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A survey of the Cretaceous ammonite *Placenticeras* Meek, 1876, in the United States Western Interior, with notes on the earliest species from Texas

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ABSTRACT

Cobban, W.A. (edited and with additions by W.J. Kennedy) 2016. A survey of the Cretaceous ammonite *Placenticeras* Meek, 1876, in the United States Western Interior, with notes on the earliest species from Texas. *Acta Geologica Polonica*, **66** (4), 587–608. Warszawa.

This contribution documents the record of the late Cretaceous ammonite *Placenticeras* Meek, 1876, from the late Cenomanian of Texas and the southern part of the U. S. Western Interior up to the late Middle Campanian zone of *Baculites scotti*, reconstructed and updated from an incomplete manuscript by the late W. A. Cobban based on the collections of the U. S. Geological Survey. The original manuscript dates from the late 1980's, and there is now additional information on the occurrence of the genus that is incorporate here; much of this comes from Neal Larson of Hill City, South Dakota, to whom I am indebted for his help in preparing Bill's manuscript for publication. It now provides an objective documentation of the distribution of *Placenticeras* in space and time on which any subsequent analysis of the evolution of the genus will depend.

Key words: Cretaceous; Ammonites; *Placenticeras*; U.S. Western Interior.

'…..In fact, I do not see here nor elsewhere any possibility of drawing sharp lines, except between genera; the species all run in to one another.'(Alpheus Hyatt 1838–1902) in discussing *Placenticeras pseudoplacenta* in his posthumous *Pseudoceratites of the Cretaceous* (1903, p. 217).

INTRODUCTION (W.J.K.)

Revising and publishing the incomplete work of a colleague, thirty years after the manuscript was put aside, risks damaging the reputation of the author, and the judgement of the revisor. In the present case, I decided to go ahead with the project because it documents, objectively, where in space and time representatives of the late Cretaceous ammonite *Placenticeras* occur in the U.S. Western Interior, that vast area of ammonite-bearing Cretaceous rocks of which Bill Cobban was the unchallenged authority, and whose depth and extent of knowledge will likely never be matched, or surpassed.

The original manuscript dates from the late 1980's, and deals with the Upper Cenomanian to Middle Campanian interval. There is now additional information on the occurrence of the genus that is incorporate here; much of this comes from Neal Larson of Hill City,

South Dakota, to whom I am indebted for his help in preparing Bill's manuscript for publication. It now provides an objective documentation of the distribution of *Placenticeras* in space and time on which any subsequent analysis of the evolution of the genus will depend.

Placenticeras are 'difficult'. In the case of material from the Western Interior this is to a degree a reflection of the proliferation of names in another posthumous publication, Alpheus Hyatt's *Pseudoceratites of the Cretaceous* (1903) where, given the state of knowledge of the times, the horizon, and sometimes exact locality of specimens then available for study was often imprecisely known. Some of that imprecision is clarified below. The latest cited publication in the manuscript is dated from 1986. Since then, there have been a number of overviews that deal with *Placenticeras* and its allies, notably the comprehensive summary of species and genera of Placenticeratidae by Klinger and Kennedy (1989), and the revision of the relevant *Treatise* volume by C. W. Wright, a long-term admirer and correspondent of Bill's. A radically different view is to be found in Cooper and Owen (2011).

CONVENTIONS

Dimensions are given in millimetres, or as percentages of diameter. The suture terminology is that of Korn *et al.* (2003): E = external lobe; A = adventive lobe (= lateral lobe, L, of Kullmann and Wiedmann 1970); U = umbilical lobe; I = internal lobe. USNM: collections of the United States National Museum of Natural History, Washington D. C.

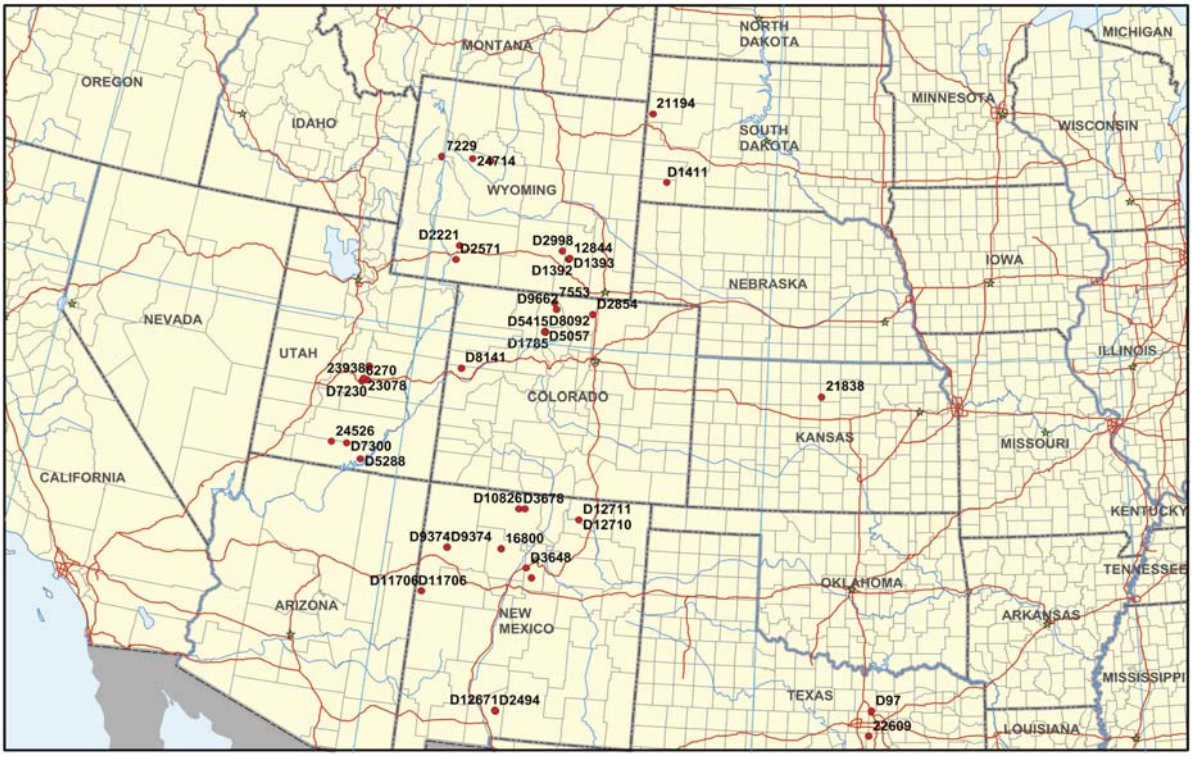
U.S. GEOLOGICAL SURVEY LOCALITIES CITED IN THE TEXT (Text-fig. 1)

6270: Mancos Shale, *Cremnoceramus deformis erectus* inoceramid Zone; beds with *Scaphites frontierensis* Cobban, 1951, 4 miles east of Oak Springs, Toey Creek, Sevier County, Utah.

7229: ?Frontier Formation; NE¼ sec. 8, T40N, R111 W, Teton County, Wyoming.

7523: Pierre Shale, *Baculites scotti* Zone, North Park Field, SW ¼ NE¼ sec. 24, T10 N, R79 W, 2 miles east of Dwinell's Ranch, about 8.5 miles NE of Walden, Jackson County, Colorado.

12844: Rock River Formation, *Baculites reduncus* Zone,with *Menuites portlocki complexus* (Hall and Meek, 1856); 2.5 to 4 miles east of Rock River, Wyoming, in second ridge, north of Lincoln Highway, Albany County; Wyoming.



Text-fig. 1. Index map showing the *Placenticeras* USGS localities in the U.S. Western Interior

16800: Mancos Shale; *Desmoscaphites bassleri* Zone; SE point of La Ventana Mesa in Ojo del Espiritu Santo Grant, 1 mile south of sec. 2, T18N, R1W, Sandoval County, New Mexico.

21194: Carlile Shale, *Scaphites whitfieldi* Zone; USGS Mesozoic locality 21194, six miles north of Belle Fourche in the N½ sec. 10, T9N, R2E, Butte County, South Dakota.

21838: Carlile Shale (upper part of Blue Hill Member), with *Scaphites carlilensis* Morrow, 1935, and *Scaphites morrowi* Jeletzky, 1949; 3 miles SSE of Tipton, in SE¼sec. 4, T9S, R10W, Mitchell County, Kansas.

22609: Eagle Ford Formation, Upper Cenomanian; Highway # 287, 9 miles SE of Mansfield, Ellis County, Texas.

23078: Niobrara Formation, *Cremnoceramus deformis deformis* inoceramid Zone; About 1 mile NW of abandoned white bridge over Ivie Creek. About 8 miles SW of Emery. NE¼SW¼ sec. 7, T23S, R6E, Sevier County, Utah.

23113: Cody Shale, *Scaphites hippocrepis* Zone; SE, SE, NW¼ sec. 24, T6N, R2E, West Dry Creek (Upper Cretaceous section unit 1), 65 feet below top of Cody, Fremont County, Wyoming.

23438: Frontier Formation, *Cremnoceramus deformis deformis* inoceramid Zone, SW¼NW¼ sec. 14, T6N, R2E, Fremont County, Wyoming.

23938: Mancos Shale, *Cremnoceramus deformis erectus* inoceramid Zone; Large concretions in Mancos Shale 100 feet above top of Ferron Sandstone Member; NW¼ SE¼ sec. 7, T23N, R6E, about 6 miles SW of Emery County, Utah.

24526: Tropic Shale, concretion 230 feet above base, *Sciponoceras gracile* Zone, in about NW¼ NW¼ sec.23, T38S. R1W, Round Valley, 15 miles southeast of Tropic, Kane County, Utah.

24714: Frontier Formation, *Cremnoceramus deformis erectus* inoceramid/*Scaphites preventricosus* Zone; Lenore Area, sec. 20,T6N, R3W, Wind River Basin, Wyoming, unit #50.

D97: Britton Formation, *Sciponoceras gracile* Zone; California Crossing, north-facing bluff on right bank of Elm Fork of Trinity River at Missouri-Kansas-TX of TX R.R. bridge 10 miles NW of Dallas, Dallas County; Texas.

D11706: Mancos Shale, Lower Turonian *Mammites nodosoides* Zone, from 20 foot thick unit of silty shale containing numerous limestone concretions, centre of the E½ sec. 6, T6N, R9W, Cibolla County, New Mexico.

D1285: Pierre Shale, *Baculites cuneatus* Zone, SW¼ sec.17, T3N, R80W, Grand County, Colorado.

D1349: Pierre Shale, *Baculites compressus* Zone, SE¼ NE¼ sec. 18, T3 N, R80W, Grand County, Colorado.

D1351: Pierre Shale, *Baculites compressus* Zone, from grey and brown sandy calcareous concretions 30–36 ft below large conspicuous ridge-forming concretions, N¼SW¼ sec. 17, T3N, R80W, Grand County, Colorado.

D1353: Pierre Shale, *Baculites cuneatus* Zone, from brown and grey sandy calcareous concretions 13–20 ft above a row of huge concretions, NW¼SW¼ sec. 17, T3N, R 80W, Grand County, Colorado.

D1357: Pierre Shale; from dark shale with small gray limestone concretions in upper part of shale unit below Richard Sandstone, Middle Park; Kremmling 3, Grand County, Colorado.

D1387: Mesaverde Formation, *Didymoceras stevensoni* Zone, NE¼ sec. 16, T20N, R76W, Albany County, Wyoming.

D1392: Mesaverde Formation (Rock River Formation), *Baculites reduncus* Zone, with *Menuites portlocki complexus*; north side of ridge, 2.3–2.5 miles ESE of Rock River in SW¼NW¼NE¼ and SW¼NE¼NE¼ sec.9, T20N, R76 W, Albany County, Wyoming.

D1393: Rock River Formation, *Baculites reduncus* Zone, southeast of Rock River in NE¼ sec. 9, T20N, R76W, Albany County, Wyoming.

D1411: Pierre Shale, *Baculites scotti* Zone, northeast of Oral in the NW¼ sec. 26, T7S, R7E, Fall River County, South Dakota.

D1785: Pierre Shale, *Baculites cuneatus* Zone higher in the section than D1353 (q. v.), NW¼SW¼ sec. 17, T3N, R80W, Grand County, Colorado.

D2221: Blair Formation, from sandstone about 100–125 feet below top; South of Winton in the SE¼ SE¼ sec. 5, T20N, R104, Sweetwater County; Wyoming.

D2494: Mancos Shale, *Prionocyclus germari* Zone; east-facing slope in centre of the SW¼ sec. 19, T20S, R4E, Love Ranch Section, sandstone concretions in the D Cross Tongue, Dona Ana County, south-central New Mexico.

D2571: Rock Springs Formation, *Baculites* sp. (weak flank ribs) Zone; 700–735 feet above base, SE¼ NW¼ SW¼, sec. 13, T17N, R105W, Sweetwater County, Wyoming.

D2854: Pierre Shale, *Exiteloceras jenneyi* Zone. SW¼ SW¼ sec. 11, T8N, R69W, Larimer County, Colorado.

D2998: Steele – Mesaverde transition, from third from lowest visible sandstone, centre of the N½ sec. 22, T22N, R78W, Carbon County, Wyoming.

D3648: Mancos Shale, *Clioscaphites vermiformis* Zone; Omera Mine, sec. 6, T12N., R9E. 35.4864N-106.1865W, *Clioscaphites vermiformis* Zone; Santa Fe County, New Mexico.

D3664: Mancos Shale, *Desmoscaphites erdmanni* Zone about 150 feet below top, near Omera Mine east of Ortiz Mts., in sec. 6, T12N, R9E, Santa Fe County, New Mexico.

D3678: Mancos Shale, *Scaphites hippocrepis* I Zone; iron-stained limestone concretions about 175 feet below base of Point Lookout Sandstone, Rio Ariba County, New Mexico.

D5057: Pierre Shale, *Baculites cuneatus* Zone, from brown sandstone concretions above the conspicuous bed of *Inoceramus vanuxemi* concretions. SE¼ SE¼ SE¼ sec. 12, T3N, R81W, Grand County, Colorado.

D5288: Straight Cliffs Formation, *Scaphites depressus* Zone, about 350 feet above base; Garfield County, Utah.

D5415: Pierre Shale, *Baculites gregoryensis* Zone, NE¼NE¼ sec. 13, T3N, R81W, Grand County, Colorado.

D7229: Mancos Shale, Emery Sandstone Member, *Clioscaphites vermiformis* Zone; Emery County, Utah.

D7230: Mancos Shale, *Scaphites preventricosus* Zone; from teepee-butte limestone masses about 100 feet above top of Ferron Sandstone Member, Emery County, Utah.

D7300: Straight Cliffs Formation, *Scaphites depressus* Zone, Kane County, Utah.

D7235: Mancos Shale, about 30 m below the base of the Emery Sandstone Member, *Clioscaphites saxitonianus* Zone, Emery County, Utah.

D8092: Pierre Shale, *Baculites compressus* Zone; SE¼SE¼SE¼ sec. 12, T3N, R81 W, Grand County, Colorado.

D8141: lower part of Sego Sandstone, *Baculites gregoryensis* Zone, SW¼SE¼ sec. 35, T8S., R101W. Mesa County, Colorado.

D9374: Point Lookout Sandstone, Santonian, from upper 6 feet of Hosta Tongue; Burned Water Canyon 1.5 miles above crossing of unimproved dirt road, McKinley County, New Mexico.

D9662: NW¼ sec. 3, T8N, R78W, Jackson County, Colorado.

D10826: Mancos Shale, *Scaphites hippocrepis* II Zone; both sides of highway 64 just north of Rito de Tierra Amarilla 5.4 miles E of W edge of Cebolla 15-minute quadrangle and 5.45 miles south of north edge, Rio Ariba County, New Mexico.

D11706: Mancos Shale, Lower Campanian, from 20 foot thick unit of silty shale containing numerous limestone concretions; centre E½ sec. 6, T.6N, R19W, Cibola County; New Mexico.

D12671: Mancos Shale, D Cross Tongue, *Prionocyclus germari* Zone N of Davis Well in NW¼NW sec. 19, T20S, R4E., Dona Ana County, New Mexico.

D12710: Pierre Shale; from grey and brown weathering limestone concretions about 75 ft below the base of the Pierre-Trinidad transition beds (30 ft thick), east of Ponil Creek and ¼ mile north of Pepper's Reservoir, Colfax County, New Mexico (Cimarron Quadrangle).

D12711: Pierre Shale; from grey and brown weathering limestone concretions about 75 ft below the base of the Pierre-Trinidad transition beds (30 ft thick), east of Ponil Creek and about ½ mile east of Chase Ranch, 2.4 miles north of Cimarron, Colfax County, New Mexico (Cimarron Quadrangle).

SCOPE OF THE GENUS

DIAGNOSIS: *Placenticeras* Meek, 1876, includes moderate-sized to large, generally compressed, more or less involute ammonites that have at some growth stage of the phragmocone narrow, flat (Pl. 8, figs 1, 4), or concave venters (Pl. 3, Figs 10, 11), usually bordered by small alternately placed clavi (Pl. 3, Figs 10, 11). The suture has three large frilled lobes on the outer part of the flank and much smaller lobes on the inner part of the flank. Dimorphism is conspicuous in many species that have large, slender or smooth or nearly smooth macroconchs and smaller, stouter, and more ornamented microconchs.

EARLY WHORLS: sketches of the earliest whorls by Hyatt (1903, pl. 45) show a rapid change from whorls that have rounded sections about as high as wide to those that have high, compressed sections with flattened flanks converging to a narrow, flat venter. A small, complete juvenile illustrated here (Pl. 1, Figs 6–8) from the zone of *Didymoceras stevensoni* (Text-fig. 2 sets out the zonal scheme used in this contribution) at USGS Mesozoic locality D1387 in Albany County, Wyoming, is 4.4 mm in diameter, has a whorl breath to height ratio of 33%, and an umbilical diameter of 34%. The body chamber, which occupies half a whorl, is much higher than wide with flattened flanks that converge to a narrow flat venter bordered by a sharp ventrolateral shoulder. Ornament consists of poorly defined, irregular, rib-like, lateral swellings on the phragmocone and more clearly defined, prorsiradiate sinuous ribs on the body chamber.

ORNAMENT: Specimens that retain shell material have biconcave growth lines that are concave on the umbilical wall and outer part of the flank (Text-fig. 3A). Although the growth lines are projected forward at the margin of the venter, they cross the narrow venter transversely (Text-fig. 3B) or in a shallow convexity (Pl. 12, Fig. 2). On some individuals growth lines may be raised conspicuously (Text-fig. 3A) or even strengthen into lirae (Pl. 11). Ribs are usually low crescentic folds on the outer part of the flanks (Pl. 8, Fig. 5; Hyatt 1903, pl. 35), but there can be well-defined closely-spaced crescentic ribs as in *Placenticeras maherndli* Summesberger, 1979 (pls 14, 15). Tubercles are usually nodate on the umbilical shoulder and flanks and clavate on the margin of the venter (Pl. 1, Fig. 4). Microconchs of *Placenticeras intercalare* Meek, 1876 however, usually have nodate ventral tubercles (Pl. 7, Fig. 3). Lateral tubercles are generally located on the crest of concentric folds (Pl. 8, Fig. 5), but they may stand alone (Pl. 9, Fig. 4). Feather structure is present on the outer part of the flanks on a few specimens that retain some shell material (Hyatt 1903, pl. 47, figs 4, 5; Haas 1961, text-fig. 1; Text-fig. 7)

SUTURES: The sutures of *Placenticeras* tend to be very closely spaced (Pl. 2, Figs 15, 19; Text-fig. 4). The external suture follows a sinuous course (Text-fig. 5). The external lobe E is broad and short, and has a major branch directed away from the middle of the venter at

SUBSTAGE	ZONE
Middle Campanian	*Baculites reduncus* *Baculites gregoryensis* *Baculites perplexus* *Baculites* sp. (smooth) *Baculites asperiformis* *Baculites mclearni* *Baculites obtusus*
Lower Campanian	*Baculites* sp.(weak flank ribs) *Baculites* sp. (smooth) *Scaphites hippocrepis* III *Scaphites hippocrepis* II *Scaphites hippocrepis* I *Scaphites leei* III
Upper Santonian	*Desmoscaphites bassleri* *Desmoscaphites erdmanni* *Clioscaphites choteauensis*
Middle Santonian	*Clioscaphites vermiformis*
Lower Santonian	*Clioscaphites saxitonianus*
Upper Coniacian	*Scaphites depressus*
Middle Coniacian	*Scaphites ventricosus*
Lower Coniacian	*Scaphites preventricosus*
Upper Turonian	*Prionocyclus germari* *Scaphites nigricollensis* *Scaphites whitfieldi* *Scaphites ferronensis* *Scaphites warreni* *Prionocyclus macombi*
Middle Turonian	*Prionocyclus hyatti* *Prionocyclus percarinatus* *Collignoniceras woollgari*
Lower Turonian	*Mammites nodosoides* *Vascoceras birchbyi* *Pseudaspidcoceras flexuosum* *Watinoceras devonense*
Upper Cenomanian (part)	*Neocardioceras juddii* *Burroceras clydense* *Sciponoceras gracile*

Text-fig. 2. Late Cenomanian through late Campanian ammonite, zones used in this contribution (based on Cobban *et. al*. 2006, with minor simplifications)

Text-fig. 3. *Placenticeras* sp. USNM 619382, from the Pierre Shale, *Baculites reduncus* Zone, USGS Mesozoic locality 7253, Jackson County, Colorado. The specimen retains the original aragonitic shell. Figures are × 1

a large angle. The principal adventive lobe A, and two further adventive lobes (A1 and A2) all follow a sagging course, are large and expanded, and have narrow necks. These lobes are irregularly bifid or trifid, and the lobes that separate them are bifid. The rest of the lobes are much smaller, and may number as many as seven or eight. These auxiliary lobes tend to be expanded, with narrow necks. In the older species, the auxiliaries are separated by broader, bifid saddles, whereas in the younger species, the saddles are about the same size as the auxiliaries. The first three or four saddles in the younger species (Text-figs 6, 8) are of nearly the same size, but in the older species, the auxiliary nearest the lateral lobe is smaller than the next one. This feature is characteristic of the genus *Karamaites* Sokolov, 1965 (in Casey 1965, p. 461), regarded as a synonym of *Placenticeras* herein, as discussed below. Sutures of the latest species are deeply frilled (Text-figs 6, 8) whereas those of older species are much simpler (Text-fig. 5); Hyatt 1903, pl. 27, figs 15–17). In addition, the older species have fewer auxiliaries (Kennedy and Wright 1983, text-fig. 3).

DIMORPHISM: Marked dimorphism is well-docu-

Text-fig. 4. *Placenticeras* sp., USNM 619383 from the Carlile Shale, *Scaphites whitfieldi* Zone, USGS Mesozoic locality 21194, Butte County, South Dakota. Figure is × 1

mented in some species of *Placenticeras* (Summesberger 1979; Wright and Kennedy 1983; Kennedy 1984). Macroconchs are large, compressed, usually high-whorled, fairly involute, and weakly ornamented or smooth (Pl. 5). Microconchs are moderately small, rather stout, somewhat evolute, and strongly ornamented (Pl. 14, Figs 1–3). Both have the same biconcave aperture (Pl. 3, Fig. 8; Pl. 5; Pl. 10). In their treatment of *Placenticeras polyopsis* (Dujardin, 1837), Kennedy and Wright (1983) presented many good illustrations of microconchs and macroconchs.

INTRASPECIFIC VARIATION: That species of *Placenticeras* are highly variable, has been observed by many authors. Hyatt (1903, p. 88) noted that adults were both large and small ("dwarfed") and that "The species are all connected so closely by intermediate forms that distinct lines are difficult to draw between contiguous species." Kennedy *et al.* (1981, p. 31) further noted that …"placenticeratid species are extremely variable. Each population shows a graduation from smooth oxyconic individuals with narrow tabulate venters to robust, ribbed and tuberculate individuals…and that evolutionary changes consist in large part of a shift in population mode and proportion of morphotypes within successive species."

THE OLDEST SPECIES

The oldest known specimens of *Placenticeras* from the U.S. Western Interior region consist of a few fragments of inner whorls from the late Cenomanian zone of *Sciponoceras gracile* (Pl. 4, Figs 3, 4) and occasional large individuals. These specimens are typical of *Placenticeras cumminsi*, a species originally described as *Placenticeras syrtalis* var. *cumminsi* Cragin, 1893 (p. 237), from the Britton Formation of northeast Texas. Late Cenomanian *Placenticeras* from Texas are described and illustrated by Kennedy (1988), and those from New Mexico by Cobban *et al*. (1989). Cragin described *cumminsi* as having early compressed whorls with flattened flanks and narrow, flat venter, ornament of umbilical tubercles, ventral clavi and outer flank rib-like swellings. A large specimen of 170 mm diameter was described as having a rounded venter on the body chamber. Many excellent examples of *P. cumminsi* from Texas are in the collections of the U. S. Geological Survey, and some are illustrated herein in lieu of the scarcity of Western Interior specimens. The best collection of large specimens was donated to the U. S. Geological Survey by the late James P. Conlin of Fort Worth, Texas. This collection, from 2.4–2.9 km southeast of Britton, Ellis County, contains sixteen specimens that retain part or all of the body chamber. Two specimens have diameters of 295 and 302 mm.

Phragmocones of specimens in the Conlin collection have umbilical ratios of 12–16%. All phragmocones have small, nodate tubercles on the umbilical shoulder, and these number 3–5 per half whorl. The tubercles may weaken and disappear on the outer whorl of the phragmocone, or may persist onto the older part of the body chamber. Most specimens have clavi that border the narrow, flat venter on the older part of the outer whorl, but on the younger part, the clavi usually weaken and disappear. Clavi number 14–21 per half whorl on phragmocones, and vary from weak to strong. Crescentic folds on the outer part of the flank are faint or absent; where present, they number six to eight per half whorl.

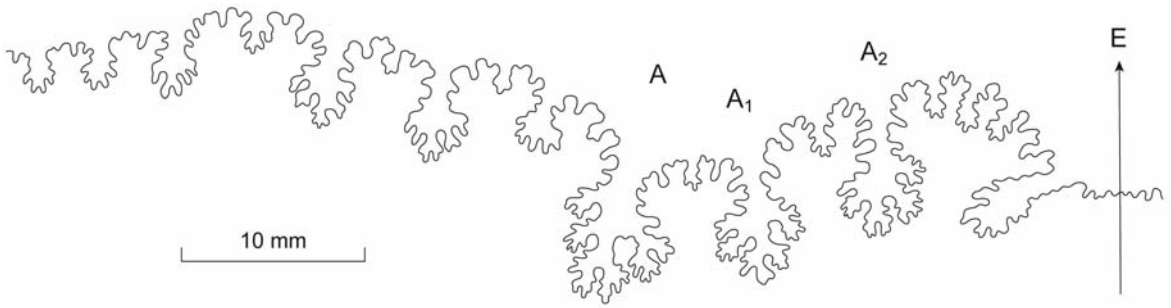
Each body chamber of the 16 specimens in the Conlin collection occupies a little more than half a whorl. All become more inflated adorally with a corresponding change in the venter from narrow and flattened to broader and rounder. The aperture follows the biconcave course of the growth lines (Pl. 5). Diameters at the base of the 16 body chambers do not fall into two distinct groups, as would be expected for sexual dimorphism. The diameters (rounded) are 72, 101, 102, 126, 130, 132, 141, 148, 162, 171, 183, 186, 190, 213, 215, and 242 mm.

Some specimens from the Britton Formation at other localities in northeastern Texas are almost smooth. Small, inconspicuous, nodate umbilical tubercles are usually present, but ventral clavi and lateral ribs may be absent. Venters are either flat or concave. Occasional small specimens have well-defined outer flank concentric ribs, and these can even extend to the margin of the venter, where the secondary ribs may be present (Pl. 3, Figs 1–5, 8–11).

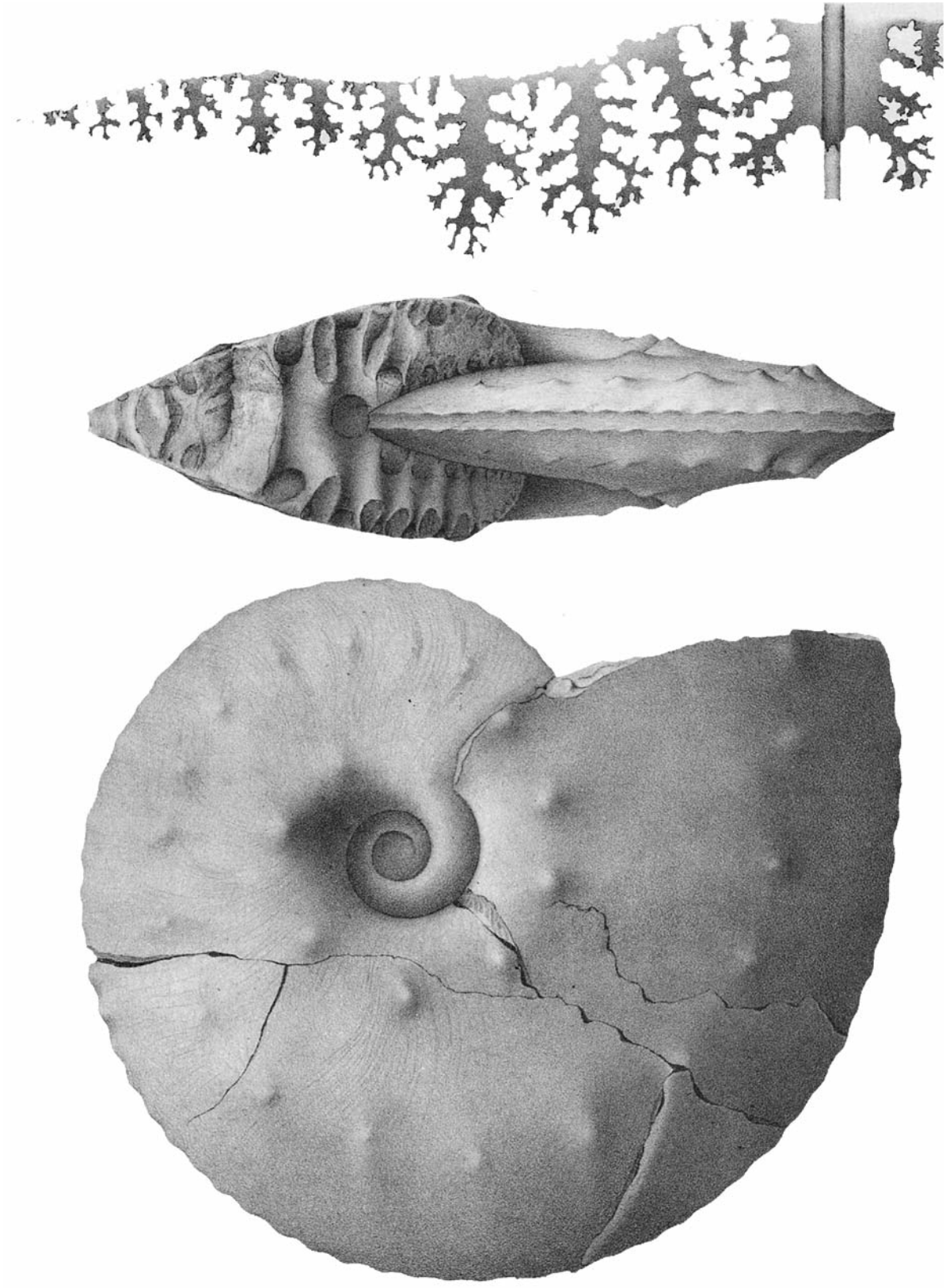
The suture of *Placenticeras cumminsi* (Text-fig. 5) is not as deeply frilled as those of the latest species. Another difference is that the first auxiliary lobe, A_1, is smaller than the next auxiliary lobe. Aside from this minor difference in the suture, *P. cumminsis* is like most of the later species of *Placenticeras* in its general form and ornament, and *Karamaites* is here considered as meriting at most subgeneric rank [but see below: Ed.]. Other specimens from the Britton Formation that have *Karamaites*-like sutures are the forms described as *Placenticeras stantoni* var. *bolli* Hyatt, 1903 (p. 214, pl. 40, figs 6, 7; pl. 41, figs 1–5; pl. 42, figs 1, 2; pl. 43, figs 1, 2).

THE YOUNGER SPECIES

Some of the youngest species in the Western Interior were described by Meek (1876) and Hyatt (1903). Meek (1876, pl. 24, figs 2a, b) illustrated a nearly smooth, compressed phragmocone "from Cheyenne River, Dakota; where it occurs in the Fort Pierre group". and the suture of a specimen "from North Red River, Minnesota". Both specimens were referred to *Placenticeras*

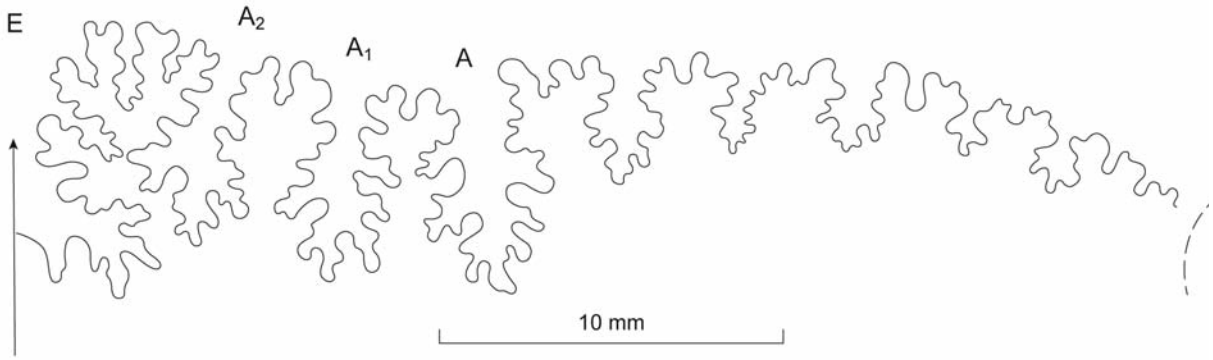


Text-fig. 5. *Placenticeras cumminsi* Cragin, 1893. External suture of USNM 411451, from the Britton Formation, *Sciponoceras gracile* Zone, first creek north east of Britton, 2.5 miles on farm road, Ellis County, Texas



Text-fig. 6. *Placenticeras intercalare* Meek, 1876. The holotype, copy of Meek 1876, pl. 23. The specimen is 155 mm in diameter, and from the Pierre Shale "Cheyenne River, at the mouth of Sage Creek, Dakota."

Text-fig. 7. *Placenticeras tuberculatum* Hyatt, 1903. Copy of Hyatt's figure (1903, pl. 47, fig. 5) of the holotype, no. 2373 in the collections of the Museum of Comparative Zoology, Harvard, and from the "Montana group, Upper Cretaceous, Black Hills". The original is 159 mm in diameter



Text-fig. 8. *Placenticeras costatum* Hyatt, 1903. Composite suture based on USNM 486622, from the Pierre Shale, *Baculites cuneatus* Zone USGS Mesozoic locality 1353, Grand County, Colorado

placenta (DeKay, 1828), a species described from much older, early Campanian deposits of New Jersey (*Placenticeras* from the Santonian and Campanian of New Jersey, other parts of the Eastern Seaboard and Gulf Coast are revised by Kennedy and Cobban 1991, 1993, 1994a, b; Cobban and Kennedy 1992, 1993; Kennedy *et al*. 1997, 2001; Kennedy, Cobban, Landman and Johnson 1997). In addition, Meek (1876, p. 468, pl. 23, figs 1a–c; Text-fig. 6) described a new form, *Placenticeras placenta intercalare*, from the Pierre Shale of the Cheyenne River area. Böhm (1898, p. 200, footnote) later gave the name *Placenticeras meeki* to the specimen from the Red River. The specimen probably came from the Pierre Shale of eastern North Dakota.

Hyatt (1903, p. 207) raised Meek's variety *intercalare* to species rank, and illustrated, but did not describe, a variety *costatum*. Hyatt (1903, p. 221) also described the new species *Placenticeras whitfieldi* for the large, nearly smooth, compressed forms from the Western Interior that Meek had assigned to *Placenticeras placenta*. Hyatt was unaware of Böhm's earlier name, *meeki*, for these specimens. A new form, *Placenticeras whitfieldii* var. *tuberculatum* Hyatt, 1903 (p. 232, pl. 47, fig. 5; Text-fig. 7) was also described. Hyatt described his *Placenticeras whitfieldi* in much detail, and recorded one individual 630 mm in diameter. He also noted that his variety *tuberculatum* was transitional to *Placenticeras intercalare*.

More than 90 years later, Kennedy *et al.* (1996) redescribed *Placenticeras costatum* from the *Baculites cuneatus* and *B. reesidei* Zones of Colorado and South Dakota, and their new species, *Placenticeras pingue* Kennedy, Cobban and Landman 1996, from the *Baculites reduncus* and *B. scotti* Zones of Wyoming and South Dakota.

The many collections of *Placenticeras* now at hand from the northern Great Plains region reveal that specimens of *intercalare-meeki* type are abundant in the zone of *Baculites compressus* in the Pierre Shale of South Dakota and in the zones of *Baculites compressus* and *B. cuneatus* in the Bearpaw Shale of Montana. Meek's specimens, and most of Hyatt's are assumed to be from the zone of *Baculites compressus*. The coarsely ornamented specimens illustrated by Hyatt (1903, pl. 36, fig. 5; pl. 37, figs 1, 2; pl. 38, fig. 1) as *Placenticeras intercalare* from Harper, Wyoming, are from older rocks (early part of the late Campanian).

Placenticeras intercalare, as understood here, is a highly variable species that ranged from small, somewhat robust, ornate forms (microconchs) to large, compressed, smooth to nearly smooth forms (macroconchs). Meek's *Placenticeras intercalare* is a microconch, and Hyatt's *Placenticeras whitfieldi* [*meeki*] is the macroconch.

The holotype of *Placenticeras intercalare* (Meek, 1876, pl. 23, figs 1a–c) (Text-fig. 6) is a well-preserved, moderately robust phragmocone whose dimensions, according to Meek's figures, are a diameter of 155 mm and a whorl breadth of 45 mm. Ornament, which is fairly strong, consists of nine nodate umbilical tubercles, 19 nodate lateral tubercles, and 61–62 ventral clavi per whorl. The lateral tubercles are on low crescentic ribs on the outer part of the flank.

The holotype of *Placenticeras whitfieldi* var. *tuberculatum* Hyatt, 1903 (Text-fig. 7) is no. 2373 in the collections of the Museum for Comparative Zoology, Harvard. It is a partly damaged phragmocone that retains much original shell material. Matrix on one side of the umbilicus indicates a dusky ferruginous concretion as the source of the specimen. The specimen has a diameter of 159 mm, a whorl breadth of 44.0 mm (27.7%), and an umbilical diameter of 17 mm (10.7%). The flanks are flattened, and converge to the narrow, concave venter. Shell material on the middle of the flank at the adoral end reveals an injury that the animal had suffered during growth. Ornament is very subdued. Flanks are almost smooth except for growth striae, and on the outer part, feather structure and faint arcuate folds number about 20 per whorl. Seven small, nodate tubercles are present on the umbilical shoulder on the older half of the outer whorl, but tubercles seem to be absent on the younger half. Minute clavi bound the venter on the older half of the outer whorl; they are difficult to count, but there are 56–58 per half whorl at a diameter of 108 mm. The venter on the younger half of the whorl is too damaged to determine the presence of clavi.

Placenticeras intercalare var. *costatum* Hyatt, 1903 (pl. 38, fig. 2; pl. 39, figs 1, 2), which was illustrated without description, is a well-preserved phragmocone about 180 mm in diameter, the umbilicus comprising 12% of the diameter. It resembles the type of *Placenticeras intercalare* in having nine umbilical, and 20 lateral tubercles per whorl, but differs in having conspicuous, sinuous growth striae and many more ventral clavi, possibly as many as 110 per whorl. The locality is unknown.

Collections of *Placenticeras* from the Pierre Shale of the Kremmling area in north-central Colorado are particularly instructive inasmuch as they include complete microconchs of *P. costatum* as well as fragments of macroconchs. The fossils are most abundant in sandstone concretions in the *Baculites cuneatus* Zone about 128 m above the Carter Sandstone Member (Izett *et al*. 1971, p. A15). One of the larger collections (USGS Mesozoic locality D1353 in Grand County, Colorado) has several complete microconchs whose diameters at the base of the body chamber are 145, 153, 153,156, 160, 162, and 162 mm. These seven specimens are moderately robust and have umbilical diam-

eters of 12–18% of the total diameter. Umbilical tubercles on the outer whorl are low, and usually nodate; they number 9–11. The lateral tubercles on the inner whorls become low, crescentic folds on the outer whorl and gradually migrate outward to the ventrolateral shoulder, where the whorl section may become fastigiate. The folds usually disappear near the aperture. Body chambers are more inflated than the phragmocone, and the well-defined, narrow, flat venter of the phragmocone disappears at the base of the narrowly rounded venter of the body chambers. The ventral clavi of the phragmocone become low, closely spaced, nodate tubercles, arranged alternately near the middle of the venter of the body chamber before disappearing near the aperture.

In addition to the seven adult microconchs from locality D1353, there are about 20 incomplete microconchs that are mostly phragmocones. Inner whorls have sharply defined narrow, flat venters bounded by clavi that number 33–53 per half whorl. These clavi are usually placed alternately, but occasional specimens have matched clavi at some growth stage. Matched tubercles were also observed on a few specimens from the slightly older zone of *Baculites compressus* in the Kremmling area.

Macroconchs of *Placenticeras costatum* are abundant at locality D1353 and many large specimens were observed in the field (Izett *et al*. 1971, p. A15).

ZONAL AND GEOGRAPHIC DISTRIBUTION

Placenticeras ranges from the late Cenomanian to the late Campanian in the Western Interior region. Specimens are scarce in some zones and abundant in others. The following account chiefly concerns those specimens in the collections of the U. S. Geological Survey at the Denver Federal Centre that can be definitely related to the zonal scheme shown in Text-fig. 2, together with a number of additions and updates based on subsequent observations. The present revision, and Cobban's original manuscript, deals in detail only material from late Cenomanian to the middle Campanian.

Upper Cenomanian

Zone of *Sciponoceras gracile*

A few specimens of *Placenticeras cumminsi* have been collected from limestone concretions in the Tropic Shale in southern Utah and from concretions of limestone and sandstone in the Frontier Formation in east-central and north-central Wyoming. Although ammonites are abundant and varied in this zone, *Placenticeras* is seldom present, and then represented by only an occasional specimen.

Zone of *Burroceras clydense*

A few specimens referable to *Placenticeras* have been found in this zone only at one locality in southwestern New Mexico. The specimens are from limestone concretions in the shale member of the Colorado Formation, and are described by Cobban *et al.* (1989, p. 20, text-figs 20, 75a–e, 96z).

Zone of *Neocardioceras juddii*

A single crushed, septate specimen from the Greenhorn Member of the Cody Shale of south-central Montana represents the only *Placenticeras* in the Geological Survey collections from this late Cenomanian zone. The suture is like that of *P. cumminsi*. The specimen is from a limestone concretion associated with a thick bentonite bed (bed M of Knechtel and Patterson 1956, p. 95).

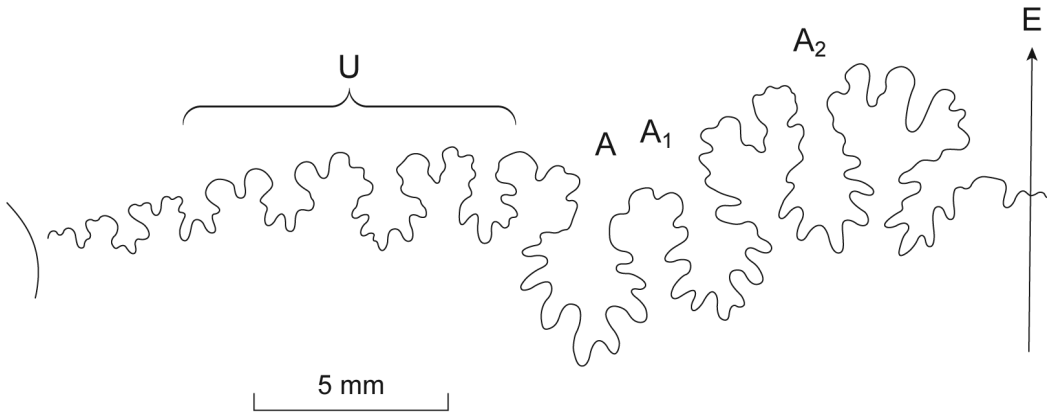
Turonian

Zone of *Watinoceras devonense*

Placenticeras has not been found in this zone of earliest Turonian age. Other ammonites, however, are locally abundant and varied (Cobban 1985, p. 137).

Zone of *Mammites nodosoides*

Placenticeras appears again in the later part of this early Turonian zone. Specimens are known from six localities in New Mexico, three localities in Utah, and one in Colorado. Five of the New Mexico localities are clustered in the Fence Lake area, near the western edge of the state, where well-preserved specimens occur in limestone concretions in the upper part of the Rio Salado Tongue of the Mancos Shale (Cobban and Hook 1983, p. 6). Of the 10 septate specimens collected from these concretions, four have the first auxiliary lobe a little smaller than the second (Cobban and Hook 1983, pl. 3, fig. 12), which is a feature of *Karamaites*. Two specimens have the first two auxilliaries of equal size, and four have the first auxiliary larger than the second (Cobban and Hook 1983, pl. 5, fig. 4), which is more like *Placenticeras sensu stricto*. Eight of the specimens are ornate, and two are smooth. These specimens can be assigned to *Placenticeras stantoni* Hyatt, 1903 (p. 214). As noted by Kennnedy and Cobban (1991, p. 20) this population falls partly into *Placenticeras*, partly into *Karamaites* on the supposedly diagnostic features of the ex-



Text-fig. 9. *Placenticeras stantoni* Hyatt, 1903. External suture of the holotype, USNM 22939b, from the Tropic Shale of the Upper Kanab valley, Utah

ternal suture line, suggesting that separation of *Karamaites* from *Placenticeras*, even at subgeneric level is invalid.

The holotype of *P. stantoni* was figured as *Placenticeras placenta* DeKay? by Stanton (1894, p. 169, p. 39, figs 1–3). Stanton's type came from beds now assigned to the Tropic Shale in the Kanab area in southwestern Utah. The holotype (USNM 22939b) is a slender phragmocone 80.4 mm in diameter with an umbilicus that comprises 15% of the diameter. Ornament is faint on the older half of the outer whorl, but on the younger half, five small nodate tubercles are located on the umbilical shoulder, and 17 clavate tubercles bound the fairly narrow, flat venter. Fourteen low concentric folds are present on the outer part of the flattened flank of the outer whorl. The suture, which was not illustrated by either by Stanton or Hyatt, is shown in Text-fig. 9. It is much like that of *Placenticeras cumminsi* except the first auxiliary lobe is not noticeably smaller than the second.

Zone of *Collignoniceras woollgari*

Placenticeras has been found in this zone of earliest middle Turonian age at 12 localities in Wyoming, South Dakota, Utah, and New Mexico. The largest collection consists of seven smooth to nearly smooth specimens (Cobban 1983, p. 12, pl. 7, figs 1, 2) from concretionary limestone that rests directly on Precambrian granite in the Dakota Granite Company quarry near Milbank in eastern South Dakota. The smooth specimens were assigned to *Proplacenticeras pseudoplacenta* Hyatt, 1903, and ornate individual to *Proplacenticeras stantoni*, although the possibility that both forms represented a single species was noted (Cobban 1983, p. 12). Sutures reveal the first auxiliary lobe to be larger than the second.

Zone of *Collignoniceras praecox*

Placenticeras becomes rare again in this middle Turonian Zone. Only a single fragment of a smooth body chamber is known from a limestone concretion in the Carlile Shale of northeastern Nebraska.

Zone of *Prionocyclus hyatti*

Towards the close of the middle Turonian, *Placenticeras* became widely distributed over the Western Interior region at 27 localities in Montana, Wyoming, South Dakota, Utah, Colorado, Kansas, and New Mexico. However, the genus is never abundant at any one locality, and most collections have only one or two specimens. Most specimens are from silty limestone concretions and from ferruginous concretions in the Carlile Shale, Frontier Formation, and Mancos Shale.

All specimens are smooth and can be assigned to *Placenticeras pseudoplacenta*. A noted by Reeside (1927a, p. 8) "Hyatt did not anywhere offer a real diagnosis of this species, though from his figures and casual remarks it may be deduced that he had in mind a moderately stout shell, with height of the whorl about twice the width, flanks of whorl flattened in younger stages, very gently arched in later stages; narrow umbilicus; venter moderately broad, about as in *P. planum* Hyatt and *P. stantoni* Hyatt; nodes and ribs inconspicuous or absent at all stages; suture with first three lobes and first three saddles subequal; all the parts of the suture short, very solid, and only moderately incised; fourth lateral lobe much shorter than third."

Hyatt (1903, p. 216), however, seems to have based much of his species on the suture. He began his description by stating that "the sutures are peculiar and un-

like those of true *P. placenta* or *whitfieldi.* This fact was noted by Stanton, who considered the Colorado species to be different from *placenta*." The specimen that he was referring to was the one from the "Colorado formation of the Kanab area in southwestern Utah, whose suture was figured by Stanton (1894, pl. 39, fig. 1) as *P. placenta* Dekay with a query. This specimen was designated lectotype by Kennedy and Cobban (1991, p. 20) inasmuch as Hyatt did not designate a lectotype. The specimen (Text-figs 10–12) consists of part of the body chamber that encloses the older half of the outer whorl of the phragmocone. Diameter at the base of the body chamber is about 135 mm. The body chamber is smooth and has a rounded venter. The phragmocone is also smooth except for faint crescentic folds on the outer part of the flattened flanks. The venter of the phragmocone is fairly broad and flat. The suture has been redrawn, and is shown in Text-fig. 10. The first two auxiliaries are the same size, and the next two slightly smaller. Preservation of this specimen suggests that it came from a septarian limestone concretion from rocks now included in the Tropic Shale. The specimen is probably from the zone of *Prionocyclus hyatti* (other specimens of *P. pseudoplacenta* studied and figured by Hyatt are shown in Text-fig. 13). All specimens from this zone in the Geological Survey's collections are like the lectotype in that they have smooth shells with flat venter on the inner whorls and rounded venter on the body chamber. Dimorphism is apparent inasmuch as some specimens have diameters of as little as 90 mm at the base of the round-ventered body chamber, whereas fragments of other body chambers suggest diameters of twice this size.

Zone of *Prionocyclus macombi*

Following the wide distribution of *Placenticeras* at the close of the middle Turonian, the genus nearly disappeared from the Western Interior region. Only a single fragment has been found in the earliest late Turonian zone of *Prionocyclus macombi*. This fragment, which is smooth and round-ventered, can be referred to *Placenticeras pseudoplacenta*. The specimen came from a bed of sandstone in the Mancos Shale in south-central New Mexico, where it was associated with *Inoceramus dimidius* White, 1874, and *Prionocyclus macombi.*

Zone of *Prionocyclus wyomingensis*

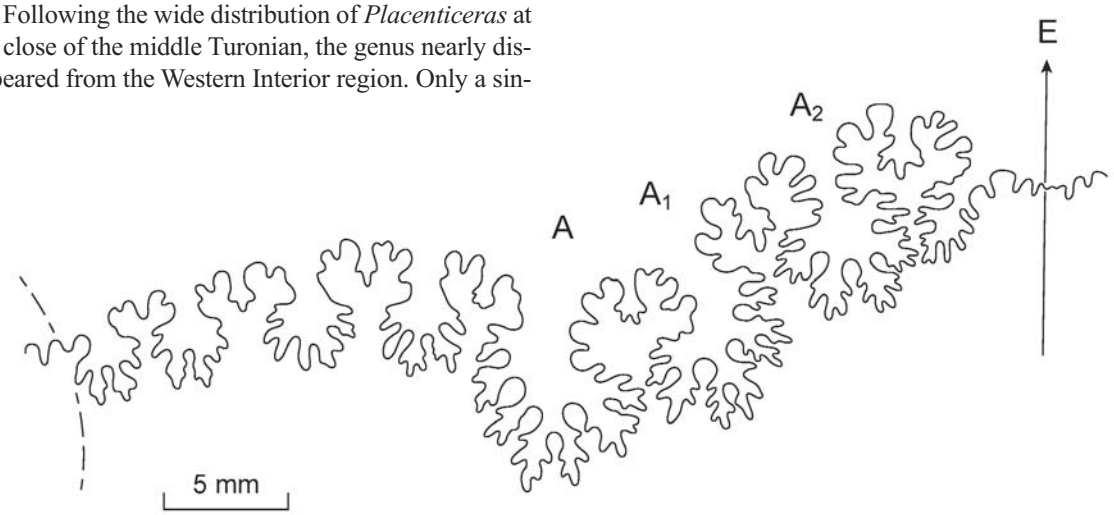
Although molluscan fossils are abundant in this zone in much of the Western Interior, the only known specimen, resembling *Placenticeras pseudoplacenta*, is in the collections of the Black Hills Institute of Geological Research, and from Fall River County in South Dakota (Neal Larson, personal communication, 2016).

Zone of *Scaphites whitfieldi*

A few smooth specimens of *Placenticeras* have been found at two localities in theTurner Sandy Member of the Carlile Shale in western South Dakota and one locality in the equivalent part of the Frontier Formation in south-central Wyoming. In their form and smoothness, the specimens resemble *Placenticeras pseudoplacenta*, but the sutures are much more frilled.

Zone of *Scaphites nigricollensis*

Placenticeras has not been found in this late Turonian zone. *Scaphites nigricollensis* is known only from a belt that extends from the Black Hills northwestward to north-west Montana.



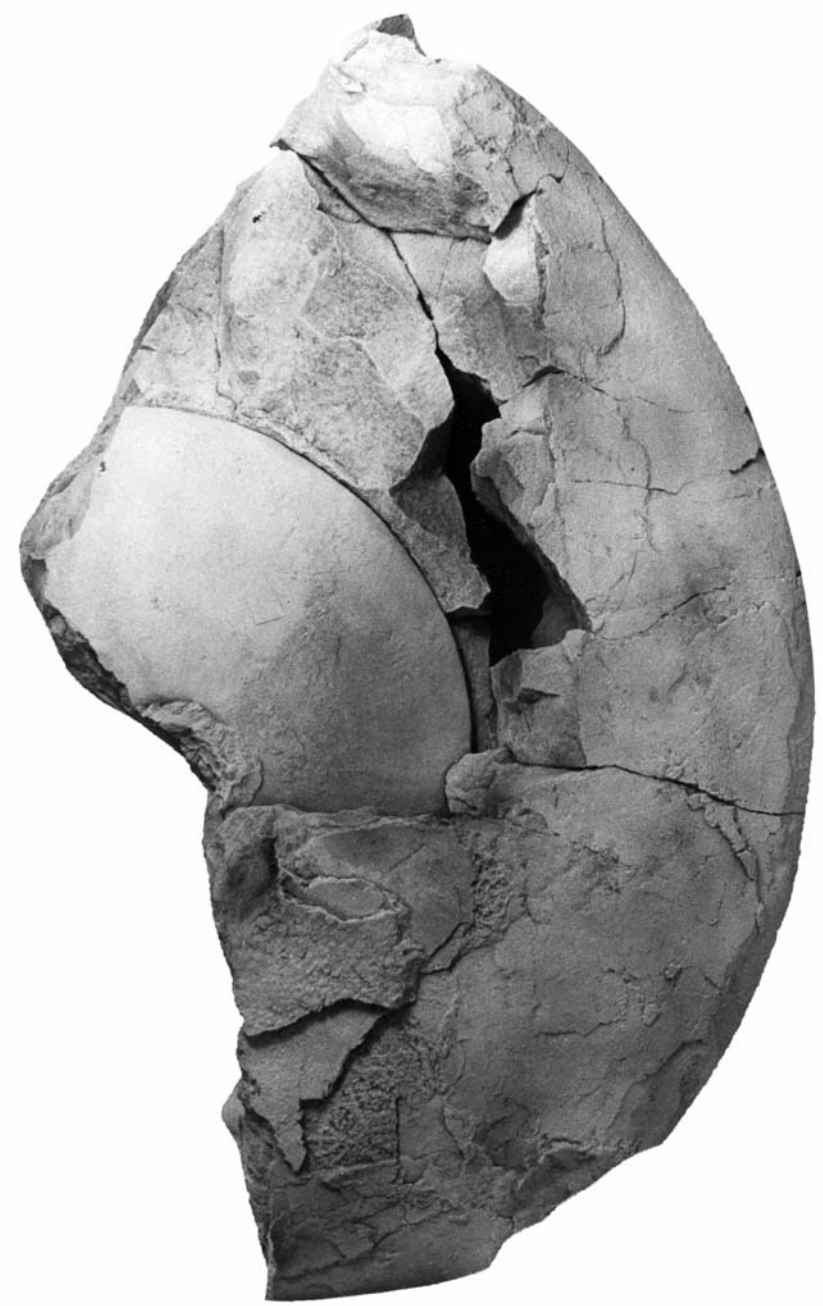
Text-fig. 10. *Placenticeras pseudoplacenta* Hyatt, 1903. External suture of the holotype, USNM 22939a, from the "Colorado Formation" of the Kanab Valley, Utah, and inferred to be from the *Prionocyclus hyatti* Zone Tropic Shale

Zone of *Prionocyclus germari*

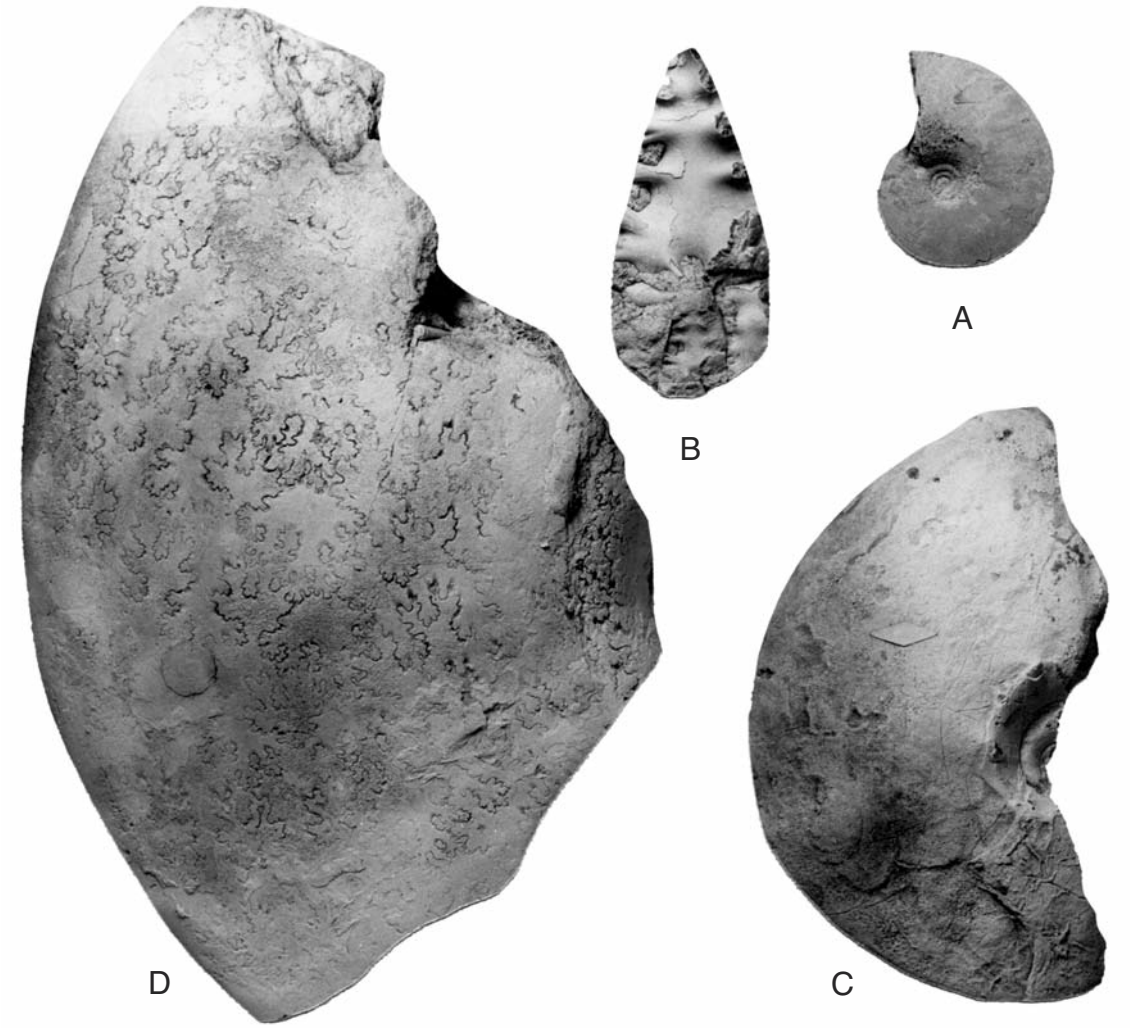
In this zone of latest Turonian age, *Placenticeras* returned to having both ornate and smooth forms, and, in addition, specimens became widely distributed and locally common across the Western Interior region from southern Montana to southern New Mexico. Specimens are present in 47 collections of the U.S. Geological Survey of which about half are from the Frontier Formation in Wyoming. The largest collection (USGS D2494 and D12671) from sandstone concretions in the D Cross Tongue of the Mancos Shale of

Text-fig. 11. *Placenticeras pseudoplacenta* Hyatt, 1903. The holotype, USNM 229389a, from the "Colorado Formation" of the Kanab Valley, Utah, and inferred to be from the *Prionocyclus hyatti* Zone Tropic Shale. Figures are × 0.95

south-central New Mexico has12 specimens 80 mm or more in diameter of which eight are ornate and four are smooth. There are, in addition, four small smooth specimens 18–50 mm in diameter. Ornate specimens are weakly ornamented by small nodate tubercles on the umbilical shoulder, clavate tubercles that bound a fairly broad, flat venter, and faint arcuate folds near mid-flank. Umbilical tubercles number four or five per half whorl, and ventral clavi number 16–20 per half whorl. Body chambers are fairly stout, round-ventered, smooth, or with just umbilical tubercles. The largest specimen in the New Mexico collection has a diameter of 185 mm at the base of the body chamber. Specimens from the Frontier Formation are much like those from New Mexico. About half are smooth and about half weakly ornamented. The largest specimen at hand has a diameter of about 250 mm at the base of the body chamber.



Text-fig. 12. *Placenticeras pseudoplacenta* Hyatt, 1903. The holotype, USNM 229389a, from the "Colorado Formation" of the Kanab valley, Utah, and inferred to be from the *Prionocyclus hyatti* Zone Tropic Shale. Figure is × 0.9



Text-fig. 13. *Placenticeras pseudoplacenta* Hyatt, 1903. A, the original of Hyatt 1903, pl. 43, figs 7–10; B, fragment of phragmocone showing whorl section. C, the original of Hyatt 1903, pl. 43, figs 3, 4; D, large phragmocone fragment. These, and a number of additional fragments are collectively USNM no. 22344, and from "Colorado group of the upper Kanab valley, Utah." Figures are × 0.95

Coniacian

Zone of *Scaphites preventricosus* – lower part (= *Cremnoceramus deformis erectus* inoceramid Zone)

In this inoceramid zone of early Coniacian age, *Placenticeras* has been found at 20 localities in the Frontier Formation in Wyoming and one locality in the Upton Sandstone Member of the Frontier Formation in northeastern Utah. The largest collection, from USGS Mesozoic locality 23438 from the Wind River Basin of Wyoming, consists of 26 specimens larger than 25 mm in diameter (examples are illustrated in Pl. 2). All have weak concentric folds on the outer part of the flank, where most number 13 per whorl. Fifteen of the specimens lack any tubercles; eight have six to eight small, nodate umbilical tubercles per whorl and 18–24 ventral clavi; three have only small umbilical tubercles. Several of the tuberculate specimens are small microconchs that have diameters of 62–82 mm at the base of the body chambers. Ventral clavi on these specimens disappear on the older half of the body chamber, which then assumes a rounded venter. Sutures are moderately frilled with the first auxiliary larger than the second. This assemblage was described by Kennedy and Cobban (1991, p. 16, pl 1, figs 1–8; pl. 2, figs 2–14; pl. 3 figs 1–6; text-figs 3, 4A), and referred to *Placenticeras kaffrarium* Etheridge, 1904.

Another large collection (USGS 2471) from the Frontier Formation of the Wind River Basin of Wyoming contains 23 specimens 33–100 mm in diameter. Eleven lack tubercles, and the rest have no-

date umbilical tubercles and weak to strong ventral clavi.

Zone of *Scaphites preventricosus* – middle part (= *Cremnoceramus deformis deformis* inoceramid Zone)

Placenticeras is present in this inoceramid zone in 15 collections from Montana, Wyoming, and Utah. The largest collections (USGS localities 6270, 23078, 23938, D7230), from the same stratigraphic position in a small area in central Utah, are from limestone concretions in the Mancos Shale. These collections have 44 fragments of phragmocones more than 25 mm in diameter as well as several small individuals. Of the 44 specimens, 43 are smooth except for 7–9 weak concentric ribs per half whorl. The one ornate specimen is a phragmocone 103 mm in diameter that has in half a whorl four nodate umbilical tubercles.

Zone of *Scaphites ventricosus* (= *Volviceramus involutus* inoceramid Zone)

Localities of *Placenticeras* are scarce as well as specimens in this middle Coniacian zone. Only four localities are known, and each has yielded a single smooth specimen. Two localities are in the Straight Cliffs Formation of southern Utah and two are in the Carter Creek Formation of Gwinn (1961, 1965) in west-central Montana.

Zone of *Scaphites depressus* (= *Magadiceramus subquadratus* inoceramid Zone)

Eighteen localities in Montana, Wyoming, Utah, and New Mexico have yielded *Placenticeras* in this late Coniacian zone. Specimens are not, however, abundant at any locality. The largest collection (USGS D7300), from the Straight Cliffs Formation of southern Utah, consists of five specimens that are smooth except for faint concentric ribs on the outer part of the flanks. Two are microconchs that have a diameter of about 77 mm at the base of the body chamber. Body chambers have narrow rounded venters, and phragmocones have narrow, flat venters. Another collection (USGS D5288) from the Straight Cliffs Formation has four specimens, of which three are smooth and one (a microconch) has nodate umbilical tubercles that arise on the body chamber and rapidly migrate out to the lower part of the flanks.

Santonian

Zone of *Clioscaphites saxitonianus*

Stout trinodose forms came in style in this zone of earliest Santonian age. Stout forms seemed so different from typical oxycones that Johnson (1903, p. 136) proposed his new genus *Stantonoceras* for them. The name has been accepted in full generic rank by some authors (e.g. Wiedmann 1978, p. 667; Summesberger 1979, p. 145) has been regarded as a subgenus of *Placenticeras* by some authors (e. g. Young 1963, p. 62; Cobban1976, p. 123) or has been considered a synonym of *Placenticeras* (e. g. Wolleben 1967, p. 1157; Kennedy and Wright 1983, p. 869).

Placenticeras is present in this zone in at least seven collections from Colorado, Utah, and New Mexico. The only large collection consists of 35 more or less crushed internal moulds from sandstone concretions from the Mancos Shale about 30 m below the base of the Emery Sandstone Member at USGS Mesozoic locality D7235 in central Utah. All are ornate except for four fragments that may be from smooth specimens. Most of the ornamented specimens are microconchs that have wide umbilici and stout body chambers with flattened convergent flanks and broad, flattened to rounded venters. Umbilical tubercles are conspicuous and usually nodate; they number four to six per half whorl and migrate out onto the lower part of the flank on the body chamber. From each tubercle one or two low, broad, faint ribs cross the flanks and rise into nodate lateral tubercles near the ventrolateral shoulder. There are generally nine to eleven lateral tubercles per half whorl. Smaller clavate tubercles lie on the ventrolateral shoulder; these number 17–20 per half whorl. All three rows of tubercles tend to persist to or near the aperture, although on some individuals, the ventral tubercles weaken and disappear on the older half. Microconchs have diameters of 60–100 mm at the base of body chambers. Fragments of three macroconchs have septate whorl heights of as much as 170 mm. These fragments have broad ribs that are accentuated on the outer part of the flanks like those of the large phragmocone from this zone illustrated as *Stantonoceras pseudocostatum* Johnson by Cobban and Scott (1964, p. L15, pl. 8). On the large fragments from locality D7235, the umbilical tubercles, which are located well out on the flanks, become low and bullate. The specimens are much like the holotype of *Stantonoceras costatum* (Johnson 1903, p. 137, pl. 10; pl. 11, fig. 29b, c).

Zone of *Clioscaphites vermiformis*

In the collections from this early Santonian zone *Placenticeras* is present in 15 lots from Montana, Utah, and New Mexico. The largest collection (USGS D3648) consists of 13 specimens from ferrocalcareous concretions in the upper part of the Mancos Shale in north-central New Mexico. All are microconchs that have nodate umbilical tubercles that migrate out to the lower part of

the flank on body chambers. The more robust specimens have nodate outer flank tubercles that bound a flattened venter. In half a whorl there are four to six umbilical tubercles, seven to eleven lateral tubercles, and 16–19 ventral clavi. The ornament is much like that in specimens from the underlying zone.

A collection of 10 specimens (locality D7229) from the Emery Sandstone Member of the Mancos Shale of central Utah is similar to collections from locality D3648 in that all the specimens are small microconchs. These specimens are unusual in that they have low transverse ribs of irregular height on the venter of body chambers.

Zone of *Clioscaphites choteauensis*

Only two collections from the Mancos Shale of north-central New Mexico have *Placenticeras*. Specimens are sparse but include inflated forms like those in the lower zones. (Reeside 1927b describes Santonian *Placenticeras* from the Western Interior; they were not included in Bill's original manuscript, which was based on material in the Denver collections).

Zone of *Desmoscaphites erdmanni*

A few fragments of *Placenticeras* have been found in rocks of this zone at one locality each in Montana, Wyoming, and New Mexico. The largest collection (USGS D3364) has only three specimens; a slender, smooth phragmocone 70 mm in diameter; a moderately stout microconch that has a diameter of about 94 mm at the base of the rounded body chamber and ornament of only nodate umbilical tubercles; and a fragment of a larger robust adult that has only umbilical tubercles and a very broadly rounded body chamber.

Zone of *Desmoscaphites bassleri*

Although *Placenticeras* is present in eight collections from Montana, Wyoming, Utah, and New Mexico in this very late Santonian zone, none of the lots consists of more than two or three specimens. The most instructive lot (USGS 16800) has two microconchs from silty, calcareous concretions in the upper part of the Mancos Shale on the eastern side of the San Juan Basin in northwestern New Mexico. Both specimens have slender inner septate whorls ornamented by nodate umbilical tubercles, crescentic outer flank ribs, and clavi that border a narrow, flat venter. Body chambers differ greatly from the slender inner whorls in their stoutness and very broadly rounded venter. A few widely spaced nodate umbilical tubercles are present on the body chamber as well as weak, nodate ventrolateral tubercles. The specimens are like *Placenticeras newberryi* Hyatt, 1903 (pl. 31, figs 3–5).

Campanian

Zones of *Scaphites hippocrepis* I–III

Sixty collections from this interval have specimens of *Placenticeras*. Specimens from the early part of the interval have both stout and slender forms, but none is as stout as some of those from the older, Santonian zones. A typical collection is that from the zone of *Scaphites hippocrepis* I at USGS locality D3768 (Cobban 1969, pp. 6, 19) in the upper part of the Mancos Shale in north-central New Mexico. The four specimens in the collection include a slender, conspicuously nodate phragmocone typical of *Placenticeras syrtale* (Morton, 1834) (p. 40, pl. 16, fig. 4). The phragmocone has four nodate umbilical tubercles per half whorl, eight nodate outer flank tubercles, and fourteen clavate tubercles that border a narrow, flat venter. The other three specimens are microconchs that have diameters at the base of the body chamber of 82, 84, and 88 mm (rounded). These body chambers are moderately stout with flattened flanks and rounded venters. Two are smooth except for widely spaced umbilical tubercles, and one has, in addition, low, nodate ventrolateral tubercles that are probably a continuation of the outer flank tubercles of the inner whorls. Specimens from the zone of *Scaphites hippocrepis* II (Cobban 1969, p. 6) are more slender. The largest collection (USGS D10826), from silty concretions in the Mancos Shale in north-central New Mexico, has nine specimens of *Placenticeras*, all of which are compressed and trinodose like *Placenticeras syrtale*. Specimens from the zone of *Scaphites hippocrepis* III (Cobban 1969, p. 6) are slender and include small, ornate forms like *Placenticeras syrtale* and large smooth or nearly smooth forms like those of *Placenticeras planum* Hyatt, 1903 (p. 202, pl. 33, figs 2–4; pl. 34, figs 1–3). Body chambers of the large form retain a narrow flat venter to the aperture. (There are additional records in Reeside 1927b and Larson *et al*. 1997.)

Zone of *Baculites* sp. (smooth)

Placenticeras is present in 11 collections from Montana and Wyoming. Specimens are sparse, and no collection has more than two or three. Most are trinodose, like *Placenticeras syrtale*.

Zone of *Baculites* sp. (weak flank ribs)

Placenticeras is present in 31collections from this zone in Wyoming, Utah, and Montana. The largest col-

lection, made by the late James H. Smith of Salt Lake City, Utah, consists of 43 specimens, mostly parts of phragmocones. This collection is from a bed of sandstone in the Black Bute Tongue of the Rock Springs Formation at USGS Mesozoic locality D2571 in southwestern Wyoming (Smith 1961, p. 108; Roehler 1983, measured section 4376). Five fragments seem to be from smooth specimens, and the remainder from ornate specimens. Most of the ornate specimens are like *Placenticeras syrtale*, but some of the more weakly ornamented ones lose the outer flank tubercles. Tubercle counts per half whorl are four for the umbilical ones, nine to ten for the outer flank ones, and 16–19 for the ventrolateral clavi.

Zones of *Baculites obtusus, B. maclearni,* and *B. asperiformis*

In the collection from these three middle Campanian zones, *Placenticeras* is poorly represented by fragments of trinodose and smooth forms. The genus is present in five collections from the zone of *Baculites obtusus* in Wyoming and Colorado. Specimens are present in seven collections from the zone of *Baculites maclearni* in Montana, Wyoming, Utah, and Colorado. Eleven localities of *Placenticeras* are known from the zone of *Baculites asperiformis* in Wyoming, Utah, and Colorado.

Zone of *Baculites perplexus*

This middle Campanian zone is used in a broad sense; it includes the zones of *Baculites perplexus* (early form), *B. gilberti*, and *B. perplexus* (late form) of Gill and Cobban (1966, table 3, pp. A29, A30). Because this broad zone includes as much as 274 m of Pierre Shale and equivalent rocks (Gill and Cobban 1966, p. A41, pl. 2), many collections of fossils have *Placenticeras*. Of the 82 collections with *Placenticeras*, 50 are from Colorado, 24 are from Wyoming, four are from Utah, and two each are from Montana and New Mexico.

Most collections consist of microconchs that have diameters of 66–76 mm at the base of the body chamber. Phragmocones are slender and usually ornamented with four or five nodate umbilical tubercles per half whorl, six to eleven very small, nodate outer flank tubercles, and 16–22 short clavi that bound the narrow, flat venter. Body chambers are moderately stout with broad rounded flanks and narrowly rounded to slightly flattened venters. Umbilical tubercles may persist to the aperture. Lateral and ventral tubercles usually weaken and disappear on the older half of body chambers.The suture is fairly frilled with the first auxiliary lobe much larger than the second.

POSTSCRIPT

Cobban's draft manuscript ends with these observations on the *Placenticeras* of the broad middle Campanian zone of *Baculites perplexus*.

Two later species, originally to be included in the text, but described separately by Kennedy *et al*. in 1996 are *Placenticeras costatum* Hyatt, 1903 (Pl. 1, Figs 1–3, 9–11; Pls 15–17; Pl. 18, Figs 2, 3)), from the upper Middle Campanian zones of *Baculites cuneatus* and *B. reesidei* of Colorado and South Dakota, and *Baculites pingue* Kennedy, Cobban and Landman, 1996 (Pl. 9, Figs 1–6; Pls 10–12; Pl. 18, Fig. 1)), from the zones of *Baculites reduncus* and *B. scotti* in Wyoming and South Dakota.

Placenticeras extend into the lower part of the Upper Campanian. Larson (personal communication, 2016) reports that the highest and youngest species is *Placenticeras costatum*, which extends to the lower half of the *Baculites reesidei Zone*, with *Placenticeras meeki* also extending into that zone but disappearing before *P. costatum*.

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PLATES 1–18

PLATE 1

1-3, 9, 10, 11 – *Placenticeras costatum* Hyatt, 1903. 1–3 – USNM 486620; 9, USNM 486623, from the Pierre Shale, *Baculites cuneatus* Zone, USGS Mesozoic locality D1353, Grand County, Colorado. 10, 11 – USNM 486610, from the Pierre Shale, *Baculites cuneatus* Zone, USGS Mesozoic locality D1785, Grand County, Colorado.

4, 5 – *Placenticeras intercalare* Meek, 1876. USNM 486627, from the Pierre Shale, *Baculites compressus* Zone, USGS Mesozoic locality D1351, Grand County, Colorado.

6-8 – *Placenticeras* sp. juv., USNM 619384, from the Mesaverde Formation, *Didymoceras stevensoni* Zone, USGS Mesozoic locality D1387, Albany County, Wyoming.

Figures 1–5, 9–11 are × 0.9. Figures 6–8 are × 3 approximately; the original specimen is 4.8 mm in diameter

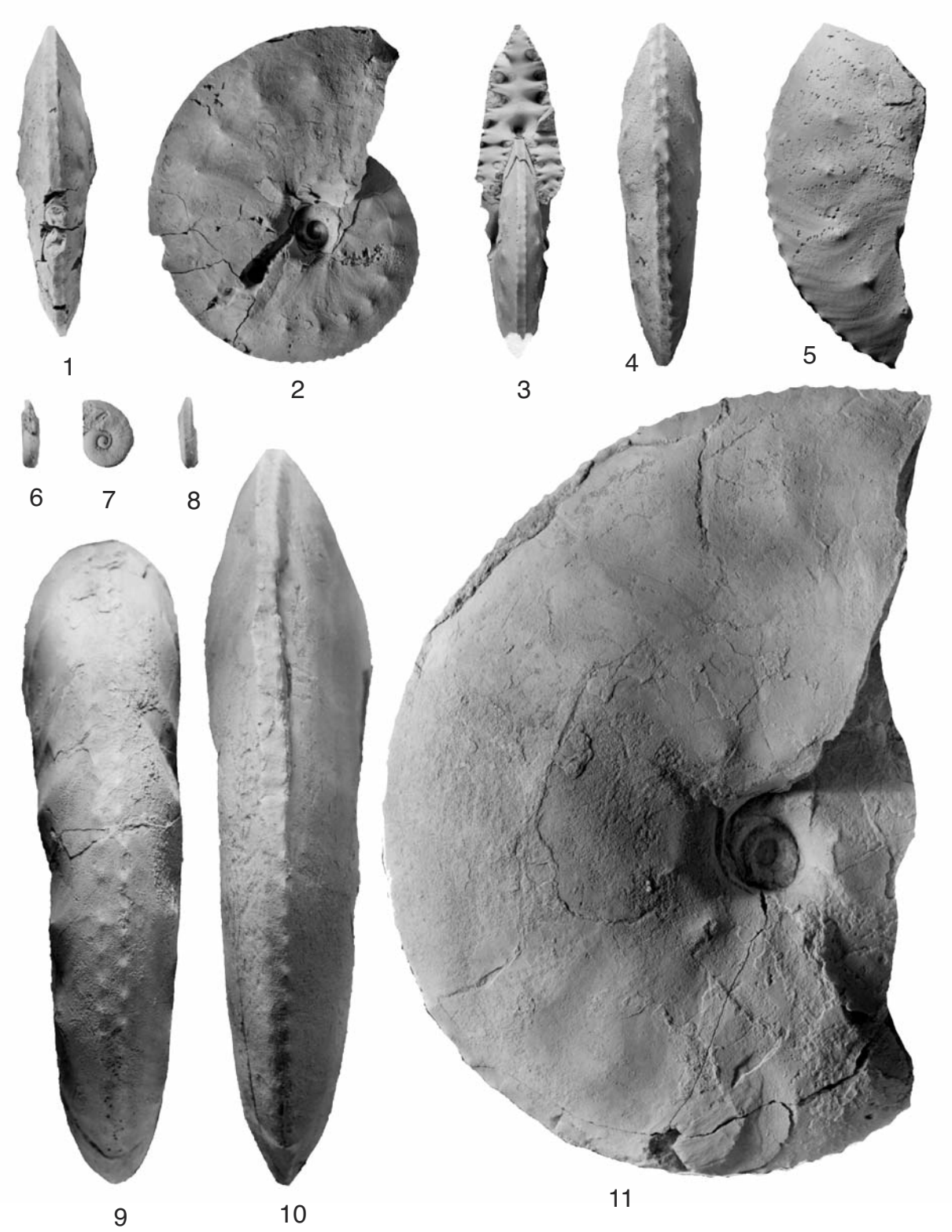

PLATE 2

Placenticeras kaffrarium Etheridge, 1904

1, 2 – USNM 433743; 3, 6 – USNM 433744; 4, 5 – USNM 433741; 7, 8 – USNM 433748, all from the Frontier Formation, *Cremnoceramus inconstans* Zone, USGS Mesozoic locality 23438, Fremont County, Wyoming.

Figures are × 1

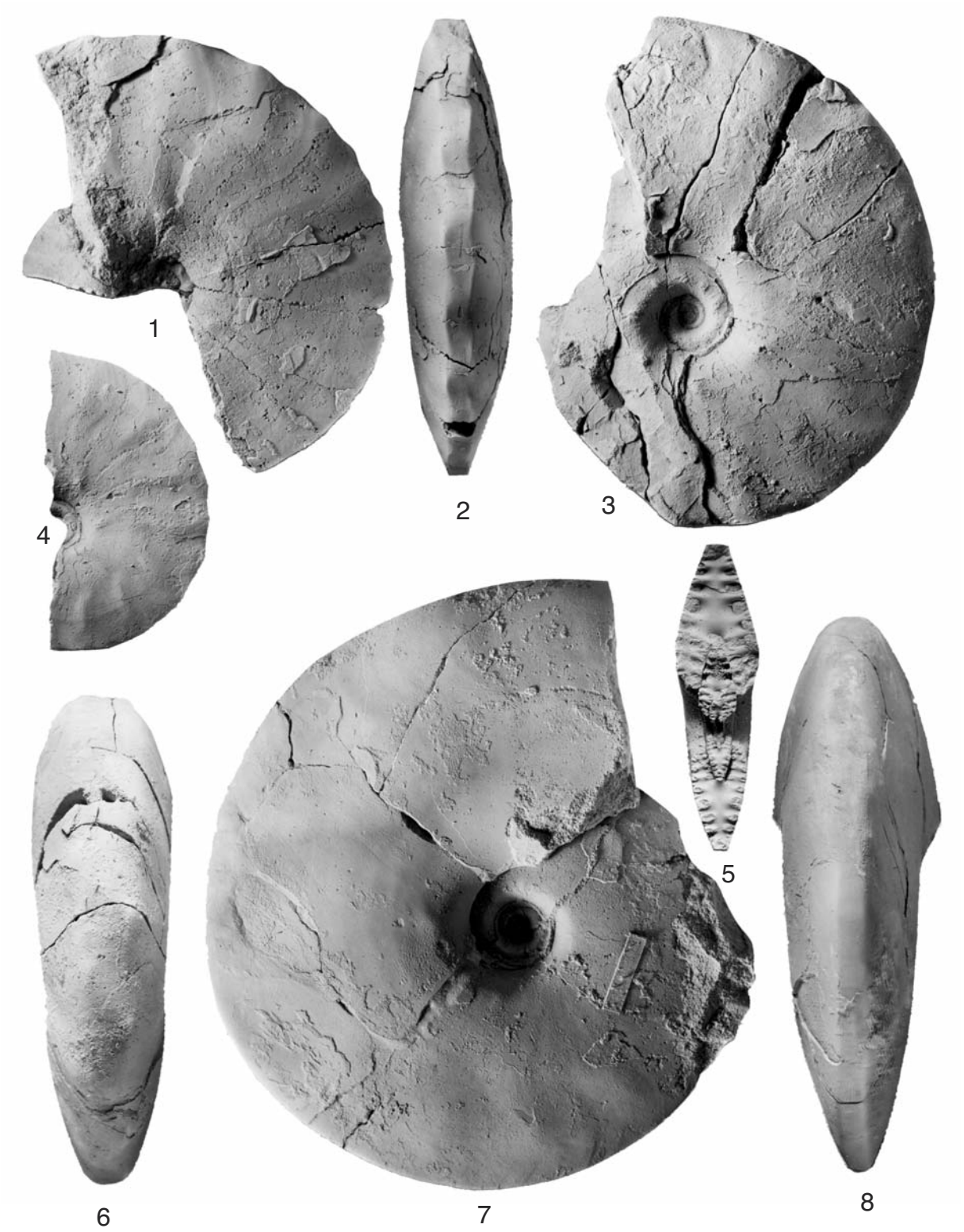

PLATE 3

1-5, 8-11 – *Placenticeras cumminsi* Cragin, 1893. 1 – USNM 619385 (formerly Conlin collection 10205), from the Britton Formation, *Sciponoceras gracile* Zone, of northeast Texas. 2, 3 – USNM 619386 (formerly Conlin collection 8456), from the Britton Formation, *Sciponoceras gracile* Zone, on Hackberry Creek, 6 miles northwest of the centre of Irving, Dallas County, Texas. 4, 5 – USNM 619387, from the Britton Formation, *Sciponoceras gracile* Zone, USGS Mesozoic locality D97, California Crossing, north-facing bluff on right bank of Elm Fork of Trinity River at Missouri-Kansas-TX of TX R.R. bridge 10 miles NW of Dallas, Dallas County, Texas. 8 – USNM 619388 (formerly Conlin collection 366), from the Britton Formation, *Sciponoceras gracile* Zone, on the east bank of a stream 2.5 miles south of Britton on the old Britton-Midlothian Road, Ellis County, Texas. 9-11 – USNM 411451, from the Britton Formation, *Sciponoceras gracile* Zone, on the first creek northeast of Britton, 2.5 miles on farm road, Ellis County, Texas.

6, 7 – *Placenticeras stantoni* Hyatt, 1903, USNM 619389, from the Tropic Shale, *Mammites nodosoides* Zone, USGS Mesozoic locality D11706, Cibollo County, New Mexico.

Figures are × 0.9

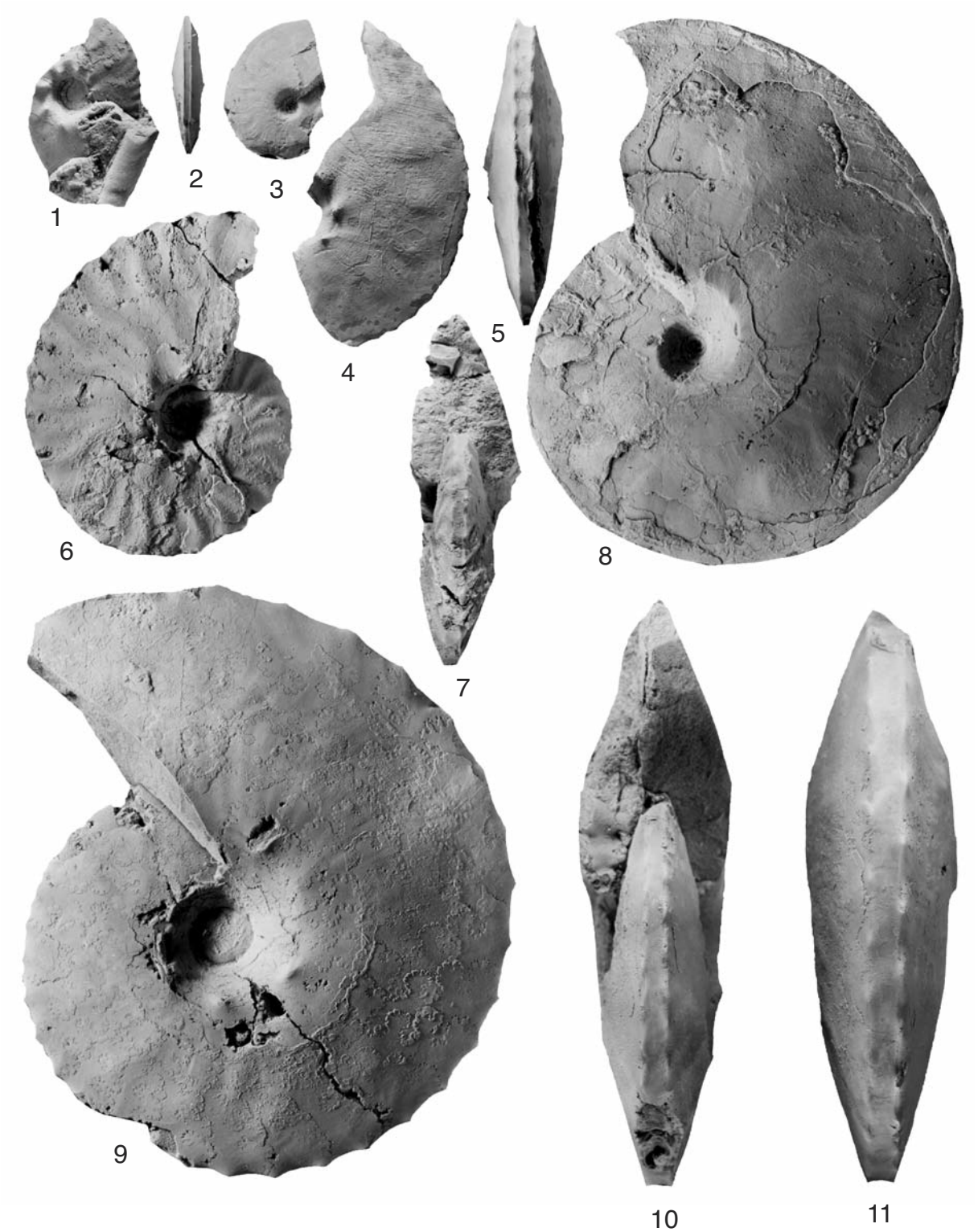

PLATE 4

Placenticeras cumminsi Cragin, 1893

1, 2 – USNM 619390 (formerly Conlin collection 477), from the Britton Formation, *Sciponoceras gracile* Zone, on the first creek northeast of Britton, 2.5 miles on farm road, Ellis County, Texas. 3, 4 – USNM 619391, from the Tropic Shale, *Sciponoceras gracile* Zone, USGS Mesozoic locality 24526, Kane County, Utah. 5, 6 – USNM 619342, from the Britton Formation, *Sciponoceras gracile* Zone, USGS Mesozoic locality 22609, Highway 287, 9 miles southeast of Mansfield, Dallas County, Texas.

Figures are × 0.9

PLATE 5

Placenticeras cumminsi Cragin, 1893, USNM 411455, from Britton Formation, *Scipono-ceras gracile* Zone, 1.5 to 1.8 miles southeast of Britton, Ellis County, Texas. An adult macroconch, 195 mm in diameter (see also Plate 13, figs 4, 5).

Figure is × 1

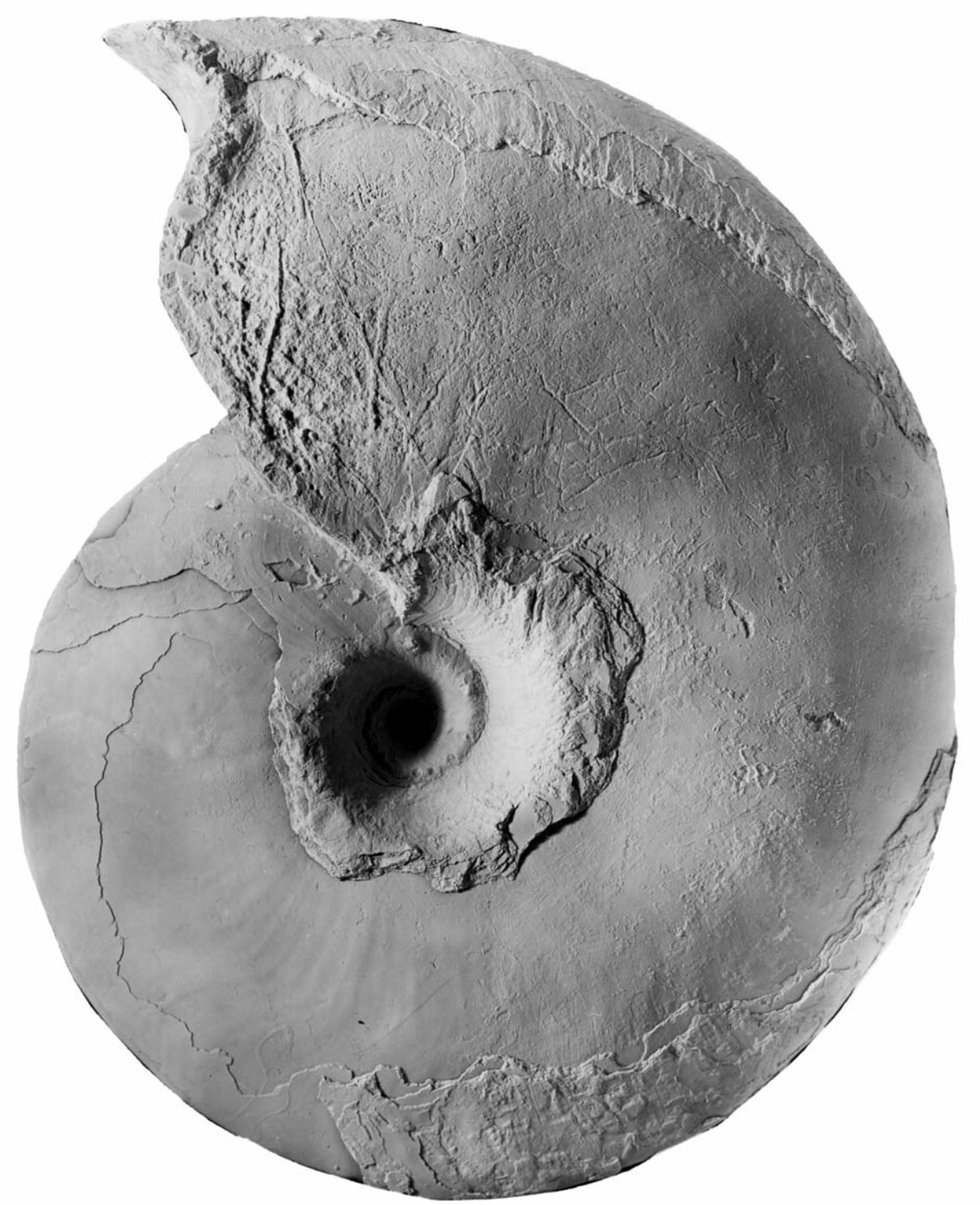

PLATE 6

1-4 – *Placenticeras pseudoplacenta* Hyatt, 1903. 1, 2 – USNM 61934; 3, 4 – USNM 61935, both from Carlile Shale, upper party of Blue Hill Member, *Prionocyclus hyatti* Zone, USGS Mesozoic locality 21838, Mitchell County, Kansas.

5-10 – *Placenticeras costatum* Hyatt, 1903. 5-7 – USNM 61936, from the Mesaverde Formation, *Baculites reduncus* Zone, USGS Mesozoic locality D1392, Albany County, Wyoming 8-10 – USNM 619397, from the Pierre Shale, *Exiteloceras jennneyi* Zone, USGS Mesozoic locality D2854, Larimer County, Colorado.

Figures are × 0.9

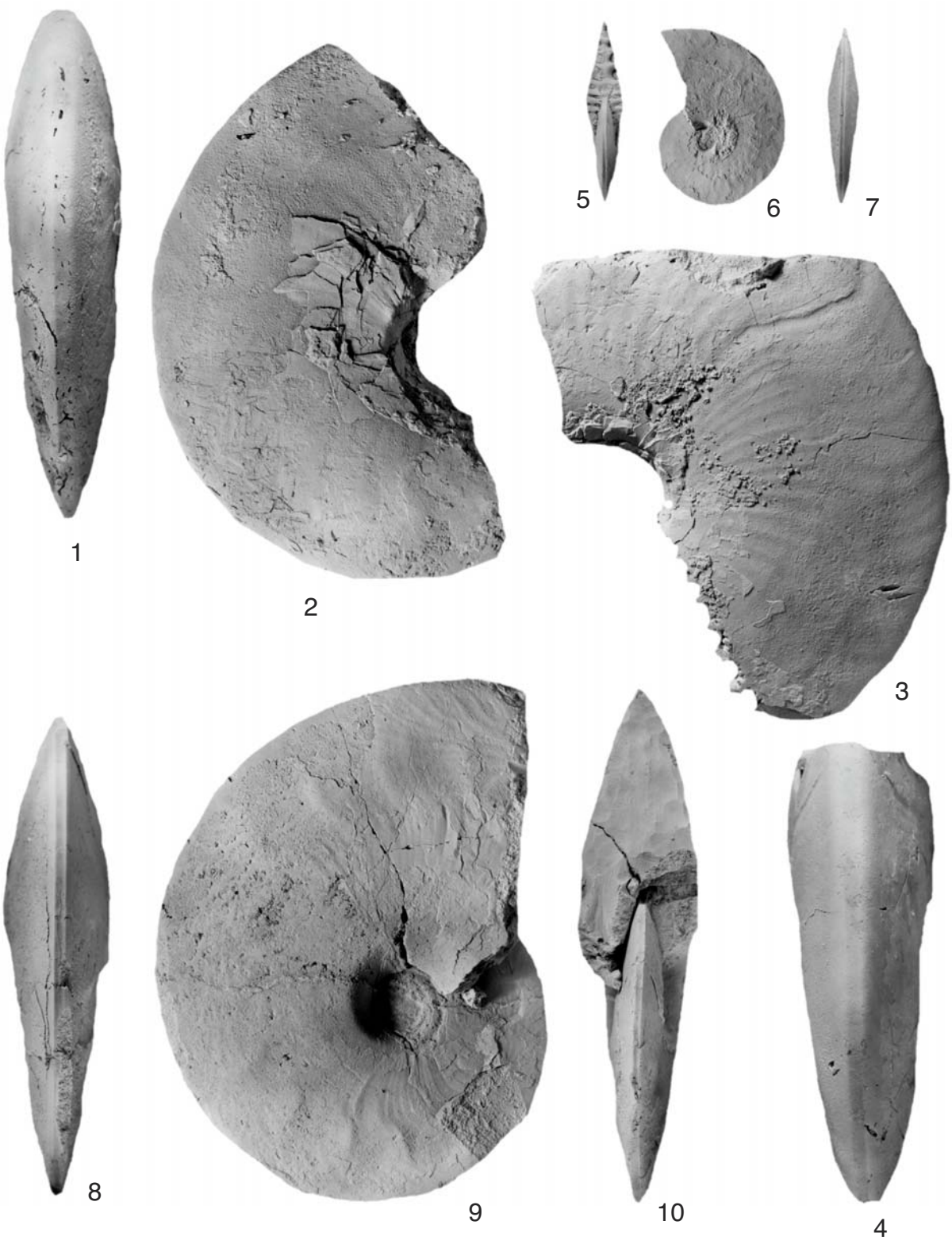

PLATE 7

1-3 – *Placenticeras intercalare* Hyatt, 1903, USNM 486628, from the Pierre Shale, *Baculites compressus* Zone, USGS Mesozoic locality D1349, Grand County, Colorado.

4-7 – *Placenticeras costatum* Hyatt, 1903. 4 – USNM 486621, from the Pierre Shale, *Baculites cuneatus* Zone, USGS Mesozoic locality D1353, Grand County, Colorado. 5-7 – USNM 486613, from USGS Mesozoic locality D1785, Pierre Shale, *Baculites cuneatus* Zone, Grand County, Colorado.

Figures are × 0.9

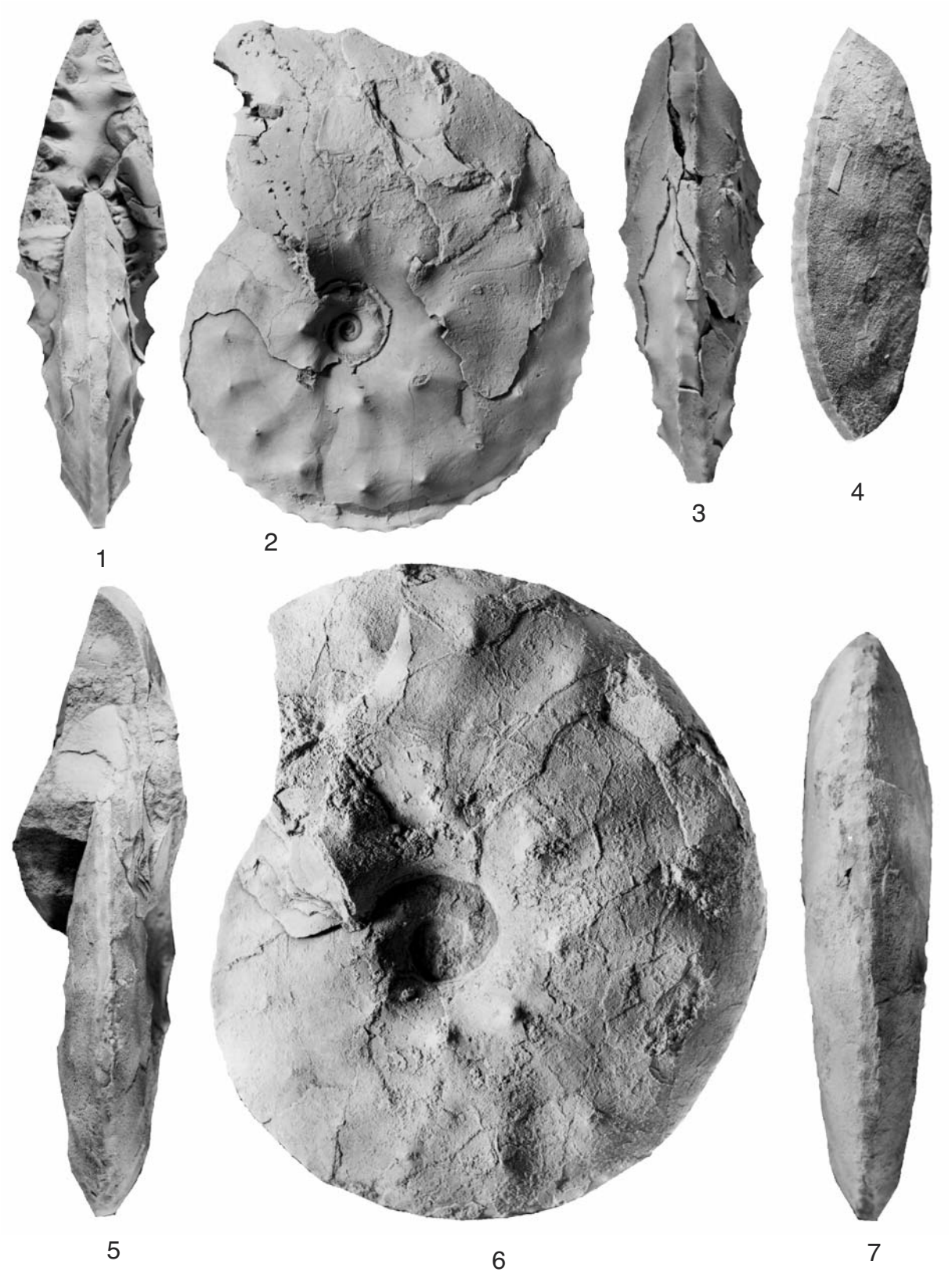

PLATE 8

1-3, 5-7 – *Placenticeras* syrtale (Morton, 1834); 1-3 – USNM 619398, from the Hosta Tongue of the Point Lookout Sandstone, Santonian, at USGS Mesozoic locality D9374, McKinley County, New Mexico. 5, 6 – USNM 619399 from the Cody Shale, *Scaphites hippocrepis* I Zone, USGS Mesozoic locality 23113, Fremont County, Wyoming. 7 – USNM 619400, from the Blair Formation, *Scaphites hippocrepis* III Zone, USGS Mesozoic locality D2221, Sweetwater County, Wyoming.

4, 8, 9 – *Placenticeras* sp.; USNM 619401, from the Steele-Mesaverde transition, *Baculites perplexus* Zone, USGS Mesozoic locality D2998, Carbon County, Wyoming.

Figures are × 0.9

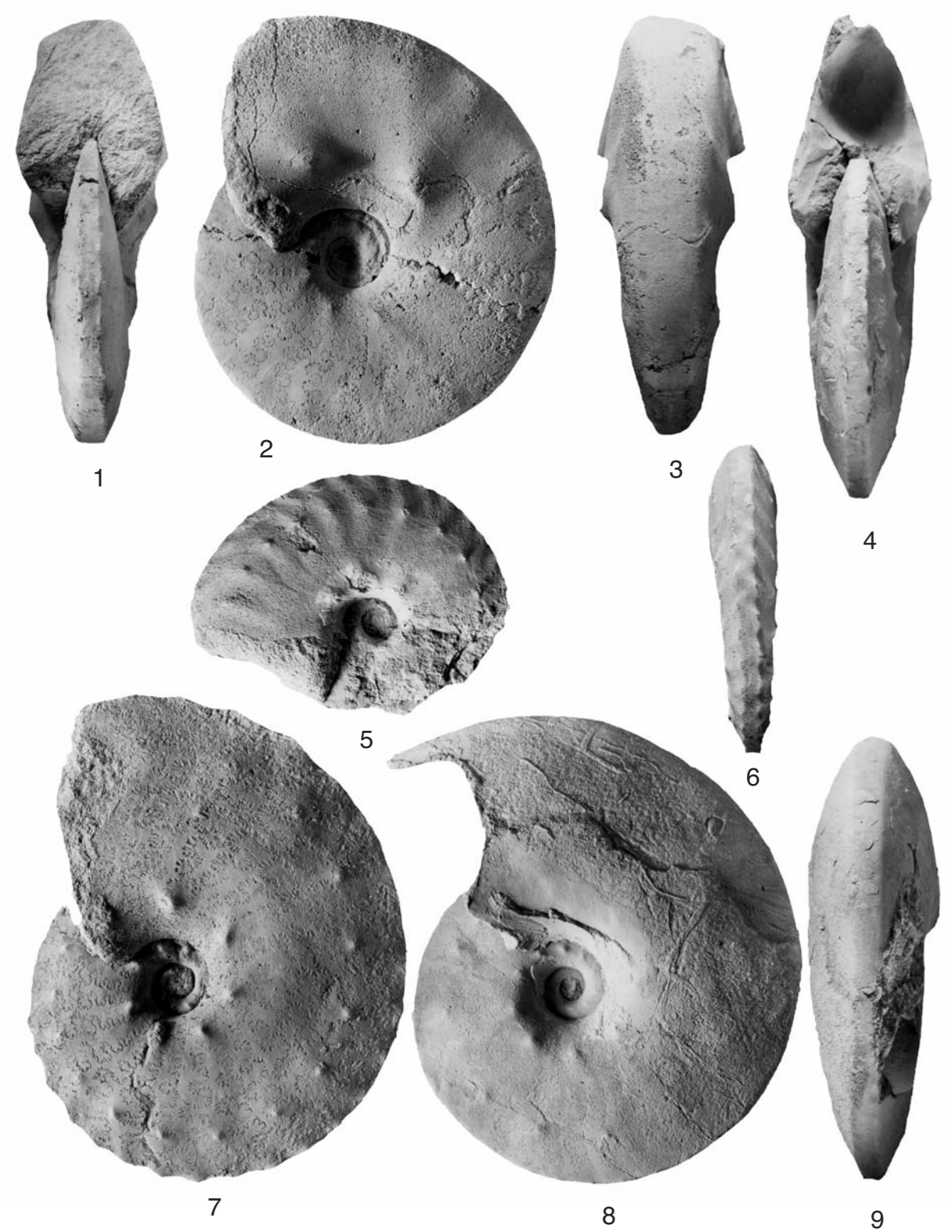

PLATE 9

Placenticeras pingue Kennedy, Cobban and Landman, 1996

1, 2 – USNM 619402; 3, 4 – USNM 619403, from the Mesaverde Formation (Rock River Formation), *Baculites reduncus* Zone, USGS Mesozoic locality D1392, Albany County, Wyoming; 5, 6 – USNM 619404, from USGS Mesozoic locality D1393, Mesaverde Formation (Rock River Formation), *Baculites reduncus* Zone, Albany County, Wyoming.

Figures are × 0.9

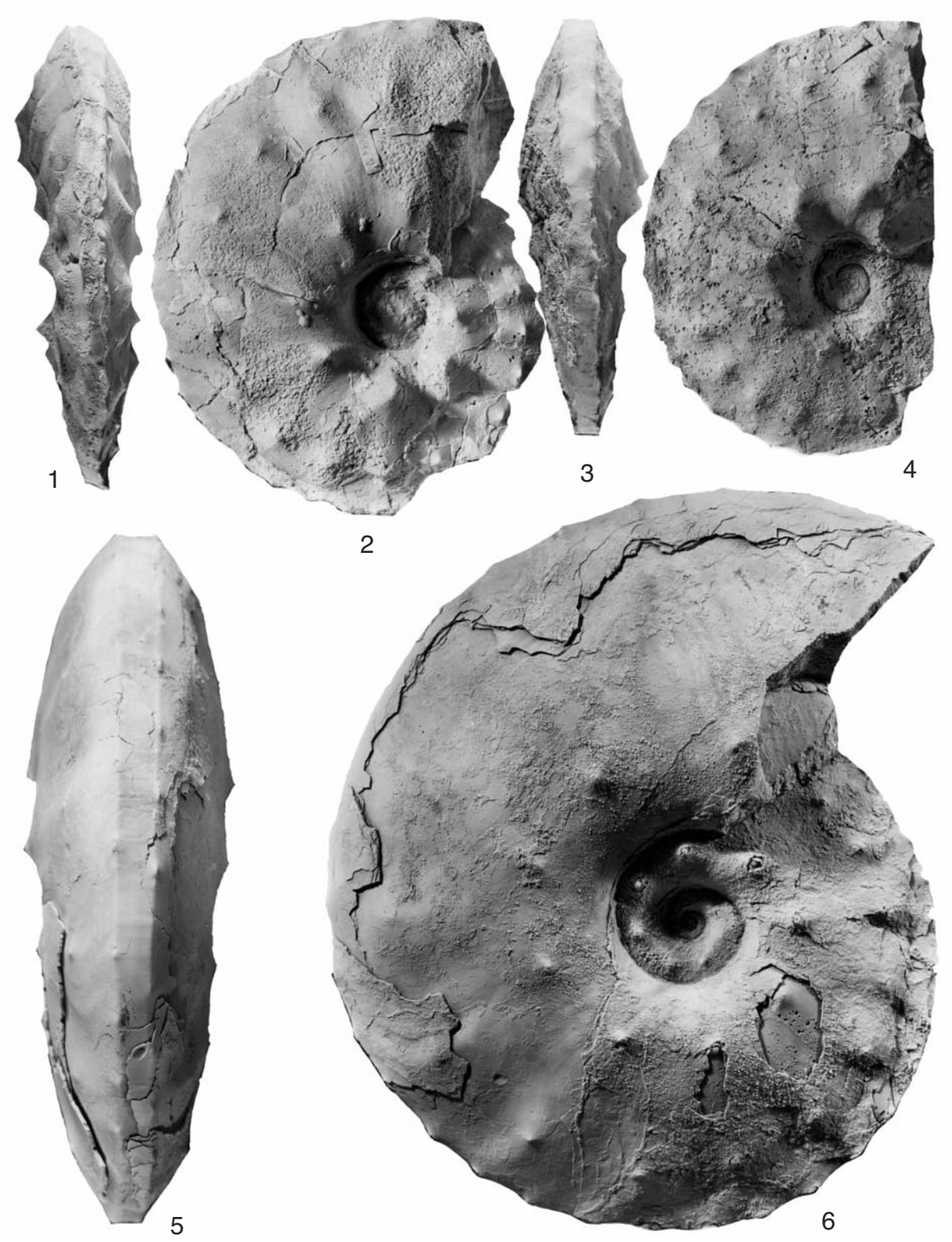

PLATE 10

Placenticeras pingue Kennedy, Cobban and Landman, 1996. USNM 619405, from the Rock River Formation, *Baculites reduncus* Zone, USGS Mesozoic locality 12844, Albany County, Wyoming.

Figures are × 0.9. The original is 185 mm in diameter

PLATE 11

Placenticeras pingue Kennedy, Cobban and Landman, 1996.The holotype, USNM 486629, from the Rock River Formation, *Baculites reduncus* Zone, USGS Mesozoic locality D1393, Albany County, Wyoming.

Figure is × 0.7; the original is 275 mm in diameter

PLATE 12

Placenticeras pingue Kennedy, Cobban and Landman, 1996. Paratype USNM 486630, from the Pierre Shale, *Baculites scotti* Zone, USGS Mesozoic locality D1411, Fall River County, South Dakota.

Figures are × 0.9

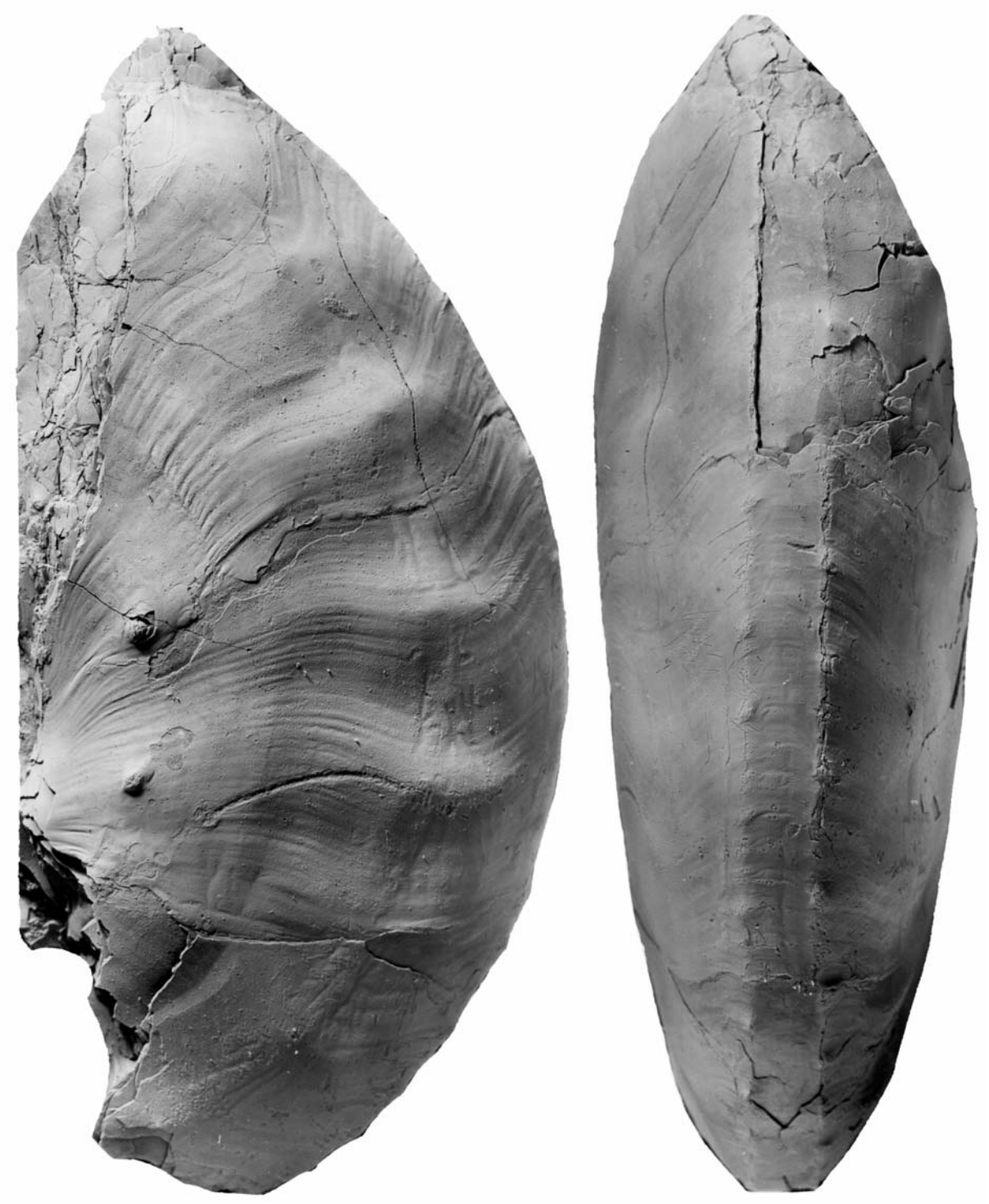

PLATE 13

1-3 – *Placenticeras costatum* Hyatt, 1903. USNM 619406, from the Pierre Shale, *Baculites compressus* Zone, USGS Mesozoic locality D8092, Grand County, Colorado.

4, 5 – *Placenticeras cumminsi* Cragin, 1893, from the Upper Cenomanian *Sciponoceras gracile* Zone Britton Formation, 1.5 to 1.8 miles southeast of Britton, Ellis County, Texas. An adult macroconch, 195 mm in diameter (see also Plate 5).

Figures are × 0.9

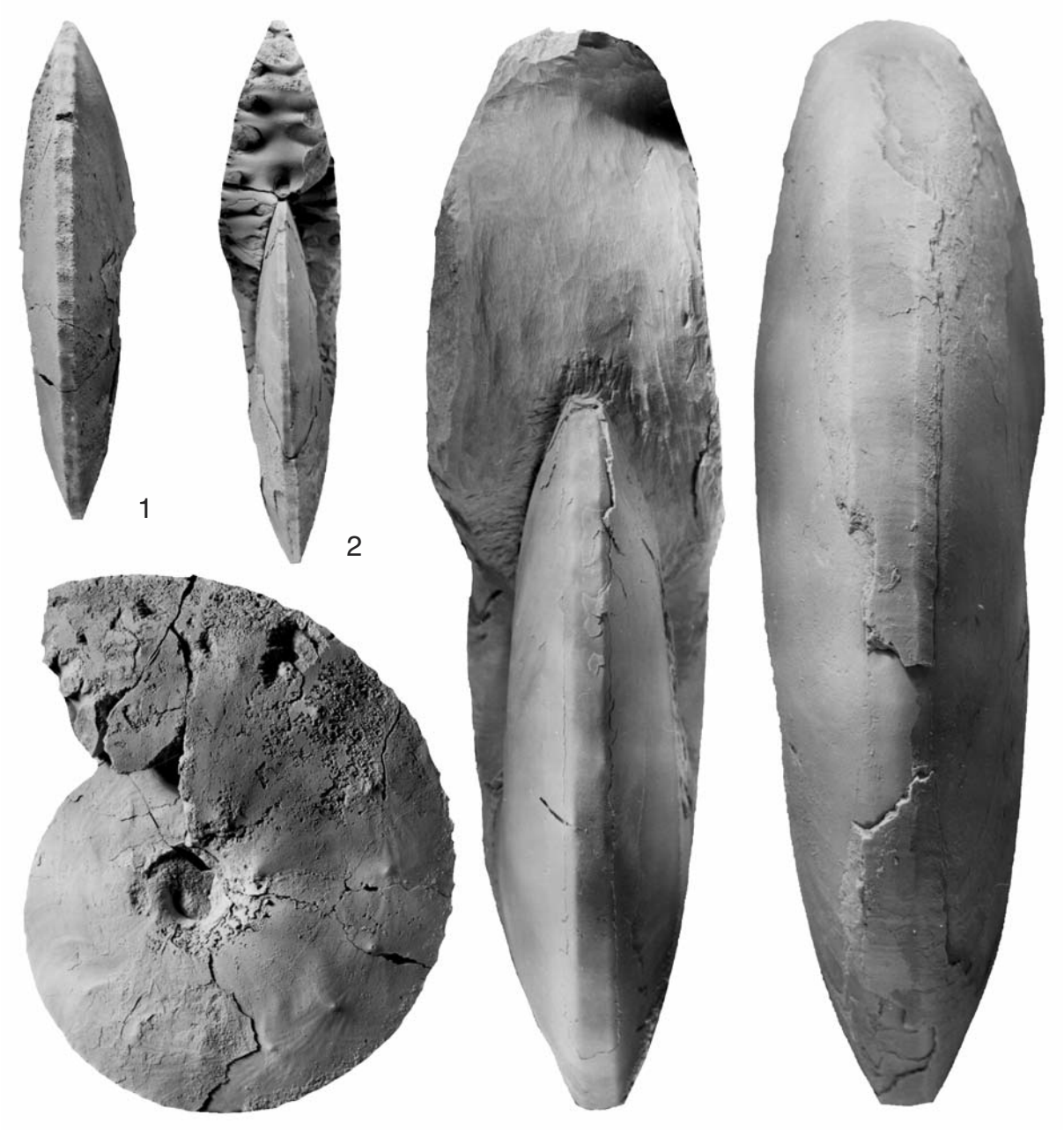

PLATE 14

1, 2 – *Placenticeras intercalare* Meek, 1876, USNM 619393, from the Pierre Shale, *Exiteloceras jenneyi* Zone, USGS Mesozoic locality D2584, Larimer County, Colorado.

3 – *Placenticeras costatum* Hyatt, 1903, USNM 486623 from the Pierre Shale, *Baculites cuneatus* Zone, USGS Mesozoic locality D1353, Grand County, Colorado.

Figures are × 0.8

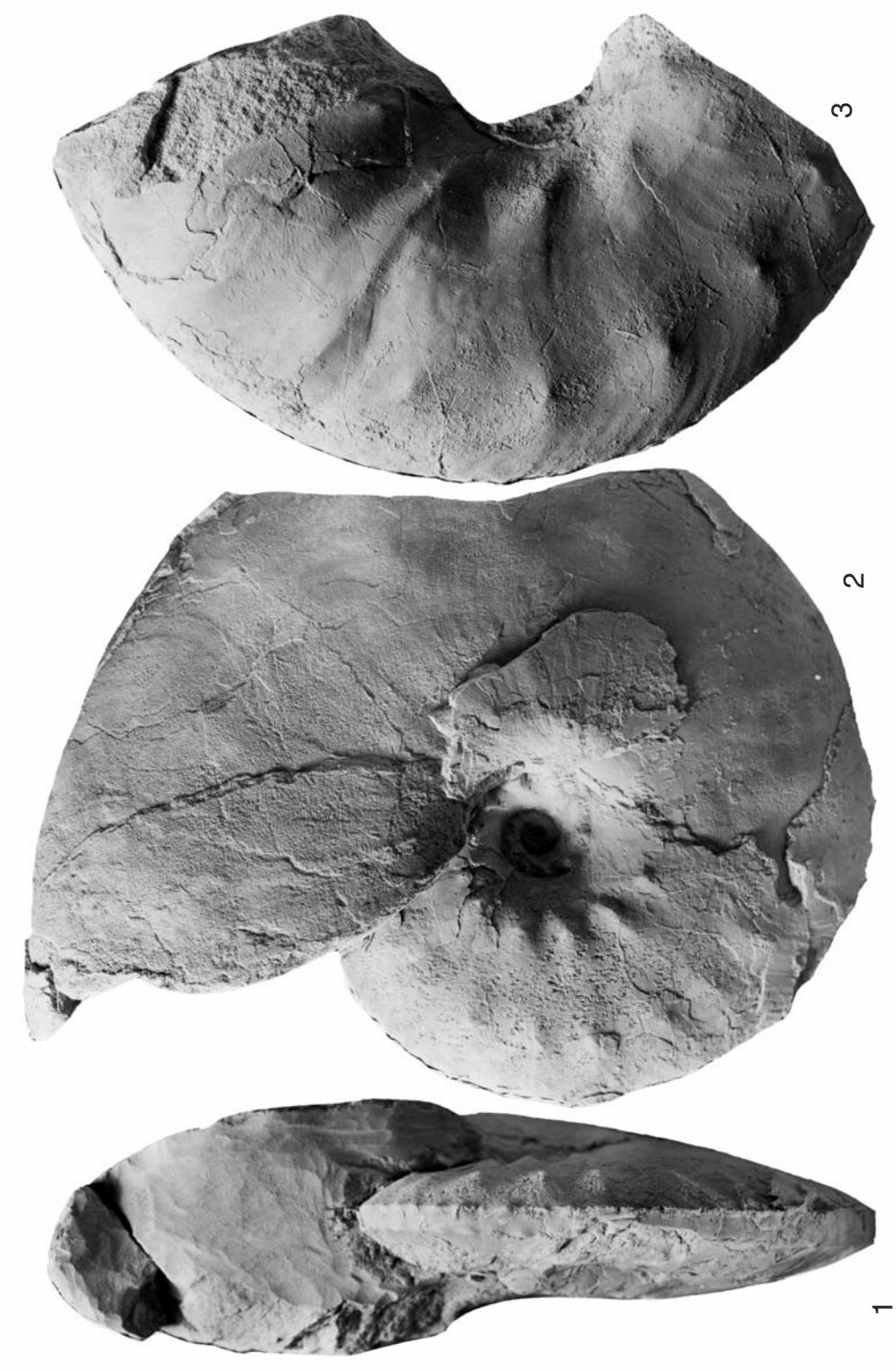

PLATE 15

Placenticeras costatum Hyatt, 1903. USNM 486612, from the Pierre Shale, *Baculites cuneatus* Zone, USGS Mesozoic locality D1785, Grand County, Colorado.

Figures are × 0.85

PLATE 16

1-6 – *Placenticeras costatum* Hyatt, 1903. 1-3 – USNM 486611, from the Pierre Shale, *Baculites cuneatus* Zone, USGS Mesozoic locality D1785, Grand County, Colorado. 4-6 – USNM 486617, from the Pierre Shale, *Baculites cuneatus* Zone, locality D1353, Grand County, Colorado.

Figures are × 0.9

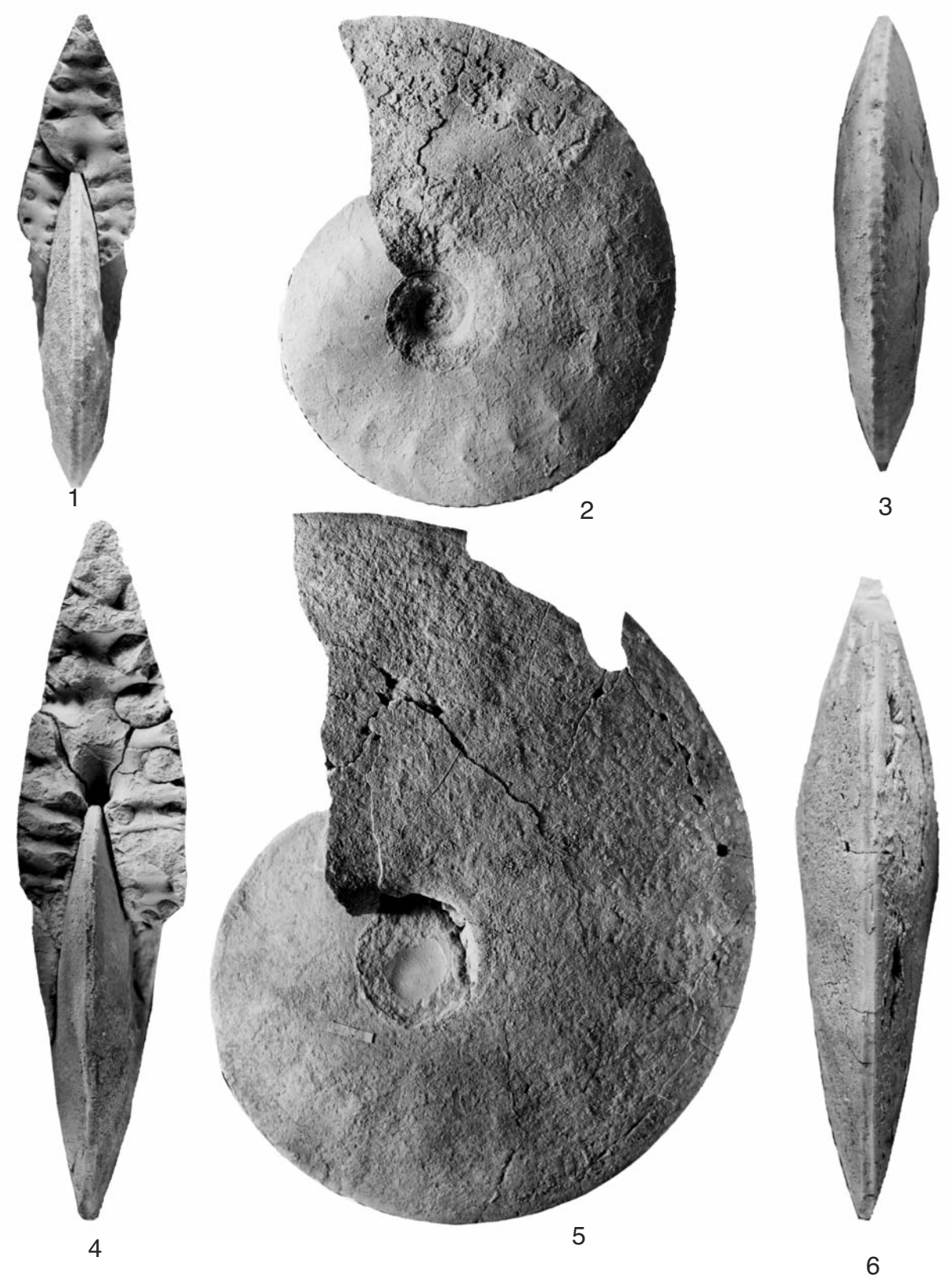

PLATE 17

Placenticeras costatum Hyatt, 1893. USNM 486615, from the Pierre Shale, *Baculites cuneatus* Zone, locality D1353, Grand County, Colorado (see also Plate 18, figs 2, 3).

Figure is × 0.8

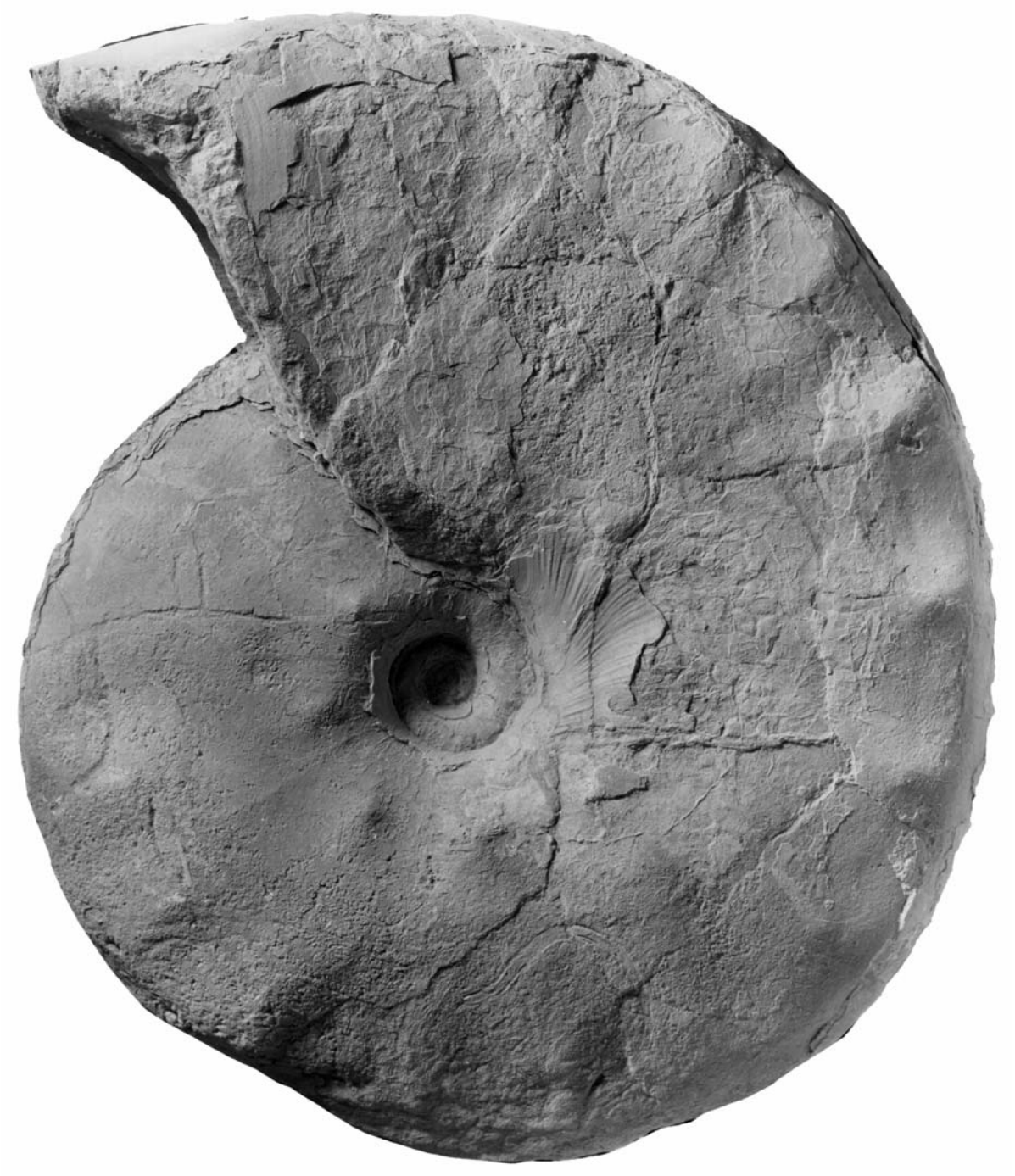

PLATE 18

1 – *Placenticeras pingue* Kennedy, Cobban and Landman 1996. Ventral view of the holotype, USNM 486628, from the Mesaverde Formation (Rock River Formation), *Baculites reduncus* Zone, USGS Mesozoic locality D1393, Albany County, Wyoming (see also Plate 11). Figure is × 0.67; the original is 275 mm in diameter.

2, 3 – *Placenticeras costatum* Hyatt, 1893. Ventral and apertural views of USNM 486615, from the Pierre Shale, *Baculites cuneatus* Zone, locality D1353, Grand County, Colorado (see also Plate 17). Figures are × 0.85; the original is 220 mm in diameter.

1 2 3