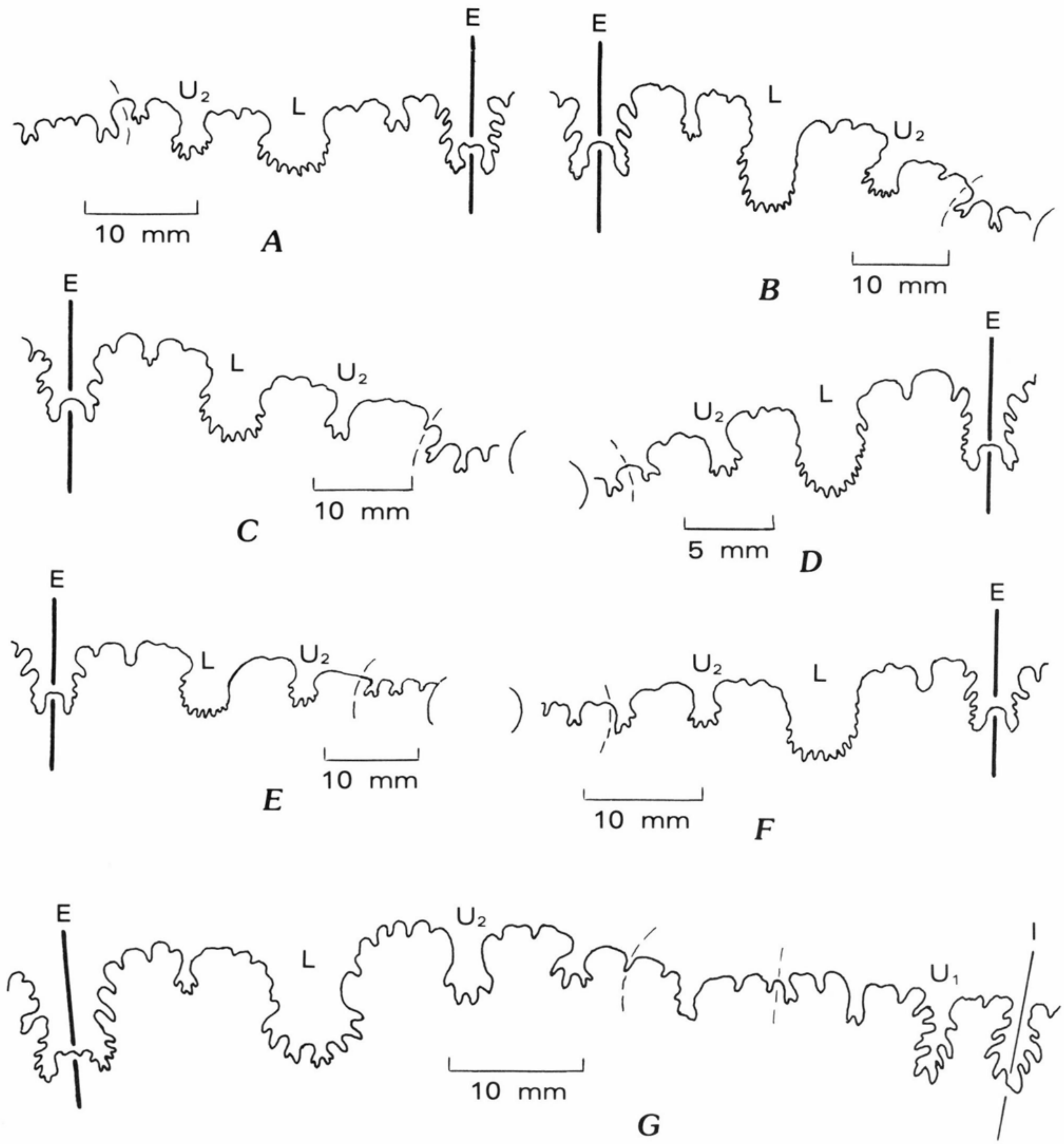

FIGURE 14—Sutures of *Spathites puercoensis* (Herrick & Johnson): **A**, USNM 404371 at a diameter of 58.6 mm, from USGS Mesozoic locality 15797 (Fig. 1, loc. 28). **B**, USNM 404372 at a diameter of 65.5 mm, from USGS Mesozoic locality D4020 (Fig. 1, loc. 11). **C**, USNM 404373 at a diameter of 62 mm, from USGS Mesozoic locality 15797 (Fig. 1, loc. 28). **D**, USNM 404374 at a whorl height of 20 mm, from USGS Mesozoic locality D4020 (Fig. 1, loc. 11). **E**, USNM 404375 at a diameter of 62.3 mm, from USGS Mesozoic locality 3672 (Fig. 1, loc. 27). **F**, USNM 404377 at a diameter of 51.6 mm, from USGS Mesozoic locality 15947 (Fig. 1, loc. 17). **G**, USNM 404376 from USGS Mesozoic locality 15947 (Fig. 1, loc. 17), complete suture at a diameter of 72.7 mm.

of crushed *Spathites* from farther west in the Gallup area (Fig. 1, loc. 4) may be *S. puercoensis.* East of Albuquerque, *S. puercoensis* has been found at one locality (Fig. 1, loc. 32).

SPATHITES sp.
Fig. **9D-F**

Type—Figured specimen USNM 404379 from the Carlile Shale north of Las Vegas, New Mexico.

Description—An external mold 35.5 mm in diameter with an umbilicus of 5.3 mm (0.15) differs from other slender specimens of *Spathites* in that ribs are strong and inner ventrolateral tubercles are absent. Whorl section is trapezoidal with flat flanks and narrow, concave venter sharply bounded by conspicuous ventrolateral clavi. Greatest whorl width is at the narrowly rounded umbilical shoulder. Broad, rectiradiate ribs arise singly or in pairs from strong, nodate, umbilical tubercles. These ribs are separated by one to three secondaries that arise on the lower half of the flank. All ribs are flattened a little on the outer part of the flank, where they bend slightly forward and rise into ventrolateral clavi. The ribs then cross the venter transversely as low, broad swellings. Ventrolateral clavi on the older part of the whorl are unusual in that they are doubled. Five umbilical tubercles and 20 ventrolateral clavi are present on the complete whorl. The poorly preserved suture has a *Spathites* pattern.

Remarks—The specimen was found as float from the Codell Sandstone Member of the Carlile Shale. A collection from a sandstone concretion in the Codell Member at this locality has *Spathites puercoensis* and *Prionocyclus hyatti.* None of the slender specimens of S. *puercoensis* from the sandstone concretion and none of the slender specimens from the prolific localities farther west in the Rio Puerco valley resemble the float specimen in its conspicuous ribbing and lack of inner ventrolateral tubercles. It is possible the specimen is from a slightly higher or lower stratigraphic position than typical S. *puercoensis.* In the northern Great Plains region, a zone of *Prionocyclus percarinatus* (Hall & Meek) lies between the zones of *Collignoniceras woollgari* and *P. hyatti* (Cobban, 1984: 84), and this zone has been questionably recorded in western New Mexico (Hook et al., 1983, fig. 7; Cobban, 1984, fig. 2). A few badly crushed *Spathites* from the Rio Salado Tongue of the Mancos Shale of western New Mexico associated with possible *P. percarinatus* may be the same as the float specimen from the Codell Member (Hook et al., 1983, sheet 1, loc. D7075).

Occurrence—USGS Mesozoic locality D10769 (Fig. 1, loc. 10).

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The Late Cretaceous ammonite *Romaniceras* Spath, 1923, in New Mexico

W. J. Kennedy[1] and W. A. Cobban[2]

[1]*Department of Geology and Mineralogy, Parks Road, Oxford, OX1 3PR, U.K.;*
[2]*U.S. Geological Survey, Mail Stop 919, Box 25046, Federal Center, Denver, Colorado 80225, U.S.A.*

Abstract—*Romaniceras,* represented by *R. (Romaniceras) mexicanum* Jones and *R. (Obiraceras)* sp., has been found in two areas of north-central New Mexico. Most specimens, as well as the best preserved ones, occur in silty, calcareous concretions in the Semilla Sandstone Member of the Mancos Shale or a little below that member in the Rio Puerco valley northwest of Albuquerque. Other specimens have been found in septarian limestone concretions in the Blue Hill Member of the Carlile Shale in the Canadian River valley east of Springer. Ammonites associated with *Romaniceras* in New Mexico include *Prionocyclus hyatti* (Stanton), *Hoplitoides sandovalensis* Cobban & Hook, *Coilopoceras springeri* Hyatt, and *Spathites puercoensis* (Herrick & Johnson). A middle Turonian age is assigned.

Introduction

Some remarkable ammonites were collected in 1931 by C. B. Hunt and assistants of the U.S. Geological Survey in the course of mapping the geology and fuel resources of an area on the west side of the Albuquerque basin. The fossils, which came from limestone concretions in the Mancos Shale, belong to the genera *Hoplitoides, Spathites, Prionocyclus,* and *Romaniceras* with the subgenus *Obiraceras*. All are well preserved and uncrushed. Specimens of *Hoplitoides* in the Hunt collections were described by Cobban & Hook (1980: 8-11) and those of *Spathites* are treated by Cobban (1988: this volume). The present report is largely based on the Hunt collections of *Romaniceras.*

Fossils described in this report are kept in the National Museum of Natural History in Washington, D.C., where they have USNM catalog numbers. Plaster casts of some of the specimens are at the New Mexico Bureau of Mines & Mineral Resources, Socorro, New Mexico, and in the U.S. Geological Survey's Mesozoic invertebrate fossil collections at the Denver Federal Center, Lakewood, Colorado. All photographs were made by Robert E. Burkholder of the U.S. Geological Survey.

Stratigraphic position

Regarding the stratigraphic position of the ammonites in the Rio Puerco valley, Hunt (1936: 43) noted that "About 300 feet above the top of sandstone no. 3 is a 20-foot zone of limestone concretions. The concretions vary in size, the largest being 2 feet in diameter, and commonly contain an abundant and excellently preserved ammonite fauna." Sandstone no. 3 of Hunt was later named the Twowells Sandstone Tongue of the Dakota Sandstone; the overlying part of the Mancos Shale, which includes the ammonite-bearing concretions, was referred to as the main body of the Mancos Shale (Landis et al., 1973). The fossiliferous beds crop out at many places in an extensively faulted area known as the Puerco fault belt (Kelley & Clinton, 1960: 52; Kelley, 1977, fig. 19) or zone (Slack & Campbell, 1976; Woodward & Callender, 1977: 211). The ammonites occur in silty limestone concretions that are septarian with dark-brown, light-brown, and white calcite veins. Some collections are from the Semilla Sandstone Member of the Mancos Shale, and

In the Canadian River valley, *Romaniceras* occurs in limestone concretions in the upper part of the Blue Hill Member of the Carlile Shale as well as in the lower part of the overlying Code11 Sandstone Member, where the genus was identified as *Shuparoceras* (Hook & Cobban, 1980, fig. 4). Associated fossils include *Prionocyclus hyatti* (Stanton) and *Coilopoceras springeri* Hyatt. Fossils are generally poorly preserved inasmuch as the concretions are highly septarian.

Outside New Mexico, *Romaniceras* is known from the western interior region only in southeastern Colorado and Texas. The Colorado record is based on a crushed fragment in shaly limestone from the Fairport Chalky Shale Member of the Carlile Shale at USGS Mesozoic locality D12726 in the SE1/4 sec. 26, T20S, R66W, Pueblo County. *Romaniceras* is fairly common in the Chispa Summit Formation in Trans-Pecos Texas, where *(R.) mexicanum* Jones occurs in the *Prionocyclus hyatti* Zone and *R. (Yubariceras) ornatissimum* (Stoliczka) occurs in the *Collignoniceras woollgari* Zone. *Romaniceras (R.) mexicanum* also occurs in the "condensed zone" of Adkins (1932: 435) in the upper part of the Eagle Ford Group in the Austin area (University of Texas and J. P. Conlin collections).

Collection localities

Romaniceras has been found in New Mexico only in the north-central part of the state, where most localities are clustered in the Rio Puerco valley northwest of Albuquerque and in the Canadian River valley east of Springer (Fig. 1). The localities, names of collectors, and years of collections are given in Table 1. The prefix D indicates Denver Mesozoic locality numbers; the rest are Washington, D.C., Mesozoic locality numbers.

Systematic paleontology

Dimensions are given in millimeters and abbreviations are as follows: D = diameter, U = umbilical diameter, Wb = whorl breadth, Wh = whorl height, Wb:Wh = ratio of whorl breadth to whorl height, is = intercostal dimensions, c = costal dimensions. Suture terminology is that of Wedekind (1916; see Kullman & Wiedmann, 1970). Repositories of specimens are indicated as follows: UM = University of Michigan Paleontology Collections, USNM = U.S. National Museum, Washington, D.C.

TABLE 1—Localities at which *Romaniceras* was collected.

Locality (Fig. 1)	U.S. Geological Survey Mesozoic locality	Collector, year, locality description, and stratigraphic assignment
1	D10309	S. C. Hook, 1977. SW$^1/_4$ NE$^1/_4$ sec. 11, T20N, R1W, Sandoval County. Mancos Shale, about 30 m above top of Greenhorn Limestone Member.
2	D12725	S. C. Hook, 1979. SW$^1/_4$ sec. 14, T19N, R1W, Sandoval County. Mancos Shale.
3	D3670	R. E. Burkholder and W. A. Cobban, 1961; S. C. Hook, 1977. SE$^1/_4$ sec. 14, T19N, R1W, Sandoval County. Mancos Shale, about 10 m below Juana Lopez Member.
4	D12727	Neal La Fon, 1978. Arroyo Lopez 1.15 km north of Holy Ghost Spring, Sandoval County. Semilla Sandstone Member of Mancos Shale.
5	D10307	S. C. Hook, 1977. SW$^1/_4$ SE$^1/_4$ sec. 14, T19N, R1W, Sandoval County. Mancos Shale, about 45 m below Juana Lopez Member.
6	D3884	C. H. Dane and Ed John, 1962. Arroyo Lopez about 1 km north of Holy Ghost Spring, Sandoval County. Semilla Sandstone Member of Mancos Shale.
7	D12728	T. Lehman, 1978. About 1.6 km southwest of Ojito Spring, Sandoval County. Semilla Sandstone Member of Mancos Shale.
8	D10575	L. F. Gunther and W. A. Cobban, 1965. N$^1/_2$ sec. 6, T14N, R1E, Sandoval County. Semilla Sandstone Member of Mancos Shale.
9	D10508	Neal La Fon, 1977–78; S. C. Hook and W. A. Cobban, 1978. NW$^1/_4$ sec. 7, T12N, R2W (unsurveyed) Agua Salada Grant, Sandoval County. Mancos Shale, just below Semilla Sandstone Member.
10	15799	C. B. Hunt, 1931. NE$^1/_4$ sec. 15, T12N, R2W, Sandoval County. Mancos Shale.
11	15925	C. B. Hunt and J. W. Wyckoff, 1931. Agua Salada Grant, 274 m north of south line and 914 m west of east line, Sandoval County. Mancos Shale.
12	15947	C. B. Hunt and J. W. Wyckoff, 1931. Agua Salada Grant, 274 m north of south line and 914 m west of east line, Sandoval County. Mancos Shale.
13	7983	W. T. Lee and T. W. Stanton, 1912. "Arroyo south of road from Albuquerque to Casa Salazar and 2$^1/_2$ miles east of west boundary of Albuquerque quadrangle" [possibly in area of locality 15795]. Mancos Shale.
14	15792	C. B. Hunt, 1931. Northeastern part of Bernabe M. Montano Grant, Sandoval County. Mancos Shale.
15	15795	C. B. Hunt, 1931. Bernabe M. Montano Grant, 305 m west of east line and 2,743 m south of north line, Sandoval County. Mancos Shale.
16	3672	T. W. Stanton and J. G. Walthers, 1906. Rio Puerco 5 mi above San Ignacio, Sandoval County. Mancos Shale.
17	D10469	S. C. Hook, 1978; S. C. Hook, E. A. Merewether, and W. A. Cobban, 1978. SW$^1/_4$ SE$^1/_4$ sec. 23, T12N, R2W, Sandoval County (unsurveyed). Mancos Shale.
18	D10740	S. C. Hook, 1979. West bank of Canadian River 6.4 km east of Springer, Colfax County. Blue Hill Member of Carlile Shale and basal part of Codell Sandstone Member.
19	D10737	S. C. Hook and J. R. Wright, 1979. SW$^1/_4$ sec. 12, T24N, R23E, Colfax County. Blue Hill Member of Carlile Shale.
20	D10785	S. C. Hook, 1979. NE$^1/_4$ sec. 2, T24N, R23E, Colfax County. Blue Hill Member of Carlile Shale.
21	D11426	G. R. Scott, 1980. SE$^1/_4$ NE$^1/_4$ sec. 5, T26N, R25E, Colfax County. Blue Hill Member of Carlile Shale.

FIGURE 1—Map of a part of north-central New Mexico showing localities where *Romaniceras* was collected.

Order AMMONOIDEA Zittel, 1884
Suborder AMMONITINA Hyatt, 1889
Superfamily ACANTHOCERATACEAE de Grossouvre, 1894
Family ACANTHOCERATIDAE de Grossouvre, 1894
Subfamily EUOMPHALOCERATINAE Cooper, 1978

Genus *ROMANICERAS* Spath, 1923

Type *species—Ammonites* *deverianus* d'Orbigny, 1841: 356, pl. 110, figs. 1, 2; by original designation.

Discussion—The type species was revised at length by Kennedy, Wright & Hancock (1980: 332, pl. 39, figs. 7-10, pl. 41, figs. 1-6, pl. 42, figs. 1-7, pl. 43, figs. 1-3, text-figs. 1, 3D, 4, 5). It shows an early stage with smooth, constricted whorls, followed by a stage with collar-ribs to the constrictions, and thereafter an ornamented stage with primary ribs that have nine rows of tubercles (umbilical, lateral, inner and outer ventrolateral, and siphonal) and secondary ribs with no or feeble lateral, inner and outer ventrolateral, and siphonal tubercles. Medium-sized specimens vary in whorl proportions and strength of ribbing and tuberculation, as is normal in such decorated ammonites. Kennedy and others pointed out that there was a sequence in France from *Kamerunoceras turoniense* (d'Orbigny, 1850) (see revision in Kennedy & Wright, 1979) to *Romaniceras kallesi* (Zázvorka, 1958) involving development of nine rows of tubercles throughout ontogeny and stabilization of ventral ornament with rows of siphonal and ventrolateral tubercles equal in number. Later work has revealed constricted inner whorls in *Kamerunoceras* species, including the type (Cobban & Hook, 1983: 8, figs. 1, 2), and stabilization of ventral ornament is shown by some North American material (Kennedy & Wright, 1979, text-fig. 4). The similarity of the overall shell form of *K. turoniense* to that of *R. (R.) kallesi,* with which it overlaps in the latter part of its range, is so striking that close affinity cannot be doubted. In France, *R. (R.) kallesi* is succeeded by *Romaniceras (Yubariceras) ornatissimum* (Stoliczka, 1865), which has a more massive shell and constricted inner whorls, just as in *R. (R.) kallesi* and *Kamerunoceras* species; *ornatissimum* differs, however, in having 11 rows of tubercles in middle-late growth: umbilical, lateral, outer lateral, inner and outer ventrolateral, and siphonal. The ontogenetic development of these tubercles is clearly shown by well-preserved California material studied by Matsumoto (1959; especially pl. 29, fig. 4) and other specimens, casts of which are before us, together with specimens donated by Professor W. P. Popenoe. They show an early stage with nine rows of tubercles and constrictions succeeded by later stages in which an outer lateral row develops giving the 11 rows. We see no reason other than to regard *Yubariceras* as a subgenus of *Romaniceras.*

Shuparoceras Matsumoto, 1975 (p. 110, type species *Shuparoceras yagii* Matsumoto, 1975: 110, pl. 12, fig. 1, text-fig. 3) was characterized by, among other features, the presence of constrictions and nine rows of tubercles (umbilical, lateral, inner and outer ventrolateral, and siphonal). Matsumoto regarded it as closely allied to the subgroup of *Calycoceras choffati* (Kossmat, 1897: 12, pl. 4, fig. 1) of the Cenomanian, from which it differed in having a lateral tubercle; it was believed to be Turonian in age. The present material referred to *R. (Romaniceras) mexicanum* Jones, 1938, includes variants that have all the characters of *Shuparoceras* (e.g. Fig. 7F-G) and indeed, one of our specimens was referred to the genus by Kennedy, Wright & Hancock (1980, text-fig. 2; see Fig. 8C-E herein). We conclude that *Shuparoceras* is no more than a feebly ribbed variant of *Romaniceras* and regard the former as a synonym of the latter.

A final genus to consider in this discussion of *Romaniceras* and its allies is *Neomphaloceras* Matsumoto & Obata, 1982, with *Yubariceras pseudomphalum* Matsumoto (1975: 146, pl. 22, fig. 1) as type species of uncertain, but probably Turonian age. Matsumoto & Obata (1982: 71) also included *Yubariceras fujishimai* Matsumoto (1975: 148, pl. 22, fig. 2, pl. 23, fig. 3, text-fig. 17), undoubtedly an upper Turonian species, in the genus and suggested that *Yubariceras japonicum* Matsumoto, Saito & Fukada (1957: 31, pl. 8, fig. 2, text-figs. 11, 12; see also Matsumoto, 1975: 139, pl. 19, figs. 2, 3, pl. 21, fig. 2, text-figs. 13, 14) might also belong there. They diagnose *Neomphaloceras* as very similar to *Euomphaloceras* in shell form, ornamentation, and suture, but distinguish it in having extra rows of tubercles. The type species of *Neomphaloceras* has nine rows of tubercles on the primary ribs, with secondary ribs and short ventral ribs, so that there are more ventrolateral and siphonal than lateral and umbilical tubercles per whorl. This is a character shown by certain of the present specimens of *Romaniceras* (e.g. Fig. 8B), although to a lesser degree than in the Japanese species; *Neomphaloceras* seems to us to be at most a subgenus of *Romaniceras,* and possibly not even that.

ROMANICERAS (ROMANICERAS) MEXICANUM Jones, 1938
Figs. 2, 3, 5, 6A-D, G, 7-10

1938. *Romaniceras adkinsi* Jones, p. 120 (pars), p1. 8, figs. 4, 5.
1938. *Romaniceras mexicanum* Jones, p. 121, pl. 7, figs. 1, 6. 1938.
Romaniceras santaanaense Jones, p. 121, pl. 8, figs. 1, 6. 1938.
Romaniceras toribioense Jones, p. 122, pl. 7, figs. 7, 8. 1959.
Romaniceras pseudodeverianum (Jimbo): Matsumoto, p. 93 (pars).
1980. *Shuparoceras* sp. nov., Kennedy, Wright & Hancock, p. 329, text-fig. 2.
1980. *Romaniceras (Romaniceras) kallesi* (Zázvorka, 1958): Kennedy, Wright & Hancock, p. 342 (pars), text-fig. 6.

Types—Holotype is UM 16928, the original of Jones (1938: 121, pl. 7, figs. 1, 6), by original designation. Paratypes are UM 16098, 16929-16931, from members 2 and 3 of the upper Turonian Indidura Formation north of Tanque Toribio, Sierra de Santa Ana, Coahuila, Mexico. Hypotypes are USNM 411600-411610, from the Mancos and Carlile Shales of New Mexico.

Dimensions:

USNM		D	Wb	Wh	Wb:Wh	
411600	c	62.5(100)	23.8(38.1)	26.0(41.6)	0.92	20.0(32.0)
411601	c	72.0(100)	28.8(40.0)	31.0(43.1)	0.92	21.3(29.6)
411604	c	119.0(100)	53.3(44.8)	50.0(42.0)	1.06	37.0(31.1)
411602	c	136.0(100)	69.4(51.0)	61.2(45.0)	1.13	42.0(30.9)
is			63.0(—)	60.0(—)	1.05	
411607	c	195(100)	120(61.5)	82.5(42.3)	1.45	77.5(39.7)
			104(—)	76(—)	1.37	
411608	c	293(100)	132(45.0)	109(37.2)	1.21	102.5(34.9)
			125(—)	109(—)	1.15	
411609	c	345(100)	156(45.2)	141(40.9)	1.11	115(33.3)
			134.5(—)	132(—)	1.01	

Description—The early whorls to a diameter of approximately 15 mm are evolute and rounded in section. The most prominent ornament is four deep, narrow constrictions per half-whorl, prorsiradiate and straight on the inner and middle flank and projected forwards over the ventrolateral shoulder, crossing the venter in a broad convexity (Figs. 6A, 7B). These constrictions are flanked by adapical and adoral collared ribs which bear feeble umbilical bullae and ventrolateral and siphonal nodes; the latter also occur between constrictions. This constricted stage is followed by rapid acquisition of ornament (Figs. 5A-F, 6A-D, 7A-B). Coiling remains evolute, and the umbilicus is of moderate depth with flattened wall. The whorl section varies from slightly compressed (Fig. 2A) to slightly depressed; the latter is most common. The flanks are flattened and convergent in intercostal section, with a broadly rounded venter. The costal section is compressed polygonal, with a whorl breadth to height ratio of 0.92 to 1.13, the greatest breadth being at the lateral bullae. Between diameters of 50 and 100 mm, the majority of specimens bear dense, crowded ribs. Small umbilical bullae that number 10-22 per whorl give rise to low, straight primary ribs, either singly or in pairs, while additional intercalated ribs are inserted low or high on the flank to give up to 50 ribs in total per whorl. There may be occasional feeble constrictions (Fig. 6C). The ribs are straight and prorsiradiate on the flank, and bear a conical lateral tubercle below mid-flank on the primaries and on some of the longer secondaries; all ribs bear a conical inner ventrolateral tubercle connected to a feebly clavate outer ventrolateral one by a broadened and strengthened prorsiradiate rib. A weakened rib projects slightly forward and links to a clavate siphonal tubercle. At this stage in development, the umbilical and outer ventrolateral tubercles are strongest, and the lateral one weakest (Figs. 7C-D, 8A-E). Beyond 106 mm in diameter the whorls become progressively more massive, depressed, and trapezoidal in section (Fig. 7D). Rib density decreases to 36-38 per whorl at a diameter of 120-150 mm, by the progressive elimination of secondary ribs. The lateral tubercles increase in relative size and dominate the tuberculation, while the inner ventrolateral ones remain conical and stronger than the clavate outer ventrolateral and siphonal tubercles (Fig. 8D). The outer whorl of the adult phragmocone has an even more

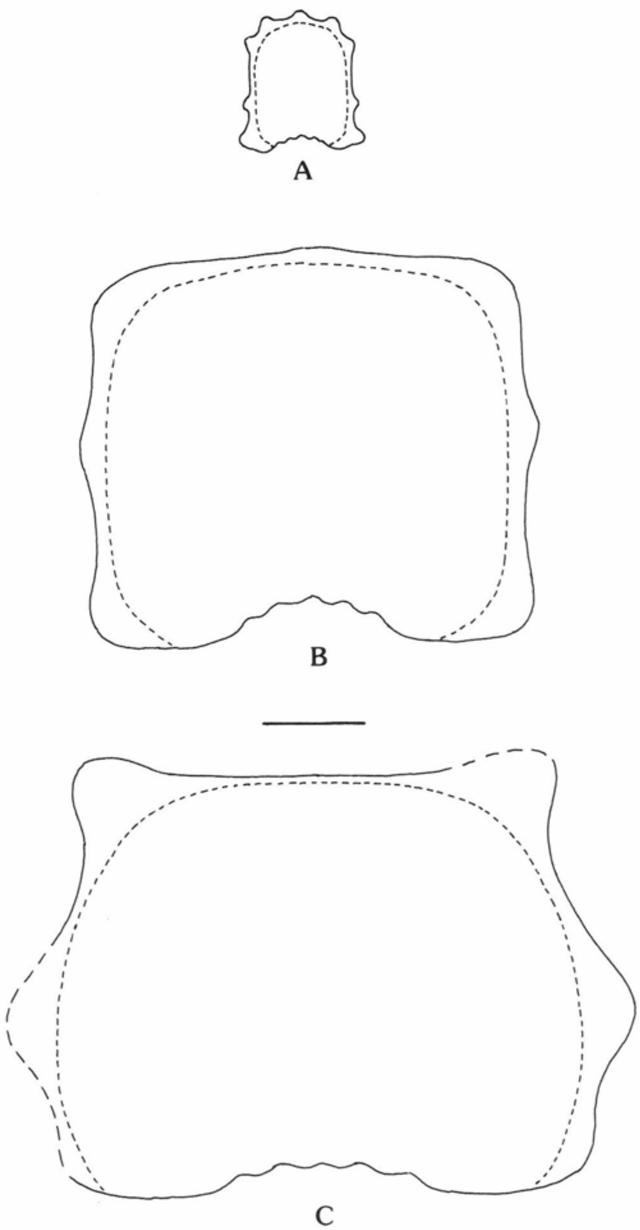

FIGURE 2—Whorl sections of *Romaniceras* (*R.*) *mexicanum* Jones: **A,** USNM 411600 at a shell diameter of 63 mm, from locality 15925 (Fig. 1, loc. 11); Figs. 6A, 7A, B. **B,** USNM 411604 at a whorl height of 78 mm, from locality 15799 (Fig. 1, loc. 10). **C,** USNM 411607 at a shell diameter of 199 mm, from locality D10508 (Fig. 1, loc. 9). Scale equals 2 mm.

depressed, trapezoidal section (Fig. 2C) with 13-16 primary ribs and a total of 24-26 ribs at the ventrolateral shoulder (Figs. 5G, 6G, 9, 10). The bullae remain strong and give rise to broad, blunt prorsiradiate primary ribs with a massive conical to somewhat radially elongate lateral tubercle. All ribs bear a massive inner ventrolateral tubercle, but there is a progressive decline of first the siphonal tubercles and then the outer ventrolateral clavi, so that at the end of the phragmocone the venter is slightly concave in costal section, with faint swellings only marking the site of these tubercles (Fig. 10A).

Specimens are adult at phragmocone diameters of 250, 190, and 195 mm; a fourth large phragmocone is just over 250 mm in diameter. It is likely that the larger phragmocones are those of macroconchs (Figs. 9, 10A) and the smaller of microconchs (Figs. 5G, 6G), but the sample is too small for certainty on this point.

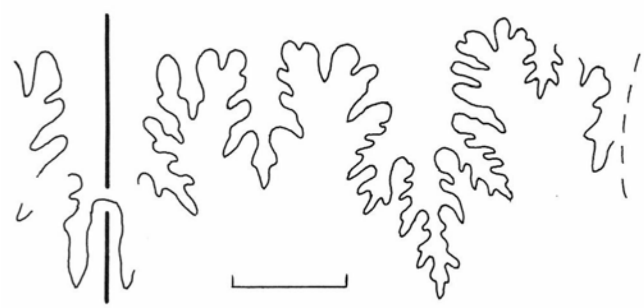

FIGURE 3—Part of the external suture of *Romaniceras* (*R.*) *mexicanum* Jones, USNM 411610, at a whorl height of 66 mm, from locality D10309 (Fig. 1, loc. 10). Scale bar equals 20 mm.

The body chamber extends for just over half a whorl (Fig. 5G), with possible microconchs just over 300 mm in diameter and an adult macroconch with incomplete body chamber nearly 380 mm in diameter. The whorl section is depressed and massive. The umbilical seam egresses, umbilical bullae decline, and secondary ribs are lost; lateral tubercles persist. Inner ventrolateral tubercles develop into massive horns on the older part of the body chamber (Fig. 9), but seem to weaken towards the last-formed section. The horns have a characteristic asymmetric profile in side view, with a long, gently inclined adapertural side and steeper adapical one; they project outwards from the venter, which is concave at the beginning of the body chamber, the concavity decreasing towards the aperture as a broad bar-like ventral rib develops and strengthens progressively.

External suture with broad, bifid E/L; narrow, symmetrical L; and broad, bifid L/U2 (Fig. 3).

Discussion—Most specimens show finely and evenly ribbed early and middle growth stages, but there is a range of variation. At one extreme is USNM 411605 (Fig. 7F-G),

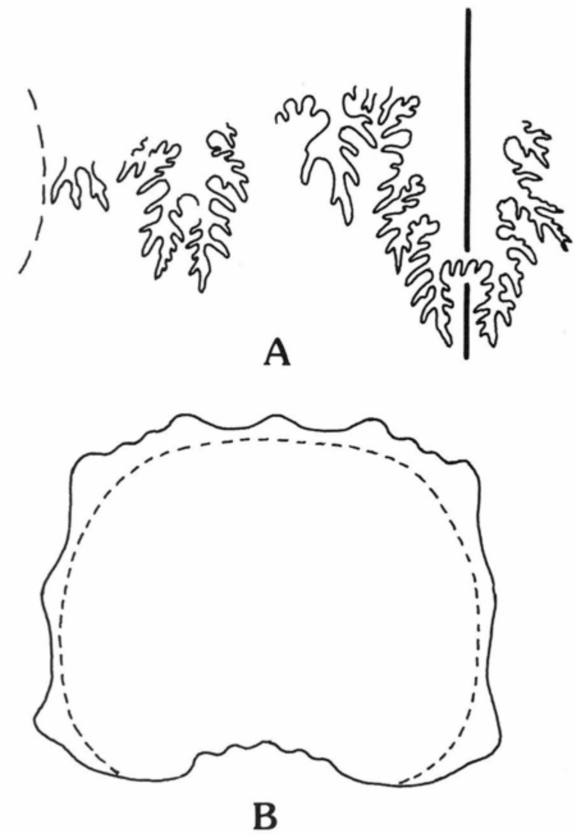

FIGURE 4—*Romaniceras* (*Obiraceras*) sp., USNM 411611, from locality 15792 (Fig. 1, loc. 14). **A,** suture at a whorl height of 47 mm. **B,** whorl section at a whorl height of 49 mm.

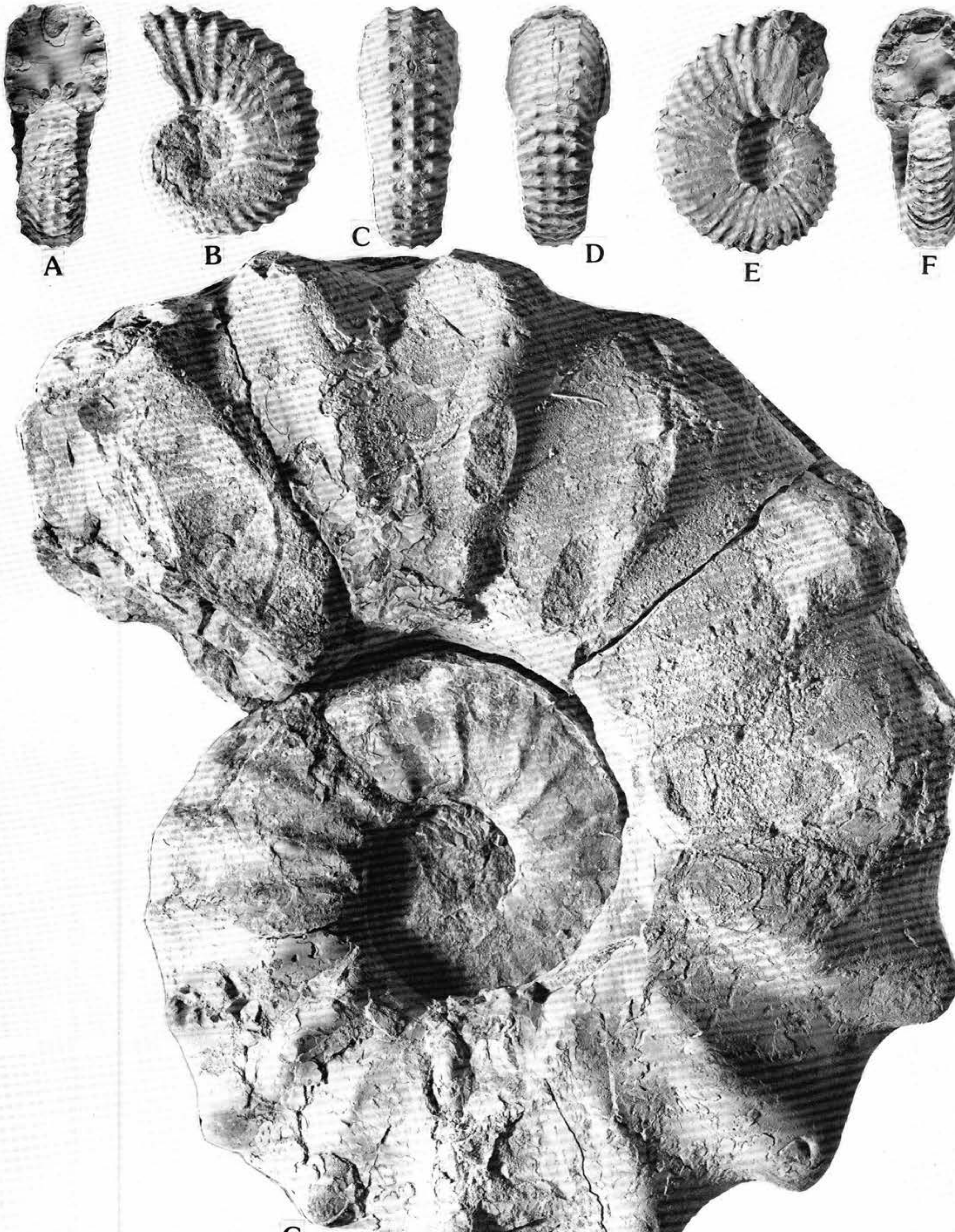

FIGURE 5—*Romaniceras* (*R.*) *mexicanum* Jones: **A–C,** USNM 411604, from locality 15799 (Fig. 1, loc. 10); inner whorls of the phragmocne shown in Fig. 8A, B. **D–F,** USNM 411603, from locality D10508 (Fig. 1, loc. 9). **G,** USNM 411608, from the same locality. See Figs. 6G and 10B for end views. All figures are natural size except for G which is × 0.7.

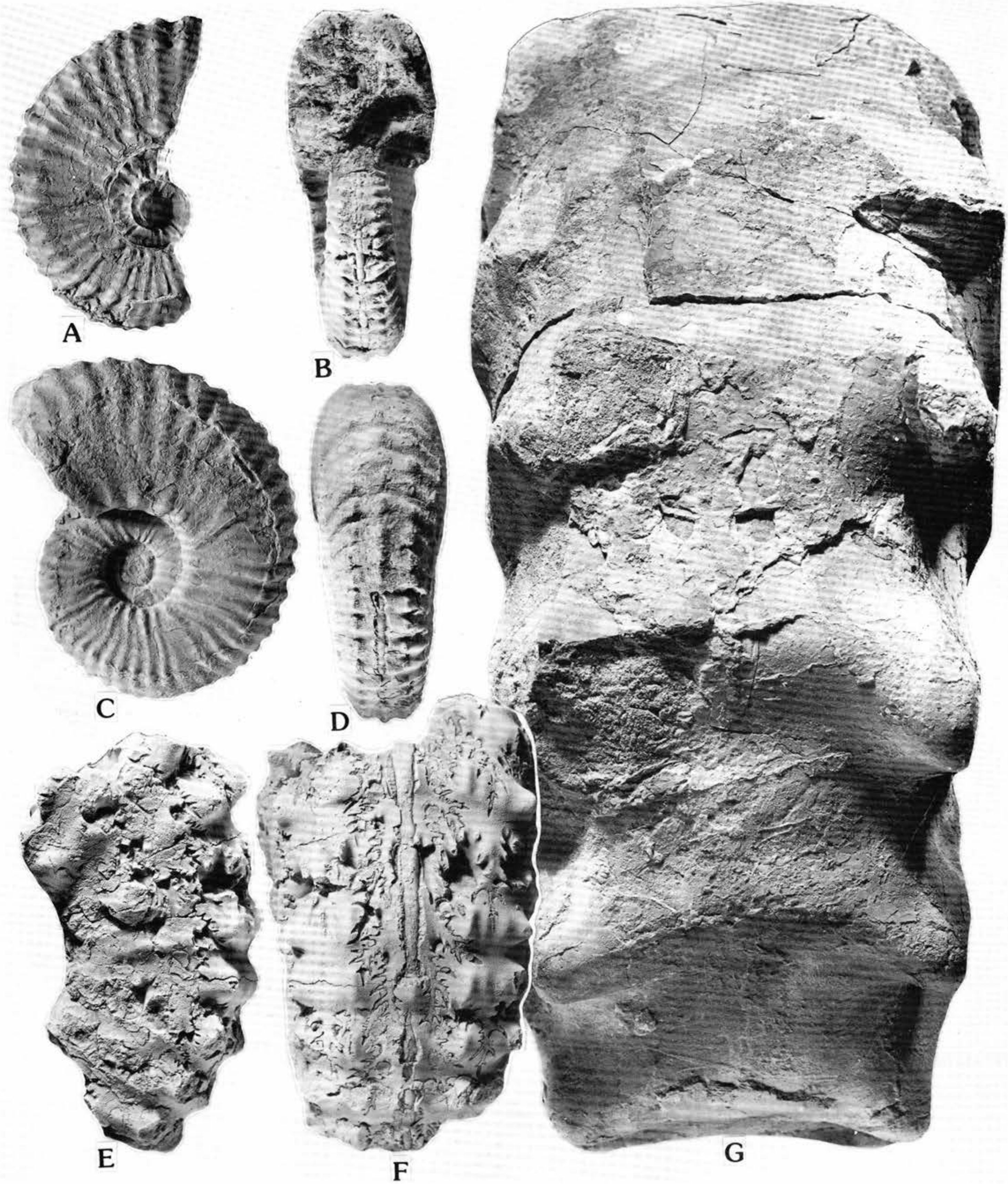

FIGURE 6—**A–D, G,** *Romaniceras* (*R.*) *mexicanum* Jones: **A,** USNM 411600, from locality 15925 (Fig. 1, loc. 11); see Fig. 7A, B for other views and Fig. 2A for whorl section. **B–D,** USNM 411601, from locality D10508 (Fig. 1, loc. 9). **G,** USNM 411608, from locality D10508 (Fig. 1, loc. 9); see Fig. 5G for side view. **E–F,** *Romaniceras* (*Obiraceras*) sp., USNM 411611, from locality 15792 (Fig. 1, loc. 14); see Fig. 4 for whorl section and suture. All figures are natural size except for G which is × 0.7.

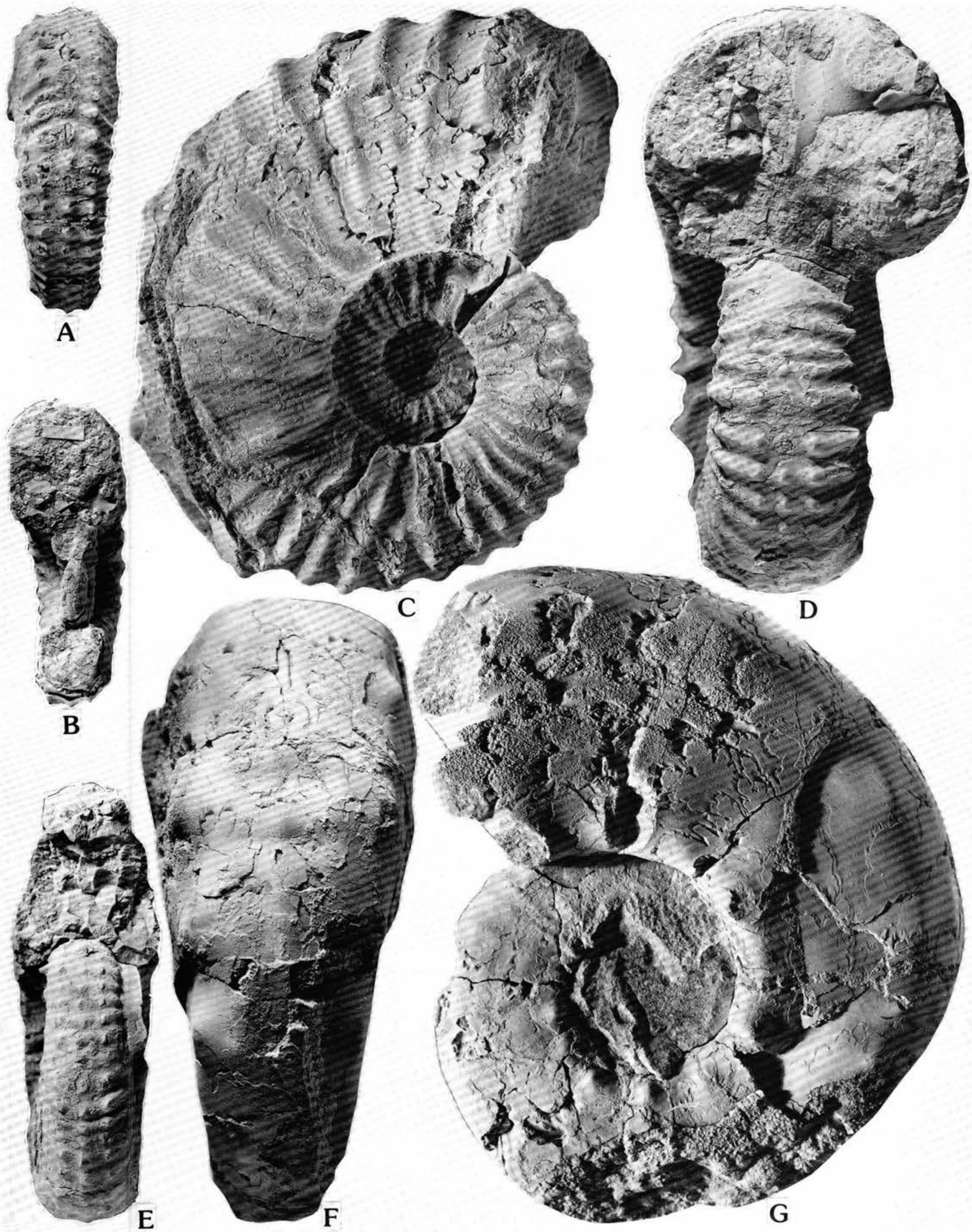

FIGURE 7—*Romaniceras* (*R.*) *mexicanum* Jones: **A, B,** USNM 411600, from locality 15925 (Fig. 1, loc. 11); see Fig. 6A for side view. **C, D,** USNM 411606, from locality D10508 (Fig. 1, loc. 9). **E–G,** USNM 411605, from locality 15792 (Fig. 1, loc. 14); E shows the ornamented inner whorls. All figures are natural size.

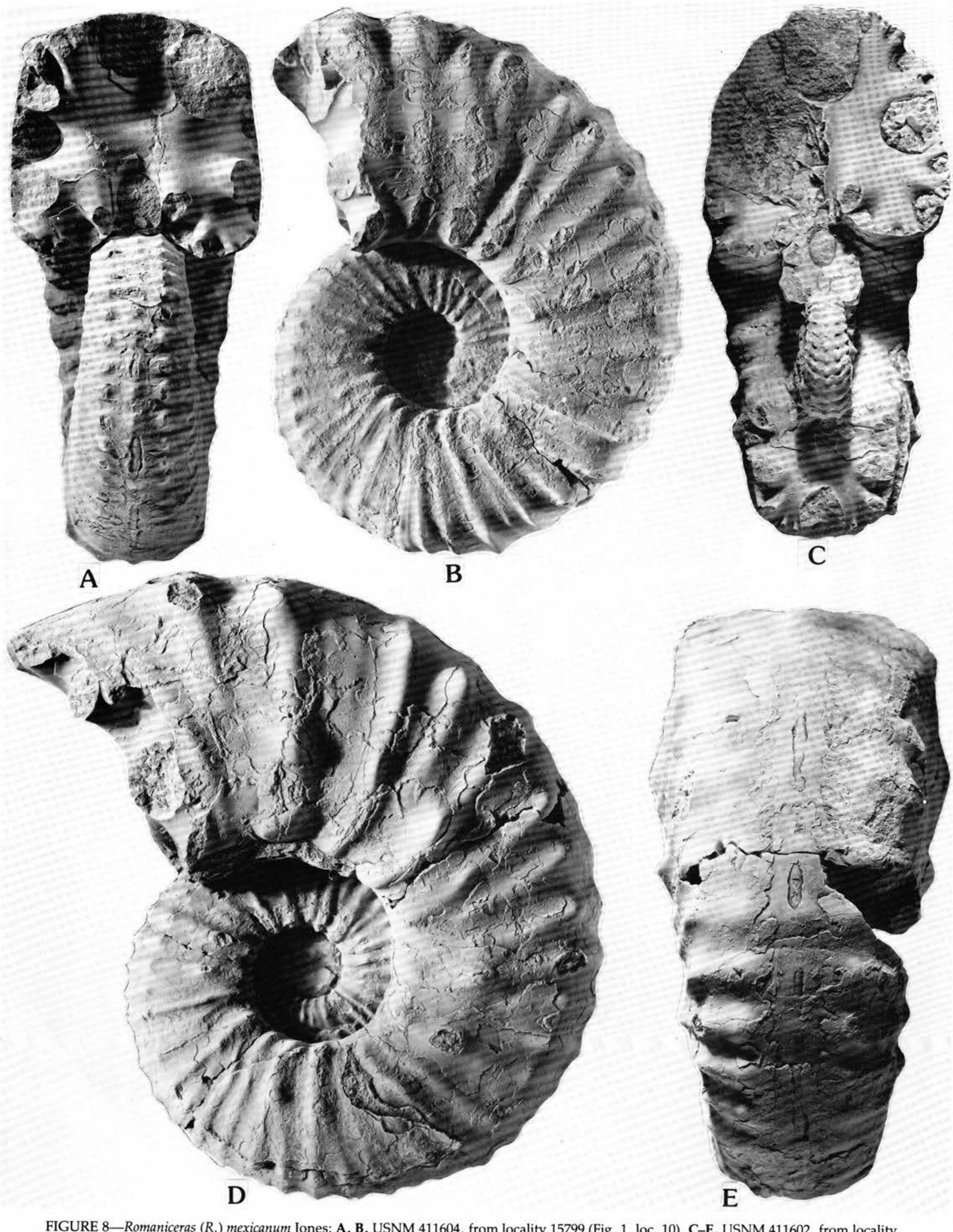

FIGURE 8—*Romaniceras* (*R.*) *mexicanum* Jones: **A, B,** USNM 411604, from locality 15799 (Fig. 1, loc. 10). **C–E,** USNM 411602, from locality 15947 (Fig. 1, loc. 12). All figures are natural size.

FIGURE 9—*Romaniceras* (*R.*) *mexicanum* Jones, USNM 411609, × 0.6, from locality 15799 (Fig. 1, loc. 10); see Fig. 10A for end view.

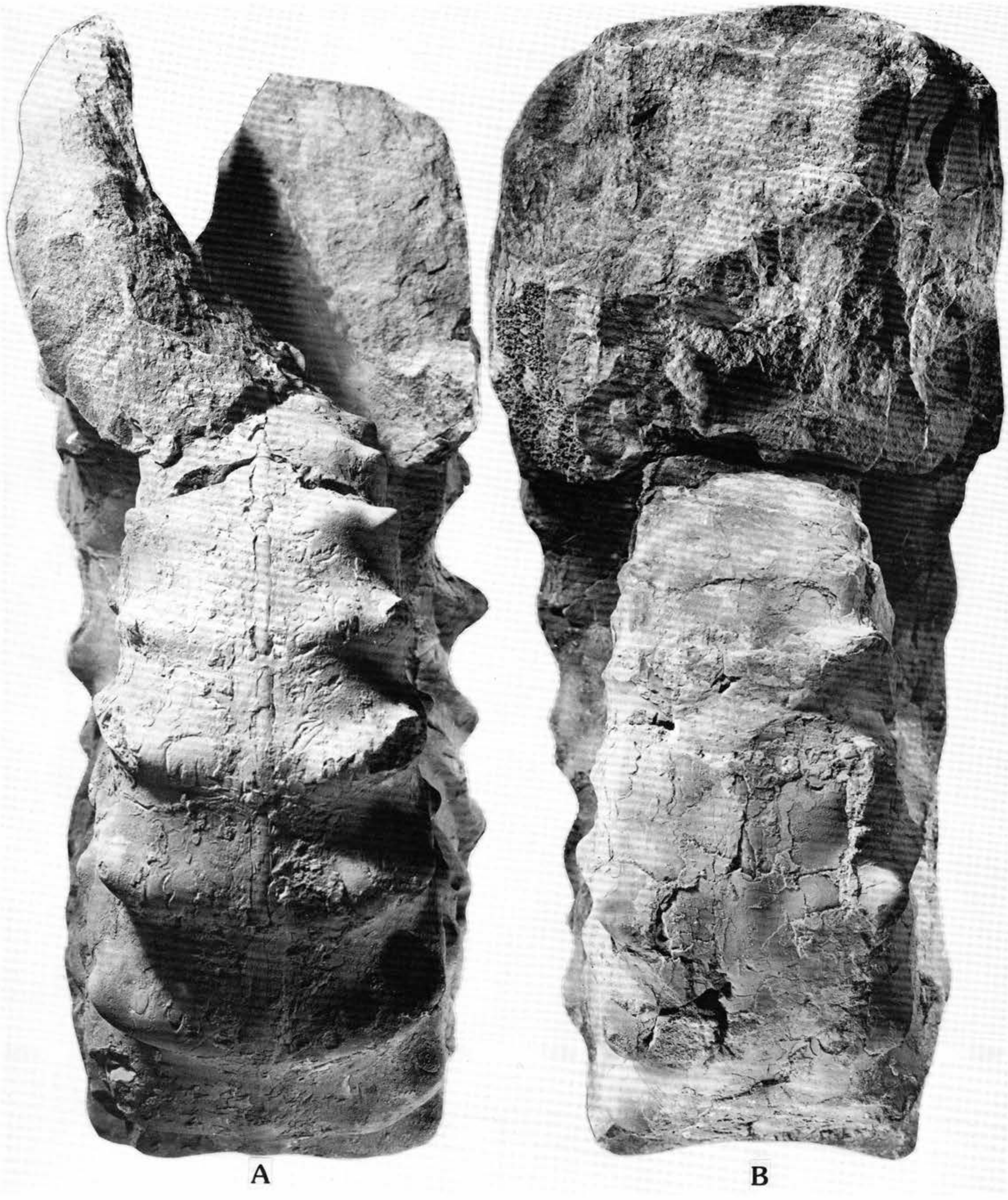

FIGURE 10—*Romaniceras* (*R.*) *mexicanum* Jones: **A,** USNM 411609, × 0.6, from locality 15799 (Fig. 1, loc. 10); see Fig. 9 for side view. **B,** USNM 411608, × 0.7, from locality D10508 (Fig. 1, loc. 9); see Fig. 5G for side view.

where there is a decline in flank ornament in middle growth, leaving prominent umbilical bullae and inner ventrolateral tubercles plus weakened outer ventrolateral and siphonal tubercles, although nuclei are well ornamented (Fig. 7E). USNM 411604 (Fig. 8A-B) links this to the more common variants, showing renascent distant flank ornament at diameters above 150 mm. At the other extreme is USNM 411606 (Fig. 7C-D), with coarse ribbing and tuberculation throughout. We take these differences to be normal intraspecific variation.

The holotype of *Romaniceras mexicanum* (Jones, 1938: 121, pl. 7, figs. 1, 6), from the Turonian of Sierra de Santa Ana, Coahuila, Mexico, is very poorly preserved, but shows, at a diameter of 150 mm, an estimated 15-16 umbilical bullae giving rise to strong primary ribs with a much stronger lateral tubercle and a strong outer ventrolateral one. The total rib density is 12 per half-whorl. All these characters match with our material, and as first revising authors, we select Jones' name *mexicanum* for the species, although the holotype is appallingly abraded and does not show the inner whorls. The type series of *Romaniceras coahuilense* Jones (1938: 118, pl. 6, fig. 1, pl. 7, fig. 5) consists of equally worn and battered specimens. That species comes from the same horizon and locality as *mexicanum*. The holotype is much coarser and distantly ribbed, and has 11 rows of tubercles (not eight as stated by Jones), being *a Yubariceras,* as is the slender *R. kanei* Jones (1938: 120, pl. 8, figs. 2, 7, 8, pl. 9, fig. 6). *Romaniceras adkinsi* Jones (1938: 120, pl. 8, figs. 4, 5) is also based on a very worn and battered holotype with nine rows of tubercles, the lateral row becoming increasingly prominent with growth; it is a possible synonym of *mexicanum* and comes from the same locality as the types of that species. The holotype of *Romaniceras santaanaense* Jones (1938: 121, pl. 8, figs. 1, 6), from the same locality as the types of *mexicanum* and *adkinsi,* is probably a worn example of the common variant amongst our material, with well-developed lateral tubercles. *Romaniceras toribioense* Jones (1938: 122, pl. 7, figs. 7, 8), characterized according to Jones by its small size and flexuous ribs, seems to be no more than a worn example of *R. mexicanum* and is from the same locality.

Romaniceras loboense Adkins (1931: 44, pl. 2, figs. 1, 21, pl. 3, fig. 5) is a *R. (Yubariceras)* with 11 rows of tubercles per whorl, as is *Romaniceras cumminsi* Adkins (1931: 43, pl. 3, fig. 6), as pointed out by previous authors (Matsumoto, 1959; Kennedy et al., 1980); both are synonyms of *R. (Yubariceras) ornatissimum* (Stoliczka, 1865: 75, pl. 40).

Kennedy, Wright & Hancock (1980) referred one of the present specimens to *Shuparoceras* sp. nov. (loc. cit., text-fig. 2), but it is now seen to be an immature individual of *R. mexicanum* (for our current view of *Shuparoceras* see above). These same authors illustrated a juvenile with constricted inner whorls as *a Romaniceras kallesi* (Zázvorka, 1958). It is again a specimen of *R. mexicanum;* during middle and later growth *R. kallesi* retains evolute coiling with slender whorls, never developing the massive, coarsely ribbed adult form of *Romaniceras mexicanum* and reaching maturity at less than half the size of our material (Kennedy et al., 1980): 342, pl. 44, figs. 1-3, pl. 45, figs. 3-7, non 1, 2, pl. 47, figs. 1-4, text-fig. 6). The type species of *Romaniceras, R. deverianum* (d'Orbigny, 1841: 346, pl. 110, figs. 1, 2; see Kennedy et al., 1980: 332, pl. 39, figs. 7-10, pl. 41, figs. 1-6, pl. 42, figs. 17, pl. 43, figs. 1-3, text-figs. 1, 3D, 4, 5), has a similar smooth constricted initial stage as in *R. mexicanum,* but develops umbilical bullae that project into the umbilicus in middle growth, whereas adults are slender and do not develop the massively ribbed and tuberculate adult stage seen in the present material. The adults in the present collection resemble to a degree adult *Romaniceras (Yubariceras) ornatissimum* (Stoliczka, 1865: 75, pl. 40), but that species has 11 rows of tubercles in all but the latest growth stages.

Occurrence-Middle Turonian *Prionocyclus hyatti* Zone, *Coilopoceras springeri* Subzone in New Mexico and at Chispa Summit, Jeff Davis County, Trans-Pecos Texas; Eagle Ford "condensed zone" of the Austin area, Travis County, Texas. The type material from Coahuila, Mexico, is imprecisely placed within the Turonian.

Subgenus *OBIRACERAS* Matsumoto, 1975

Type *species-Obiraceras ornatum* Matsumoto, 1975: 151, pl. 23, fig. 1, text-fig. 18.

Discussion-Matsumoto (1975: 150) proposed *Obiraceras* for multituberculate Turonian acanthocerataceans that have primary ribs with nine rows of tubercles (umbilical, lateral, inner and outer ventrolateral, and siphonal) and secondaries with or without feeble lateral, inner and outer ventrolateral, and siphonal tubercles in early growth; inner and outer ventrolateral tubercles show doubling in middle growth.

The presence of constricted inner whorls reveals that *Obiraceras* belongs to the Euomphaloceratinae. Kennedy, Wright & Hancock (1980) noted that the genus was comparable to other *Romaniceras/Yubariceras* species except for the doubling of tubercles, and noted that such doubling of tubercles was shown by Nigerian material referred to *Romaniceras uchauxiense* Collignon, 1939 (which they thought to be a synonym of *R. deverianum).* The present specimens would, on all other characters but doubling of the ventrolaterals, be inseparable from *Romaniceras,* and treatment as subgenus of that genus is followed here.

ROMANICERAS (OBIRACERAS) sp.
Figs. 4A, B, 6E, F

Types-Figured specimens USNM 411611, 411612.

Description-Two fragmentary specimens are North American representatives of *Obiraceras.* USNM 411611 is a wholly septate fragment with a maximum preserved whorl height of 49 mm and a whorl breadth to height ratio of 0.82; its whorls are depressed, with greatest breadth at the lateral tubercle (Fig. 4B). The inner flanks are broadly rounded, the outer flanks flattened and convergent, the ventrolateral shoulders broadly rounded, and the venter flattened in intercostal section. Prominent umbilical bullae give rise to broad, blunt prorsiradiate primary ribs, all of which develop a strong, pointed lateral tubercle (damaged in most cases). Occasional intercalated ribs arise around mid-flank without developing a lateral tubercle. All ribs bear a strong, conical inner ventrolateral tubercle; a broad, low rib extends to a strong ventral clavus with two much weaker clavi between (Fig. 6F). The rib effaces markedly over the venter, leaving a broad, effectively smooth zone on either side of a row of siphonal clavi only slightly weaker than the ventrolateral ones. There are thus a total of nine rows of major tubercles and four rows of weak tubercles. The second specimen is poorly preserved, but shows the same style of ornament with relatively strong lateral tubercles.

Sutures with broad bifid E/L, narrower L, and broad bifid L/U2 (Fig. 4A).

Discussion-The type species of *Obiraceras* has the same pattern of ribbing and tuberculation as the present material, but has only a slightly depressed whorl section in middle growth, becoming compressed at a diameter when the New Mexico specimens are very depressed. There is too little material to determine the significance of these differences. Specimens from the Turonian of Nigeria referred to *Romaniceras uchauxiense* Collignon by Reyment (1955: 46, pl. 9, fig. 2) show doubling of ventral tubercles and closely resemble our specimens.

Occurrence-Middle Turonian *Prionocyclus hyatti* Zone, *Coilopoceras springeri* Subzone of New Mexico (Fig. 1).

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Middle Cenomanian (Late Cretaceous) molluscan fauna from the base of the Boquillas Formation, Cerro de Muleros, Dona Ana County, New Mexico

W. J. Kennedy,' W. A. Cobban,[2] and S. C. Hook3

'Department of Geology and Mineralogy, Oxford University, Oxford, U.K.;
'2U.S. Geological Survey, Denver, Colorado, U.S.A.;
3Texaco Exploration and Production Technology Division, Houston, Texas, U.S.A.

Abstract—A thin bed of calcarenitic and coquinoidal limestone forms the base of the Boquillas Formation and rests disconformably on the lower Cenomanian Buda Limestone. This bed contains a fauna that indicates the zone of *Acanthoceras amphibolum* Morrow. The following stratigraphically important molluscan fossils (chiefly ammonites) are described and illustrated: *Desmoceras (Pseudouhligella)* sp., *Moremanoceras straini* sp. nov., *Acanthoceras amphibolum* Morrow, *Cunningtoniceras* cf. *johnsonianum* (Stephenson), *Paracompsoceras landisi* Cobban, *Tarrantoceras sellardsi* (Adkins), *Anisoceras* cf. *plicatile* **(J.** Sowerby), *Turrilites acutus* Passy, *Ostrea beloiti* Logan, and *Inoceramus arvanus* Stephenson.

Introduction

Cerro de Muleros, also known as Cerro de Cristo Rey, is approximately 8 km (5 mi) northwest of downtown El Paso, Texas, in part in Dona Ana County, New Mexico, and in part in Chihuahua, Mexico. The main mass of the uplift is a hypabyssal plutonic complex of early Tertiary age that has deformed the surrounding Lower and Upper Cretaceous rocks. The general geology of the area was described by Lovejoy (1976), who provided a detailed geologic map and reviewed early work on the region. The Cretaceous succession was first studied by Bose (1910), who recognized 11 units on the basis of lithology and fauna. Strain (1968, 1976) reviewed Bose's work in detail and proposed a series of lithostratigraphic units. The material described below came from the base of unit 11 of Bose, referred to as the Boquillas Formation by Strain in 1968, although he subsequently (Strain, 1976: 82) suggested that Ojinaga Formation or Chispa Summit Formation might be more appropriate; taxonomy of the name is of no importance in the present context, and we use Boquillas, following Strain (1968). This unit rests with marked disconformity on the underlying Buda Limestone and crops out only intermittently. Bose (1910) gave a thickness of 110 m (360 ft) for his unit 11.

The fauna described herein came from a few centimeters thick bed of coquinoidal and calcarenitic limestone at the base of the formation. These fossils are of much interest because the nearest large fauna of comparable age (zone of *Acanthoceras amphibolum)* is from some 400 km (250 mi) farther north in New Mexico (Cobban, 1977a, table 1). All fossils came from a single locality about 1.2 km north of Cerro de Cristo Rey in the center of the N^1/2 SW^1/4 sec. 9, T29S, R4E, Dona Ana County. The fossils were collected by W. S. Strain, D. V. LeMone and students (University of Texas at El Paso), J. D. Powell (Grand Junction, Colorado), E. R. Landis and W. A. Cobban (U.S. Geological Survey, Denver, Colorado), and S. C. Hook (Texaco Research Center, Houston, Texas).

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Systematic paleontology

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

Repositories of specimens: TMM, Texas Memorial Museum, University of Texas at Austin; USNM, National Museum of Natural History, Washington, D.C.

Order AMMONOIDEA Zittel, 1884
Suborder AMMONITINA Hyatt, 1889
Superfamily DESMOCERATACEAE Zittel, 1884
Family DESMOCERATIDAE Zittel, 1885
Subfamily DESMOCERATINAE Zittel, 1895

Genus *MOREMANOCERAS* Cobban, 1972

Type-species—Tragodesmoceras *scotti* Moreman, 1942: 208, pl. 33, fig. 8, text-fig. 2d; by original designation.

Discussion—Moremanoceras was originally proposed as a subgenus of *Desmoceras* Zittel, 1884 (Cobban, 1971: 5), from which it differs chiefly in having a simpler suture with much broader L and short auxiliary lobes. The type species is from the upper Cenomanian *Sciponoceras gracile* Zone, but subsequent work has revealed a succession of species, first appearing in the middle Cenomanian, some with distinct flank and ventrolateral ribs in early growth and widely separated flared ribs in later growth (as in the type species) and some also with a siphonal ridge in middle and late growth. These forms are restricted to the Western Interior region and are so far removed from *Desmoceras* in both suture and ornament that in recent years *Moremanoceras* has been considered a full genus (e.g. Cobban, 1984a: 79-81, 1984b: 19, 1986: 81). We further refer *Desmoceras (Pseudouhligella) elgini* Young, 1958 (p. 292, pl. 39, figs..4-20, 24, 25, 30, 31, text-fig. 1a-e), originally described from the base of the Boquillas Formation of Trans-Pecos Texas, to *Moremanoceras.* The suture (Young, 1958, text-fig. la) has a simple, broad, trifid L as in the present genus, and adult topotypes before us develop distant bar-like ribs as in other members of the *Moremanoceras* lineage.

MOREMANOCERAS STRAINI, new species
Fig. 1a-g, i-t

1955. *Desmoceras?* sp.: Stephenson, p. 58, pl. 4, figs. 12, 13. 1977a. *Desmoceras (Pseudouhligella)* aff. *D. japonicum* Yabe: Cobban, p. 22, pl. 11, figs. 1-6, 9, 10.

197Th. *Desmoceras (Pseudouhligella) aff. D. japonicum* Yabe: Cobban, fig. 4a-e.

Types-Holotype USNM 416051, figured paratypes USNM 416052-416059, unfigured paratypes USNM 416060.

Etymology-Named in honor of the late William S. Strain, former Professor Emeritus at the University of Texas at El Paso, for his research on the Cretaceous stratigraphy of the Cerro de Muleros area. Prof. Strain also collected several of the fossils illustrated in this report.

Material-32 specimens. Dimensions:

USNM	D	Wb	Wh	Wb:Wh	
416058	36.9(100)		16.9(45.8)		6.0(16.3)
416051	56.5(100)	21.3(37.7)	25.0(44.2)	0.85	11.4(20.2)
416052	55.0(100)	23.9(43.3)	26.4(48.0)	0.91	9.0(16.4)

Diagnosis-Moremanoceras with compressed to slightly depressed whorl section, smooth with biconcave growth lines on shell and periodic biconcave constrictions on internal mold that form acute chevrons on venter. Venter initially rounded, but develops a blunt rounded keel at maturity, when constrictions appear accompanied by blunt adapical ventrolateral collar ribs.

Description-Coiling involute, with 60% of previous whorl covered. Umbilicus small (16-20% of diameter), with vertical wall. Umbilical shoulder narrowly rounded, inner flanks flattened, subparallel, outer flanks converging to arched, rounded venter in early growth stages becoming raised into a blunt keel flanked by shallow depressions in later growth stages. Shell surface bears faint, flexuous prorsiradiate growth striae, feebly concave on the inner flank, feebly convex across the middle of the flanks, and concave on the outer flank where they are projected forwards over the ventrolateral shoulder to form a narrow linguoid peak over the venter. Parallel to these are periodic constrictions, five to six per whorl, weak on the shell exterior but stronger on the mold. These constrictions deepen and broaden markedly across the ventrolateral shoulder, but narrow and attenuate before reaching the line of the mid-venter. A collar rib develops adapically to these constrictions in most cases, and is most conspicuous on the ventrolateral shoulder.

Discussion-The 32 specimens from Cerro de Muleros reveal the development of the species from 9.5 mm in diameter to a whorl height of 33 mm. The early whorls (Fig. 1f, g, i-k) are flat-sided and resemble very much *Desmoceras* sensu stricto, although the later development of a keel (Fig. 1n, s) separates them from all described species of that genus. *Desmoceras (Pseudouhligella) elgini* Young (1958: 292, pl. 39, figs. 4-20, 24, 25, 30, 31, text-fig. 1a-e) is much more compressed when young, develops thickened collar-ribs at only 15 mm diameter and, when mature, has distant flank and ventrolateral ribs, and never develops a keel. *Moremanoceras straini* of the *amphibolum* Zone is succeeded, in the *Calycoceras canitaurinum* Zone of the Western Interior, by an undescribed species in which the keel is sharper and present from a much earlier ontogenetic state, and concave ribs are well developed over the ventrolateral shoulders. *Moremanoceras scotti* (Moreman, 1942: 208, pl. 33, fig. 8, text-fig. 20) (see Cobban, 1971: 6, pl. 2, figs. 1-23, text-figs. 35), from the *Sciponoceras gracile* Zone of Texas and the Western Interior, lacks a siphonal keel/ridge at any stage of development, and has a tiny umbilicus; it also has regular, distant collar-ribs that extend to the umbilical shoulder and are prorsiradiate on the flank rather than biconcave.

Occurrence-Middle Cenomanian *Acanthoceras amphibolum* Zone of the Western Interior and Trans-Pecos Texas; Cloice Member of the Lake Waco Formation of Adkins & Lozo (1951) at Cloice Branch, McLennan County, Texas; *Tarrantoceras rotatile* concretions in lower part of Eagle Ford Group of Johnson County, Texas.

Genus *DESMOCERAS* Zittel, 1884
Subgenus DESMOCERAS *(PSEUDOUHLIGELLA)* Matsumoto, 1938

Type *species-Desmoceras dawsoni* Whiteaves var. *japonica* Yabe, 1904: 35, pl. 5, fig. 3a, b; by subsequent designation (Matsumoto, 1938).

DESMOCERAS (PSEUDOUHLIGELLA) sp.
Fig. lu, v

1977a. *Desmoceras (Pseudouhligella)* sp.: Cobban, p. 22, pl. 4, fig. 7.

Material-One specimen only, USNM 416061.

Description-The specimen, an internal mold crushed on one side, has a diameter of 36 mm and an umbilical ratio of 0.24. Its whorl section is compressed, flat-sided with an arched, rounded venter. The umbilicus is shallow with a narrowly rounded umbilical shoulder. A conspicuous constriction is present at a diameter of 31.5 mm; it is narrow and convex on the inner to mid-flank, then deepens and broadens and becomes concave on the outer flank before projecting forward and narrowing to form an acute chevron over the venter. A broad, coarse, blunt collared rib is present on the adapical side and is strengthened into a bulla-like development on the ventrolateral shoulder. Sutures are not preserved.

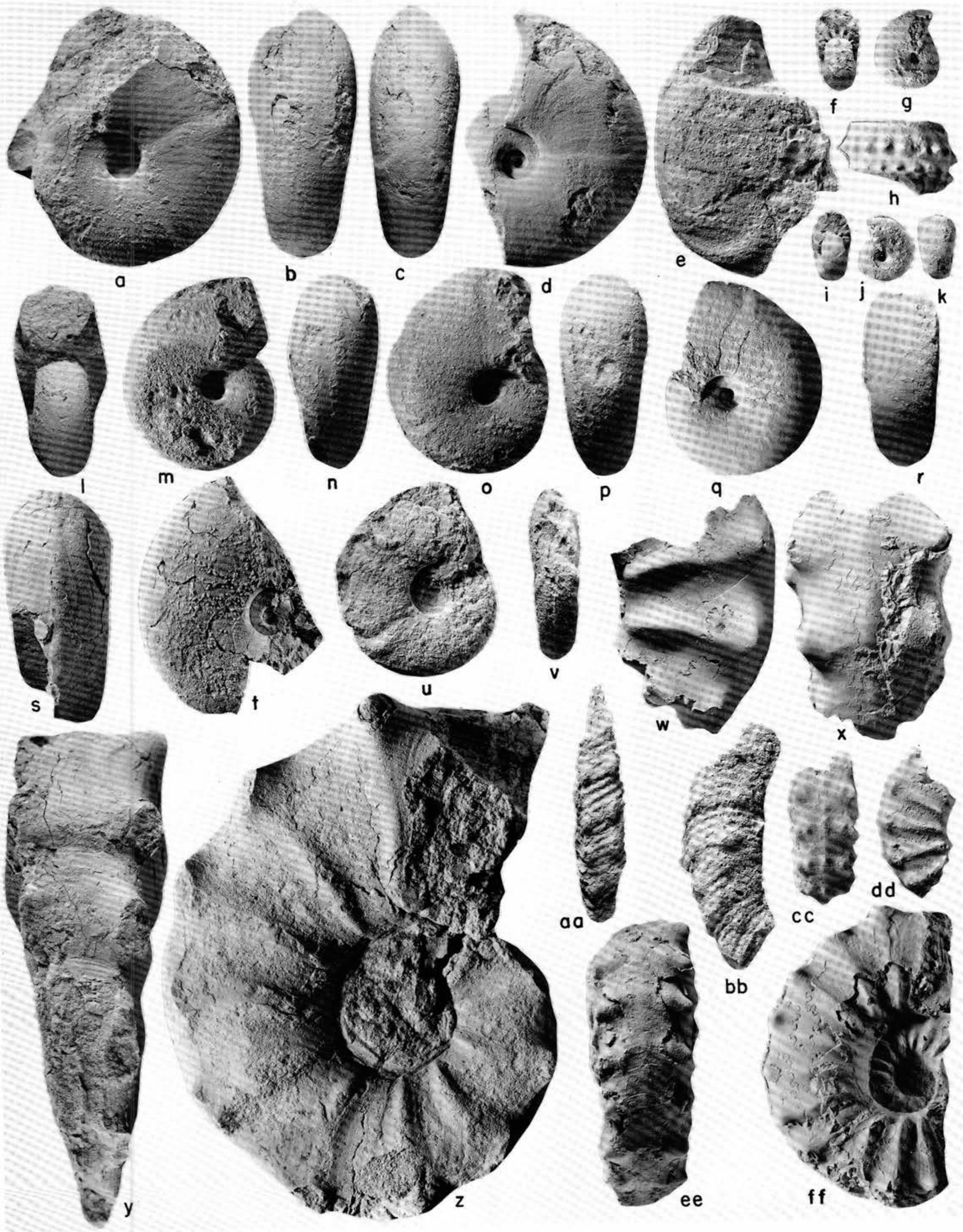
Discussion-The specimen probably represents the inner whorls of the same species that was illustrated from this zone farther northwest in Sandoval County, New Mexico (Cobban, 1977a: 22, pl. 4, fig. 7). The Sandoval specimen is a phragmocone 100 mm in diameter that has flat flanks, conspicuous constrictions, and a complex suture.

Superfamily ACANTHOCERATACEAE de Grossouvre, 1894
Family ACANTHOCERATIDAE de Grossouvre, 1894
Subfamily ACANTHOCERATINAE de Grossouvre, 1894

Genus *CUNNINGTONICERAS* Collignon, 1937

Type *species-Ammonites cunningtoni* Sharpe, 1855:35, pl. 15, fig. 2; by original designation.

FIGURE 1—*Moremanoceras straini* sp. nov.: **a, b,** paratype USNM 416052; **c, d,** holotype USNM 416051; **e,** paratype USNM 416053; **f, g,** paratype USNM 416054; **i–k,** paratype USNM 416055; **l–n,** paratype USNM 416056; **o, p,** paratype USNM 416057; **q, r,** paratype USNM 416058; **s, t,** paratype USNM 416059. *Turrilites (Turrilites) acutus* Passy: **h,** hypotype USNM 416076. *Desmoceras (Pseudouhligella)* sp.: **u, v,** figured specimen USNM 416061. *Acanthoceras amphibolum* Morrow: **w, x, cc, dd,** hypotype USNM 416063; **y, z,** hypotype USNM 416064; **ee, ff,** hypotype USNM 416065. *Anisoceras* cf. *plicatile* (J. Sowerby): **aa, bb,** figured specimen USNM 416075. All figures are natural size.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CUNNINGTONICERAS cf. *JOHNSONIANUM* (Stephenson, 1955)
Fig. 2o, p

1955. *Acanthoceras johnsonianum* Stephenson, p. 58, pl. 4, figs. 14-17.
1955. *Euomphaloceras lonsdalei* (Adkins): Stephenson, p. 62 (pars), pl. 6, figs. 9-20 only.

Type—USNM 108846, from the basal Eagle Ford Group at USGS Mesozoic locality 14853, 2.5 mi northeast of Alvarado, Johnson County, Texas, is the holotype by monotypy. Middle Cenomanian *Acanthoceras amphibolum* Zone.

Material—A single hypotype, USNM 416062. Description—The specimen is a distorted internal mold just over 60 mm in diameter. Coiling is moderately evolute, with depressed whorls that are trapezoidal in intercostal section; the costal section is polygonal, with greatest breadth at the umbilical bullae. Fourteen primary ribs arise at the umbilical seam and strengthen into variably developed but generally strong umbilical bullae which give rise to coarse, straight, prorsiradiate primary ribs. These bear a strong, conical innermost ventrolateral horn and a low, broad rib that extends across the venter bearing strong outer ventrolateral and siphonal clavi. One or two short ribs are intercalated between the primaries on the venter and generally bear clavate outer ventrolateral and siphonal clavi only. As a result, there are twice as many outer ventrolateral and siphonal tubercles as inner ventrolateral and umbilical tubercles.

Discussion—This rather poorly preserved specimen, which we compare to *C. johnsonianum,* is easily distinguished from other acanthoceratids occurring in the present fauna by the ventral ribbing and tuberculation pattern. This matches that of both the holotype of *"Acanthoceras" johnsonianum* and other specimens before us from the same horizon in north-central Texas. Stephenson confused this species with the older *Cunningtoniceras lonsdalei* (Adkins, 1928: 244, pl. 26, fig. 5, pl. 27, fig. 3) and referred several juveniles of *C. johnsonianum* to *lonsdalei* (Stephenson, 1955, pl. 6, figs. 9-20). The two are easily distinguished: *lonsdalei* has a rounded rather than angular/polygonal whorl section and more intercalated ribs whose tubercles are commonly much weaker than those on the primaries. Co-occurring *Acanthoceras amphibolum* (Morrow, 1935: 470, pl. 49, figs. 1-4, 6, pl. 51, figs. 3, 4, text-fig. 4; see below) may be superficially similar at small sizes, but at the diameter of the present specimen, most specimens have already developed distant flank ribs and lost the inner ventrolateral and siphonal clavi, leaving a ventrolateral horn and low siphonal ridge only.

Occurrence—Middle Cenomanian *Acanthoceras amphibolum* Zone of north-central Texas and Cerro de Muleros only.

Genus *ACANTHOCERAS* Neumayr, **1875**

Type *species—Ammonites rhotomagensis* Brongniart in Cuvier & Brongniart, 1822, pl. N, fig. 2a, b; by subsequent designation (de Grossouvre, 1894).

ACANTHOCERAS AMPHIBOLUM Morrow, 1935
Figs. 1w-z, cc-ff, 2a, b

1935. *Acanthoceras? amphibolum* Morrow, p. 479, pl. 49, figs. 1-4, 6, pl. 51, figs. 3, 4, text-fig. 4.
1942. *Acanthoceras alvaradoense* Moreman, p. 205, pl. 32, fig. 6, text-fig. 2o, t.
1953. *Acanthoceras hazzardi* Stephenson, p. **201,** pl. 48, figs. 1, 2, pl. 49, fig. 4. (1952 imprint)
1955. *Euomphaloceras alvaradoense* (Moreman): Stephenson, pl. 63, pl. 7, figs. 1-9.
1960. *Acanthoceras amphibolum* Morrow: Matsumoto, p. 41, text-fig. 5b-d.
1960. *Acanthoceras hazzardi* Stephenson: Matsumoto, p. 41, text-fig. 5a.
1960. *Acanthoceras alvaradoense* Moreman: Matsumoto, p. 41, text-fig. 6a-c.
1963. *Paracanthoceras amphibolum* (Morrow): Haas, p. 18. 1964. *Plesiacanthoceras [amphibolum]* (Morrow): Haas, p. 610.
1965a. *Plesiacanthoceras amphibolum* (Morrow): Hattin, pl. 4, figs. J, K, pl. 5, figs. C-F.
1965b. *Plesiacanthoceras amphibolum* (Morrow): Hattin, text-fig. 3 (8). 1966. *Acanthoceras amphibolum* Morrow: Matsumoto & Obata, p. 45, text-figs. 4-6.
1966. *Acanthoceras hazzardi* Stephenson: Matsumoto & Obata, p. 45, text-fig. 7.
1968. *Plesiacanthoceras [amphibolum* Morrow]: Laporte, text-figs. 6-10H.
1968. *Acanthoceras amphibolum* Morrow: Hattin, p. 1087.
1969. *Acanthoceras amphibolum* Morrow: Matsumoto, Muramoto & Takahashi, p. 266, pl. 31, fig. 1.
1972. *Acanthoceras amphibolum* Morrow: Cobban & Scott, p. 65, pl. 9, pl. 10, figs. 12-16, text-fig. 26.
1977a. *Acanthoceras amphibolum* Morrow: Cobban, p. 23, pl. 8, figs. 8, 9, pl. 12, figs. 10-12, 15-23, text-fig. 5.
1977b. *Acanthoceras amphibolum* Morrow: Cobban, fig. 4n-q.
1977. *Acanthoceras amphibolum* Morrow: Hattin, fig. 4 (13).
1977. *Acanthoceras amphibolum* Morrow: Kauffman, pl. **15, figs. 1,** 2.
1977a. *Acanthoceras alvaradoense* Moreman: Cobban, p. 24, pl. 6, figs. 1-7, 11-20, text-fig. 6.
1977b. *Acanthoceras alvaradoense* Moreman: Cobban, fig. 3a-i. 1978. *Acanthoceras amphibolum* Morrow: Hattin & Siemers, **fig. 5 (14).**
1978. *Acanthoceras amphibolum* Morrow: Kauffman, Cobban & Eicher, pl. 4, figs. 1, 2.
1979. *Acanthoceras amphibolum* Morrow: Merewether, Cobban & Cavanaugh, pl. 1, figs. 1, 2, 8, 9.
1979. *Acanthoceras alvaradoense* Moreman: Merewether, Cobban & Cavanaugh, pl. 1, figs. 3-7.
1985. *Acanthoceras amphibolum* Morrow: Zaborski, p. 35, figs. 38-41.
1985. *Plesiacanthoceras amphibolum* (Morrow): Atabekian, p. 87.

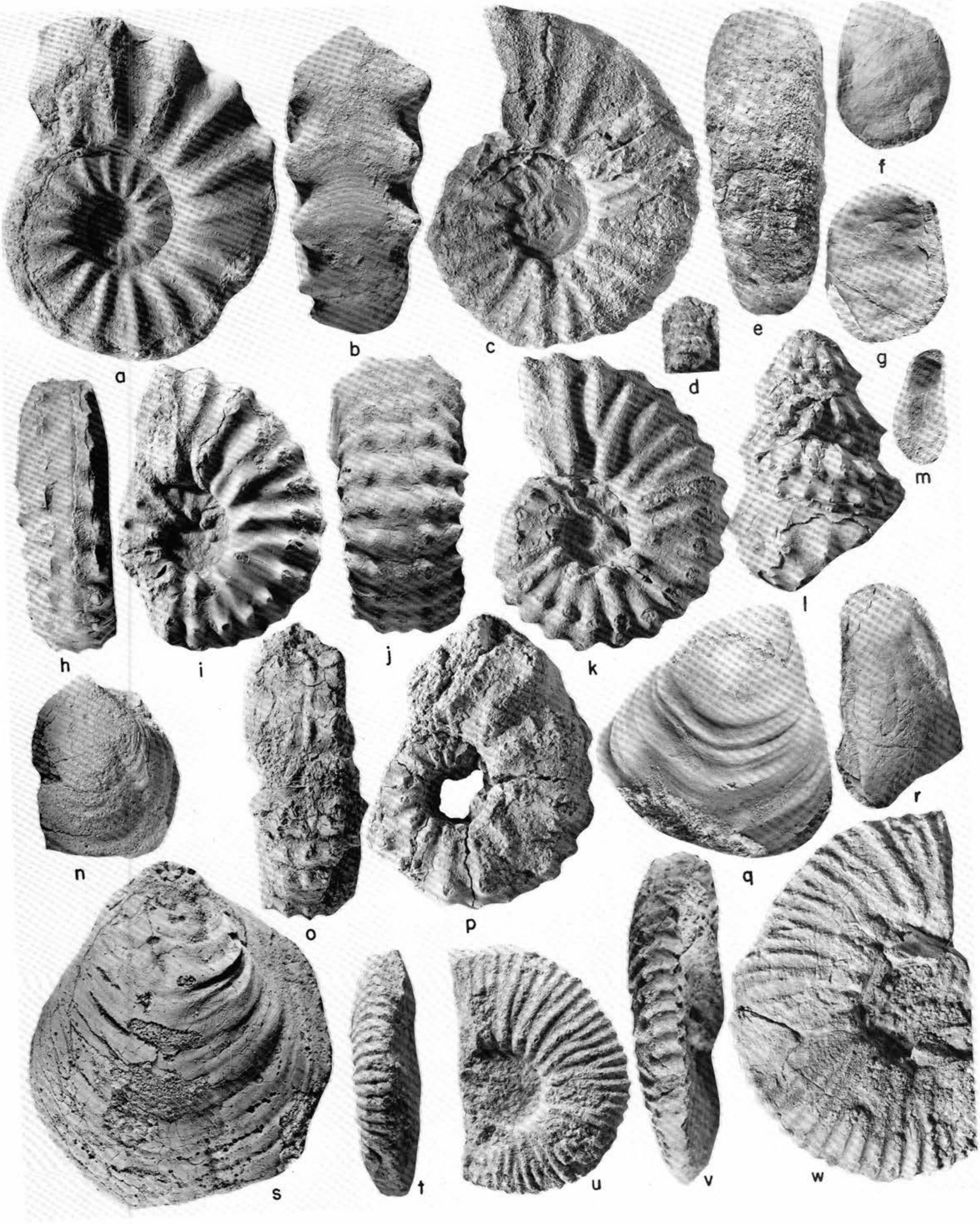
Material—Seven hypotypes, USNM 416063-416066. Dimensions:

USNM	D	Wb	Wh	Wb:Wh	
416066	c 73.5(100)	33.2(45.2)	27.7(37.7)	1.20	24.5(33.3)
416065	c 63.5(100)	24.8(39.1)	24.5(38.6)	**1.01**	21.2(33.4)

Description—Coiling evolute, with U = 33% approximately; umbilicus shallow, with low, outward-inclined wall. Whorl section trapezoidal, with broadly rounded inner flanks, flattened convergent outer flanks, broadly rounded ventrolateral shoulder, and flattened venter. Costal section polygonal in early growth, thereafter with convex inner flanks, concave outer flanks and concave venter. Our smallest specimens at diameters of approximately 30 mm have 17-18 ribs per whorl. Ribs arise at the umbilical seam and strengthen across the wall into long umbilical bullae. These give rise to broad, distant, straight prorsiradiate primary ribs somewhat weakened on the outer flank. All ribs bear strong, clavate, inner ventrolateral tubercles; weaker outer ventrolateral and siphonal clavi are borne on a low, broad, transverse rib.

Siphonal clavi are linked by a blunt siphonal ridge with

FIGURE 2—*Acanthoceras amphibolum* Morrow: **a, b,** hypotype USNM 416066. *Paracompsoceras landisi* Cobban: **c, e,** hypotype USNM 416067; **h, i,** hypotype USNM 416068; **j, k,** hypotype USNM 416069. *Turrilites acutus* Passy: **d,** hypotype USNM 416077; **i,** hypotype USNM 416078. *Ostrea beloiti* Logan: **f,** hypotype USNM 416079; **g,** hypotype USNM 416080; **m,** hypotype USNM 416081; **r,** hypotype USNM 416082. *Inoceramus arvanus* Stephenson: **n,** hypotype USNM 416083; **q,** hypotype USNM 416084; **s,** hypotype USNM 416085. *Cunningtoniceras* cf. *johnsonianum* (Stephenson): **o, p,** figured specimen USNM 416062. *Tarrantoceras sellardsi* (Adkins): **t, u,** hypotype USNM 416072; **v, w,** hypotype USNM 416073. All figures are natural size.



additional intercalated clavi, while there may also be short intercalated ventral ribs associated with the additional clavi (Fig. 1cc, dd). These lack inner ventrolateral tubercles. The intercalated ribs and clavi are rapidly lost, while outer ventrolateral clavi decline progressively, first leaving a flat venter and then a progressively more deeply sulcate venter in costal section (Fig. ly, z), as ventrolateral horns become progressively larger. Where external shell surface is well preserved, a low, blunt siphonal ridge is visible as are delicate convex ventral riblets, lirae, and striae, looping between the horns and covering the interspaces between (Figs. lx, y, 2b). USNM 416006 (Fig. 2a, b) has 17 ribs at a diameter of 76.5 mm; USNM 416064 (Fig. ly, z) has 12 or 13 at a diameter of 107 mm.

Adult body-chamber fragments have intercostal whorl heights of up to 80 mm. The ribs are very distant, with strong bullae that migrate from umbilicolateral to inner lateral position toward the adult aperture; strong ventrolateral horns are linked by weak looped riblets across a venter which is deeply sulcate in costal section. The final rib before the final tubular section of the body chamber is strengthened ventrally into a high bar-like flange with the horns disappearing, as mentioned by Stephenson (1955: 62).

Suture with broad, moderately incised bifid E/L, narrow L, and broad U_2.

Discussion-Unpublished work by Cobban has shown *Acanthoceras amphibolum, A. alvaradoense,* and *A. hazzardi* of previous authors to be synonyms and strict contemporaries. Suggestions that *amphibolum* sensu stricto and *alvaradoense* were early and late subspecies of *amphibolum* (Cobban, 1984a: 77) must be abandoned. Early and late forms certainly exist and differ in that the early whorls of the early form have constrictions and nodate ventrolateral and siphonal tubercles, whereas the early whorls of the later form lack constrictions and generally have clavate tubercles (Fig. 1cc, dd); the latter requires a new subspecific name. The present material all belongs to the early form of the species, but the synonymy encompasses all references to the species. Late forms are illustrated by Cobban & Scott (1972: 65 [pars], pl. 9, pl. 10, figs. 12-16, text-fig. 26), Cobban (1977a: 23, pl. 8, figs. 8, 9, pl. 12, figs. 10-12, 15-23, text-fig. 5), Kauffman (1977, pl. 15, figs. 1, 2), Kauffman, Cobban & Eicher (1978, pl. 4, figs. 1, 2), and Merewether, Cobban & Cavanaugh (1979, pl. 1, figs. 1, 2, 8, 9).

Occurrence-Middle Cenomanian *Acanthoceras amphibolum* Zone, New Mexico, Trans-Pecos and north-central Texas, Kansas, Colorado, Wyoming, South Dakota and Montana; Japan; USSR. Zaborski (1985) has recently recorded the species from Nigeria.

Genus *PARACOMPSOCERAS* Cobban, 1972

Type *species-Paracompsoceras landisi* Cobban, 1972: 10, pl. 2, figs. 24-26, pls. 6-8, pl. 9, figs. 5-8, text-figs. 9-11; by original designation. Middle Cenomanian *Acanthoceras amphibolum* Zone of west-central New Mexico.

Discussion-Paracompsoceras is a heterochronous homeomorph of *Acompsoceras* Hyatt, 1903. Whereas the latter is the probable *ancestor* of *Acanthoceras* and typically lower Cenomanian with a wide geographic distribution, the former is a middle Cenomanian *derivative* of *Acanthoceras* and is restricted to the Western Interior of the United States. The present material is better preserved than the type series and considerably amplifies our knowledge of the early ontogeny of this remarkable genus.

PARACOMPSOCERAS LANDISI Cobban, 1972
Figs. 2c, e, h-k, 3

1972. *Paracompsoceras landisi* Cobban, p. 10, pl. 2, figs. 24-26, pls. 6-8, pl. 9, figs. 5-8, text-figs. 9-11.

1977a. *Paracompsoceras landisi* Cobban: Cobban, p. 25, pl. 14.

Types-Holotype of *P. landisi* is USNM 166358; paratypes are USNM 166359-166361 and 166395 from the middle Cenomanian *Acanthoceras amphibolum* Zone at USGS Mesozoic locality D7084, 4.8 km north of Laguna, Valencia County, New Mexico.

Material-Five specimens, USNM 416067-416071. Dimensions:

USNM	D	Wb	Wh	Wb:Wh	
416069 c	61.3(100)		24.9(40.6)	-	19.0(31.0)
416068 c	62.8(100)	29.5(47.0)	24.8(39.5)	1.19	19.4(30.9)
is	59.1(100)	27.2(47.0)	24.0(40.6)	1.13	19.4(32.8)
416067 c	69.5(100)		29.2(42.0)	-	21.8(31.4)

Description-Three specimens show the inner whorls to a diameter of 70 mm (Fig. 2c, e, h-k). Coiling is involute with just over 20% of the previous whorl covered; the umbilicus is of moderate depth and comprises 31-33% of the diameter at this stage. The umbilical wall is flat and sub-vertical, with the umbilical shoulder quite narrowly rounded. The costal whorl section is depressed trapezoidal, with greatest breadth below mid-flank; the inner flanks are rounded, the mid-outer flanks flattened and covergent, the ventrolateral shoulders broadly rounded, and the venter somewhat flattened. The costal whorl section is depressed polygonal, with the greatest breadth at the umbilical bullae. Twelve to 13 primary ribs arise at the umbilical seam and strengthen into prominent bullae that are variable in strength in and between individuals. These bullae give rise to one or rarely a pair of broad, blunt, straight, rectiradiate ribs, and single intercalatories arise below mid-flank. All ribs strengthen and are equally developed at the umbilical shoulder where there are estimated 26 ribs per whorl. All ribs bear strong conical inner ventrolateral tubercles. A broad transverse rib connects these across the broad venter and bears strong davate outer ventrolateral and somewhat weaker siphonal clavi, the latter borne on a feebly developed siphonal ridge. Beyond a diameter of 75 mm, ornament modifies progressively (Fig. 3), and two large specimens, USNM 416070 and 416071, reveal a middle growth stage at 150-200 mm diameter in which the whorl section is markedly compressed (whorl breadth to height ratio 0.8), with a narrowly rounded umbilical shoulder, broadly rounded inner flanks, and flattened, convergent outer flanks with sharp ventrolateral shoulders and a shallow concave venter. Nearly all tuberculation has disappeared, leaving only distant bullae on the umbilical shoulder that give rise to low ribs effaced across the flanks and separated by somewhat deepened and constriction-like interspaces.

Suture only imperfectly exposed.

Discussion-We initially identified the inner whorls of the present material as *Acanthoceras.* Yet they develop outer whorls that are utterly distinct from that genus, matching with the types of *P. landisi.* The present material differs from the holotype and topotypes of the older *Acompsoceras bifurcatum* Powell (1963: 311, pl. 31, figs. 1, 7, 11, text-fig. 31, r) in lacking a lateral tubercle, although it is otherwise very similar in early growth stages. It might be argued that this is no more than intraspecific variation, yet it is the relatively feebly ornamented *A. bifurcatum* that has this tubercle, coarsely ribbed juvenile *P. landisi* lacking it. This is the reverse of the normal pattern of covariance in Acanthoceratacea, and these two species are maintained separate. *Acompsoceras bifurcatum is* considered a junior synonym of *A. inconstans* (Schluter, 1871) (Wright & Kennedy, 1987: 143).

Occurrence-Middle Cenomanian *Acanthoceras amphibolum* Zone of New Mexico only.

Genus *TARRANTOCERAS* Stephenson, 1955

Type ***species-Tarrantoceras*** *rotatile* Stephenson, 1955 (=

Mantelliceras sellardsi Adkins, 1928), from the middle Cenomanian *Acanthoceras amphibolum* Zone of northeastern Texas.

FIGURE 3—*Paracompsoceras landisi* Cobban, hypotype USNM 416071, natural size.

TARRANTOCERAS SELLARDSI (Adkins, 1928)
Fig. 2t-w

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, p1. 6, figs. 21-23.
1971. *Eucalycoceras sellardsi* (Adkins): Kennedy, p. 84.
1972. *Tarrantoceras rotatile* Stephenson: Cobban & Scott, p. 64, pl. 10, figs. 1-11, text-fig. 25.
1977a. *Tarrantoceras rotatile* Stephenson: Cobban, p. 23, pl. 6, figs. 8-10, 28-29, p1. 11, figs. 7, 8, 11-16, pl. 12, figs. 13, 14, text-fig. 4.
1977b. *Tarrantoceras rotatile* Stephenson: Cobban, figs. 3n, o, 4g. 1978.
Tarrantoceras rotatile Stephenson: Cooper, p. 92, text-fig. 20. 1978.
Utaturiceras(?) sellardsi (Adkins): Young & Powell, p. xxv.18. 1984a.
Tarrantoceras sellardsi (Adkins): Cobban, p. 78.
1986. *Tarrantoceras sellardsi* (Adkins): Cobban, fig. 3c, d.

Types—Holotype TMM 34048, from the lower part of the Eagle Ford Group south of Moody, McLennan County, Texas, middle Cenomanian *Acanthoceras amphibolum* Zone; by monotypy. Hypotypes USNM 416072-416074.

Material—Fourteen fragments.

Discussion—Cobban & Scott (1972: 65) pointed out that *T. rotatile, T. stantoni,* and *T. lillianense* of Stephenson (1955) were no more than variants of a single species, and that view is supported by the present material which varies markedly in relative strength of ribbing and degree of dominance of ribs over tubercles. Two large fragments, USNM 416073 (Fig. 2v, w) and 416074, 75 and 84 mm in diameter, appear to be incomplete macroconchs; USNM 416072, 57 mm in diameter, seems to be a microconch lacking the terminal portion of the body chamber (Fig. 2t, u).

Occurrence—Middle Cenomanian *Acanthoceras amphibolum* Zone of Texas, New Mexico, southeastern Colorado, and eastern Wyoming.

Suborder ANCYLOCERATINA Wiedmann, 1966
Superfamily TURRILITACEAE Gill, 1871
Family ANISOCERATIDAE Hyatt, 1900

Genus *ANISOCERAS* Pictet, 1854

Type *species*—*Anisoceras saussureanus* Pictet, 1847: 374, pl. 13, figs. 1-4; by original designation.

ANISOCERAS cf. PLICATILE (J. Sowerby, 1819)
Fig. 1aa, bb

Compare:
1819. *Hamites plicatilis* J. Sowerby, p. 281, pl. 234, fig. 1.
1971. *Anisoceras plicatile* (J. Sowerby): Kennedy, p. 12, pl. 3, figs. 12, 13, pl. 4, figs. 1-3 (with synonymy).
1983. *Anisoceras plicatile* (J. Sowerby): Kennedy & Juignet, p. 25, figs. 10q—e, 16a—m, p, q, 34e, m.

Material—A single fragment, USNM 416075.

Discussion—The specimen is crushed, with a maximum apparent whorl height of 18 mm. Large round-based tubercles at mid-flank link groups of two or three narrow ribs which loop to smaller ?clavate ventrolateral tubercles that are in turn linked over the venter by two or three ribs; there are two, rarely three, nontuberculate ribs that are strong on the flanks and venter but somewhat weakened on the dorsum between the tuberculate groups. Rather poor fragments of *Anisoceras* are known from the zone of *Acanthoceras amphibolum*, but these are generally too incomplete to determine whether they are indeed helically coiled as in *A. plicatile* of comparable size or represent some other species.

Family TURRILITIDAE Meek, 1876
Genus *TURRILITES* Lamarck, 1801

Subgenus *TURRILITES* Lamarck, 1801

Type species—*Turrilites costatus* Lamarck, 1801: 102; by original designation.

TURRILITES (TURRILITES) ACUTUS Passy, 1832
Figs. 1h, 2d, 1

1832. *Turrilites acutus* Passy, p. 334, pl. 16, figs. 3, 4.
1977a. *Turrilites acutus* Passy: Cobban, p. 22, pl. 4, figs. 4, 5.
1977b. *Turrilites acutus* Passy: Cobban, figs. 2i, 4k.
1983. *Turrilites acutus* Passy: Kennedy & Juignet, p. 51 (with synonymy).
1985. *Turrilites acutus* Passy: Atabekian, p. 77, pl. 28, figs. 5-13, pl. 29, figs. 1-10, pl. 30, figs. 1-11 (with synonymy). Types—Lectotype, the original of Passy (1832, pl. 16, fig. 3), from the middle Cenomanian of Rouen, France, designated by Juignet & Kennedy (1976: 65). Hypotypes USNM 416076-416078.

Material—Fourteen fragments.

Discussion—Specimens vary from 1.5 to 21 mm in whorl height. Ribs number 15-16 per whorl in middle growth. These ribs arise at the upper whorl suture and are produced into sharp tubercles at mid-flank. A weakened rib sweeps forward to a smaller sharp tubercle located just above the lower whorl suture, and a third, much smaller, spirally elongate tubercle lies in notches in the whorl seam. The base of the whorls is smooth. These specimens overlap in rib density and ornament with topotypes of *Turrilites acutus* from Rouen illustrated and described by Juignet & Kennedy (1976: 65, pl. 3, fig. 6, pl. 4, figs. 1-3), and with numerous specimens from the middle Cenomanian *Acanthoceras rhotomagense* Zone, *Turrilites acutus* Subzone of Snowdon Hill, Chard, Somerset (Oxford University Museum collections), which have up to 21 tuberculated ribs per whorl and show a third row of tubercles exposed at the inter-whorl suture. These suggest that *Turrilites acutus americanus* Cobban & Scott (1972: 53, pl. 11, figs. 1-11, text-fig. 21), with estimated 25-26 tuberculated ribs per whorl, may be a synonym. Certainly the well-preserved *Turrilites* with only 21 ribs from west-central New Mexico (Cobban, 1977a: 22, pl. 4, figs. 4, 5) belongs to *acutus* sensu stricto, as does the present material.

Occurrence—The species first appears in the middle of the middle Cenomanian, where it is widespread and common; it ranges to the lower part of the upper Cenomanian, where it is generally rare. The species is known from western and eastern Europe, the USSR, North Africa, Nigeria, Angola, Zululand (South Africa), Madagascar, and Mozambique. In the United States there are records from California, Texas, New Mexico, and Colorado; in the Western Interior the species is particularly widespread in the *Acanthoceras amphibolum* Zone, but may range as low as the *Conlinoceras tarrantense* Zone.

Class BIVALVIA Linnaeus, 1758
Subclass PTERIOMORPHIA Beurlen, 1944
Order PTERIOIDA Newell, 1965
Suborder OSTREINA Férrusac, 1822
Superfamily OSTREACEAE Rafinesque, 1815
Family OSTREIDAE Rafinesque, 1815
Subfamily OSTREINAE Rafinesque, 1815

Genus *OSTREA* Linnaeus, 1758

Type species—Ostrea *edulis* Linnaeus, 1758: 696 (ICZN Opinion 94, 1958).

OSTREA BELOITI Logan, 1899
Fig. 2f, g, m, r

1876. *Ostrea elegantula* Newberry, p. 33 (nomen oblitum).
1884. *Ostrea elongatula* Newberry: White, p. 295, pl. 36, figs. 5-7.
1899. *Ostrea beloiti* Logan, p. 214, pl. 25, figs. 7, 8.
1965a. *Ostrea beloiti* Logan: Hattin, p. 40, pl. 4, figs. A, B, D, G, I.
1965b. *Ostrea beloiti* Logan: Hattin, p. 13, fig. 3.4, 3.9.
1977a. *Ostrea beloiti* Logan: Cobban, p. 20, pl. 7, figs. 4-7.
1977b. *Ostrea beloiti* Logan: Cobban, fig. 4 H.
1977. *Ostrea beloiti* Logan: Kauffman & Powell, p. 92, pl. 8, figs. 9, 10.
1978. *Ostrea beloiti* Logan: Hattin & Siemers, fig. 5.16, 5.17.
1980. *Ostrea beloiti* Logan: Cobban & Hook, p. 169, fig. 2A, B.
1984b. *Ostrea beloiti* Logan: Cobban, p. 13, pl. 5, fig. 11.
1986. *Ostrea beloiti* Logan: Cobban, fig. 5i.

Types—Lectotype, the original of Logan (1899, pl. 25, figs. 7, 8). Hypotypes USNM 416079-416082.

Material—Abundant specimens.

Discussion—Kauffman & Powell (1977: 92, pl. 8, figs. 9, 10) described this species in detail, and Cobban & Hook (1980) discussed its stratigraphic and geographic occurrences. The present material is very typical.

Occurrence—Middle Cenomanian *Conlinoceras tarrantense* Zone to upper Cenomanian *Dunveganoceras pondi* Zone. This oyster is abundant and commonly a rock-former in the middle Cenomanian *Acanthoceras amphibolum* Zone ranging from Manitoba (McNeil & Caldwell, 1974) to west and north-central Texas.

Suborder PTERIINA Newell, 1965
Superfamily PTERIACEA Gray, 1847
Family INOCERAMIDAE Giebel, 1852

Genus *INOCERAMUS* J. Sowerby, 1814

Type species—*Inoceramus cuvierii* J. Sowerby, 1814: 448 (ICZN Opinion 473, 1957).

INOCERAMUS ARVANUS Stephenson, 1953
Fig. 2n, q, s

1953. *Inoceramus arvanus* Stephenson, p. 65, pl. 12, figs. 6-9.
1955. *Inoceramus arvanus* Stephenson: Stephenson, p. 55, pl. 4, figs. 1-3.
1977a. *Inoceramus arvanus* Stephenson: Cobban, p. 15, pl. 6, fig. 27.
1977b. *Inoceramus arvanus* Stephenson: Cobban, fig. 3 p. 1977. *Inoceramus arvanus* Stephenson: Kauffman, pl. 4, figs. 6, 7.

Types—Holotype USNM 105157, the original of Stephenson (1953: 65, pl. 12, fig. 7); by original designation. Hypotypes USNM 416083-416085.

Material—Numerous specimens.

Discussion—The present collection includes individuals up to 75 mm in height that show variation in ornament, outline, and degree to which the shallow posterior fold is developed. These specimens overlap with the holotype in morphology.

Occurrence-In the Western Interior and Texas, this species is an excellent marker for the *Acanthoceras amphibolum* Zone. Kauffman (1978) recorded the species from the lower and middle Cenomanian of southern England.

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Selected conversion factors*

TO CONVERT	MULTIPLY BY	TO OBTAIN
Length		
inches, in	2.540	centimeters, cm
feet, ft	3.048×10^{-1}	meters, m
yards, yds	9.144×10^{-1}	m
statute miles, mi	1.609	kilometers, km
fathoms	1.829	m
angstroms, Å	1.0×10^{-8}	cm
Å	1.0×10^{-4}	micrometers, μm
Area		
in^2	6.452	cm^2
ft^2	9.29×10^{-2}	m^2
yds^2	8.361×10^{-1}	m^2
mi^2	2.590	km^2
acres	4.047×10^{3}	m^2
acres	4.047×10^{-1}	hectares, ha
Volume (wet and dry)		
in^3	1.639×10^{1}	cm^3
ft^3	2.832×10^{-2}	m^3
yds^3	7.646×10^{-1}	m^3
fluid ounces	2.957×10^{-2}	liters, l *or* L
quarts	9.463×10^{-1}	l
U.S. gallons, gal	3.785	l
U.S. gal	3.785×10^{-3}	m^3
acre-ft	1.234×10^{3}	m^3
barrels (oil), bbl	1.589×10^{-1}	m^3
Weight, mass		
ounces avoirdupois, avdp	2.8349×10^{1}	grams, gr
troy ounces, oz	3.1103×10^{1}	gr
pounds, lb	4.536×10^{-1}	kilograms, kg
long tons	1.016	metric tons, mt
short tons	9.078×10^{-1}	mt
oz mt^{-1}	3.43×10^{1}	parts per million, ppm
Velocity		
ft sec^{-1} (= ft/sec)	3.048×10^{-1}	m sec^{-1} (= m/sec)
mi hr^{-1}	1.6093	km hr^{-1}
mi hr^{-1}	4.470×10^{-1}	m sec^{-1}
Pressure, stress		
lb in^{-2} (= lb/in^2), psi	7.03×10^{-2}	kg cm^{-2} (= kg/cm^2)
lb in^{-2}	6.804×10^{-2}	atmospheres, atm
lb in^{-2}	6.895×10^{3}	newtons (N)/m^2, N m^{-2}
atm	1.0333	kg cm^{-2}
atm	7.6×10^{2}	mm of Hg (at 0° C)
inches of Hg (at 0° C)	3.453×10^{-2}	kg cm^{-2}
bars, b	1.020	kg cm^{-2}
b	1.0×10^{6}	dynes cm^{-2}
b	9.869×10^{-1}	atm
b	1.0×10^{-1}	megapascals, MPa
Density		
lb in^{-3} (= lb/in^3)	2.768×10^{1}	gr cm^{-3} (= gr/cm^3)
Viscosity		
poises	1.0	gr cm^{-1} sec^{-1} *or* dynes cm^{-2}
Discharge		
U.S. gal min^{-1}, gpm	6.308×10^{-2}	l sec^{-1}
gpm	6.308×10^{-5}	m^3 sec^{-1}
ft^3 sec^{-1}	2.832×10^{-2}	m^3 sec^{-1}
Hydraulic conductivity		
U.S. gal day^{-1} ft^{-2}	4.720×10^{-7}	m sec^{-1}
Permeability		
darcies	9.870×10^{-13}	m^2
Transmissivity		
U.S. gal day^{-1} ft^{-1}	1.438×10^{-7}	m^2 sec^{-1}
U.S. gal min^{-1} ft^{-1}	2.072×10^{-1}	l sec^{-1} m^{-1}
Magnetic field intensity		
gausses	1.0×10^{5}	gammas
Energy, heat		
British thermal units, BTU	2.52×10^{-1}	calories, cal
BTU	1.0758×10^{2}	kilogram-meters, kgm
BTU lb^{-1}	5.56×10^{-1}	cal kg^{-1}
Temperature		
°C + 273	1.0	°K (Kelvin)
°C + 17.78	1.8	°F (Fahrenheit)
°F − 32	5/9	°C (Celsius)

**Divide by* the factor number to reverse conversions.
Exponents: for example 4.047×10^{3} (see acres) = 4,047; 9.29×10^{-2} (see ft^2) = 0.0929.

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