

Heteromorph ammonites from the Upper Campanian (Upper Cretaceous) *Baculites cuneatus* and *Baculites reesidei* zones of the Pierre Shale in Colorado, USA

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ABSTRACT:

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Calcareous sandstone concretions in the Upper Cretaceous Pierre Shale in Middle Park and in the Fort Collins area of Colorado in the U.S. Western Interior contain heteromorph ammonites of the families Nostoceratidae HYATT, 1894, and Diplomoceratidae SPATH, 1926. The following species are described: *Nostoceras* cf. *N. approximans* (CONRAD, 1855), *Nostoceras* cf. *N. obtusum* HOWARTH, 1965, *N. larimerense* sp. nov., *Nostoceras* cf. *N. splendidum* (SHUMARD, 1861), *Didymoceras aurarium* sp. nov., *D. draconis* (STEPHENSON, 1941), *Cirroceras conradi* (MORTON, 1841), *Anaklinoceras minutum* sp. nov., *Solenoceras texanum* (SHUMARD, 1861), *Solenoceras* cf. *S. reesidei* STEPHENSON, 1941, *Lewyites oronensis* (LEWY, 1969), and *Lewyites?* sp. All these species are migrants from the Gulf coastal region. *Didymoceras draconis* and *Cirroceras conradi* are also known from the Delaware-New Jersey area, and these two species, together with *Solenoceras texanum* are known from as far away as Israel.

Key words: Ammonites, Cretaceous, Campanian, U.S.A.

INTRODUCTION

Heteromorph ammonites, other than baculites and scaphites, are scarce in rocks of latest Campanian age in the US Western Interior and are restricted to sediments deposited in certain shallow-water, sandy environments. Other heteromorph ammonites, notably members of the families Baculitidae and Scaphitidae are abundant and widely distributed over much of the Western Interior in offshore shales as well as in nearshore sandstones. The present account treats the Campanian heteromorph species of the families Nostoceratidae HYATT, 1894, and Diplomoceratidae SPATH, 1926,

found in relatively shallow-water sandy sediments mostly in two areas in Colorado, Middle Park in north-central Colorado (Text-fig. 1) and the Fort Collins area farther east in north-central Colorado (Text-fig. 2). In both areas, the heteromorph species are either migrants from the Gulf coastal region, or have evolved from such migrant taxa. Species in Middle Park are associated with the Western Interior endemic species *Baculites cuneatus* COBBAN, 1962, and those from the Fort Collins area are found with the slightly younger endemic species *B. reesidei* ELIAS, 1933, which places them in the standard zonal framework developed for the Western Interior (Text-fig. 3).

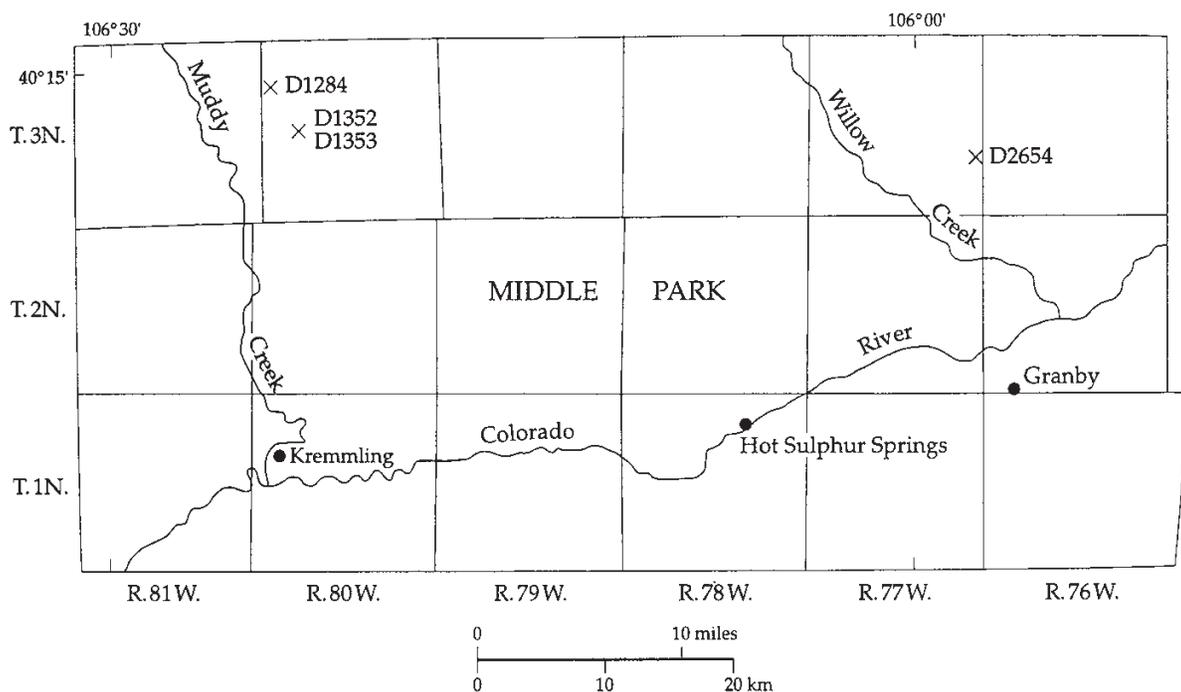


Fig. 1. Map showing localities where heteromorph ammonites were collected from the Pierre Shale in Middle Park, Colorado

STRATIGRAPHY OF THE HETEROMORPH FAUNAS

Middle Park

In Middle Park, about 1,524 meters (m) of Pierre Shale are preserved beneath the Cretaceous-Paleocene unconformity. Here the Pierre Shale has been subdivided by IZETT & *al.* (1971) into five formal members separated by unnamed shale units (Text-fig. 3). The formal members, from oldest to youngest, are: Sharon Springs Member, Kremmling Sandstone Member, Muddy Buttes Sandstone Member, Hygiene Sandstone Member, Carter Sandstone Member, and Gunsight Pass Member. The lower part of the Sharon Springs Member is typical of the Gammon Member of the Pierre Shale in Wyoming, and the name Gammon Member is extended herein into the Middle Park area. The two youngest members, Carter Sandstone Member and Gunsight Pass Member, are separated by 275 m of dominantly shaly beds. A little below the middle of this unnamed shaly member, is a sandy unit about 10 m thick that contains brown-weathering, fossiliferous, sandstone concretions (Text-fig. 4). These

concretions contain inoceramids, *Placenticerus*, *Baculites cuneatus*, *Jeletzkyites nodosus* (OWEN, 1852), and other molluscs including an occasional heteromorph characteristic of the Gulf coast region. This Gulf coast heteromorph fauna consists of *Didymoceras draconis* (STEPHENSON, 1941), *Cirroceras conradi* (MORTON, 1841), *Lewyites oronensis* (LEWY, 1969), and *Solenoceras texanum* (SHUMARD, 1861). Gray limestone concretions and silty limestone beds 12-52 m above the brown sandstone concretion level contain *Baculites reesidei* and *J. nodosus* but no other heteromorphs. Limestone concretions about 12 m below the *B. cuneatus* concretions contain *Placenticerus meeki* BÖHM, 1898, *P. intercalare* MEEK & HAYDEN, 1860, *Axonoceras compressum* STEPHENSON, 1941, *Anaklinoceras reflexum* STEPHENSON, 1941, *A. gordiale* COBBAN, KENNEDY & SCOTT, 1993, *Solenoceras reesidei* STEPHENSON, 1941, *Baculites compressus* SAY, 1820, *B. undatus* STEPHENSON, 1941, *Jeletzkyites nodosus* (OWEN, 1852), and *Hoploscaphites* cf. *H. landesi* RICCARDI, 1983. The general stratigraphic positions of these faunas are shown by IZETT & *al.* (1971, Fig. 2) and by IZETT & BARCLAY (1973).

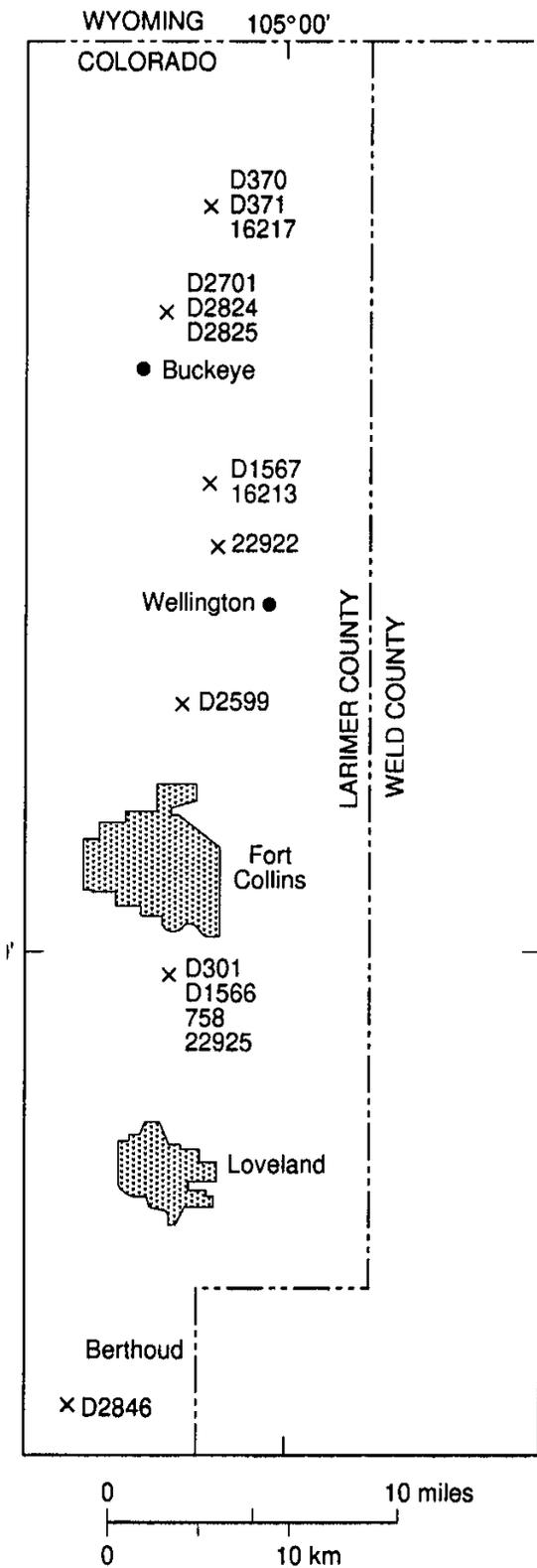


Fig. 2. Map showing localities where heteromorph ammonites were collected from the Pierre Shale in the Fort Collins area, Colorado

Fort Collins area

The entire Pierre Shale (2,070 m) is present in the Fort Collins area, where eight named members and eight unnamed members are recognized (SCOTT & COBBAN 1986). Three closely spaced sandstone members in the middle of the Pierre Shale are, from oldest to youngest: Rocky Ridge, Larimer, and Richard. The Rocky Ridge and Larimer Sandstone Members lie in the zone of *Baculites reesidei*, and the Richard Sandstone Member lies in the zone of *B. jenseni* of latest Campanian age. A 131-m-thick unnamed shale member that underlies the Rocky Ridge Sandstone Member contains *B. cuneatus* and *Jeletzkytes nodosus* just below the middle, but other heteromorph ammonites have not been found. The Rocky Ridge Sandstone Member contains a large molluscan fauna, but *J. nodosus* and *Baculites* cf. *B. reesidei* are the only known heteromorphs. The Larimer Sandstone Member contains a still larger molluscan fauna (listed in SCOTT & COBBAN 1986) that includes *B. reesidei*, *J. nodosus*, *Rhaeboceras subglobosum* (WHITEAVES, 1885) (p. 52, Pl. 7, Fig. 3; Pl. 8, Fig. 1, 1a (not 2, 2a) (COBBAN, 1987, p. 11), and several heteromorphs of Gulf coast affinities. The latter include the following species: *Nostoceras* cf. *N. approximans* (CONRAD, 1855), *Nostoceras* cf. *N. obtusum* HOWARTH, 1965, *N. larimerense* sp. nov., *Nostoceras* cf. *N. splendidum* (SHUMARD, 1861), *Didymoceras aurarium* sp. nov., *Cirroceras conradi* (MORTON, 1841), *Anaklinoceras minutum* sp. nov., *Solenoceras texanum* (SHUMARD, 1861), *Solenoceras* cf. *S. reesidei* STEPHENSON, 1941, *Lewyites oronensis* (LEWY, 1969), and *Lewyites?* sp.

LOCALITIES OF COLLECTIONS

Localities in Colorado at which the heteromorph ammonites were collected are shown in Text-figs 1 and 2. The U.S. Geological Survey Mesozoic locality number, names of collectors, year of collection, locality, and stratigraphic assignment are as follows (prefix D indicates Denver Mesozoic locality numbers; the others are Washington, D.C., Mesozoic locality numbers):

D301. G.R. SCOTT & W.A. COBBAN, 1955. South of Fossil Creek in the SW1/4SW1/4 sec. 1, T. 6 N., R. 69 W., Larimer County. Pierre Shale, from uppermost ledge of Larimer Sandstone Member.

D370. G.R. SCOTT, 1955. Round Butte in the

- SE1/4NW1/4 sec. 19, T. 11 N., R. 68 W., Larimer County. Pierre Shale, from a sandstone bed.
- D371. G.R. SCOTT, 1955. Round Butte in the NW1/4SW1/4 sec. 19, T. 11 N., R. 68 W., Larimer County. Pierre Shale, from equivalent of Larimer Sandstone Member.
- D1284. D. ARNOLD and W.A. GILLESPIE, 1956. SW1/4 sec. 7, T. 3 N., R. 80 W., Grand County. Pierre Shale.
- D1352. G.R. SCOTT and W.A. COBBAN, 1957. NW1/4SW1/4 sec. 17, T. 3 N., R. 80 W.,

- Grand County. Pierre Shale, from very large brown-weathering sandstone concretions.
- D1353. G.R. SCOTT and W.A. COBBAN, 1957. Same locality as D1352. Pierre Shale, from calcareous, sandstone concretions 4-6 m above D1352.
- D1566. G.R. SCOTT, 1957. SW1/4NW1/4 sec. 1, T. 6 N., R. 69 W., Larimer County. Pierre Shale, Larimer Sandstone Member.
- D1567. G.R. SCOTT, 1957. SW1/4NW1/4 sec. 7, T. 9 N., R. 68 W., Larimer County. Pierre

CRETACEOUS STAGE		AMMONITE ZONE	STRATIGRAPHIC UNITS IN MIDDLE PARK	STRATIGRAPHIC UNITS IN THE FORT COLLINS AREA
Maastrichtian (part)		<i>Hoploscaphites nicolletii</i>		Laramie Formation (part)
		<i>Hoploscaphites birkelundi</i>		Fox Hills Sandstone
		<i>Baculites clinolobatus</i>		Transition Member
		<i>Baculites grandis</i>		shale
		<i>Baculites baculus</i>		sandstone
		<i>Baculites eliasi</i>		shale
Campanian	upper	<i>Baculites jenseni</i>	Gunsight Pass Member	Richard Sandstone Member
		<i>Baculites reesidei</i>	shale	shale
		<i>Baculites cuneatus</i>		Larimer Sandstone Member
		<i>Baculites compressus</i>		shale
		<i>Didymoceras cheyennense</i>	shale	Rocky Ridge Sandstone Member
		<i>Exiteloceras jenneyi</i>		shale
		<i>Didymoceras stevensoni</i>		Terry Sandstone Member
		<i>Didymoceras nebrascense</i>	Carter Sandstone Member	shale
		middle	<i>Baculites scotti</i>	Hygiene Sandstone Member
	<i>Baculites gregoryensis</i>		shale	Mitten Member
	<i>Baculites perplexus</i>		Muddy Buttes Sandstone Member	
	<i>Baculites sp. (smooth)</i>		shale	
	<i>Baculites asperiformis</i>		Kremmling Sandstone Member	Sharon Springs Member
	<i>Baculites mclearnii</i>		shale	
	lower	<i>Baculites obtusus</i>	Sharon Springs Member	Gammon Member
		<i>Baculites sp. (weak flank ribs)</i>	Gammon Member	
		<i>Baculites sp. (smooth)</i>	Smoky Hill Shale Member (part)	Smoky Hill Shale Member (part)
		<i>Scaphites hippocrepis III</i>		
<i>Scaphites hippocrepis II</i>				
<i>Scaphites hippocrepis I</i>				
	<i>Scaphites leei III</i>	Niobrara Formation (part)	Niobrara formation (part)	

Fig. 3. Campanian and Maastrichtian ammonite zones and formations in Middle Park and in the Fort Collins area, Colorado

- Shale, from calcareous, sandstone concretions.
- D2599. G.R. SCOTT, 1960. SW1/4 sec. 24, T. 8 N., R. 69 W., Larimer County. Pierre Shale.
- D2654. W.R. BROWN, 1957. Sec. 25, T. 3 N., R. 77 W., Grand County. Pierre Shale.
- D2701. W.A. COBBAN, 1961. SW1/4SE1/4 sec. 2, T. 10 N., R. 69 W., Larimer County. Pierre Shale, Larimer Sandstone Member.
- D2824. G.R. SCOTT, 1960. SE1/4NE1/4 sec. 11, T. 10 N., R. 69 W., Larimer County. Pierre Shale, Larimer Sandstone Member.

- D2825. G.R. SCOTT, 1960. SW1/4NE1/4 sec. 2, T. 10 N., R. 69 W., Larimer County. Pierre Shale, Larimer Sandstone Member.
- D2846. G.R. SCOTT, 1960. SE1/4NW1/4 sec. 29, T. 4 N., R. 69 W., Larimer County. Pierre Shale, Larimer Sandstone Member.
758. T.W. STANTON, 1890. Fossil Creek south of Fort Collins. Pierre Shale, Larimer Sandstone Member.
16213. R.G. COFFIN, 1932. Sec. 7, T. 9 N., R. 68 W., Larimer County. Pierre Shale, 3 m below Richard Sandstone Member.
16217. R.G. COFFIN, 1932. Round Butte, sec. 19, T. 11 N., R. 68 W., Larimer County. Pierre Shale.
22922. R.G. COFFIN, 1950. Reservoir No. 3 in the SE1/4 sec. 19, T. 9 N., R. 68 W., Larimer County. Pierre Shale.
22925. J.B. REESIDE, Jr., H.R. CHRISTNER, and W.A. COBBAN, 1950. Fossil Creek south of Fort Collins. Pierre Shale, Larimer Sandstone Member.

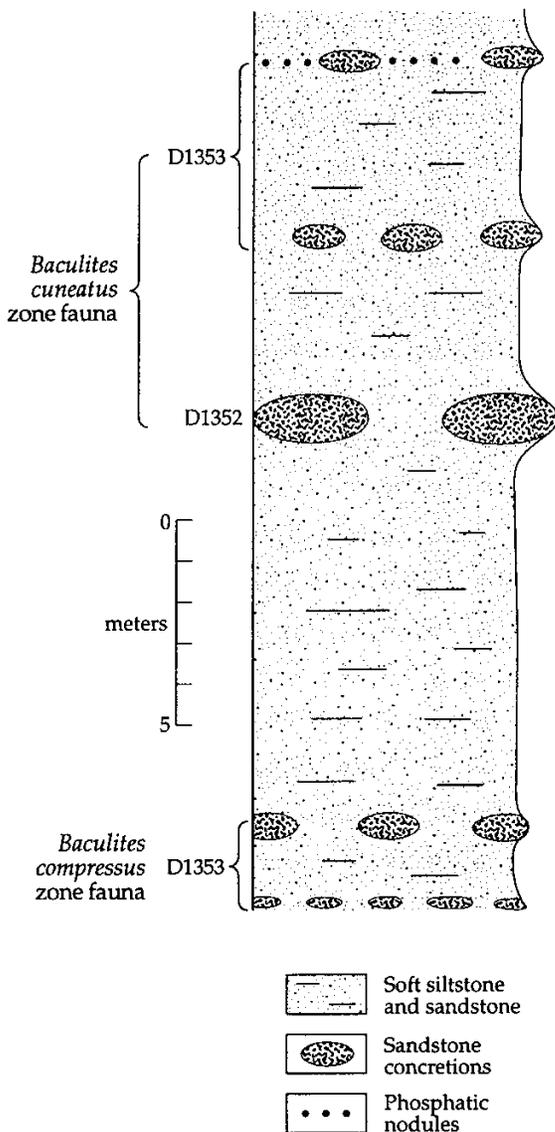


Fig 4. Columnar section of a sandy, fossiliferous part of the Pierre Shale in the NW1/4SW1/4 sec. 17, T. 3 N., R. 80 W., Grand County, showing the stratigraphic position of collections of fossils

SYSTEMATIC PALEONTOLOGY

The specimens described and illustrated are kept in the National Museum of Natural History (USNM), Washington, D.C., and have USNM catalogue numbers. Plaster casts of some are kept at the Federal Center in Denver, Colorado, and at the Denver Museum of Natural History.

Rib index refers to the number of ribs in a distance equal to the whorl diameter.

- Order Ammonoidea ZITTEL, 1884
- Suborder Ancyloceratina WIEDMANN, 1966
- Superfamily Turrilitaceae GILL, 1871
- Family Nostoceratidae HYATT, 1894 [= Jouaniceratidae WRIGHT, 1952, p. 218; Bostrychoceratinae SPATH, 1953, p. 16; Emperoceratinae SPATH, 1953, p. 17; Hyphantoceratinae SPATH, 1953, p. 16]

Genus *Nostoceras* HYATT, 1894

TYPE SPECIES: *Nostoceras stantoni* HYATT, 1894, p. 569, by original designation [= *Ancyloceras? approximans* CONRAD, 1855, p. 266].

DIAGNOSIS: *Nostoceras* includes heteromorph ammonites that have a tightly coiled helical spire except for a minute loosely coiled juvenile growth

stage. The body chamber is a retroversal coiled whorl.

Nostoceras cf. *N. approximans* (CONRAD, 1855)
(Pl. 1, Figs 1-4)

Compare:

1855. *Ancyloceras?* *approximans* CONRAD, p. 266.
1860. *Ancyloceras?* *approximans* CONRAD, Pl. 47, Fig. 4.
1894. *Nostoceras stantoni* HYATT, p. 569.
1894. *Nostoceras stantoni* var. *aberrans* HYATT, p. 572.
1894. *Nostoceras stantoni* var. *retorsus* HYATT, p. 570.
1894. *Nostoceras stantoni* var. *prematurum* HYATT, p. 572.
1941. *Nostoceras stantoni* (HYATT, emend.); STEPHENSON,
p. 407, Pl. 80, Figs 1-5.
1941. *Nostoceras stantoni prematurum* HYATT; STEPHENSON,
p. 409, Pl. 80, Figs 6-8.
1941. *Nostoceras stantoni aberrans* HYATT; STEPHENSON,
p. 409, Pl. 80, Figs 9, 10.
1994. *Nostoceras (Nostoceras) approximans* (CONRAD,
1855); COBBAN & KENNEDY, p. B2, Pl. 1, Figs 4-9, 18,
19, 22-24; Pl. 2, Figs 1-6, 11; Pl. 3, Figs 1-3.

TYPE: Holotype, by monotypy, is the original of CONRAD, 1855, p. 266, illustrated by CONRAD 1860, Pl. 47, Fig. 4, in the collections of the Academy of Natural Sciences of Philadelphia, where the specimen is numbered ANSP 72861. The type, which was said to be from White River, Arkansas (RICHARDS 1968, p. 210), can be matched by specimens from the basal part of the Saratoga Chalk of Arkansas.

MATERIAL: Figured specimens USNM 476061, 476062: Two helical spires of nearly the same size.

DESCRIPTION: USNM 476061 (Pl. 1, Figs 1, 4) is a dextral spire of 2 1/2 whorls in tight contact. It has a height of 20.4 millimeters and an apical angle of 59 degrees. Constrictions, four per whorl, are deep and conspicuous. Thirty-two ribs are present in half a whorl at a diameter of 22.5 mm. USNM 476062 (Pl. 1, Figs 2, 3) is a sinistral spire of three whorls in tight contact. It has a height of 18.5 mm and an apical angle of 66 degrees. Four constrictions are present per whorl, but only 25 ribs are present in half a whorl at a diameter of 16.3 mm. Both specimens have well-rounded outer whorl faces ornamented by closely spaced, narrow, rursiradiate ribs that arise singly or in pairs at the upper whorl suture. Ribs are slightly convex on crossing the flank, but are flexed back a little at the juncture of the outer and lower whorl faces. On the last whorl of each specimen, a

row of tubercles is present at the middle of the outer whorl face, and a row of similar-sized tubercles is present lower on the whorl face. The tubercles are flat-topped, which suggests they were the bases of septate spines. Ribs join in pairs or threes at the tubercles and may loop between tubercles of the two rows. One or two nontuberculate ribs separate the tuberculate ribs. Ribs are strongly rursiradiate on the lower whorl face and may link in pairs close to the umbilicus of the spire. Sutures are widely spaced and moderately digitate.

REMARKS: The specimens may represent *Nostoceras approximans*, but the lack of the U-shaped hooks of the body chambers of that species in the collections is puzzling. Until a body chamber is found, the specimens are left in open nomenclature.

OCCURRENCE: Both specimens are from the Larimer Sandstone Member of the Pierre Shale at locality D2846.

Nostoceras cf. *N. obtusum* HOWARTH, 1965
(Pl. 1, Figs 5, 6; Text-fig. 5)

Compare:

1965. *Nostoceras(?) obtusum* HOWARTH, p. 384, Pl. 10,
Fig. 2; Text-fig. 17.

TYPE: Holotype is BMNH C52744, from Barra do Dande, Angola.

MATERIAL: Figured specimen is USNM 476063, a single slightly flattened internal mold, from the Larimer Sandstone Member of the Pierre Shale, Larimer County, Colorado.

DESCRIPTION: USNM 476063 represents an extremely low spired dextral heteromorph that has an apical angle of 120 degrees. The specimen consists of 2 1/4 rounded whorls in tight contact. The diameter (D) is 30.3 mm, the height is 16.8 mm, and the umbilicus is 10.7 mm (ratio of D is 0.35). All but the last quarter of a whorl is septate. There are no constrictions. Ornament consists chiefly of narrow, sharp, rursiradiate ribs that are narrower than the interspaces. Forty-five ribs are present on the last whorl. Small, narrow, sharp, bullate tubercles are present on most ribs near the middle of the outer whorl face on the larger end of the specimen. A second row of tubercles seems to be present on the outer part of the lower whorl face, but the specimen is too

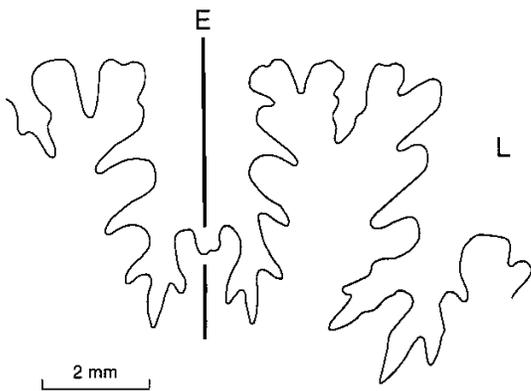


Fig 5. Part of the suture of *Nostoceras* cf. *N. obtusum* HOWARTH, 1965. USNM 476063 (Pl. 1, Figs 5, 6)

worn to reveal their true character. Only part of the fairly simple suture is preserved (Text-fig. 5).

REMARKS: The specimen closely resembles the inner whorl of the holotype of *Nostoceras obtusum* HOWARTH, 1965 (p. 384, Pl. 10, Fig. 2a-c; Text-fig. 17). The apical angle of the holotype is 125-130 degrees; at a diameter of 26.0 mm, the umbilical ratio to the diameter is 0.41, and the number of ribs per half whorl is an estimated 22 (measurements from a plastic cast). USNM 476063 has an apical angle of 120 degrees, and at a diameter of 26.0 mm, the umbilical ratio is 0.37, and ribs number 23 per one-half whorl.

OCCURENCE: The holotype (and only specimen known) came from Barra do Dande, Angola. HOWARTH (1965, p. 402) lists it with *Nostoceras hyatti* STEPHENSON, 1941 and *N. helicinum* (SHUMARD, 1861) of late Campanian age. USNM 476063 is from the Larimer Sandstone Member of the Pierre Shale at locality 16213.

Nostoceras larimerense sp. nov.
(Pl. 2, Figs 31-56, 61-67; Text-fig. 7)

ETYMOLOGY: From Larimer County, Colorado.

TYPES: Holotype is USNM 476064, paratypes are USNM 476065-476078, all from the Larimer Sandstone Member of the Pierre Shale of Larimer County. Paratype USNM 476079 is from the Pierre Shale of Fremont County, Colorado.

MATERIAL: Fifty-five specimens that consist of a whorl or more.

DIAGNOSIS: A small species that has the whorls in tight contact except for the last part of the body chamber which is slightly uncoiled. Apical angles 40-55 degrees. Conspicuous constrictions present. Ornament of narrow, rursiradiate ribs and, in addition, two rows of minute tubercles on the body chamber.

DESCRIPTION: Specimens are about evenly divided between dextral and sinistral forms and between microconchs and macroconchs. The holotype (Pl. 2, Figs 64-67) is a dextral macroconch 43.3 mm high that consists of a complete body chamber of 11/4 whorls and a septate spire of five tightly coiled whorls. The last part of the body chamber pulls away a little from the spire and then recurves slightly toward it (Pl. 2, Figs 66, 67). The aperture is normal. Apical angle is 45 degrees. Whorls have well-rounded outer flanks. Three or four deep constrictions that may or may not be bordered by high, thickened ribs are present per whorl on the septate spire. Ribs are narrow and rursiradiate on the outer whorl face, where they number 48 per whorl at a whorl diameter of 16.0 mm. Ribs are present on the smallest whorl at a diameter of 3.9 mm. Minute, bullate tubercles appear on the last whorl of the phragmocone and continue on all of the body chamber. One row of tubercles is on the middle of the outer whorl face, and the other row is lower on that face. Tubercles may be present on every rib or every other rib. Pairs of ribs arise from each tubercle of the upper row (Pl. 2, Fig. 66).

The specimens of *N. larimerense* at hand have apical angles of 40-55 degrees and, at a whorl diameter of 16.0 mm, 40-58 ribs per whorl (Text-fig. 6). The occurrence of large adults (Pl. 2, Figs 54-56, 64-67) and small adults (Pl. 2, Figs 31-41) indicate dimorphism. The smallest microconch (unfigured paratype USNM 476077) has a height of 21.3 mm, whereas the largest macroconch (the

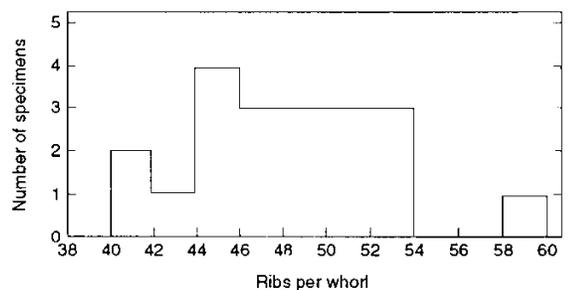


Fig 6. Histogram showing the number of ribs per whorl at 16.0 mm whorl diameter of 20 specimens of *Nostoceras larimerense* sp. nov.

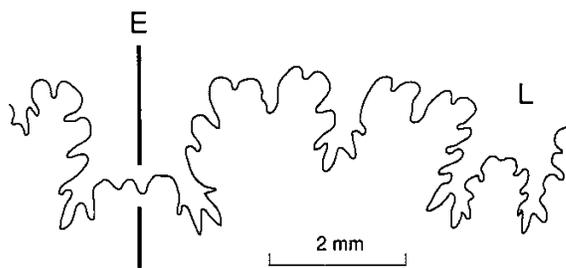


Fig 7. Part of the suture of *Nostoceras larimerense* sp. nov.
USNM 476078, from locality D371

holotype) has a height of 43.3 mm. Only parts of the suture are visible. The external and lateral lobes are fairly simple and separated by a broad, bifid saddle (Text-fig. 7).

REMARKS: The species is closely related to *N. colubriformis* STEPHENSON, 1941 (p. 412, Pl. 81, Figs 1-3) in its size and general form with the last part of the body chamber pulled slightly away from the spire. Both forms have conspicuous constrictions and two rows of minute tubercles on the body chamber. They differ in that *N. larimerense* has a wider apical angle (40-55 degrees in contrast to 30 degrees for the holotype of *N. colubriformis*) and fewer ribs (40-58 per whorl at a diameter of 16.0 mm in contrast to 60 for *N. colubriformis* at the same diameter). *Nostoceras larimerense* also resembles *N. rugosum* COBBAN & KENNEDY, 1991 in its similar apical angle and in its similar partly uncoiled body chamber, but all whorls are tuberculate on *N. rugosum*.

OCCURRENCE: The holotype of *N. larimerense* is from a calcareous sandstone concretion from the Larimer Sandstone Member of the Pierre Shale at locality D371 (Text-fig. 1), where it was associated with *Rhaeboceras subglobosum* (WHITEAVES, 1885), *Baculites reesidei* ELIAS, 1933, *Cirroceras conradi* (MORTON, 1841), *Anaklinoceras minutum* sp. nov., *Solenoceras texanum* (SHUMARD, 1861), and a large invertebrate fauna. *Nostoceras larimerense* has also been found in the Larimer Sandstone Member at localities D301, D1567, D2701, D2824, D2825, and 16213, all in the Fort Collins area. A single specimen (paratype USNM 476079) was found with *B. reesidei* in the Pierre Shale much farther south in Colorado at USGS Mesozoic locality D8750, in the NW1/4NE1/4 sec. 31, T. 18 S., R. 69 W., Fremont County.

Nostoceras cf. *N. splendidum* (SHUMARD, 1861)
(Pl. 2, Figs 57-60)

Compare:

1861. *Turrilites splendidus* SHUMARD, p. 191.

1941. *Turrilites splendidus* SHUMARD; STEPHENSON, p. 415, Pl. 82, Figs. 1-4.

TYPES: Neotype is USNM 77276, from the Nacatoch Sand near Chatfield, Navarro County, Texas. Figured topotypes are USNM 77277, from the same locality.

MATERIAL: Figured specimen USNM 476080 is an internal mould from the Larimer Sandstone Member of the Pierre Shale in Larimer County, Colorado.

DESCRIPTION: A small dextral, helical spire 18.5 mm high differs from the associated *N. larimerense* in having a smaller apical angle (34 degrees), in having coarser ornament with tubercles on nearly all whorls, and in having the earliest whorl as a loose planispire. The last whorl is an incomplete body chamber that is entirely in contact with the septate spire. The oldest growth stage preserved is represented by one-half a whorl about 3.7 mm in diameter that is set at an angle of 15 degrees from the next underlying whorl of the spire. This one-half whorl is smooth except for two constrictions. The rest of the helical spire consists of five whorls in tight contact; all have well-rounded outer flank faces. All whorls in the tight spire have ribs that are narrower than the interspaces and rectiradiate to rursiradiate on the outer whorl face. Two rows of small, nodate tubercles are present on all whorls except the early planispiral one. One row lies at the base of the whorls, and the other lies a little below the middle of the whorls. Almost every rib bears tubercles. There are 42 ribs at a whorl diameter of 11.8 mm. Sutures are quite simple probably owing to the small size of the specimen.

REMARKS: The specimen resembles *N. splendidum* (SHUMARD, 1861, p. 191) in its small size and in the presence of constrictions and tuberculated ribs. According to STEPHENSON (1941, p. 416), SHUMARD's types are lost; they were said to have come from near Chatfield and Corsicana, Navarro County, Texas. STEPHENSON had 16 more or less incomplete specimens from the Nacatoch Sand of the Chatfield area. He selected one as the neotype USNM 77276, and figured it and two topotypes. The

neotype is a spire 32 mm high of five whorls of which the smallest whorl has a diameter of about 5.8 mm. Thirty-two ribs are present per whorl at a diameter of 12 mm. The apical angle of the neotype is 25 degrees and those of the topotypes are 16 and 26 degrees. The specimen from the Larimer Sandstone Member has a broader apical angle (34 degrees) than those of the figured Nacatoch specimens but, otherwise, closely resembles them.

OCCURRENCE: *Nostoceras* cf. *N. splendidum* is from the Larimer Sandstone Member at locality D2824 (Text-fig. 1). It was associated with *Anaklinoceras minutum* sp.nov., *Solenoceras texanum* (SHUMARD, 1861), *Baculites reesidei* ELIAS, 1933 and *Jeletzkytes nodosus* (OWEN, 1852).

Genus *Didymoceras* HYATT, 1894

TYPE SPECIES: *Ancylloceras? Nebraskaensis* MEEK & HAYDEN (1856a, p. 71), by original designation by HYATT (1894, p. 574).

DIAGNOSIS: *Didymoceras* includes heteromorph ammonites that have a juvenile stage of either loose helical coils or loose straight limbs connected by elbows followed by a middle growth stage of helical whorls that may or may not be in contact; body chamber is a retroversal whorl.

Didymoceras aurarium sp. nov. (Pl. 1, Figs 7-9, Text-fig. 8)

ETYMOLOGY: Latin, aureus, golden, for the color of the types.

TYPES: Holotype is USNM 476086, from the Larimer Sandstone Member of the Pierre Shale, Larimer County, Colorado. Paratype is USNM 476087, from the same locality.

MATERIAL: Part of a helical spire and six fragments of early juvenile whorls.

DESCRIPTION: The holotype (Pl. 1, Figs 7-9) is a loose, helical spire 22.6 mm high that has an apical angle of 54 degrees. It consists of parts of three whorls of which the lower two are barely in contact, and the third one is well separated from the second one. Whorl sections are subcircular with well-rounded outer whorl faces. Three or four deep constrictions bordered by high ribs are present per whorl.

Ornament consists of narrow ribs and two rows of small, pointed tubercles. An estimated 40 ribs are present at a diameter of 18.3 mm. Ribs are narrower than the interspaces, prorsiradiate on the upper whorl face, rectiradiate to slightly rursiradiate on the outer whorl face, and rursiradiate on the lower whorl face. Small, bullate tubercles are present on every

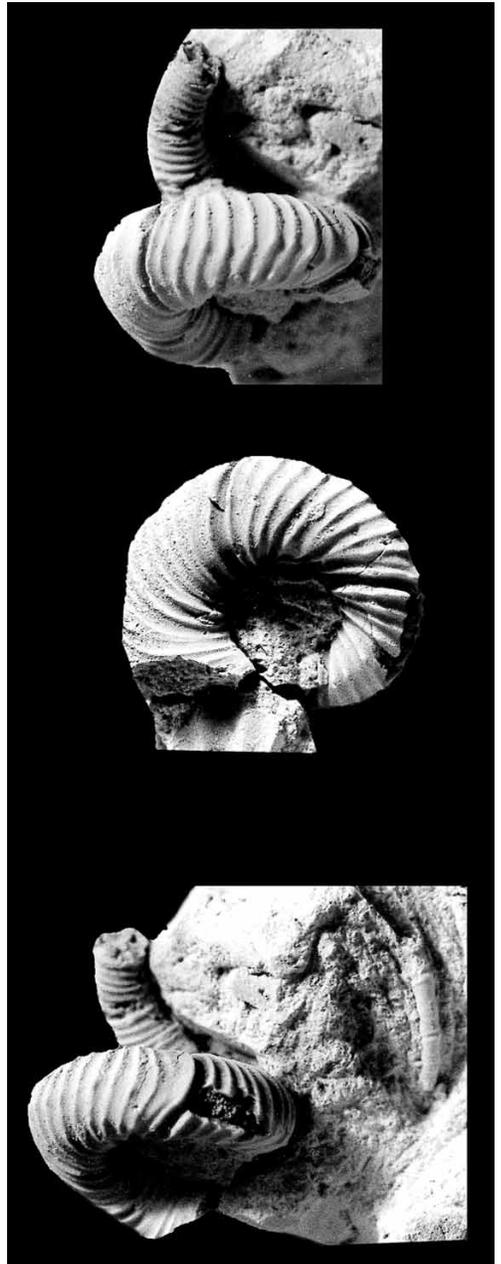


Fig 8. Early whorls of *Didymoceras aurarium* sp.nov. USNM 476087, from the Larimer Sandstone Member of the Pierre Shale at USGS Mesozoic Locality D2599 in Larimer County Colorado.

Figures are $\times 3$

other rib. At some places two ribs on the upper whorl face unite at a tubercle. Sutures are not preserved.

An earlier growth stage is revealed by a small paratype (USNM 476087, Text-fig. 8. The specimen consists of a gently curved one-half whorl set at an angle of 30 degrees to a larger helical whorl 11.3 mm in diameter. Cross section of the larger whorl is circular, and its height at the larger end is 4.8 mm. Five deep constrictions per whorl are present. Ribs, which are rursiradial on the upper, middle, and lower outer whorl faces, number 43 per whorl. Minute tubercles are present on most ribs. The gently curved early part of the specimen is separated from a still earlier part by a missing curved piece about 7 mm long. The earliest preserved part of the specimen is a very slightly curved limb 4.9 mm long that is smooth except for two constrictions bordered by thickened ribs.

REMARKS: The specimens differ from the other species of *Didymoceras* from the Western Interior in the loose, helical, juvenile coil and in having tuberculate ribs separated by nontuberculate ribs.

OCCURRENCE: The types are from a calcareous siltstone concretion from the Larimer Sandstone Member of the Pierre Shale in the Fort Collins area at locality D2599 (Text-fig. 2). Other fossils in the concretion include fragments of inoceramids and the bryozoan *Websteria cretacea* MEEK, 1864.

Didymoceras draconis (STEPHENSON, 1941)
(Pl. 3; Pl. 4, Figs 14-23)

1941. *Nostoceras? draconis* STEPHENSON, p. 413, Pl. 82, Figs 5-9.
1941. *Nostoceras* cf. *N. draconis* STEPHENSON; LEWY, p. 119, Pl. 2, Fig. 2a, b; Text-fig. 2.
1980. *Nostoceras draconis* (sic) STEPHENSON; THOMEL, Pl. 61, Fig. 107.
1993. *N. (Nostoceras)* cf. *draconis* STEPHENSON; GIUDICI & PALLINI, p. 319, Pl. 1, Figs 1, 2.
non 1993. *Nostoceras draconis* STEPHENSON; KENNEDY & COBBAN, p. 420, Fig. 7.10-7.12.
1995. *Nostoceras (Nostoceras) draconis* STEPHENSON, 1941; KENNEDY & *al.*, Pl. 5, Fig. 30.

TYPES: Holotype is USNM 77267, from the Neylandville Marl 5.6 km west-northwest of Corsicana, Navarro County, Texas. There are nine paratypes, USNM 77267, USNM 77268 (six individuals), and USNM 77270 (two individuals)

Figured specimens are USNM 445096, 476084, from the Pierre Shale, Grand County, Colorado.

MATERIAL: Six internal molds from sandstone concretions.

DIAGNOSIS: A large species characterized by a depressed helical spire and a long U-shaped body chamber.

DESCRIPTION: The holotype is a very low helical coil of nearly two sinistral whorls in contact. It has a diameter of 60 mm, a height of 30 mm, and an umbilical diameter on the underside of 27 mm (ratio to diameter of 0.45). The whorl section is subcircular. Three inconspicuous constrictions bordered by high ribs are present per whorl. Ornament consists of narrow, rursiradial ribs and two rows of small, nodate tubercles. One row lies near the base of the whorl face and the other near the top. Pairs of ribs arise from each of the tubercles. Seventy-eight ribs are present per whorl on the upper whorl face at a diameter of 60 mm.

An excellent paratype, USNM 77268, described by STEPHENSON (1941, p. 413, Pl. 82, Figs 8-9), represents a body chamber about 96 mm high. It consists of the end of the helical coil followed by a long retroversal U-shaped part that terminates with the aperture facing the helical spire. Ribs are narrower than the interspaces. On the outer whorl face, ribs are slightly rursiradial at the end of the helical coil, but gradually change to slightly prorsiradial on the hook, and then become rectiradial at the aperture. Ribs are rursiradial to rectiradial on the interwhorl face. Small, nodate to bullate tubercles are present on every rib or every other rib on the oldest part of the retroversal whorl, but at the hook, the tubercles become large and nodate, and some are connected across the venter by looped, transverse ribs. The tubercles weaken and disappear near the aperture.

Didymoceras draconis is represented by both helical coils and retroversal whorls in the collections from the Pierre Shale of Middle Park in Colorado. One specimen, USNM 445096 (Pl. 3, Figs 1-4), consists of the last two whorls of the helical coil and the complete retroversal body chamber. The dextrally coiled specimen has a height of 91 mm. The helical coil is poorly preserved, but it is more sparsely ribbed than the holotype. The well-preserved retroversal body chamber bears small nodate tubercles but on the older part of the body chamber, tubercles may occur on every rib or every other rib. Near the aperture, the ribs weaken and the tubercles disap-

pear. The aperture is normal. A slightly larger body chamber (Pl. 3, Figs 5, 6) has tubercles on every third or fourth rib on the hook, the tubercles are linked across the venter by looped ribs. A smaller body chamber (Pl. 4, Figs 20-23) has nodate tubercles on every other rib to every third rib on the hook. Helical coils are best represented by two sinistral specimens from the Kremmling area. The smaller one (Pl. 4, Figs 18, 19) has 70 ribs per whorl at a diameter of 46.5 mm. Small, nodate tubercles are present on every other rib to every third rib. The larger specimen (Pl. 4, Figs 14-17) has three inconspicuous constrictions and 90 ribs at a diameter of 69 mm. Tubercles are small and pointed; most arise from two adjacent ribs. As many as four nontuberculated ribs may separate the tuberculated ones. Sutures are not preserved on these specimens.

A specimen, USNM 476085 (not illustrated), from locality D1353 in Middle Park, is of interest in that it represents the smallest known individual. It is a little more than half of a very low helical whorl 9.8 mm in diameter. The specimen has a circular whorl section with a height of only 2.5 mm. Twenty-nine ribs are present on the last half whorl, and each rib bears a minute nodate tubercle on each side of the venter. Three inconspicuous constrictions are present.

REMARKS: The two helical coils from the Kremmling area closely resemble the holotype of *N. draconis*. The retroversal body chamber from the Neylandville Marl assigned to *Nostoceras* sp. by STEPHENSON (1941 p. 414, Pl. 81, Fig. 13) has the sparse ribbing of the Kremmling specimens.

OCCURRENCE: The holotype and paratypes of *D. draconis* are from the Neylandville Marl in the Corsicana area, Navarro County, Texas. Specimens from the Western Interior are from Middle Park, Colorado, at localities D1284, F1352, F1353, and D2654 (Text-fig. 1), where they are found with *Baculites cuneatus*. Specimens have also been found in the Mount Laurel Sand in Delaware and in the Mishash Formation in Israel.

Genus *Cirroceras* CONRAD, 1868

TYPE SPECIES: *Ammonceratites conradi* MORTON, 1841 (MORTON 1841, p. 109; 1842, p. 212, Pl. 10, Fig. 1), by original designation by CONRAD (1868, p. 730), from near Arneytown, New Jersey.

DIAGNOSIS: Heteromorph ammonites in the form

of a very open helix in which the volutions do not touch. Body chamber slightly curved away from the helix and bent up so that the aperture is oriented upward. Venter flattened and bordered by rows of tubercles of which those in the lower row are larger and fewer than those in the upper row.

Cirroceras conradi (MORTON, 1841) (Pl. 1, Figs 29-37; Pl. 5, Figs 1-6; Text-fig. 9)

1841. *Ammonceratites conradi* MORTON, p. 109.
 1842. *Ammonceratites conradi* MORTON; MORTON, p. 212, Pl. 10, Fig. 1.
 1861. *Helicoceras navarroensis* SHUMARD, p. 190.
 1868. *Cirroceras conradi* (MORTON); CONRAD, p. 730.
 non 1879. *Heteroceras conradi* (MORTON); WHITEAVES, p. 100, Pl. 12 (= *Eubostriochoceras*).
 1892. *Heteroceras conradi* (MORTON); WHITEFIELD, p. 269, Pl. 45, Figs 9-11, 14 only (Figs 12, 13, are *Nostoceras hyatti* STEPHENSON, 1941).
 1893. *Helicoceras navarroensis* SHUMARD; BOYLE, p. 146.
 1905. *Heteroceras conradi* (MORTON); JOHNSON, p. 27.
 non 1907. *Heteroceras conradi* (MORTON); WELLER, p. 833, Pl. 108, Figs 5-8 (= *Nostoceras hyatti* STEPHENSON, 1941).
 non 1910. *Heteroceras conradi* (MORTON). GRABAU & SHIMER, Pl. 45, Fig. 12 (= *Nostoceras hyatti* STEPHENSON, 1941).
 1925. *Turrilites (Heteroceras) conradi* (MORTON); DIENER, p. 90.
 1926. *Helicoceras navarroense* SHUMARD; WADE, p. 184, Pl. 61, Figs 8-11; Pl. 62, Figs 1, 2.
 1928. *Helicoceras? navarroense* SHUMARD; ADKINS, p. 210.
 1941. *Helicoceras navarroense* SHUMARD; STEPHENSON, p. 417, Pl. 83, Figs 9-13.
 1944. *Helicoceras navarroense* SHUMARD; SHIMER & SHROCK, Pl. 246, Fig. 10.
 1959. *Didymoceras* sp. ind. SORNAY in ARAMBURG & al., p. 222, Pl. 7, Fig. 3a, b.
 1962. *Cirroceras conradi* (MORTON); REESIDE, p. 120, Pl. 70, Figs 1-6.
 1965. *Didymoceras navarroense* (SHUMARD). HOWARTH, p. 373.
 1969. *Didymoceras* cf. *navarroense* (SHUMARD). LEWY, p. 115, Pl. 1, Fig. 1.
 1974a. *Didymoceras navarroense* (SHUMARD). COBBAN, p. 16, Pl. 11, Figs 1-4; Text-fig. 13.
 1994. *Didymoceras navarroense* (SHUMARD). COBBAN & KENNEDY, p. 34, p. B4, Pl. 3, Fig. 6; Pl. 4, Fig. 5; Pl. 6, Figs 4-6; Text-fig. 1.

TYPES: The lost type (RICHARDS 1968) came from the Navesink Formation near Arneytown, New Jersey; plaster casts of this specimen survive as ANSP 19495 and USNM 1800.

MATERIAL: Thirty fragments from the Pierre Shale of Middle Park and the Fort Collins area.

DIAGNOSIS: As for the genus.

DESCRIPTION: The cast of the holotype was well described and illustrated by REESIDE (1962, p. 120, Pl. 70, Figs 1-3). The cast is of a nearly complete somewhat crushed whorl about 65 mm in diameter. It has an estimated 49 rursiradiate ribs per whorl. Tubercles are barely visible; the lower row has tubercles a little larger and a little fewer than those in the upper row.

All specimens at hand from the Pierre Shale of Colorado consist of less than two whorls, and most are fragments of less than one-half whorl. All are from very loose helical spires. The smallest specimen (Pl. 1, Figs 31, 32) is more broadly curved than the later whorls of larger specimens, which suggests that the earliest growth stages may be represented by very loosely coiled or even uncoiled whorls. The venter flattens early on the helical spire and remains that way through all later growth. Annular ribs are well developed on the smallest specimens in the collections (Pl. 1, Figs 31, 32, 35, 36), and each rib supports a small, nodate tubercle. As the whorls enlarge and form a helical spire, pairs of ribs usually unite at a prominent flat-topped tubercle that was the base of a spine (Pl. 1, Fig. 30). A nontuberculated rib may separate the tuberculated ribs. Tubercles may be joined across the venter by weak looped ribs, or the tubercles may be arranged alternately across the venter and connected by zig-zag ribs. All ribs on the upper, middle, and lower whorl faces are rursiradiate, whereas those on the inner whorl face (dorsum) are slightly arched forward and greatly weakened. The two rows of tubercles are widely separated and border the broad, flattened outer whorl face (venter). Tubercles in the upper row are a little more numerous than those in the lower row. USNM 476088 (Pl. 1, Figs 29, 30) has 25 tubercles in the upper row and 21 in the lower row; USNM 476094 (Pl. 5, Figs 1-3) has 14 in the upper row and 12 in the lower row; and USNM 476095 (Pl. 5, figs 4-6) has 17 in the upper row and 14 in the lower row. The largest specimen in the collections is a body chamber of one whorl with one chamber of the phragmocone attached (Pl. 5, Figs 4-6). Ribs greatly weaken near the aperture, and tubercles disappear.

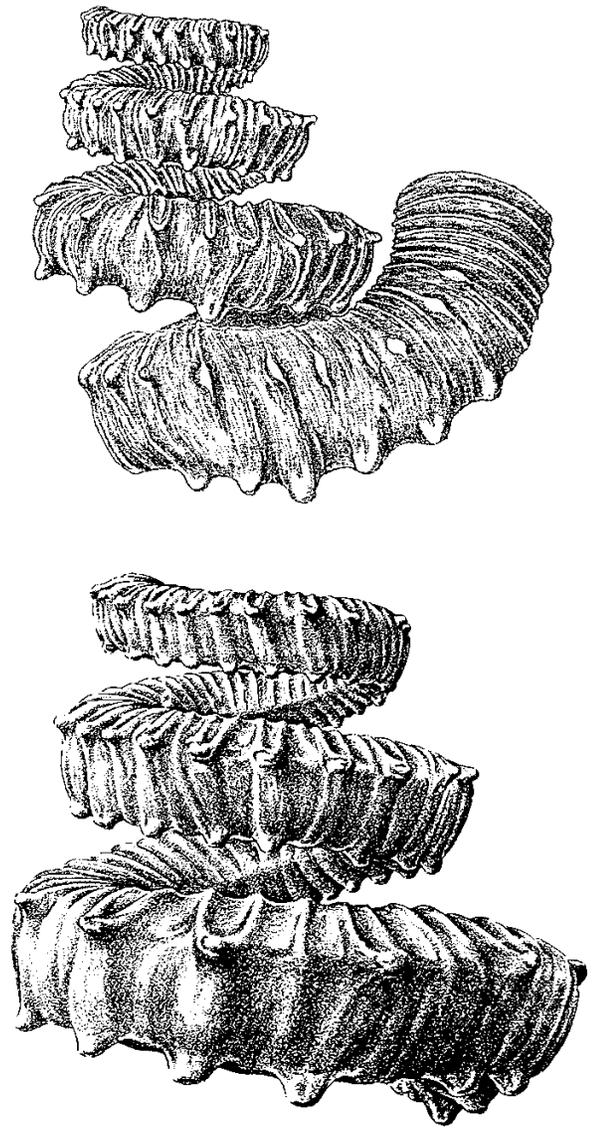


Fig 9. Reconstruction of *Cirroceras conradi* (MORTON, 1841), by John R STACEY. Figures are $\times 0.75$

Sutures are poorly preserved on the specimens from both the Middle Park and Fort Collins area. The suture is quite digitate (COBBAN, 1974a, Fig. 13).

REMARKS: *Cirroceras conradi* is the only known species of the genus in the United States. The species is easily recognized by its very loosely coiled spire, flattened venter, and distinctive ornament; reconstructions of this species are shown in Text-fig. 9.

OCCURRENCE: In Colorado *C. conradi* has been found in the zone of *Baculites cuneatus* in Middle

Park at locality D1353 (Text-fig. 1), and in the slightly younger zone of *B. reesidei* in the Fort Collins area at localities D301, D370, D371, D1566, D2824, D2825, 22925, 16217, D1567 and 16213. Both zones are regarded as late Campanian in age. *Cirroceras conradi* also occurs in the Neylandville Marl and Nacatoch Sand in northeastern Texas, in the Saratoga Chalk in southwestern Tennessee, and in the Navesink Formation in New Jersey. Outside the United States, *C. conradi* has been recorded from Colombia (as *Helicoceras navarroense* by PETTERS 1955) and from Israel (as *Didymoceras* cf. *navarroense* by LEWY 1969).

Genus *Anaklinoceras* STEPHENSON, 1941

TYPE SPECIES: *Anaklinoceras reflexum* STEPHENSON (STEPHENSON 1941, p. 414, Pl. 83, Figs 1-5), by original designation. The holotype, USNM 77272, is from the Neylandville Marl of Navarro County, Texas.

DIAGNOSIS: Largely a tightly coiled helix that has the earliest whorl or two loosely coiled. The body chamber departs from the helical spire and bends back up more or less parallel to the spire or even wraps around the apex of the spire. Constrictions may or may not be present. Ornament consists of narrow ribs that bear two rows of tubercles at some growth stage.

Anaklinoceras minutum sp. nov.
(Pl. 2, Figs 1-30; Text-fig. 10)

ETYMOLOGY: Latin, *minutus*, little, small.

TYPES: Holotype is USNM 476096; figured paratypes are USNM 476097-476106; and six unfigured paratypes USNM 476107; all from the Larimer Sandstone Member of the Pierre Shale, Larimer County, Colorado.

MATERIAL: About 60 specimens mostly consisting of three or more whorls.

DESCRIPTION: The holotype (Pl. 2, Figs 7-9) has a tightly coiled, dextral helical spire 10.2 mm high that has an apical angle of 35 degrees. The body chamber, which is complete, extends straight out from the spire and then bends abruptly upward parallel to the spire. Three constrictions are present per whorl. Ribs are

rursiradiate and narrower than the interspaces. Ribs number 35 on the last whorl of the spire at a whorl diameter of 7.0 mm. On the older, straight part of the body chamber, ribs are rursiradiate on the outer face, but curve gently and become slightly prorsiradiate on other faces. Ribs are fairly rectiradiate near the aperture, which is bounded by a constriction bordered by a high adapical rib. A row of barely visible minute tubercles is present on the lower part of the middle whorl of the helical spire, where the tubercles are on every rib. Sutures are not exposed.

The species is dimorphic. Microconchs (Pl. 2, Figs 21-28) are less than one-half the size of macroconchs (Pl. 2, Figs 1-20). The holotype is a small macroconch.

The smallest whorls observed have diameters of 2.6-3.8 mm. Whorls are smooth at first other than for widely spaced constrictions. Ribbing arises at a whorl diameter between 2.7 to 3.7 mm. Earliest whorls of the species were probably uncoiled. A microconch of only three whorls has part of the earliest whorl partly uncoiled (Pl. 2, Figs 21-26). The last half whorl of this very small individual is the early part of the body chamber that is just beginning to straighten.

Specimen (USNM)	Whorl Diameter in mm	Apical Angle in degrees	Ribs per whorl
476099	6.6	23	31
476097	6.9	33	35
476100	6.9	36	34
476096	7.0	35	35
476098	7.9	36	33
476105	8.2	30	37
476101	8.4	38	43

Table 1. Diameter, apical angle, and number of ribs per whorl of *Anaklinoceras minutum* sp. nov.

Specimens illustrated in this report (Pl. 2, Figs 1-28) have apical angles of 23-38 degrees and 31-43 ribs per whorl on the largest whorls (Table 1).

Ribbing is much like that on the holotype. Some individuals seem to lack tubercles; others have barely discernible tubercles in two rows, one below the middle of the outer whorl face and the other at its base.

Sutures are simple, which is typical of such small forms. Only parts of the suture are visible (Text-fig. 10). The symmetrically bifid saddle separating the external and lateral lobes is much broader than the external lobe.

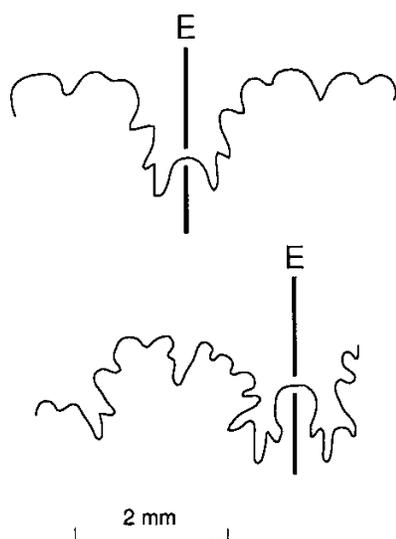


Fig 10. Parts of the sutures of *Anaklinoceras minutum* sp. nov.

A – USNM 476100, from locality D371 (Pl. 2, figs 13-15);

B – USNM 476106, from locality D2824

REMARKS: *Anaklinoceras minutum* sp. nov. has some resemblance to flattened specimens in shale from the Campanian of Colombia described by KENNEDY (1992 p. 176, Figs 12, 13A-E, 14B) as the new species *Nostoceras* (*N.*) *liratum*. Both are small species that have the body chamber recurved so that the aperture is directed upward. They differ in that the body chamber of *N. (N.) liratum* does not extend as far up and parallel to the helical spire as in *A. minutum*, and the latter is smaller and not as densely ribbed. KENNEDY noted that the Columbian species was somewhat transitional to *Anaklinoceras*. Specimens from Madagascar referred to *Bostrychoceras elongatum* (WHITEAVES, 1903) by COLLIGNON (1969, p. 27, Pl. 522, Figs 2060, 2061) have the form of *A. minutum* sp. nov. in that the body chamber straightens and then bends upward parallel to the helical spire, but are much larger and more coarsely ribbed.

OCCURENCE: *Anaklinoceras minutum* sp. nov., is known only from the zone of *Baculites reesidei* in the Larimer Sandstone Member of the Pierre Shale in northeastern Colorado at localities D301, D371, D1567, D2824, D2825, 758, 16213, and 22922.

Family Diplomoceratidae SPATH, 1926
 Subfamily Diploceratinae SPATH, 1926
 Genus *Solenoceras* CONRAD, 1860

TYPE SPECIES: *Hamites annulifer* MORTON, 1841, p. 109; 1842 p. 213, Pl. 11, Fig. 4, by subsequent designation of CONRAD, 1860, p. 284. MORTON's type came from rocks now assigned to the Mount Laurel Sand at the Chesapeake and Delaware Canal, Delaware.

DIAGNOSIS: A small ammonite that consists of two straight limbs in tight contact connected by an elbow. The older limb begins from a minute initial coil on the end of a straight or slightly curved shaft. Constrictions may or may not be present. Ornament consists of closely spaced ribs that usually bear a row of small tubercles on each side of the venter.

Solenoceras texanum (SHUMARD, 1861)
 (Pl. 1, Figs 10-16; Pl. 4, Figs 1-7; Text-fig. 11)

1861. *Ptychoceras texanus* SHUMARD, p. 189.
 1893. *Ptychoceras texanus* SHUMARD; BOYLE, p. 248.
 1894. *Ptychoceras texanum* SHUMARD; HYATT, p. 580.
 1928. *Oxybeloceras texanum* (SHUMARD); ADKINS, p. 213.
 1941. *Solenoceras texanum* (SHUMARD); STEPHENSON, p. 399, Pl. 77, Figs 4, 5; Pl. 79, Figs 1-4.
 1969. *Solenoceras* cf. *S. texanum* (SHUMARD); LEWY, p. 127, Pl. 3, Fig. 8.
 ?1976. *Solenoceras* sp. cf. *S. texanum* (SHUMARD); KLINGER, p. 77, Pl. 34, Fig. 7.
 1994. *Solenoceras texanum* (SHUMARD, 1861); COBBAN & KENNEDY, p. B6, Pl. 7, Figs 10, 16, 17, 19-24, 26-28, 30, 31.

TYPES: SHUMARD's types are lost according to STEPHENSON (1941 p. 399), who selected a neotype from a collection of three topotypes. The neotype, USNM 21092a (STEPHENSON, 1941, Pl. 79, Figs 1, 2), is from the Nacatoch Sand of Navarro County, Texas. Figured specimens are USNM 476108-476119 from the Pierre Shale of Grand and Larimer Counties, Colorado.

MATERIAL: Twenty-five specimens that consist of parts of both limbs; in addition, there are many fragments of single limbs.

DIAGNOSIS: A species characterized by the larger limb having a compressed cross section and ornament of tuberculate, uniform, rursiradiate ribs that have a rib index of about 5. Constrictions are present on the smaller limb. Ornament on the smaller limb and elbow is weak and irregular.

DESCRIPTION: The neotype, about 17.6 mm long, consists of two incomplete, tightly appressed limbs of which the larger has a compressed cross section 4.8 mm high and 3.8 mm wide. The smaller limb has a more circular cross section. A very small opening shaped like the eye of a needle is present at the elbow between the limbs. Two poorly defined constrictions are present on the smaller limb. Ornament on the larger limb consists of uniform, rursiradiate ribs; the rib index is 5; each rib bears a slightly clavate tubercle on each side of the venter. Ribs on the elbow are rursiradiate, irregular in height, and greatly weakened. Ornament on the smaller limb consists of prorsiradiate ribs of irregular strength; the stronger ribs bear minute nodate tubercles. The simple suture was well described by STEPHENSON (1941, p. 400), but not illustrated. Part of the suture of a specimen from the Nacatoch Sand is illustrated herein (Text-fig. 11).

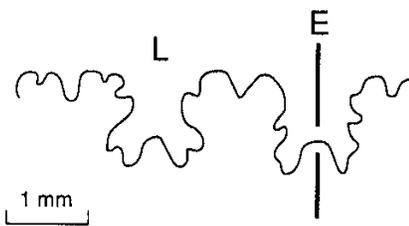


Fig 11. Part of the suture of *Solenoceras texanum* (SHUMARD, 1861); USNM 476118, from the Nacatoch Sand at USGS Mesozoic locality 17368, 4 km southwest of the courthouse in Corsicana, Navarro County, Texas

A more nearly complete specimen from the Neylandville Marl was described by STEPHENSON (1941, p. 400, Pl. 77, Figs 4, 5). The specimen comprises two tightly appressed limbs about 34.5 mm long. The body chamber, which is probably complete, is slightly curved and ornamented by uniform, rursiradiate ribs (the rib index is 5). Ornament weakens considerably on the elbow and on the smaller limb, where irregularly spaced constrictions and prorsiradiate ribs of irregular strength are present.

Specimens assignable to *S. texanum* are abundant in the Pierre Shale in Middle Park and in the Fort Collins area. The species is dimorphic; some specimens are about one-half as large as others (compare Pl. 1, Figs 10-16 with Pl. 4, Figs 4-7). Body chambers, which include the larger limb and part of the elbow, have compressed cross sections;

phragmocones have circular sections. Constrictions are absent on the body chamber except at the aperture, where a conspicuous constriction is bounded by high ribs (Pl. 4, Fig. 6). Nodes and ribs extend to the aperture. Ribs on the body chamber are of uniform height and spacing (the rib index is 5). Ribs are rursiradiate on the body chamber except at the apertural end, where they become rectiradiate (Pl. 4, Figs 2, 6). Small tubercles are present on every rib on the body chamber; they are usually very slightly clavate, and, where well preserved, they are sharp and curved back a little (unfigured specimen USNM 476119). Ribs and tubercles on the smaller limb (phragmocone) are weak. Constrictions are infrequent; they are usually bordered by a high adapical rib.

REMARKS: *Solenoceras texanum* differs from other American species by its larger size and coarser ornament. *Solenoceras reesidei* STEPHENSON 1941 (p. 401, Pl. 77, Figs 1-3) has a rib index of six or seven on the body chamber, and the phragmocone is densely ribbed. *Solenoceras multicostatum* STEPHENSON, 1941 (p. 402, Pl. 76, Figs 12-14) has a rib index of 8 or 9. *Solenoceras annulifer* (MORTON, 1841) is also more densely ribbed than *S. texanum* and has much smaller tubercles.

OCCURRENCE: *Solenoceras texanum* has been found in the *Baculites cuneatus* zone in the Pierre Shale in Middle Park at locality D1353, and in the *B. reesidei* zone in the Larimer Sandstone Member of the Pierre Shale in the Fort Collins area at localities D301, D1567, D2824, D2825, and 16213. The neotype came from the Nacatoch Sand near Chatfield, Navarro County, Texas. Specimens have also been found in the Neylandville Marl in Navarro County and in the Saratoga Chalk of Arkansas. Outside the United States, the species occurs in Israel and possibly Zululand.

Solenoceras cf. *S. reesidei* STEPHENSON, 1941

Compare:

1941. *Solenoceras reesidei* STEPHENSON, p. 401, Pl. 77, Figs 1-3.

1944. *Solenoceras reesidei* STEPHENSON, 1941; COBBAN & KENNEDY, p. B6, Pl. 7, Figs 1-9, 11, 12, 14, 15, 18, 25.

TYPES: Holotype is USNM 77238, from the Neylandville Marl of Navarro County Texas.

MATERIAL: Three fragments of internal molds.

DIAGNOSIS: A small species that has the limbs greatly appressed so that the widths are greater than the heights. Occasional constrictions present. Ribbing is dense with an index of 7; tubercles are barely visible.

DESCRIPTION: A few fragments of a very small, densely ribbed species may represent microconchs of *S. reesidei*. Limbs have sections broader than high. One specimen (USNM 476120), 10 mm long, includes the larger part of the smaller limb and the beginning of the elbow. Two constrictions are present. Ribs are well defined and uniform, and each bears nodate ventrolateral tubercles; rib index is 6. A larger, flattened, densely ribbed fragment (USNM 476121) has minute ventrolateral tubercles.

REMARKS: The specimens have flattened sections, constrictions, and uniform ribbing like that of *S. reesidei*, but the ribbing is not as dense as that on the smaller limb of the holotype. Inasmuch as only the holotype was illustrated by STEPHENSON, the variation within the species is unknown.

OCCURENCE: Larimer Sandstone Member of the Pierre Shale at localities D301 and D2599.

Genus *Lewyites* MATSUMOTO & MIYAUCHI, 1984

TYPE SPECIES: *Idiohamites(?) oronensis* LEWY, 1969, p. 127, Pl. 3, Figs 10, 11, by original designation of MATSUMOTO & MIYAUCHI 1984, p. 64.

DIAGNOSIS: Whorls coiled in a loose, elliptical planispire; ornament of narrow ribs in which pairs of ribs are linked at ventral tubercles, with nontuberculate ribs between tuberculate groups.

Lewyites oronensis (LEWY, 1969)

(Pl. 1, Figs 17, 18, 21-28; Pl. 4, Figs 8-11; Text-fig. 12)

1969. *Idiohamites(?) oronensis* (sic) LEWY, p. 127, Pl. 3, Figs. 10, 11.

1974a. *Exiteloceras oronense* (LEWY). COBBAN, p. 15, Pl. 10, Figs 22-35; Text-fig. 12.

1984. *Lewyites oronensis* (LEWY). MATSUMOTO & MIYAUCHI, p. 64.

TYPES: Holotype, by original designation, is HU30021a, in the collection of the Hebrew University, Jerusalem, from the upper part of the Mishash Formation, Oron phosphate field, Israel.

USNM 476122, 476123, 476125-476132, are from the Pierre Shale of Colorado.

MATERIAL: Twenty-five fragments of internal molds.

DIAGNOSIS: Loosely elliptical whorls that have oval sections and ornament of narrow, closely spaced ribs and ventrolateral tubercles. Two ribs usually unite at a tubercle, and a nontuberculate rib usually separates the tubercles and crosses the venter transversely along with looped ribs that connect opposite tubercles.

DESCRIPTION: The holotype is part of a loose elliptical coil 103 mm in diameter. Its ovate whorl section has the venter narrower than the dorsum and bordered by spinose ventrolateral tubercles. Narrow, closely spaced ribs have an index of 9 or 10. Two or three ribs unite at a prominent nodate tubercle.

Lewyites oronensis is represented by fragments mainly from the Larimer Sandstone Member of the Pierre Shale in the Fort Collins area. The largest specimen (USNM 476122, unfigured) represents the U-shaped bend of a phragmocone that has a whorl height of 20.5 mm. Its cross section is oval with very broadly rounded flanks, more narrowly rounded dorsum, and flattened venter. Ribs which are rather straight and narrower than the interspaces, are rectiradial to slightly prorsiradial and have an index of 8 or 9. Ribs are greatly weakened on the dorsum, where they bend forward slightly. Pairs of ribs unite at the ventrolateral shoulder and bear fairly large, flat-topped, nodate tubercles. A nontuberculate rib separates the tubercles and crosses the venter transversely. Weak, looped ribs also cross the venter and connect opposite tubercles. Part of a curved limb (Pl. 4, Figs 8-11) closely resembles the holotype except for its smaller size. The Pierre specimen has an oval cross section and a rib index of 9. Looped ribs connect tubercles across the venter. A fragment of an elbow has somewhat flexuous ribs with an index of 8 (Pl. 1, Figs 17, 18). Two nearly complete limbs and part of a third one are revealed in a specimen from a very fine grained sandstone concretion from the Larimer Sandstone Member (Pl. 1, Figs 27, 28). Whorl sections are compressed oval. The smallest limb has four or five constrictions bordered on their adapical side by a high rib. Ribs on that limb are weak and prorsiradial; most bear minute clavate to nodate tubercles. The next limb has straight, rectiradial to prorsiradial ribs having an index of 8 or 9. Some single ribs bear small clavate ventrolateral tubercles or pairs of ribs bear larger flat-

topped nodate tubercles. One or two nontuberculated ribs separate the tuberculated ones. The third or largest limb has narrow, rursiradiate to rectiradiate ribs, but only one tubercle is preserved on the incomplete venter; rib index is probably 8. The suture of this specimen is complex (Text-fig. 12. Lobes have narrow bases like those in other sutures of the species (COBBAN 1974a, Fig. 11).

Three specimens (Pl. 1, Figs 21-26) differ from

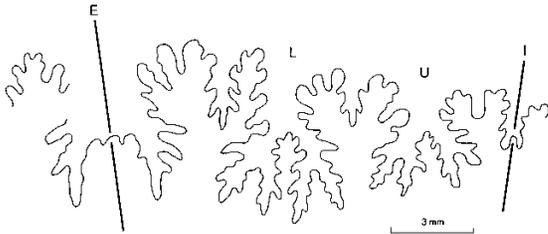


Fig 12. Suture of *Lewyites oronensis* (LEWY, 1969). USNM 476128 (pl. 1, figs 27, 28), from locality D2824

the others in having only an occasional nontuberculate rib that separates the tuberculate ones. In that respect, the specimens show some resemblance to *Parasolenoceras* COLLIGNON, 1969 (p. 44, Pl. 530, Figs 2087, 2088), which has a tubercle on every rib. One limb (unfigured specimen USNM 476130), 43 mm long with a height of 8.5 mm at its larger end, resembles *Parasolenoceras* even more in having most of the tubercles on single ribs instead of at the junction of two ribs.

The smallest limb at hand (USNM 476131, unfigured) is a fragment 8.0 mm long that has a sub-circular section 2.8 mm high. It has weak, prorsiradiate ribs but no tubercles.

REMARKS: *Lewyites oronensis* differs from *L. taylorensis* (ADKINS, 1929) (p. 209, Pl. 6, Figs 12, 13), from the Pecan Gap Chalk of Texas, in having a more compressed whorl section and a denser ribbed shell. *Lewyites clinensis* (ADKINS, 1929, p. 208, Pl. 6, Figs 10, 11), from the Anacacho Limestone of Texas, has a circular section and a rib index of only 7.

OCCURRENCE: *Lewyites oronensis* has been collected from the zone of *Baculites cuneatus* in the Pierre Shale in Middle Park at locality D1353, and from the slightly younger zone of *B. reesidei* in the Larimer Sandstone Member of the Pierre Shale in the Fort Collins area at localities D301, D371, D2824, D2825, and 16213. Two fragments were

found in the Williams Fork Formation in northwestern Colorado at USGS Mesozoic locality D6450, in sec. 14, T. 4 N., R. 68 W., Routt County. The larger specimen (USNM 476132, unfigured) is a limb 40 mm long that closely resembles the holotype in its curvature and ornament. *Lewyites oronensis* has also been found in the Nacatoch Sand in Texas, Saratoga Chalk in Arkansas, Navesink Formation in New Jersey, and Mishash Formation in Israel.

Lewyites? sp.
(Pl. 1, Figs 19, 20)

MATERIAL: A single small internal mold, USNM 476124.

DESCRIPTION: The specimen, 13.4 mm long, consists of part of a straight limb, an elbow, and part of another straight limb that is directed at an angle of 39 degrees to the other limb. The earlier limb is septate at its smaller end, where its cross-section is broader than high. The later limb has a circular section that has a diameter of 3.9 mm. A constriction is present on the more juvenile limb. Ornament consists of closely spaced, very narrow ribs that have an index of 7. Ribs are prorsiradiate on the older limb, rectiradiate and more widely spaced on the elbow, and rursiradiate on the more mature limb. There are no tubercles.

REMARKS: The specimen differs from similar-sized specimens of *L. oronensis* in its circular section and uniform ribbing. Small specimens of *L. oronensis* have oval sections and weak, irregular ribbing, and some have tubercles. A small specimen of similar size and shape assigned to *Solenoceras nitidum* COBBAN, 1974b (Fig. 1g, h) is not that genus or species, but may well be an immature limb of a *Lewyites?* like the present specimen.

OCCURRENCE: USNM 476124 is from the zone of *Baculites reesidei* in the Larimer Sandstone Member of the Pierre Shale at locality D2825.

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PLATE 1

- 1-4** – *Nostoceras* cf. *N. approximans* (CONRAD, 1855); 1, 4. USNM 476061, from locality D2846; 2, 3. USNM 476062, from locality D2846.
- 5-6** – *Nostoceras* cf. *N. obtusum* HOWARTH, 1965; USNM 476063, from locality 16213
- 7-9** – *Didymoceras aurarium* sp.nov.; Holotype USNM 476086, from locality D2599
- 10-16** – *Solenoceras texanum* (SHUMARD, 1861); 10 – USNM 476108, from locality D2825; 11 – USNM 476109, from locality D2824; 12 – USNM 476110, from locality D2825; 13 – USNM 476111, from locality D2825; 14-15 – USNM 476112, from locality D2824; 16 – USNM 476113, from locality D2824
- 17-18, 21-28** – *Lewyites oronensis* (LEWY, 1969); 17-18 – USNM 476123, from locality D371; 21-22 – USNM 476125, from locality 16213; 23-24 – USNM 476126, from locality 16213; 25-26 – USNM 476127, from locality D2825; 27-28 – USNM 476128, from locality D2824
- 19-20** – *Lewyites?* sp.; USNM 476124, from locality D2825
- 29-37** – *Cirroceras conradi* (MORTON, 1841); 29-30 – USNM 476088, from locality 16213; 31-32 – USNM 476089, from locality D371; 33-34 – USNM 476090, from locality D371; 35-36 – USNM 476091, from locality 16213; 37 – USNM 476092, from locality 16213

Figures 1-8, 10-37 are $\times 1$; Fig. 9 is $\times 2$

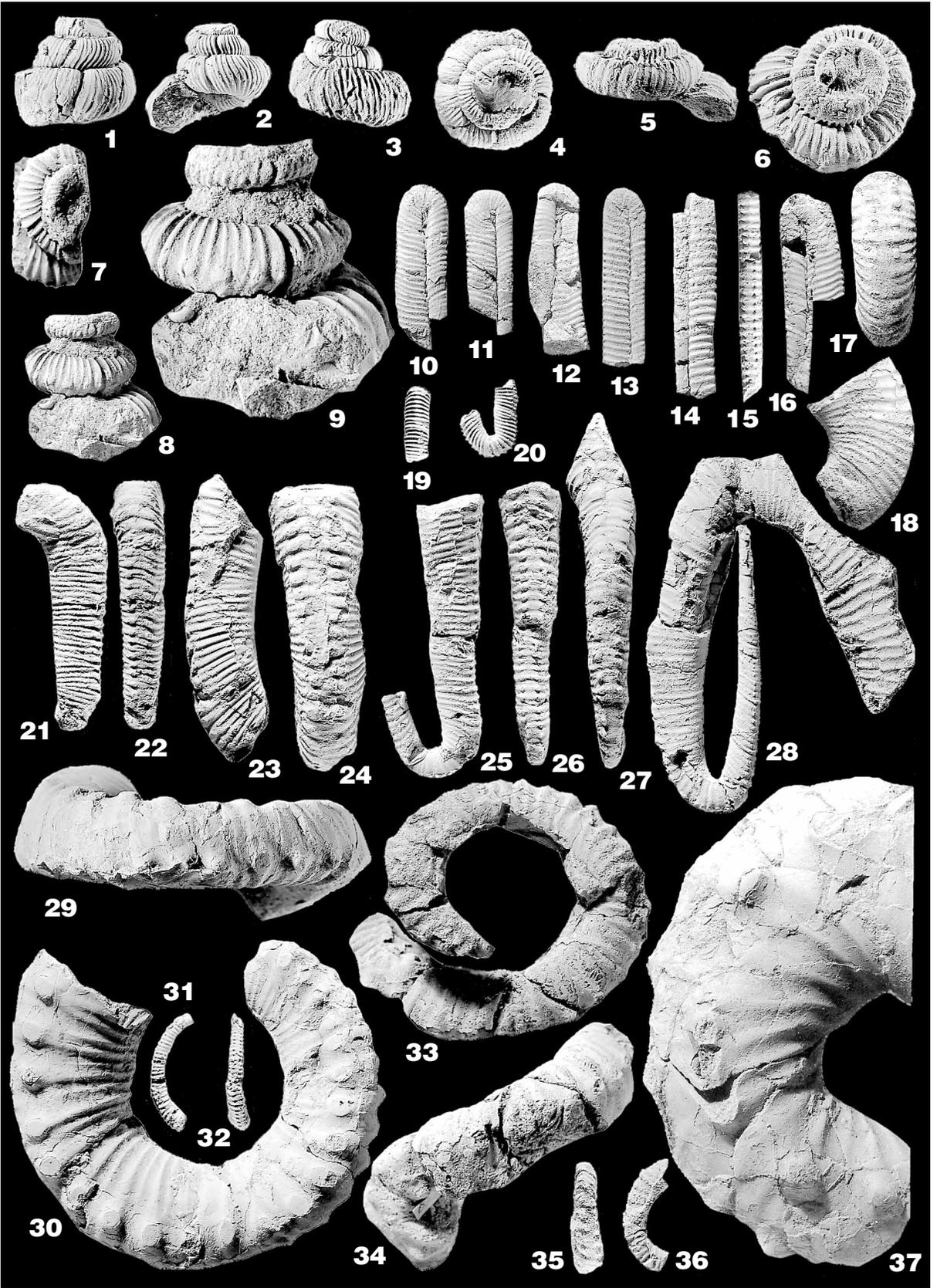


PLATE 2

- 1-30** – *Anaklinoceras minutum* sp.nov.; 1-4 – Paratype USNM 476097, from locality D2824; 5-6 – Paratype USNM 476098, from locality 16213; 7-9 – Holotype USNM 476096, from locality D2824; 10-12 – Paratype USNM 476099, from locality D2825; 13-15 – Paratype USNM 476100, from locality D371; 16-18 – Paratype USNM 476101, from locality D371; 19-20 – Paratype USNM 476102, from locality D371; 21-26 – Paratype USNM 476103, from locality D2824; 27-28 – Paratype USNM 476104, from locality D371; 29-30 – Paratype USNM 476105, from locality D1567
- 31-56, 61-67** – *Nostoceras larimerense* sp.nov.; 31-32 – Paratype USNM 476065, from locality 16213; 33-35 – Paratype USNM 476066, from locality D2824; 36-38 – Paratype USNM 476067, from locality D371; 39-41 – Paratype USNM 476068, from locality D2825; 42-43 – Paratype USNM 476069, from locality 16213; 44-45 – Paratype USNM 476070, from locality 16213; 46-47 – Paratype USNM 476071, from locality D1567; 48-49 – Paratype USNM 476072, from locality D2824; 50-51 – Paratype USNM 476073, from locality D371; 52-53 – Paratype USNM 476074, from locality D371; 54-56 – Paratype USNM 476075, from locality D2824; 61-63 – Paratype USNM 476076, from locality D2701; 64-67 – Holotype USNM 476064, from locality D371
- 57-60** – *Nostoceras* cf. *N. splendidum* (SHUMARD, 1861); USNM 476080, from locality D2824.

Figures 1-21, 23, 25, 27, 29-56, 58, 59, 61-67 are $\times 1$;

Figs 22, 24, 26, 28, 57, 60 are $\times 2$

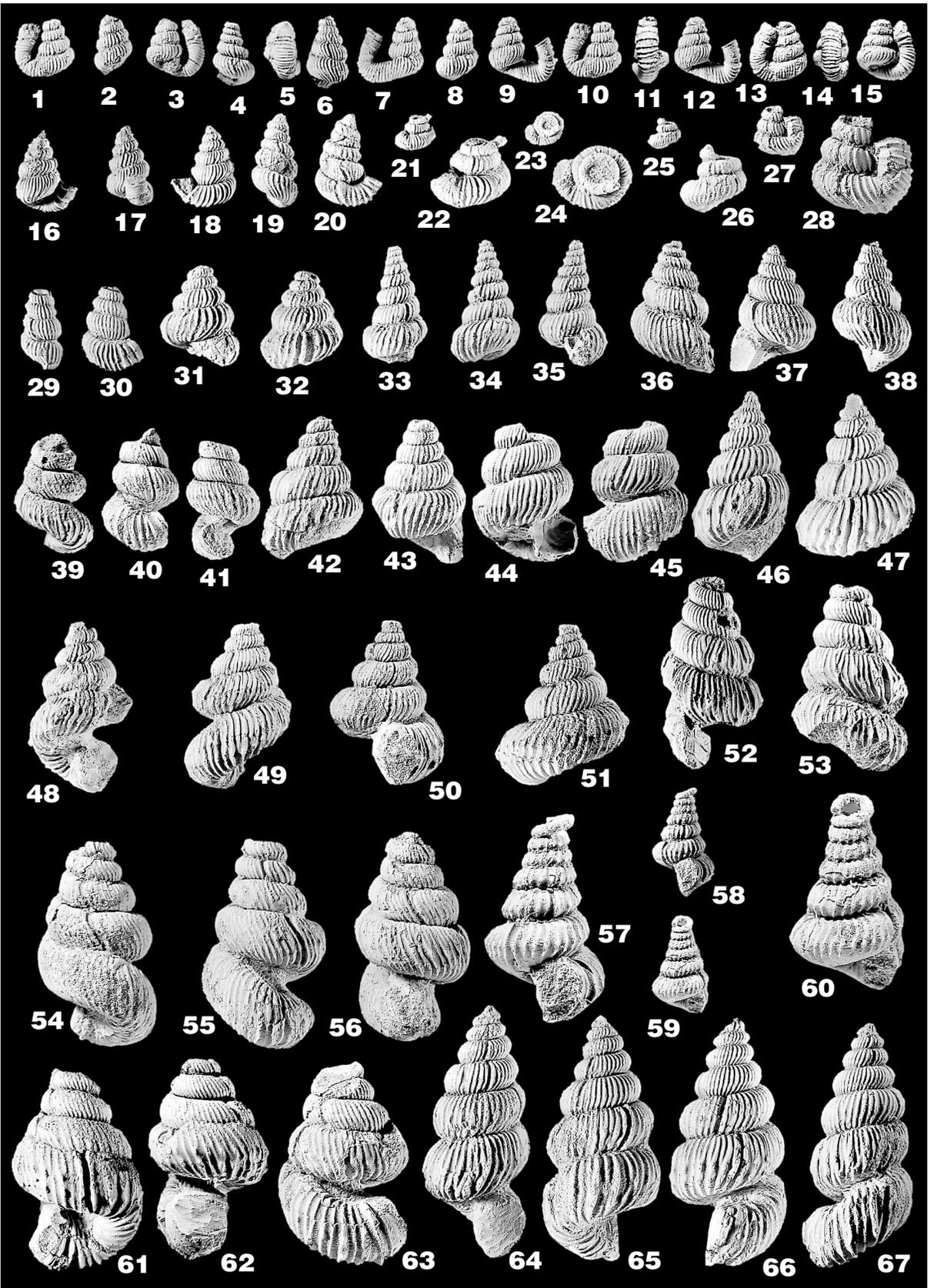


PLATE 3

Didymoceras draconis (STEPHENSON, 1941).

- 1-6** – From the Pierre Shale of Middle Park, Colorado
1-4 – USNM 445096, from locality D1352
5-6 – USNM 476081, from locality D1353

All figures are $\times 1$

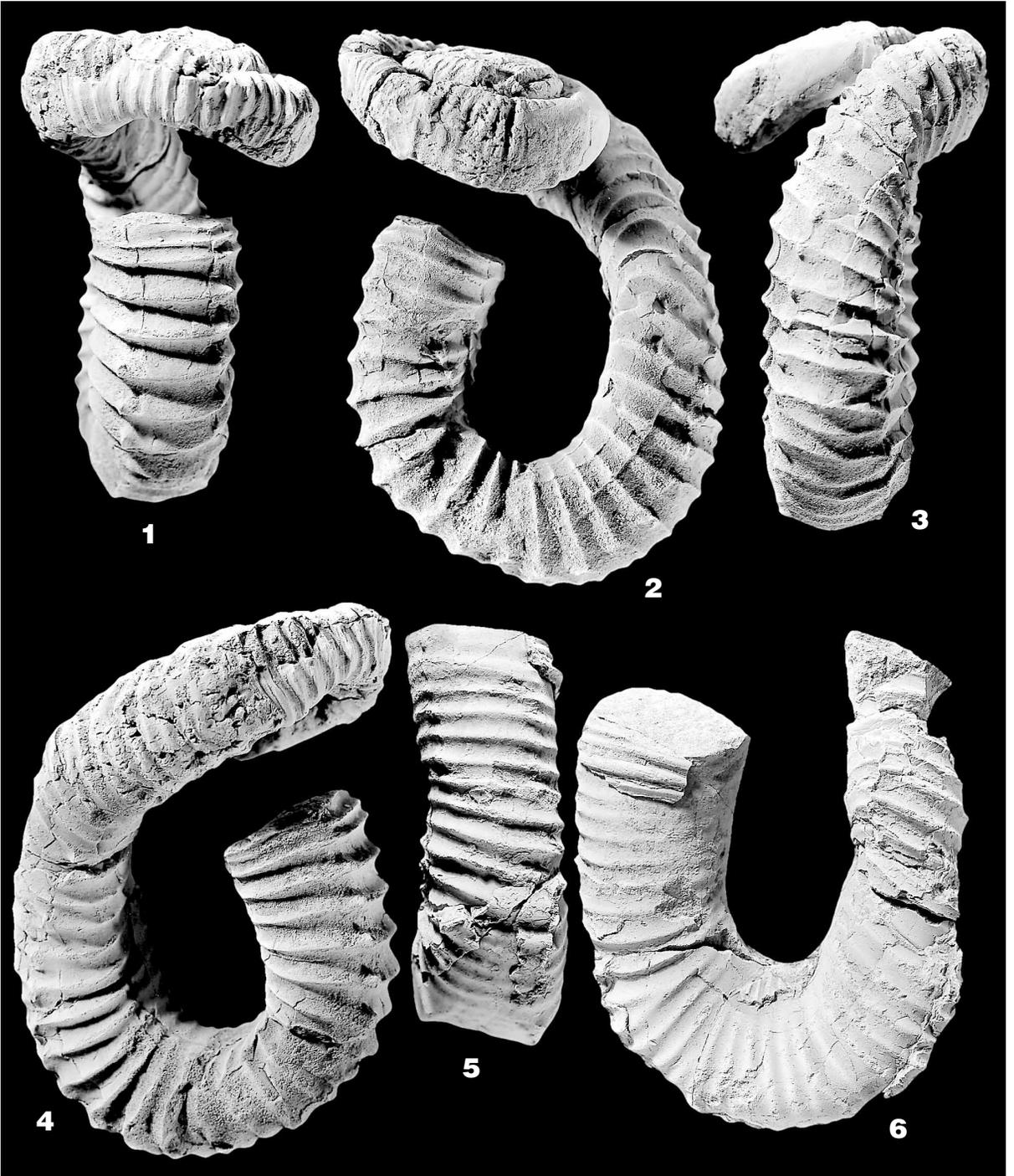


PLATE 4

- 1-7** – *Solenoceras texanum* (SHUMARD, 1861); From locality D1353 in Middle Park Colorado; 1-3 – USNM 476114; 4 – USNM 476115; 5-6 – USNM 476116; 7 – USNM 476117
- 8-11** – *Lewyites oronensis* (LEWY, 1969); USNM 476129, from locality D1353
- 12-13** – *Cirroceras conradi* (MORTON, 1841); USNM 476093, from locality D1353
- 14-23** – *Didymoceras draconis* (STEPHENSON, 1941); 14-17 – USNM 476082, from locality D1353; 18-19 – USNM 476083, from locality D1353; 20-23 – USNM 476084, from locality D2654

All figures are $\times 1$

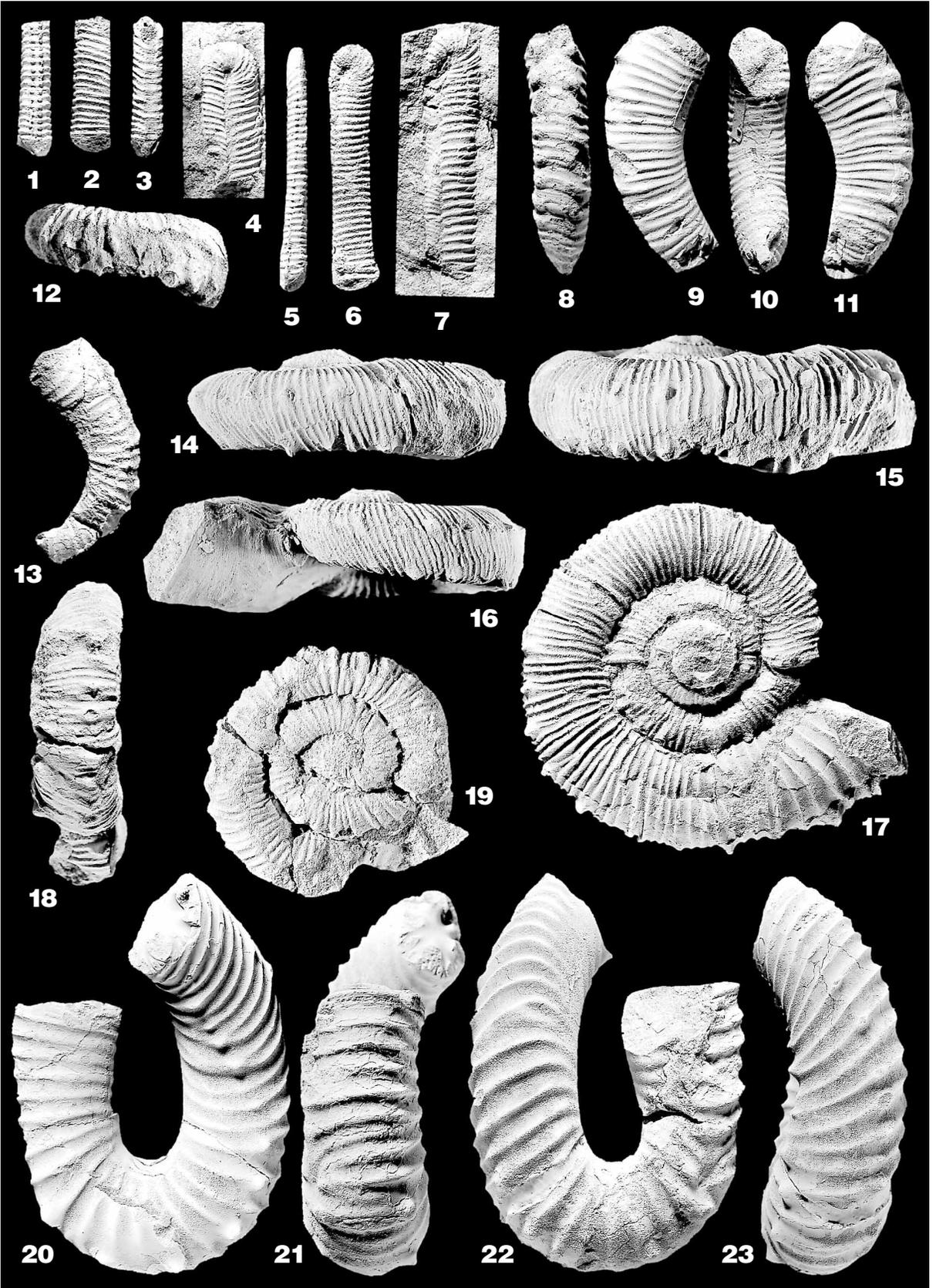


PLATE 5

1-6 – *Cirroceras conradi* (MORTON, 1841), from locality D1353 in Middle Park, Colorado; 1-3 – USNM 476094; 4-6 – USNM 476095

All figures are $\times 1$

