The Upper Cretaceous Dimorphic Pachydiscid Ammonite *Menuites* in the Western Interior of the United States

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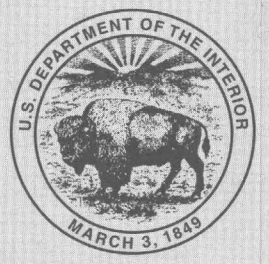

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By William A. Cobban *and* W. James Kennedy

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Descriptions and illustrations of two important species of Menuites

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THE UPPER CRETACEOUS DIMORPHIC PACHYDISCID AMMONITE *MENUITES* IN THE WESTERN INTERIOR OF THE UNITED STATES

By William A. Cobban[1] *and* W. James Kennedy[2]

ABSTRACT

Highly dimorphic pachydiscid ammonites are fairly abundant in Montana, South Dakota, Wyoming, and Colorado, and a few specimens are known from Utah and New Mexico. Two chronologic species are recognized, each represented by small adults (microconchs) and large adults (macroconchs). Microconchs have been assigned to *Menuites* Spath, 1922, whereas macroconchs have usually been assigned to *Anapachydiscus* Yabe and Shimizu, 1926. Both forms are considered *Menuites* in the present report. *Menuites portlocki complexus* (Hall and Meek, 1856), the older of the two species, occurs in the zones of *Baculites gregoryensis* and *B. reduncus*. The younger species, from the zone of *B. scotti,* is designated as *Menuites oralensis* n. sp.

INTRODUCTION

Hall and Meek (1856, p. 394, pl. 4, figs. 1a–f) described the new species *Ammonites complexus* based on two small pyritized ammonites from the "Great Bend on the Missouri. Lower part of division No. 4." The specimens, both juvenile whorls, came from rocks now assigned to the Gregory Member of the Pierre Shale in south-central South Dakota. Most of the member lies in the ammonite zone of *Baculites gregoryensis*, which is in the upper part of the middle Campanian in the Western Interior sense and in the middle part of the upper Campanian in the European sense. Subsequent collecting from the Gregory Member has shown that Hall and Meek's (1856) specimens are examples of the innermost whorls of a dimorphic pachydiscid ammonite that occurs as a moderately sized form (microconch) having ventrolateral tubercles on the adult body chamber and as a much larger form (macroconch) lacking ventrolateral tubercles. Both forms occur together, and they cannot be differentiated by their innermost whorls alone. Adults of the microconch have all the characteristics of the genus *Menuites* Spath (1922, p. 123, type species by original designation *Ammonites Menu* Forbes, 1846, p. 111, pl. 10, fig. 1). Some specimens from the Western Interior have been assigned to *Menuites*? n. sp. (for example, Gill and Cobban, 1966, p. A56). The macroconch form has all of the characteristics of the genus *Anapachydiscus* Yabe and Shimizu (1926). The type species of *Anapachydiscus* is, by original designation, *Pachydiscus* (*Parapachydiscus*) *fascicostatus* Yabe (Yabe and Shimizu, 1921, p. 57, pl. 8, fig. 5; pl. 9, figs. 2–5). Hall and Meek's (1856) *Ammonites complexus* has been assigned to *Pachydiscus* (Grabau and Shimer, 1910), *Parapachydiscus* (Dane and others, 1937), and *Anapachydiscus* with a query (for example, Scott, 1963, 1969; Scott and Cobban, 1965) or without a query (for example, Schultz, 1965; Izett and others, 1971).

The same co-occurrence of small, tuberculate *Menuites* (described as *M. sanadai* Matsumoto, 1984, p. 17, pl. 5, fig. 1; text fig. 5) with the much larger type species of *Anapachydiscus* was described by Matsumoto (1984, p. 18), who noted that "M. *sanadai* and *A. fascicostatus* could be interpreted as constituting a dimorphic pair." It seems likely that the small tuberculate Pachydiscidae are all microconchs of larger nontuberculate forms, but not all dimorphic pairs can be linked together at this time (Kennedy and Summesberger, 1984, p. 158; and Kennedy, 1986, p. 30; provide additional discussion). The type species of *Menuites*, for example, is yet to be linked to a macroconch. In spite of this, the case for dimorphism between *Menuites* and *Anapachydiscus* is strong, and we regard the former as having priority over the latter, although it will continue to be necessary to use *Anapachydiscus* for those species of which a *Menuites* microconch has not yet been recognized (even though the nomenclature is unsatisfactory).

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LOCALITIES OF *MENUITES*

Localities where *Menuites* were collected in the Western Interior are shown in figure 1. The locality numbers, names of collectors, years of collection, geographic descriptions, and stratigraphic assignments of U.S. Geological Survey (USGS) Mesozoic localities are given in table 1.

SYSTEMATIC DESCRIPTIONS

The following prefixes are used to indicate the repositories of the specimens mentioned in the text:

USNM	(National Museum of Natural History, Washington, D.C.)
AMNH	(American Museum of Natural History, New York, N.Y.)
IGS	(Institute of Geological Sciences, Keyworth, Nottinghamshire, England)
BHI	(Black Hills Institute of Geological Research, Hill City, S. Dak.)

All dimensions are in millimeters. Umbilical diameter, whorl breadth, and whorl height are also given as ratios to the shell diameter (in parentheses immediately following the dimension). Rib and tubercle counts are given for one-half whorl in order to utilize specimens of less than a full whorl.

Family PACHYDISCIDAE Spath, 1922
Genus *MENUITES* Spath, 1922
(also *Besairieites* Collignon, 1931; and *Anapachydiscus* Yabe and Shimizu, 1926)

Type species.—By original designation, *Ammonites Menu* Forbes (1846, p. 111, pl. 10, fig. 1).

***Menuites portlocki* (Sharpe, 1855) *complexus* (Hall and Meek, 1856)**

Plates 1–3; plate 4, figures 4–10; plate 5, figures 1, 5–7; plate 6, figures 9–15; plate 7, figure 5; plate 8, figures 3, 4; text figure 2

1856	*Ammonites complexus* Hall and Meek, p. 394, pl. 4, figs. 1a–f.
1861	*Ammonites complexis* [sic] Hall and Meek. Gabb, p. 65 (part).
1864	*Ammonites complexus* Hall and Meek. Meek, p. 24.
1876	*Ammonites complexus* Hall and Meek. Meek, p. 447, pl. 24, figs. 1a–c.
1893	*Ammonites complexus* Hall and Meek. Boyle, p. 29.
?1907	*Pachydiscus complexus* (Hall and Meek)? Weller, p. 819, pl. 101, figs. 3, 4.
1910	*Pachydiscus complexus* (Hall and Meek). Grabau and Shimer, p. 174.
1916	*Pachydiscus complexus* (Hall and Meek). Gardner, p. 378.
1925	*Ammonites complexus* Hall and Meek. Diener, p. 25.
1937	*Parapachydiscus complexus* (Hall and Meek). Dane, Pierce, and Reeside, p. 230.
1952	*Pachydiscus complexus* (Hall and Meek). Cobban and Reeside, p. 1020.
1959	*Anapachydiscus* [*complexus* Hall and Meek]. Scott and Cobban, p. 126.
?1962	*Menuites* aff. *M. complexus* (Hall and Meek). Reeside, p. 122, pl. 69, figs. 1–6.
1963	*Anapachydiscus*? *complexus* (Hall and Meek). Scott, p. 101 (part).
1963	*Menuites*? n. sp. Scott, p. 101 (part).
1965	*Anapachydiscus complexus* (Hall and Meek). Schultz, p. B12.
1970	*Anapachydiscus* n. sp. Gill, Merewether, and Cobban, p. 23.
1970	*Menuites* n. sp. Gill, Merewether, and Cobban, p. 23.
1975	*Anapachydiscus complexus* (Hall and Meek). Scott and Cobban, listed on map.
1975	*Menuites* n. sp. Scott and Cobban, listed on map.
1976	*Anapachydiscus complexus* (Hall and Meek). Kennedy and Cobban, pl. 7, fig. 3.

Types.—Hall and Meek (1856, p. 349) based their new species on two small septate coils of which the larger one, AMNH 9531/1 (Hall and Meek, 1856, pl. 4, figs. 1b, c, e, f), is herein designated the lectotype. As they described it, both specimens are from the "Great Bend on the Missouri" in south-central South Dakota. They are probably from Lyman County, where the Campanian *Baculites gregoryensis* zone of the Gregory Member of the Pierre Shale contains numerous small marcasitic coils of *Menuites* like those of Hall and Meek.

Diagnosis.—Dimorphic pachydiscid ammonites characterized by strong, widely spaced ribs on robust inner whorls. Ribs mostly disappear on body chambers of microconchs but reappear strongly at the aperture. Umbilical tubercles are present on the phragmocone and body chambers of microconchs, as are large, usually nodal,

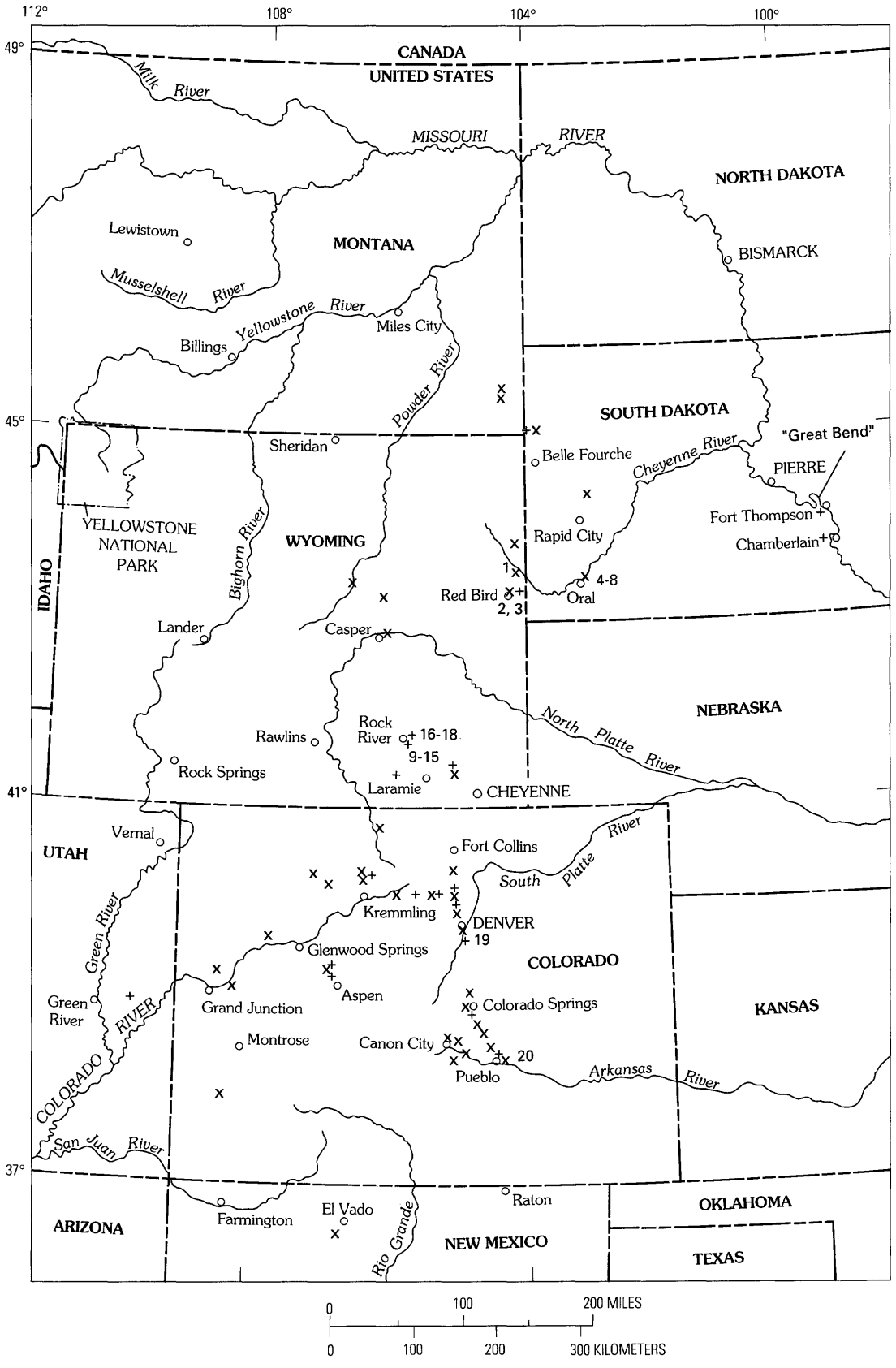

Figure 1. Index map of part of the Western Interior of the United States showing localities of *Menuites portlocki complexus* (Hall and Meek, 1856) (indicated by pluses) and *M. oralensis* n. sp. (indicated by crosses). Numbers refer to USGS Mesozoic localities listed in table 1. Unnumbered symbols are localities from private collections.

Table 1. Localities where *Menuites* were collected.

[Prefix D indicates Denver Mesozoic locality numbers; all others are Washington, D.C., Mesozoic locality numbers]

Locality (fig. 1)	USGS Mesozoic locality	Collector, year of collection, description of locality, and stratigraphic assignment
1	D13160	Harold Mendryk, 1972. Bluff along Cheyenne River in the SW¼ sec. 21, T. 40 N., R. 61 W., Niobrara County, Wyo. Pierre Shale, from limestone concretions in the Red Bird Silty Member.
2	D1922	H.A. Tourtelot and others, 1958. Near Red Bird in the NE¼ sec. 23, T. 38 N., R. 62 W., Niobrara County, Wyo. Pierre Shale, from silty, calcareous concretions 12 m below the top of the Red Bird Silty Member.
3	D1923	H.A. Tourtelot and others, 1958. Near Red Bird in the NW¼ sec. 13, T. 38 N., R. 62 W., Niobrara County, Wyo. Pierre Shale, same stratigraphic position as D1922 (loc. 2).
4	D901	W.A. Cobban, 1956. South side of Beaver Creek, near Cheyenne River in the SW¼ NE¼ and SE¼NW¼ sec. 22, T. 7 S., R. 7 E., Fall River County, S. Dak. Pierre Shale, from gray limestone concretions in the Red Bird Silty Member.
5	D903	W.A. Cobban, 1956. North side of Cheyenne River in the NW¼NW¼ sec. 23, T. 7 S., R. 7 E., Fall River County, S. Dak. Pierre Shale, from gray limestone concretions in the Red Bird Silty Member.
6	D1411	G.R. Scott and W.A. Cobban, 1957. Cheyenne River bluff 1.75 km northeast of Oral in the NW¼NW¼ sec. 26, T. 7 S., R. 7 E., Fall River County, S. Dak. Pierre Shale, from gray limestone concretions in the Red Bird Silty Member.
7	10385	T.W. Stanton, 1920. Mouth of Beaver Creek on Cheyenne River, Fall River County, S. Dak. Pierre Shale.
8	D13159	G.A. Bishop, 1968. NE¼ sec. 22, T. 7 S., R. 7 E., Fall River County, S. Dak. Pierre Shale.
9	12844	T.W. Stanton, 1924. "2½ to 4 miles east of Rock River, Wyo." [Rock River Formation].
10	12848	J.B. Reeside, Jr., and T.W. Stanton, 1924. About 8 km east of Rock River, Albany County, Wyo. "Mesaverde Formation" [Rock River Formation].
11	22935	J.B. Reeside, Jr., H.R. Christner, and W.A. Cobban, 1950. About 5.6 km east of Rock River, Albany County, Wyo. Rock River Formation.
12	D357	G. R. Scott and W.A. Cobban, 1955. NW¼ sec. 9, T. 20 N., R. 76 W., Albany County, Wyo. Rock River Formation.
13	D1392	G.R. Scott and W.A. Cobban, 1957. NE¼ sec. 9, T. 20 N., R. 76 W., Albany County, Wyo. Rock River Formation, from sandstone concretions 187–196 m above base of formation.
14	D1400	G.R. Scott and W.A. Cobban, 1957. West slope of hill 3.2 km southeast of Rock River in the SE¼NE¼ and NE¼SE¼ sec. 8, T. 20 N., R. 76 W., Albany County, Wyo. Rock River Formation, from silty calcareous concretions 157–165 m above base of formation.
15	D13161	Edward Shibata, 1968. Southeast of Rock River in the E½E½ sec. 8 and N½ sec. 9, T. 20 N., R. 76 W., Albany County, Wyo. Rock River Formation.
16	1725	T.W. Stanton, 1896. "Two to three miles northwest of Harper, Albany County, Wyo." [probably from the Rock River Formation in the S½ sec. 32, T. 21 N., R. 75 W., Albany County, Wyo.].
17	D1082	J.F. Clement and H.B. Fields, 1956. East of Rock River near the center of the south line of T. 21 N., R. 75 W., Albany County, Wyo. "Mesaverde Formation [Rock River Formation] 290–329 m below base of Pine Ridge Sandstone."
18	D3394	A.D. Zapp, 1961. SE¼NE¼ sec. 33, T. 21 N., R. 75 W., Albany County, Wyo. "About 435 feet above base of Mesaverde Formation" [Rock River Formation].
19	D297	G.R. Scott, 1955. North of Kassler in the SW¼SE¼ sec. 15, T. 6 S., R. 69 W., Jefferson County, Colo. Pierre Shale, from Hygiene Sandstone Member.
20	D715	G.R. Scott and W.A. Cobban, 1955. Arroyo in the SE¼SE¼ sec. 15, NE¼NE¼ sec. 22, and NW¼ sec. 23, T. 20 S., R. 64 W., Pueblo County, Colo. Pierre Shale, from ironstone concretions in the upper part of Rusty zone of Gilbert (1897), about 255 m above base of Pierre Shale.

moderately closely spaced ventrolateral tubercles on the adult body chambers. Inner whorls of macroconchs are like those of microconchs, but adults lack ventrolateral tubercles and terminal ribs. Adult macroconchs have inflated whorls with well-rounded flanks.

Description.—The lectotype (Hall and Meek, 1856, pl. 4, figs. 1b, c, e, f) consists of parts of two whorls. The outer, larger part represents one-third of a stout whorl 36 mm in length that has a breadth of 26.5 mm. Its cross section has a steep umbilical wall, a narrowly rounded umbilical shoulder, a very broadly rounded flank, and a well-rounded venter. Ornament consists of strong, flat-topped umbilical bullae that probably numbered 4 per one-half whorl, and narrow, rectiradiate ribs that numbered 12 or 13 per one-half whorl. Ribs arise either from the

umbilical bullae or from low on the flank between them. Suture is highly denticulate (Hall and Meek, 1856, pl. 4, figs. 1e, f). The paralectotype is a juvenile that includes half a whorl of body chamber. The specimen has a diameter of 17.0 mm and a breadth of 12.3 mm.

A large collection of 227 specimens, all juveniles or parts of or complete inner whorls preserved like those of Hall and Meek, were made available for study by the Black Hills Institute of Geological Research. The specimens were collected by Ed Cole of Delta, Utah, from the *Baculites gregoryensis* zone of the Gregory Member of the Pierre Shale at Fort Thompson just below the "Great Bend of the Missouri River" (fig. 1). Whorls less than 3.7 mm in diameter are broader than they are high and lack ornament. Weak constrictions that begin at the umbilical shoulder and cross the flank and venter with a slight forward arching arise at a diameter of 3.7–4.3 mm and number about three per whorl. They are usually bounded by weak ribs of which the adapical one may be the highest. These constrictions disappear at a diameter of 5.3–6.7 mm. Whorls then remain smooth until reaching a diameter of 7.5–10.3 mm, when tubercles arise on the umbilical shoulder. The umbilical tubercles, which number four to six per one-half whorl, are bullate at first, but at a diameter of 14 mm they may become flat-topped where they probably formed the bases of hollow spines. Rectiradiate to slightly prorsiradiate, straight, narrow ribs arise from the umbilical tubercles or intercalate between them at a diameter of 10–20 mm. The ribs are widely spaced (8–16 per one-half whorl), are much narrower than the interspaces, and cross the venter with a slight forward bending. The largest specimen in the BHI collection is part of a microconch that may have had a diameter of about 65 mm. At this size, ribbing declines and conspicuous, large, nodal ventrolateral tubercles arise. Dimensions, ratios, and node and rib counts of 18 well-preserved small specimens from the Gregory Member of the Pierre Shale are shown in table 2.

A few large, incomplete macroconchs have been found in the Chamberlain-Fort Thompson area in south-central South Dakota. Two phragmocones from this region in the collections of the Black Hills Institute of Geological Research merit description. Both have the venter and one

Table 2. Dimensions and features of *Menuites portlocki complexus* from the *Baculites gregoryensis* zone of the Pierre Shale near Fort Thompson, S. Dak.

[Abbreviations of features: D, shell diameter; U, umbilical diameter; Wb, whorl breadth; Wh, whorl height. Quantities in parentheses are ratios of measurements to shell diameter; leaders (....), no measurement]

Specimen		D	U	Wb	Wh	Wb:Wh	Umbilical nodes per half whorl	Ribs per half whorl
USNM	456636	21.8	5.0 (0.23)	15.0 (0.69)	11.4 (0.52)	1.32	6	13
	456637	22.7	5.2 (0.23)	15.7 (0.69)	11.0 (0.48)	1.43	6	14
	456638	29.9	6.2 (0.21)	18.3 (0.61)	16.5 (0.55)	1.11	6	14
	456639	34.4	7.2 (0.21)	22.5 (0.65)	16.7 (0.49)	1.35	6	12
	456640	25.5	5.3 (0.21)	18.2 (0.71)	12.6 (0.49)	1.44	6	13
	456641	27.5	6.9 (0.25)	21.3 (0.77)	13.4 (0.49)	1.59	6	13
	456642	31.1	7.1 (0.23)	19.3 (0.62)	15.2 (0.49)	1.27	8	16
	456643	33.4	6.3 (0.19)	21.6 (0.65)	16.5 (0.49)	1.31	7	16
	456644	31.6	7.7 (0.24)	21.8 (0.69)	....	....	6	15
	456645	33.3	6.8 (0.20)	21.4 (0.64)	16.6 (0.50)	1.29	7	14
	456646	32.3	5.6 (0.17)	21.3 (0.66)	16.6 (0.51)	1.28	7	15
	456647	32.5	8.3 (0.26)	20.5 (0.63)	15.9 (0.49)	1.29	6	11
BHI	2070	32.4	5.7 (0.18)	21.0 (0.65)	14.9 (0.46)	1.41	5	12
	2071	33.1	7.1 (0.21)	22.4 (0.68)	16.5 (0.50)	1.36	4	8
	2072	24.7	5.8 (0.23)	18.1 (0.73)	11.9 (0.48)	1.52	5	10
	2073	28.0	6.4 (0.23)	18.2 (0.65)	14.4 (0.51)	1.26	6	14
	2074	21.3	5.4 (0.25)	14.7 (0.69)	10.2 (0.48)	....	5	....
	2075	36.0	8.7 (0.24)	23.2 (0.64)	18.2 (0.51)	1.27	6	10

flank very well preserved, but the other flank is incomplete or somewhat crushed. BHI 2113 has a diameter of 193 mm, an umbilicus of 46.5 mm (0.24), a whorl breadth of about 122 mm (0.63), a whorl height of 85 mm (0.44), and a whorl breadth-to-height ratio (Wb:Wh) of 1.44. Umbilical bullae are present on all visible whorls, with 11 on the outer whorl. Other ornament is lacking on the well-rounded flanks and venter. BHI 2114 has a diameter of 183 mm, an umbilicus of 42.5 mm (0.23), whorl breadth of about 98 mm (0.54), a whorl height of 80 mm (0.44), and a Wb:Wh of 1.23. Flanks and venter are well rounded, and ornament consists only of 12 lengthy umbilical bullae on the outer whorl.

Although the Gregory Member of the Pierre Shale in south-central South Dakota contains numerous juveniles and inner whorls of *M. portlocki complexus* but no complete adults, the Rock River Formation in southeastern Wyoming contains good examples of adult specimens. The best collections come from outcrops a few kilometers southeast of Rock River (fig. 1, locs. 9–18).

Eleven microconchs are present in the collections from the Rock River area. Their phragmocones are coarsely ribbed like those on comparable-sized whorls from the Gregory Member of the Pierre Shale of South Dakota. Umbilical tubercles on the Rock River phragmocones are bullate and number five or six per one-half whorl. Strong, rectiradiate to slightly prorsiradiate ribs, 8–11 per one-half whorl, arise in pairs from the umbilical bullae or singly from low on the flank between them. Body chambers of the microconchs begin at diameters from 37.6 to 62.0 mm with most in the 52- to 55-mm range. Ribs weaken greatly near the end of the phragmocone, and most disappear on the older part of the body chamber. Umbilical bullae weaken but persist onto the body chamber, where they migrate out to the lower part of the flank. Ventrolateral tubercles arise rather abruptly at a diameter of 51–69 mm either near the end of the phragmocone or on the basal part of the body chamber. The first pair of tubercles is usually low and bullate, but the rest are large and nodal. Most specimens have only four pairs of tubercles, which are either matched (pl. 1, fig. 8) or alternate (pl. 6, fig. 14) or both. Weak looped ribs may connect the ventrolateral and umbilical tubercles (pl. 1, fig. 10). On some specimens, the broad space on the flank and venter that separates the sets of tubercles is either devoid of ribs (pl. 1, figs. 9, 10) or has a few barely detectable ribs. Ribbing rejuvenates near the aperture, where two or three narrow ribs arise from umbilical bullae, cross the flank rectiradially, and then bend forward slightly and cross the venter in a broad convexity (pl. 7, fig. 5). One or two weak secondary ribs may separate the primary ribs. Dimensions, ratios, and numbers of ribs and umbilical tubercles for 19 microconchs and macroconchs from Rock River are given in table 3.

Macroconchs are much more numerous than microconchs in the collections from the Rock River area. About 35 of the macroconchs are suitable for measurements. Innermost whorls are robust and are broader than they are high; the greatest breadth is at the umbilical shoulder. The umbilicus is moderately deep and has a narrowly rounded wall and shoulder. Flanks and venter are broadly rounded. Ribbing on the innermost whorls is coarse like that of comparable-sized microconchs, and most specimens have 10–12 ribs per one-half whorl. Umbilical bullae, which number five or six per one-half whorl, are usually flat-topped (pl. 6, fig. 10) and are probably the bases of hollow spines. Some individuals have both flat-topped and sharp umbilical bullae (pl. 6, fig. 13). On larger whorls, ribbing weakens and disappears at a diameter of 80–100 mm (pl. 2, figs. 4, 5; pl. 3; pl. 5, figs. 5–7). Umbilical bullae gradually weaken as the shell enlarges, and they usually disappear at a diameter of 100–150 mm. They are rejuvenated, however, on the largest shells. The largest specimen, USNM 456667 (fig. 1, loc. 9), is 360 mm in diameter and has an umbilical diameter of 100 mm (0.28). Its body chamber, which occupies three-fourths of a whorl, has a diameter of 205 mm at its base. Seven umbilical bullae are present on the last one-half whorl. Part of the outer whorl of another large specimen, USNM 456669 (fig. 1, loc. 10), which is of comparable size, has a whorl breadth of 124 mm and a whorl height of 116 mm (Wb:Wh=1.07) at the base of the body chamber. Ornament is absent except for faint rectiradiate bullae on the lower part of the flank. A smaller macroconch, USNM 456670 (fig. 1, loc. 10), has a diameter of 157.0 mm at the base of the body chamber, an umbilical diameter of 37.7 mm (0.24), a whorl breadth of 97.0 mm (0.62), a whorl height of 72.0 mm (0.46), and a Wb:Wh ratio of 1.35. Weak ribs present on the last part of the phragmocone become weaker and disappear on the older one-quarter whorl of the body chamber. Umbilical bullae, numbering six per one-half whorl, persist on the body chamber.

A small, nearly complete macroconch (USNM 456668) from USGS Mesozoic locality 1725 (fig. 1, loc. 16) shows the growth stages of the outer whorls of the phragmocone and body chamber. The specimen has a maximum diameter of 185.0 mm, a large umbilical diameter of 51.2 mm (0.28), a whorl breadth of 93.6 mm (0.51), a whorl height of 58.0 mm (0.31), and a Wb:Wh ratio of 1.61. The phragmocone has a diameter of 125.0 mm at the larger end, an umbilical diameter of 30.7 mm (0.25), a whorl breadth of 70.4 mm (0.56), a whorl height of 58.3 mm (0.47), and a Wb:Wh ratio of 1.21. Ribs are strong, narrow, rectiradiate to slightly prorsiradiate, and number about 11 per one-half whorl to a diameter of about 75 mm, where they greatly weaken. Out to this diameter, the ribs begin in pairs from prominent umbilical bullae or singly from between them. There are five bullae per one-half whorl. At a diameter of 80–90 mm, ribs have

Table 3. Dimensions and features of *Menuites portlocki complexus* from the *Baculites reduncus* zone of the Rock River Formation near Rock River, Wyo.

[Abbreviations of features: D, shell diameter; U, umbilical diameter; Wb, whorl breadth; Wh, whorl height. Quantities in parentheses are ratios of measurements to shell diameter; query (?), identification uncertain; leaders (....), no measurement]

USNM Specimen	D	U	Wb	Wh	Wb:Wh	Umbilical nodes per half whorl	Ribs per half whorl	Macroconch (M) or microconch (m)
456648	21.4	5.3 (0.25)	15.3 (0.71)	11.5 (0.54)	1.33	6	14	?
456649	48.7	10.3 (0.21)	30.3 (0.62)	22.2 (0.46)	1.36	5	13	M(?)
456650	59.2	14.0 (0.24)	36.8 (0.62)	28.4 (0.48)	1.30	6	11	m
456651	53.7	11.6 (0.22)	33.6 (0.63)	24.5 (0.46)	1.37	5	10	M
456652	60.3	14.5 (0.24)	38.0 (0.63)	28.3 (0.47)	1.34	6	16	M
456653	65.3	14.3 (0.22)	40.5 (0.62)	32.8 (0.50)	1.23	6	13	M
456654	63.9	13.6 (0.21)	47.2 (0.74)	31.6 (0.49)	1.49	5	14	M
456655	68.6	15.2 (0.22)	....	....	....	6	9	m
456656	71.0	17.1 (0.24)	44.4 (0.63)	33.7 (0.47)	1.32	5	10	M
456657	76.5	17.0 (0.22)	45.3 (0.59)	37.7 (0.49)	1.20	6	14	M
456658	80.9	19.7 (0.24)	38.5 (0.48)	37.0 (0.46)	1.04	6	8	m
456659	81.3	19.8 (0.24)	42.4 (0.52)	39.3 (0.48)	1.08	5	....	m
456660	80.7	20.1 (0.25)	40.2 (0.50)	34.3 (0.43)	1.17	5	13	M
456661	87.2	20.8 (0.24)	51.9 (0.60)	39.7 (0.46)	1.31	5	11	M
456662	110.3	27.6 (0.25)	54.3 (0.49)	48.8 (0.44)	1.11	7	....	m
456663	103.8	25.0 (0.24)	57.8 (0.56)	47.4 (0.46)	1.22	6	0	M
456664	88.2	20.8 (0.24)	56.6 (0.64)	41.4 (0.47)	1.37	5	15	M
456665	138.0	32.5 (0.24)	83.2 (0.60)	66.1 (0.48)	1.26	5	11	M
456666	196.0	49.0 (0.25)	....	....	....	0	0	M

disappeared and the umbilical bullae have weakened. All ornament is absent on the body chamber, which occupies half a whorl.

The suture of *M. portlocki complexus* is deeply incised and has a broad external lobe, a smaller bifid lateral lobe with a very narrow stem, and a smaller bifid umbilical lobe (fig. 2). Hall and Meek (1856, pl. 4, figs. 1d–f) illustrated a juvenile suture and parts of an adult suture. Meek (1876, pl. 24, fig. 1c) also showed the suture of a larger juvenile.

Discussion.—Menuites portlocki complexus (Hall and Meek, 1856) is regarded herein as a geographic subspecies of *M. portlocki* (Sharpe, 1855, p. 30, pl. 13, figs. 2, 3). Sharpe described and illustrated a juvenile coil and most of an adult from the "Chalk of Tamlaght, in the county of Derry" in northern Ireland. The adult, designated the lectotype by Wright and Wright (1951, p. 36), is IGS 37247, the original of Sharpe (1855, pl. 13, fig. 2). The juvenile coil is a paralectotype, the original of Sharpe (1855, pl. 13, fig. 3). Both are from the European upper Campanian *Belemnitella mucronata* zone. The juvenile coil is about 51.0 mm in diameter and has an umbilical diameter of 14.4 mm (0.28), a whorl breadth of 32.8 mm (0.64), a whorl height of 24.0 mm (0.47), and a Wb:Wh ratio of 1.37 (measurements from a plaster cast). It differs from *M. portlocki complexus* chiefly in being more evolute (umbilical diameter ratio of 0.28, compared to 0.17–0.25 for *M. portlocki complexus*). There are 5 umbilical tubercles and 11 ribs per one-half whorl, which is comparable to similar-sized whorls of *M. portlocki complexus* (tables 2, 3). There is no difference between the flat-topped, bullate umbilical tubercles and the strong, narrow ribs of the paralectotype and the Western Interior subspecies. The lectotype is a robust specimen that has a diameter of about 84.2 mm, an umbilical diameter of 22.3 mm (0.26), a whorl breadth of 54.2 mm (0.64), a whorl height of 39.3 mm (0.47), and a Wb:Wh ratio of 1.38 (measurements from a plaster cast). It is slightly more evolute than the Western Interior subspecies (table 3) and has more widely spaced umbilical tubercles (four per one-half whorl). The

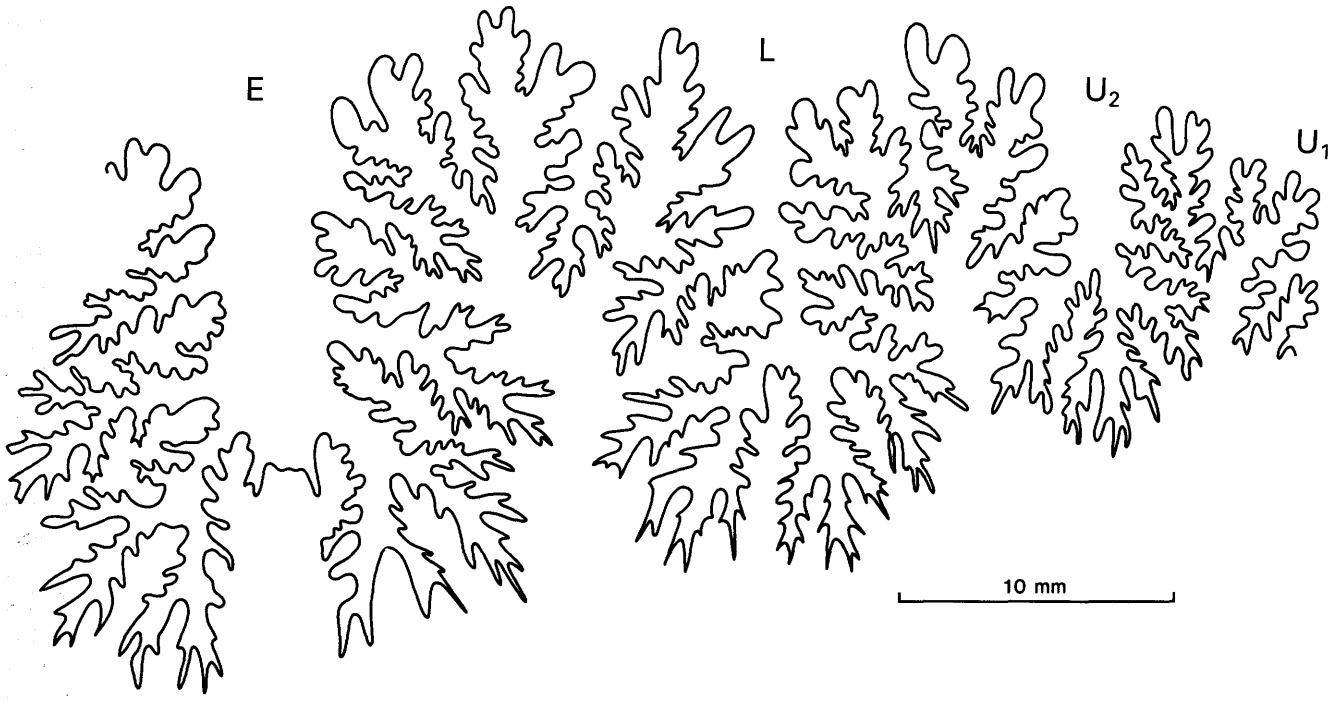

Figure 2. External suture, about four times actual size, of *Menuites portlocki complexus* (Hall and Meek, 1856). Hypotype USNM 456653 from the Pierre Shale at USGS Mesozoic locality D1923 (fig. 1, loc. 3). **E** is the external or siphonal lobe, **L** is the lateral lobe, and $\mathbf{U_1}$ and $\mathbf{U_2}$ are the umbilical lobes.

lectotype is a microconch that has the ventrolateral tubercles arising at a diameter of 77 mm (compared to 51–69 mm for *M. portlocki complexus*).

Menuites portlocki complexus differs from the Polish *M. portlocki posterior* (Błaszkiewicz, 1980, p. 48, pl. 33, figs. 1, 2; pl. 34, figs. 5, 6; pl. 39, figs. 2, 3, 5, 8, 10, 11; pl. 40, figs. 1–4, 9–11; pl. 41, figs. 1–6) in having more inflated flanks and in having whorls broader than they are high. *Menuites stephensoni* Young (1963, p. 57, pl. 15, figs. 1, 2; text figs. 7o, 9n), known only from a microconch from the Taylor Group of Texas, retains ribbing and ventrolateral tuberculation over the entire body chamber.

Occurrence.—Juveniles and inner whorls of *M. portlocki complexus* are fairly abundant in the *Baculites gregoryensis* zone of the Gregory Member of the Pierre Shale in the Chamberlain-Great Bend area in south-central South Dakota (fig. 1), where the subspecies was recorded as *Pachydiscus complexus* (Gries and Rothrock, 1941, p.14; Wing and Gries, 1941, p. 14; Gries, 1942, p. 12). A single specimen was found in the Pierre Shale in South Dakota near the intersection of South Dakota, Montana, and Wyoming (fig. 1), and several specimens were found farther south in easternmost Wyoming in the upper part of the Red Bird Silty Member of the Pierre Shale (Gill and Cobban, 1966, p. A56, A57, listed as *Anapachydiscus complexus*). Many specimens have been collected from sandstone concretions in an 8-m-thick, ridge-forming sandstone unit 188 m above the base of the Rock River Formation near Rock River in southeastern Wyoming (fig. 1, locs. 9–18) (Gill and others, 1970, p. 23; Toots, 1961, p. 165). The specimens, recorded as *Anapachydiscus* n. sp. and *Menuites* n. sp., were associated with a baculite recorded as *Baculites* n. sp. The baculite was later named *B. reduncus* Cobban (1977) and ranked as a zonal fossil between the zones of *B. gregoryensis* and *B. scotti*. The presence of *M. portlocki complexus* in the zone of *B. reduncus* in southeastern Wyoming, as well as in the zone of *B. gregoryensis* in south-central South Dakota, suggests that the two zones are contemporaneous and that *B. reduncus* occupied a nearshore environment west of the deeper water environment of *B. gregoryensis*. *Menuites portlocki complexus* has also been found south of Rock River and in an area about midway between Rock River and Cheyenne (fig. 1).

Menuites portlocki complexus has been found at many localities in Colorado. Specimens have been collected from the lower part of the Hygiene Sandstone Member of the Pierre Shale in the Denver-Fort Collins area (Scott and Cobban, 1959, p. 126, listed as *Anapachydiscus*; Scott, 1963, p. 101; and Scott and Cobban, 1965, p. 2; the last two listed as *Anapachydiscus*? *complexus* and *Menuites*? n. sp.). Farther south, in the Colorado Springs-Pueblo area, rocks equivalent to the Hygiene Sandstone Member are included in the upper part of the Rusty zone

of Gilbert (1897); *M. portlocki complexus* occurs in this part of the Pierre Shale (Scott and Cobban, 1986, listed as *Anapachydiscus*? *complexus* and *Menuites*? n. sp.). The subspecies has also been found in the Hygiene Sandstone Member north and east of Kremmling (Izett and others, 1971, p. A8, listed as *Menuites* n. sp.; Izett, 1974, listed as *Menuites* n. sp.). In the Aspen area, a few specimens were collected from above the middle of the Mancos Shale. The subspecies has also been found in the Sego Sandstone in eastern Utah (fig. 1).

Menuites oralensis n. sp.

Plate 4, figures 1–3; plate 5, figures 2–4; plate 6, figures 1–8; plate 7, figures 1–4; plate 8, figures 1, 2, 5–7; plates 9–14; text figure 6

1937 *Parapachydiscus complexus* (Hall and Meek). Dane and others, p. 230.
1952 *Pachydiscus complexus* (Hall and Meek). Cobban and Reeside, p. 1020 (part).
1959 *Anapachydiscus* [*complexus* Hall and Meek]. Scott and Cobban, p. 126 (part).
1963 *Anapachydiscus*? *complexus* (Hall and Meek). Scott, p. 102, 103 (part).
1963 *Menuites*? n. sp. Scott, p. 102, 103 (part).
1966 *Anapachydiscus complexus* (Hall and Meek). Gill and Cobban, p. A56 (part).
1966 *Menuites* n. sp. Gill and Cobban, p. A56.
1975 *Menuites* sp. Hirsch, p. 112, fig. 11 (not fig. 10).

Types.—The holotype is USNM 456671 from the Red Bird Silty Member of the Pierre Shale at USGS Mesozoic locality D1411, which is a bluff along the Cheyenne River near Oral, S. Dak. (fig. 1, loc. 6). Paratypes are USNM 456672–456693 from the Pierre Shale at USGS Mesozoic localities D903, D1411, and 10385 in Fall River County, S. Dak. (fig. 1, locs. 5–7), and D715 near Pueblo in Pueblo County, Colo. (fig. 1, loc. 20).

Diagnosis.—Innermost whorls of this species have 15–30 ribs per one-half whorl. The ribs are mostly weak and irregular in height, and are weak or absent on body chambers of microconchs, but they appear or become rejuvenated near the aperture. Strong nodal ventrolateral tubercles are present on the older halves of body chambers of microconchs but are absent on the younger halves. Macroconchs attain large sizes, have somewhat compressed whorls a little broader than they are high, and lack ribs and umbilical tubercles on adult body chambers.

Description.—The holotype (pl. 10, figs. 1–3), a microconch 87.5 mm in diameter, has an umbilical diameter of 20.0 mm (0.23), a whorl breadth of 44.0 mm (0.5), a whorl height of 38.4 mm (0.44), and a Wb:Wh of 1.15. The moderately deep umbilicus has a vertical wall and a narrowly rounded shoulder. Whorls are stout and are broadest at the umbilical shoulder; flanks are very broadly rounded, whereas the venter is more narrowly rounded. The body chamber occupies about 60 percent of the outer whorl. The aperture is normal and follows the course of growth lines and ribs. Prominent, flat-topped umbilical bullae, five per one-half whorl, are located on the umbilical shoulder of the inner whorls but migrate onto the lower part of the flank on the outer whorl (pl. 10, fig. 2). The bullae disappear rather abruptly half way across the body chamber. On the last half of the phragmocone, ribs are irregular in height and spring in pairs from the umbilical bullae or arise singly from between them. Ribs are narrow and rectiradiate at first but then bend forward a little and cross the venter with a slight forward arching. Ribs weaken greatly near the end of the phragmocone and mostly disappear on the older part of the body chamber. Large, matched nodal ventrolateral tubercles appear suddenly near the end of the phragmocone and persist on the older half of the body chamber before abruptly disappearing. There are five of these paired ventrolateral tubercles. Two of them are joined to umbilical bullae by looped ribs. All tubercles are absent on most of the younger half of the body chamber, where ornament consists mainly of irregular lirae and growth lines. Ornament is rejuvenated near the end of the body chamber (pl. 10, fig. 2), where several narrow ribs arise from narrow, low umbilical bullae or from between them. The ribs slant forward a little on crossing the flank and then bend forward and cross the venter convexly.

Microconchs of *Menuites oralensis* n. sp. from the type area (Oral area in Fall River County, S. Dak.) available for study include 52 adults suitable for measurement of the diameter at the base of the body chamber. The diameters range from 32.0 to 63.5 mm; most are in the 50- to 58-mm range (fig. 3). Umbilical ratios, which can be determined for 30 of the specimens, range from 0.17 to 0.26 (fig. 4). Ribs per one-half whorl on the outer whorl of the phragmocone range from 15 to 32. Like those of the holotype, ribs tend to be of unequal strength and weaken greatly near the base of the body chamber. Ribs are usually absent over much of the older half of the body chamber except for weak looped ribs that may connect umbilical bullae to ventrolateral tubercles (pl. 11, figs. 2, 8; pl. 12, fig. 2). An occasional individual may have both weak and strong ribs on all of the body chamber (pl. 11, fig. 6). Rejuvenated ribbing near the aperture consists usually of two to four strong, narrow prorsiradiate ribs that arch forward a little upon crossing the venter (pl. 11, figs. 6, 11; pl. 12, fig. 2). These ribs generally begin on the umbilical shoulder and attain their greatest height on the middle of the venter. The broad interspaces that separate the ribs may be smooth or may contain very weak ribs. Rare specimens have as many as seven or eight strong, narrow rejuvenated ribs (pl. 7, figs. 1–3) that appear abruptly following the disappearance of the ventrolateral tubercles. Ventrolateral tubercles are large and usually nodal (pl. 12, figs. 1, 2, 5, 6), although some may be

somewhat clavate (pl. 11, figs. 1–3, 8, 9), and the initial ones on the phragmocone are generally bullate. The tubercles arise rather abruptly near the end of the phragmocone and continue on the older two-thirds of the body chamber. The tubercles are either paired (pl. 10, fig. 1; pl. 11, figs. 3–5), alternated (pl. 11, fig. 9; pl. 12, figs. 1, 6), or both paired and alternated (pl. 11, fig. 10).

Macroconchs of *Menuites oralensis* n. sp. from the Oral area attain diameters of as much as 224 mm (pl. 14). Inner whorls of less than 50 mm in diameter are like those of microconchs in that they have similar umbilical diameters and whorl sections (fig. 5) as well as similar ribs of irregular height (pl. 4, figs. 1–3). The ribs number 15–34 per one-half whorl and mostly disappear at a diameter of 90–100 mm (pl. 13). Flat-topped umbilical bullae, numbering five to six per one-half whorl, are present on these early whorls (pl. 4, fig. 2), but they weaken and disappear at a diameter of 60–90 mm. By a diameter of about 110 mm, flanks on the macroconchs have flattened somewhat, and the shell is mostly smooth except for growth lines and low, obscure ribs that are mainly visible on the venter (pl. 13, figs. 2, 5). At larger diameters, the shell may have only growth lines (pl. 8, fig. 7; pl. 14). The suture (fig. 6) is complexly incised like that of *M. portlocki complexus* (Hall and Meek).

A fragment that represents the middle part of a huge phragmocone (USNM 433757) was recently collected by Peter Larson (Black Hills Institute of Geological Research) from the part of the Pierre Shale near Oral, S. Dak., that has yielded many *M. oralensis* n. sp. Most of one side of the specimen is well preserved, but the other side and venter are crushed. The whorl height is 236 mm. The specimen is smooth, has a well-rounded umbilical wall and shoulder, and has a flattened flank that merges evenly into a rounded venter. The specimen may represent an unusually large macroconch of *M. oralensis* n. sp.

Discussion.—Menuites oralensis n. sp. differs from its ancestor *M. portlocki complexus* (Hall and Meek) in having weaker and denser ribbed inner whorls and a smaller and more compressed microconch. *Menuites portlocki posterior* Błaszkiewicz (1980, p. 48, pl. 33, figs. 1, 2; pl. 34, figs. 5, 6; pl. 39, figs. 2, 3, 5, 8, 10, 11; pl. 40, figs. 1–4, 9–11; pl. 41, figs. 1–6) is a slightly younger subspecies than *M. portlocki portlocki* and may be close to or the same age as *M. oralensis*. *Menuites portlocki posterior* Błaszkiewicz differs from *M. oralensis* in having coarsely ribbed inner whorls like those of *M. portlocki portlocki* and in having whorls higher than they are wide.

Occurrence.—Menuites oralensis n. sp. is confined to the *Baculites scotti* zone of the Pierre Shale and equivalent rocks in the Western Interior. This zone is considered as the top of the middle Campanian in the Western Interior sequence (Cobban, in press). *Menuites oralensis* has been found in the middle part of the Pierre Shale in southeastern Montana and the adjacent part of South Dakota north of the Black Hills (fig. 1), and also in the basal part of the lower unnamed shale member of the Pierre Shale farther south along the west flank of the Black Hills in easternmost Wyoming, where the species was reported as *Anapachydiscus* sp., *A. complexus* (Hall and Meek), and *Menuites* n. sp. (Robinson and others, 1964, p. 91; Gill and Cobban, 1966, p. A56). Farther east, *M. oralensis* is fairly abundant in the Pierre Shale on the southeastern flank of the Black Hills uplift in the Oral area in Fall River County, S. Dak. (fig. 1, locs. 4–8). Here, the species is especially well preserved, with nacreous shells. Specimens have also

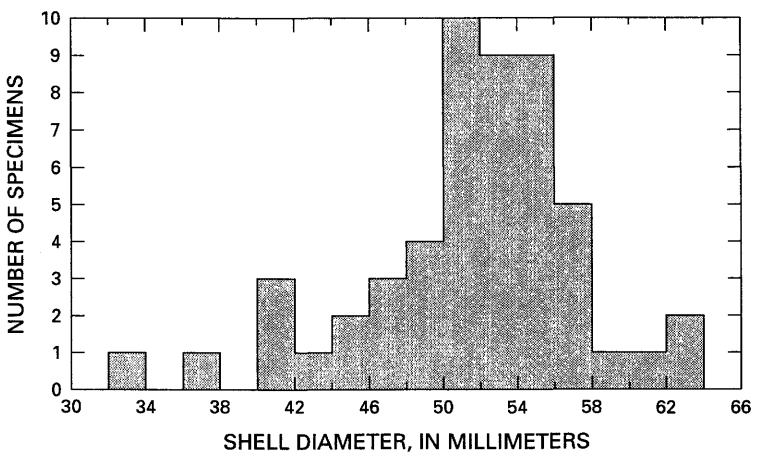

Figure 3. Histogram showing range in base diameters of body chambers of 52 *Menuites oralensis* n. sp. microconchs from the Pierre Shale in the Oral area in Fall River County, S. Dak. The microconchs are from USGS Mesozoic localities D901, D903, D1411, D13159, and 10385 (fig. 1, locs. 4–8), from the collection of the Black Hills Institute of Geological Research and from the private collection of Steve Jorgensen, Fargo, N. Dak.

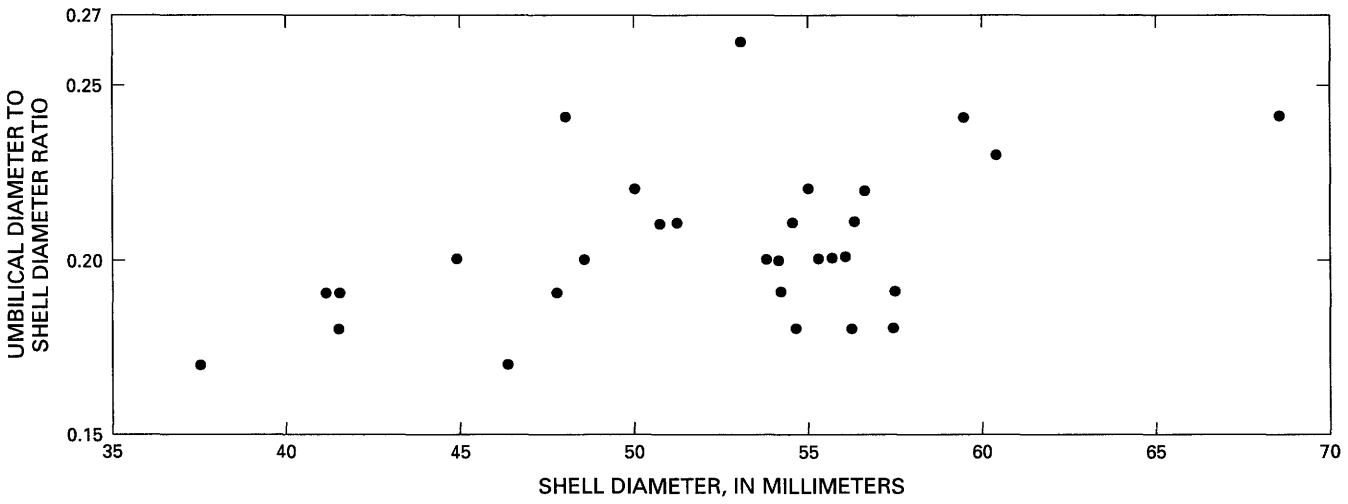

Figure 4. Scatter diagram showing umbilical- to shell-diameter ratio as a function of shell diameter for 30 *Menuites oralensis* n. sp. microconchs from the Pierre Shale of the Oral area in Fall River County, S. Dak. Specimens are from USGS Mesozoic localities D901, D903, D1411, D13159, and 10385 (fig. 1, locs. 4–8) from the collection of the Black Hills Institute of Geological Research and from the private collection of Steve Jorgensen, Fargo, N. Dak.

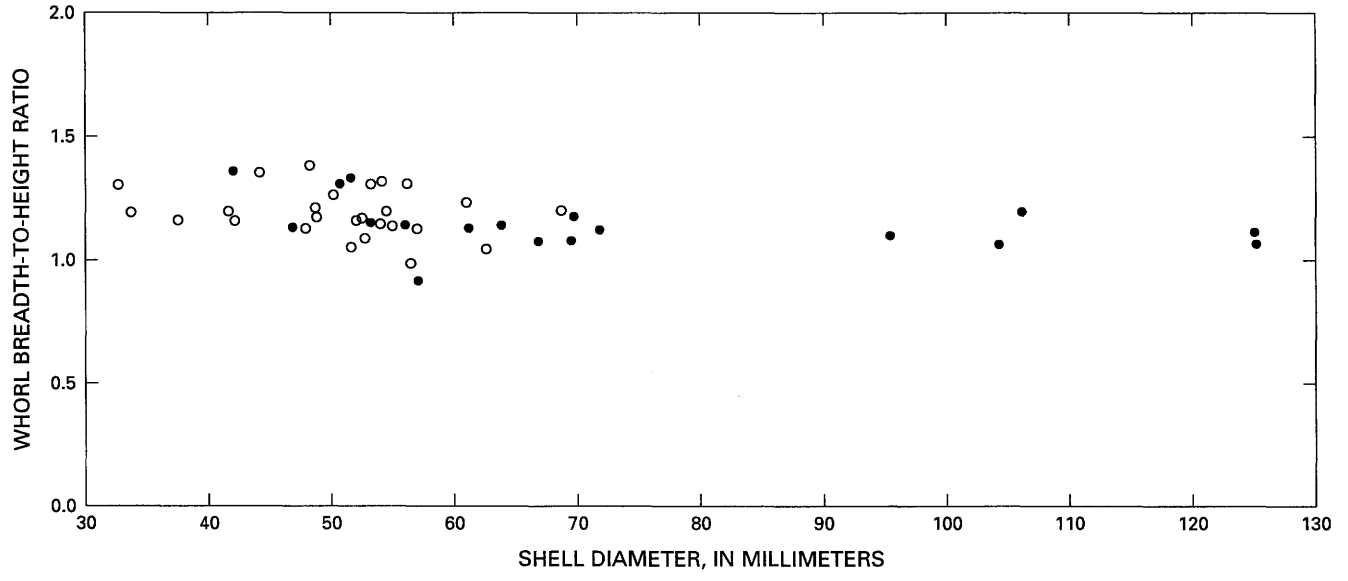

Figure 5. Scatter diagram showing whorl breadth-to-height ratio as a function of shell diameter for 44 specimens of *Menuites oralensis* n. sp. from the Pierre Shale of the Oral area in Fall River County, S. Dak. Circles are microconchs and dots are macroconchs. Specimens are from USGS Mesozoic localities D901, D903, D1411, D13159, and 10385 (fig. 1, locs. 4–8) and from the collection of the Black Hills Institute of Geological Research.

been found farther north near Rapid City, S. Dak. In west-central Wyoming, a few specimens have been collected from an unnamed tongue of marine shale in the Mesaverde Formation near Casper and from farther north (Wegemann, 1911, p. 51, listed as *Pachydiscus complexus*; Gill and Burkholder, 1979, p. 186). A few specimens were also found in a sandy unit of the Pierre Shale northwest of Cheyenne in southeastern Wyoming (Scott and Cobban, 1959, p. 129).

Menuites oralensis has been found in the Pierre Shale at many localities in the Denver-Canon City-Pueblo area in central Colorado (Scott and Cobban, 1965, 1975, 1986). One collection (D715) from Pueblo (fig. 1, loc. 20) contains 80 macroconchs and 40 microconchs. This is the locality that yielded 154 specimens of *Baculites scotti* (Cobban, 1958, p. 660) from a part of the Pierre Shale described as the Rusty zone by Gilbert (1897). The *Menuites* from this locality were listed as *Anapachydiscus*?

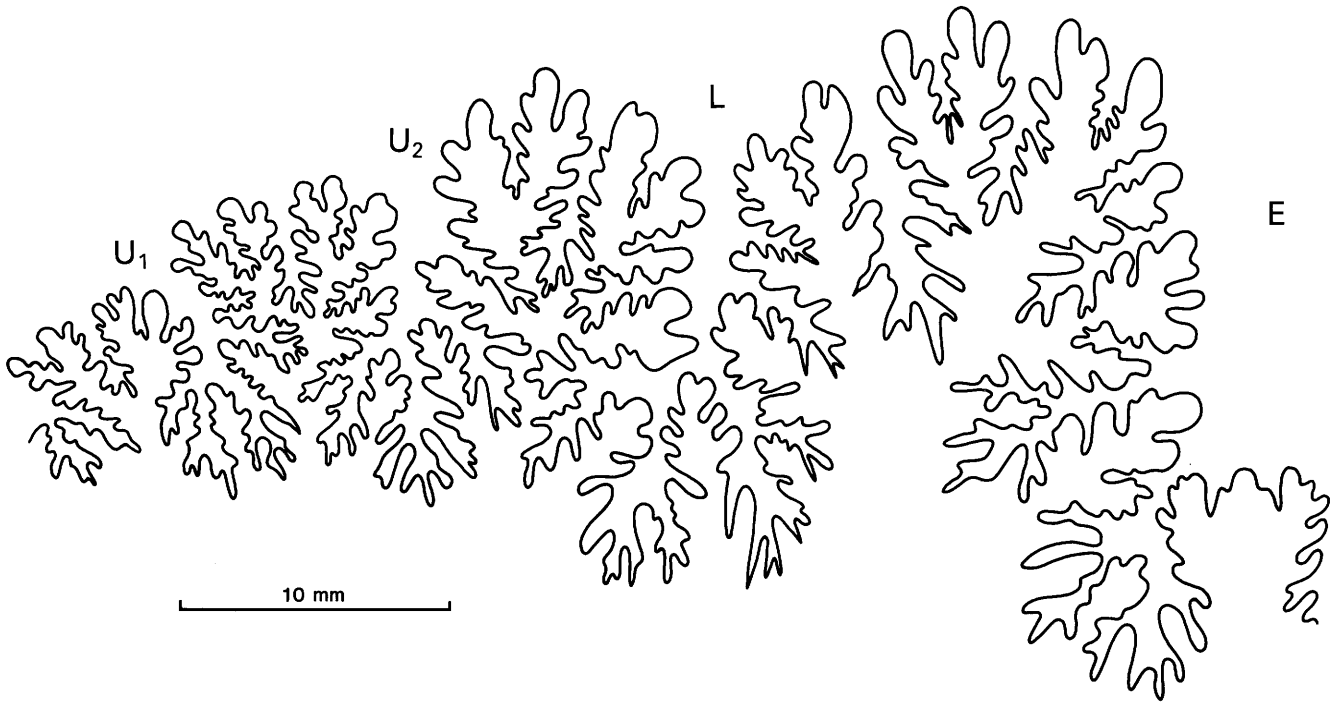

Figure 6. External suture of *Menuites oralensis* n. sp. Paratype USNM 456669 from the Pierre Shale at USGS Mesozoic locality D903 (fig. 1, loc. 5). Figure is about 3½ times actual size. **E** is the external or siphonal lobe, **L** is the lateral lobe, and U_1 and U_2 are the umbilical lobes.

complexus and *Menuites*? n. sp. by Scott (1964, 1969). In the Denver area, *M. oralensis* occurs in the Hygiene Sandstone Member of the Pierre Shale (Scott and Cobban, 1965, listed as *Anapachydiscus*? *complexus* and *Menuites*? n. sp.). Farther west, in the Kremmling area, *M. oralensis* also occurs in the Hygiene Member (Izett and others, 1971, p. A14, listed as *A. complexus*). Farther north, in North Park, a few specimens of *M. oralensis* have been found in the Pierre Shale. To the west, *Menuites oralensis* occurs in the Mancos Shale of the Glenwood Springs-Grand Junction area and in the Lewis Shale southwest of Montrose. The only known occurrence of the species in New Mexico is from the Lewis Shale near El Vado (Cobban and others, 1974, p. 280), where it was recorded as *Anapachydiscus* sp.

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PLATES

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PLATE 1

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

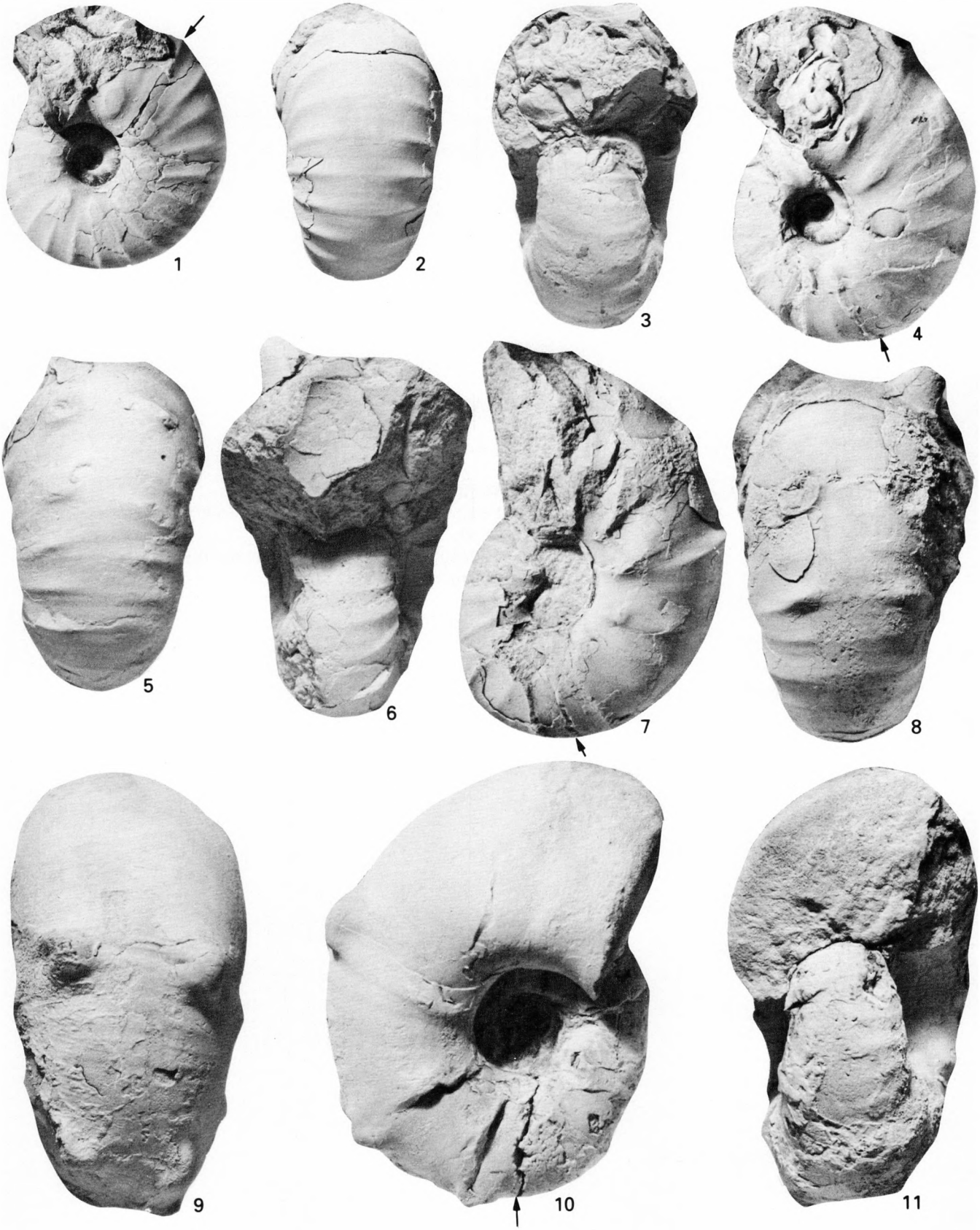
Figures 1–11. *Menuites portlocki complexus* (Hall and Meek) (p. 2).

1, 2. Hypotype USNM 456649, from USGS Mesozoic locality D13161 (text fig. 1, loc. 15).

3–5. Hypotype USNM 456650, from the same locality.

6–8. Hypotype USNM 456655, from USGS Mesozoic locality 1725 (text fig. 1, loc. 16).

9–11. Hypotype USNM 456659, from the same locality as figures 1–5.



MENUITES PORTLOCKI COMPLEXUS

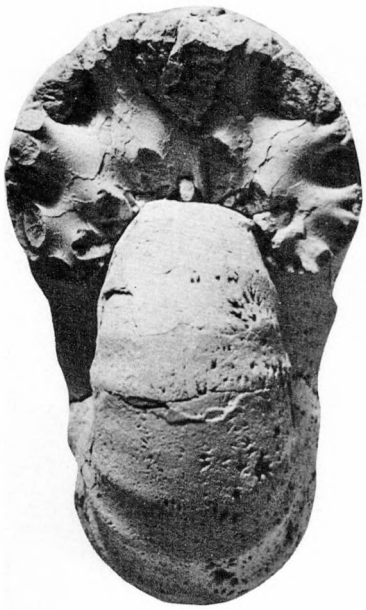
PLATE 2

[All figures natural size]

Figures 1–5. *Menuites portlocki complexus* (Hall and Meek) (p. 2).

1–3. Hypotype USNM 456661, from USGS Mesozoic locality 12844 (text fig. 1, loc. 9).

4, 5. Hypotype USNM 456665, from USGS Mesozoic locality 1725 (text fig. 1, loc. 16).



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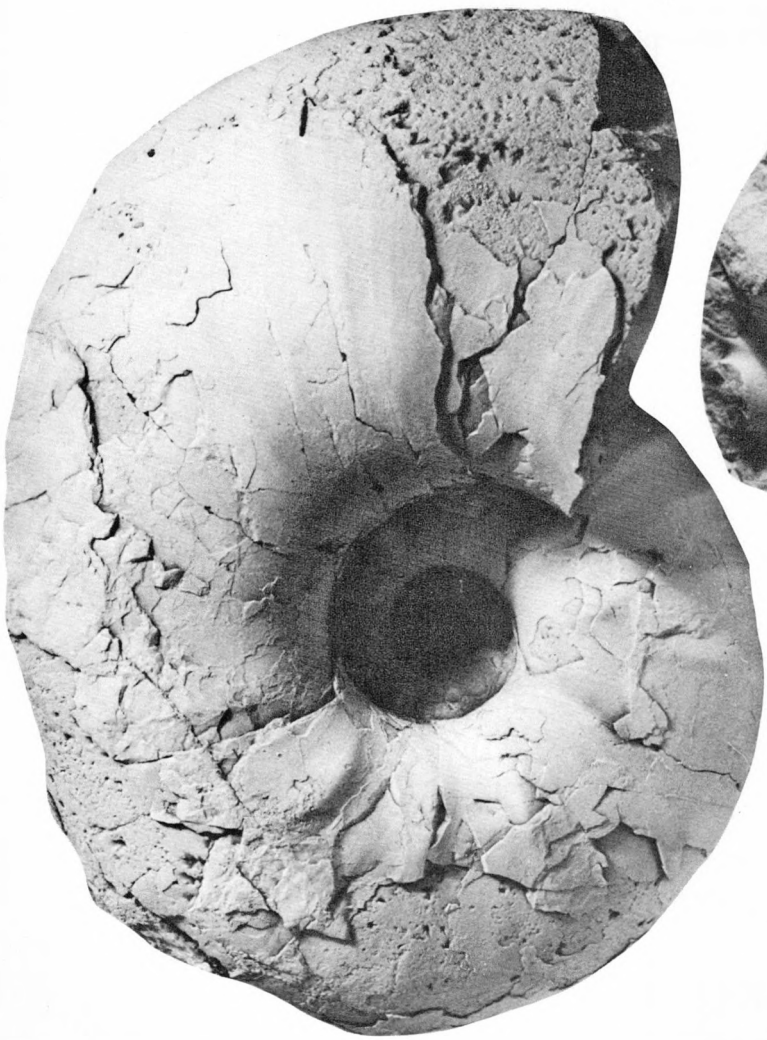

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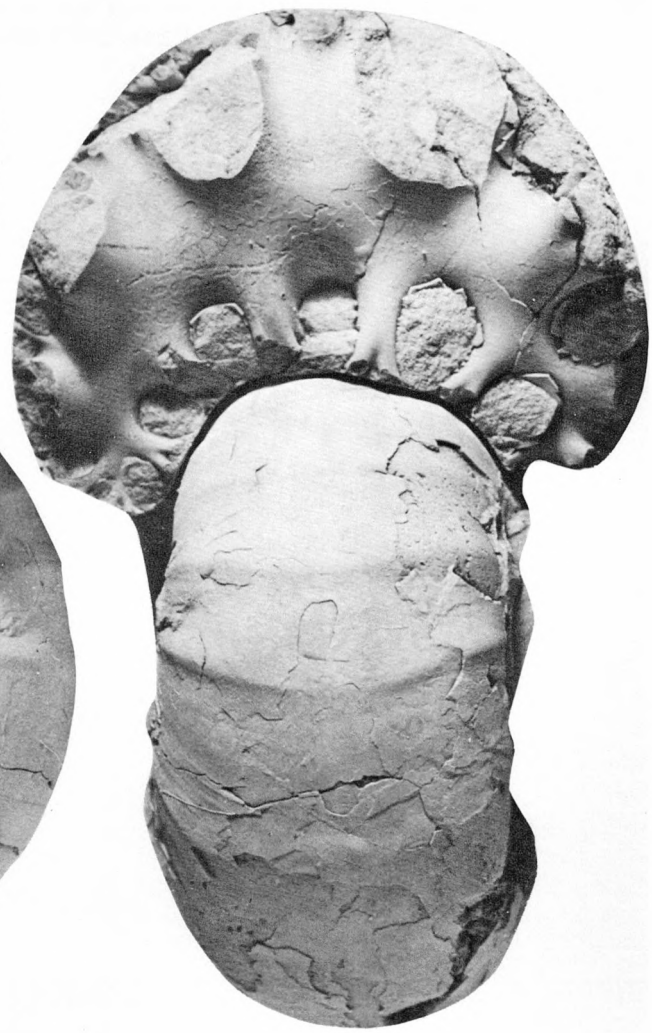

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MENUITES PORTLOCKI COMPLEXUS

PLATE 3

[Figure is natural size. Arrow points to base of body chamber]

Menuites portlocki complexus (Hall and Meek) (p. 2).
Hypotype USNM 456666, from USGS Mesozoic locality D1922 (text fig. 1, loc. 2).

MENUITES PORTLOCKI COMPLEXUS

PLATE 4

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

Figures 1–3. *Menuites oralensis* n. sp. (p. 9).
Paratype USNM 456672, from USGS Mesozoic locality D903 (text fig. 1, loc. 5).

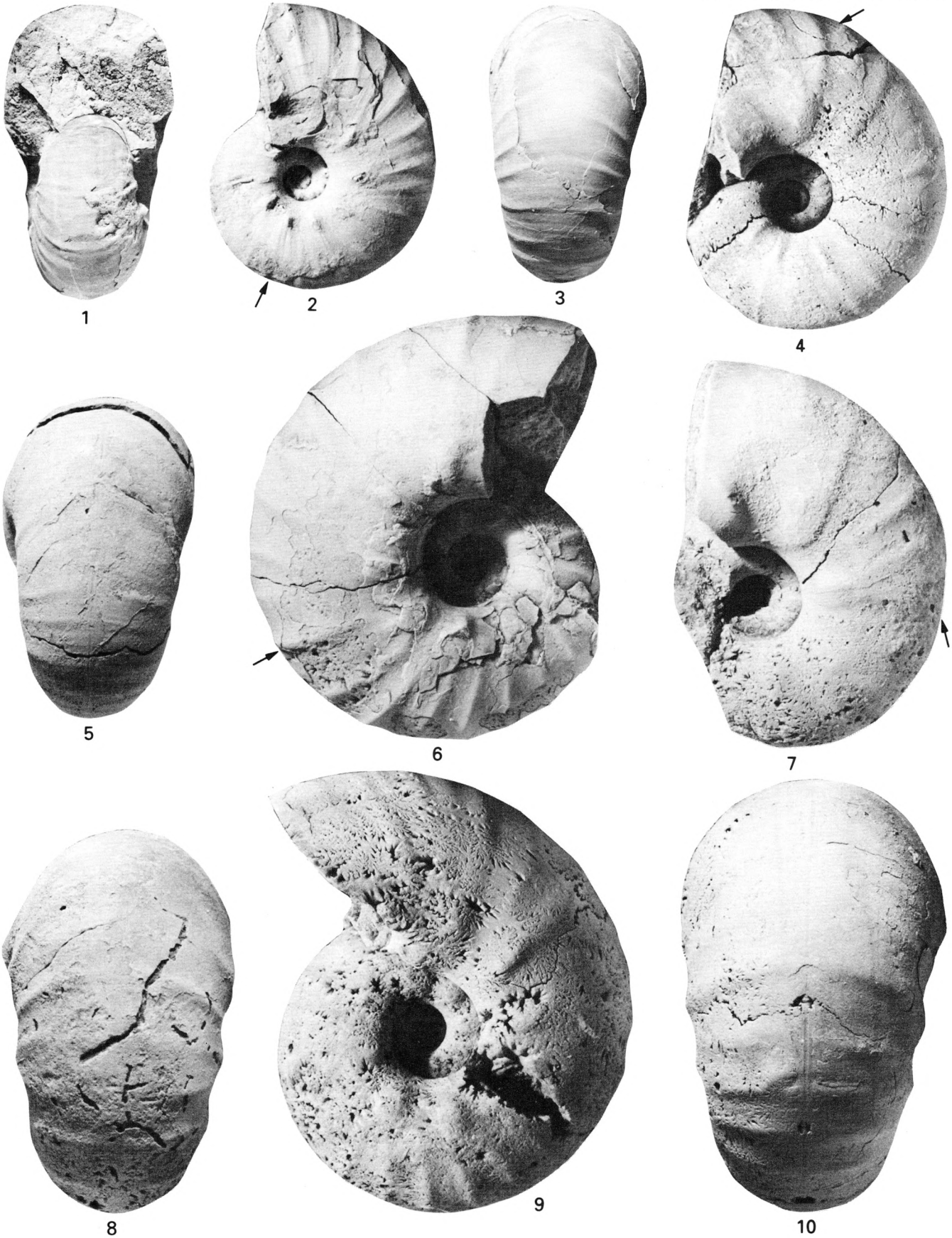
4–10. *Menuites portlocki complexus* (Hall and Meek) (p. 2).

4, 5. Hypotype USNM 456652, from USGS Mesozoic locality 12844 (text fig. 1, loc. 9).

6. Hypotype USNM 456660, from USGS Mesozoic locality D13161 (text fig. 1, loc. 15).

7, 8. Hypotype USNM 456656, from USGS Mesozoic locality D1922 (text fig. 1, loc. 2).

9, 10. Hypotype USNM 456664, from USGS Mesozoic locality 12844 (text fig. 1, loc. 9).



MENUITES ORALENSIS AND *MENUITES PORTLOCKI COMPLEXUS*

PLATE 5

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

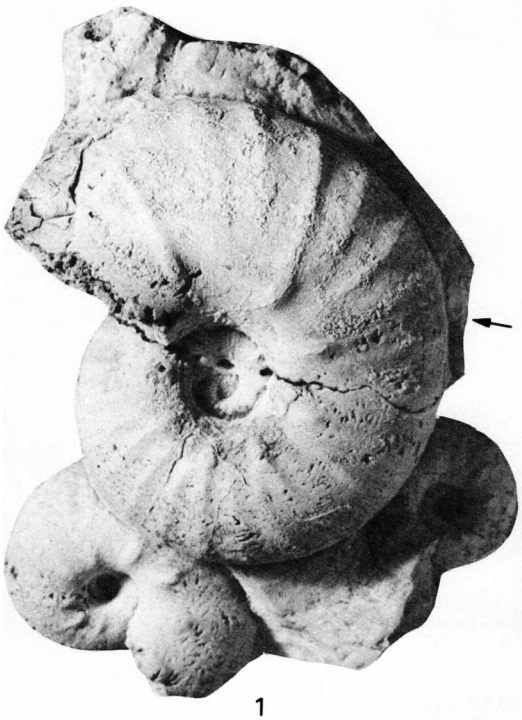
Figures 1, 5–7. *Menuites portlocki complexus* (Hall and Meek) (p. 2).

1. Hypotype USNM 456654, from USGS Mesozoic locality D297 (text fig. 1, loc. 19).

5–7. Hypotype USNM 456663, from USGS Mesozoic locality D1923 text fig. 1, loc. 3).

2–4. *Menuites oralensis* n. sp. (p. 9).

Paratype USNM 456673, from USGS Mesozoic locality 10385 (text fig. 1, loc. 7).



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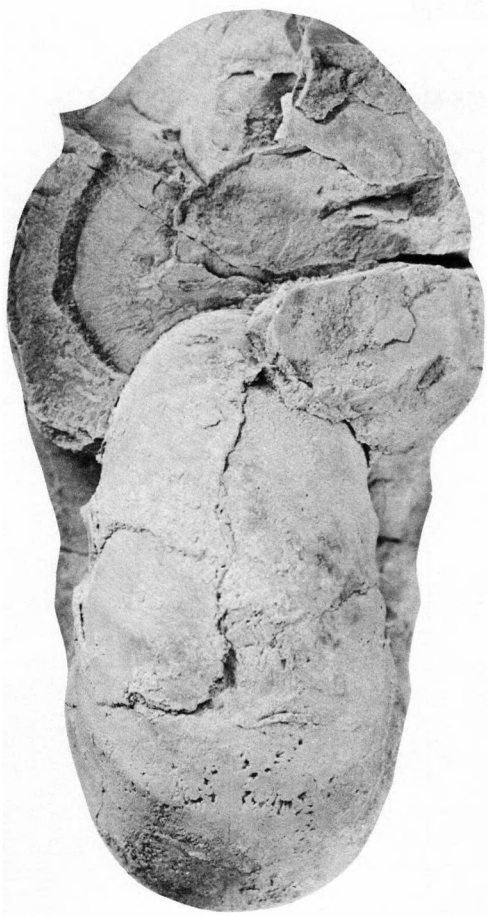

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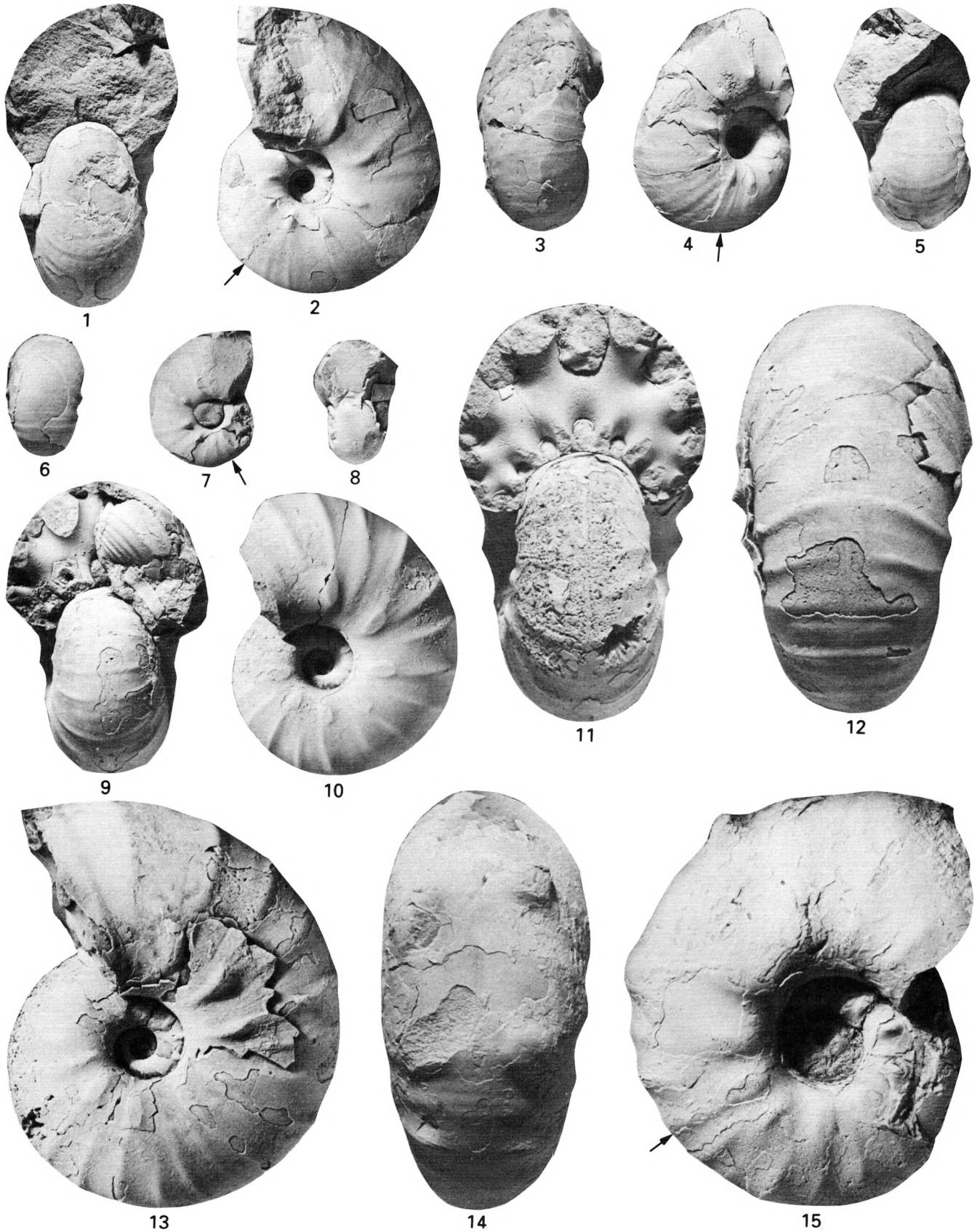
MENUITES PORTLOCKI COMPLEXUS AND *MENUITES ORALENSIS*

PLATE 6

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

Figures 1–8. *Menuites oralensis* n. sp. (p. 9).
- 1, 2. Paratype USNM 456674, from USGS Mesozoic locality D903 (text fig. 1, loc. 5).
- 3–5. Paratype USNM 456675, from the same locality.
- 6–8. Paratype USNM 456676, from USGS Mesozoic locality D1411 (text fig. 1, loc. 6).

9–15. *Menuites portlocki complexus* (Hall and Meek) (p. 2).
- 9, 10. Hypotype USNM 456651, from USGS Mesozoic locality D1392 (text fig. 1, loc. 13).
- 11–13. Hypotype USNM 456657, from USGS Mesozoic locality 12844 (text fig. 1, loc. 9).
- 14, 15. Hypotype USNM 456658, from USGS Mesozoic locality D13161 text fig. 1, loc. 15).



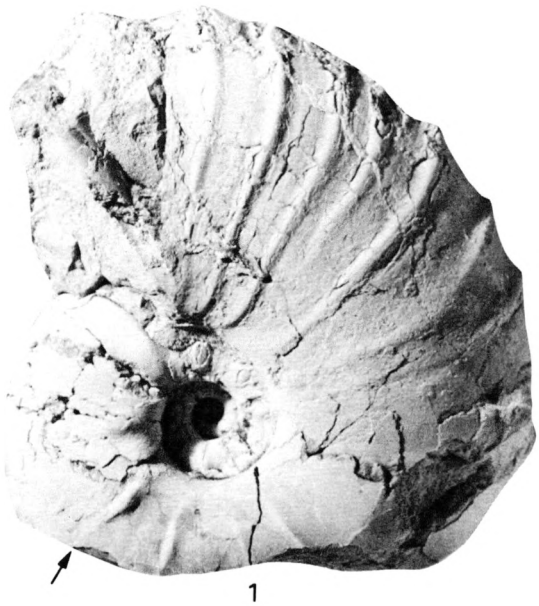
MENUITES ORALENSIS AND *MENUITES PORTLOCKI COMPLEXUS*

PLATE 7

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

Figures 1–4. *Menuites oralensis* n. sp. (p. 9).
1–3. Paratype USNM 456677, from USGS Mesozoic locality D13160 (text fig. 1, loc. 1).
4. Paratype USNM 456678, from USGS Mesozoic locality D1411 (text fig. 1, loc. 6).

5. *Menuites portlocki complexus* (Hall and Meek) (p. 2).
Hypotype USNM 456662, from USGS Mesozoic locality D1082 (text fig. 1, loc. 17).



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MENUITES ORALENSIS AND *MENUITES PORTLOCKI COMPLEXUS*

PLATE 8

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

Figures 1, 2, 5–7. *Menuites oralensis* n. sp. (p. 9).

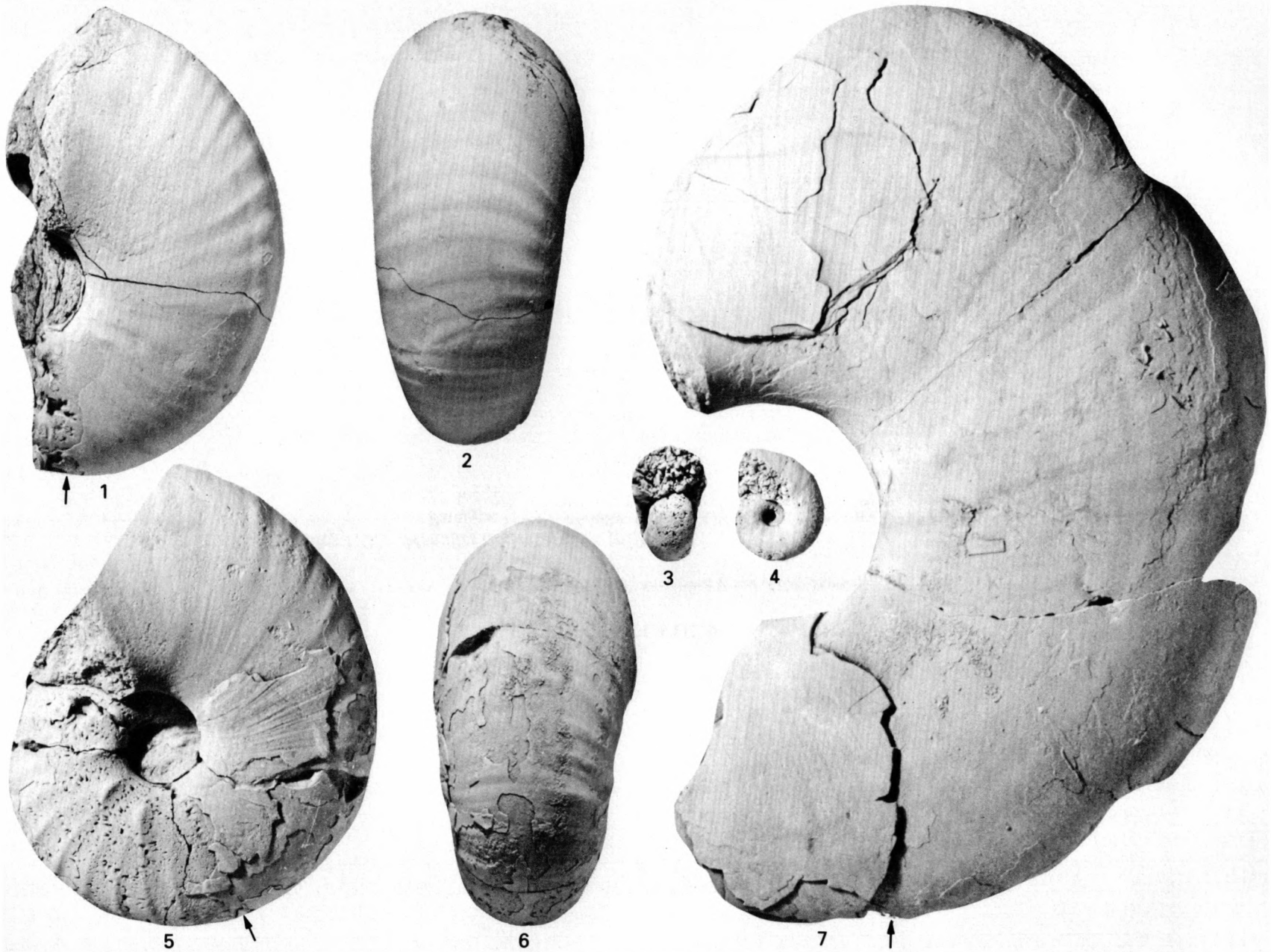
1, 2. Paratype USNM 456679, from USGS Mesozoic locality D1411 (text fig. 1, loc. 6).

5, 6. Paratype USNM 456680, from USGS Mesozoic locality D903 (text fig. 1, loc. 5).

7. Paratype USNM 456681, from USGS Mesozoic locality D1411 (text fig. 1, loc. 6).

3, 4. *Menuites portlocki complexus* (Hall and Meek) (p. 2).

Hypotype USNM 456648, from USGS Mesozoic locality D13161 (text fig. 1, loc. 15).

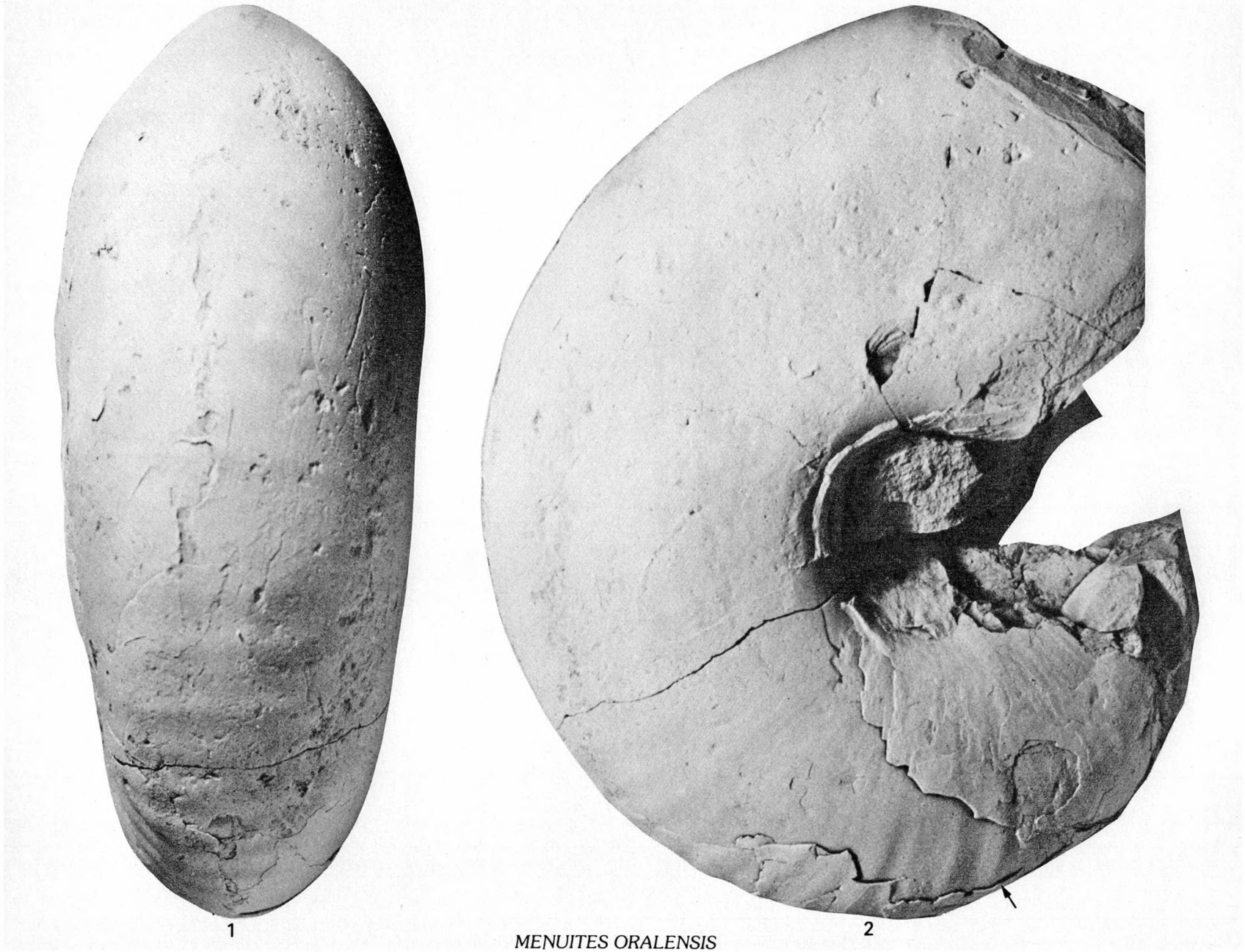


MENUITES ORALENSIS AND *MENUITES PORTLOCKI COMPLEXUS*

PLATE 9

[Both figures natural size. Arrow points to base of body chamber]

Figures 1, 2. *Menuites oralensis* n. sp. (p. 9).
Paratype USNM 456682, from USGS Mesozoic locality D715 (text fig. 1, loc. 20).



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MENUITES ORALENSIS

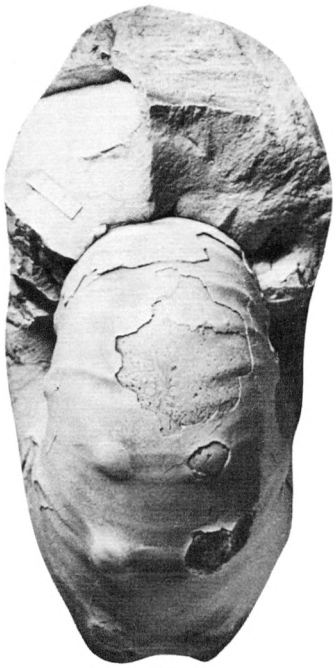
PLATE 10

[All figures natural size. Arrow points to base of body chamber]

Figures 1–6. *Menuites oralensis* n. sp. (p. 9).

1–3. Holotype USNM 456671, from USGS Mesozoic locality D1411 (text fig. 1, loc. 6).

4–6. Paratype USNM 456683, from the same locality.



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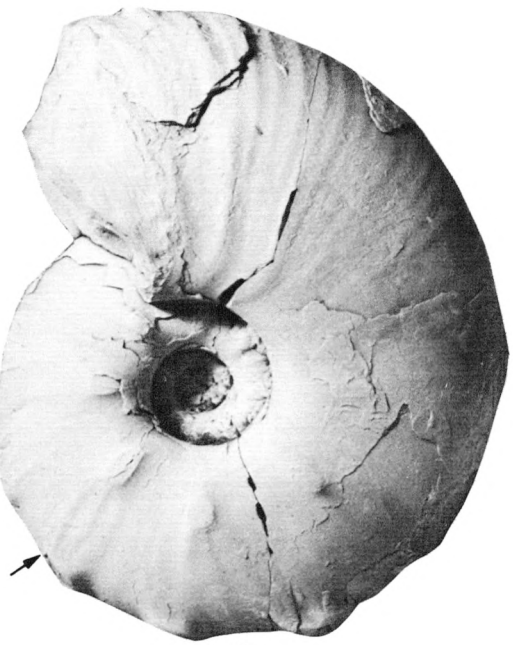

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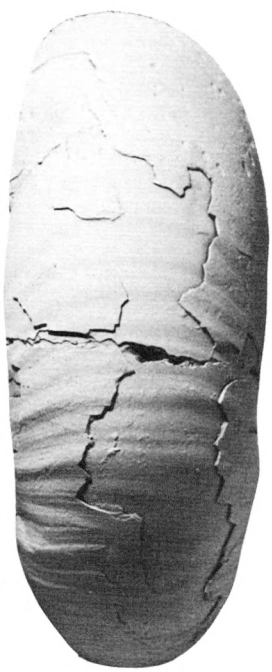

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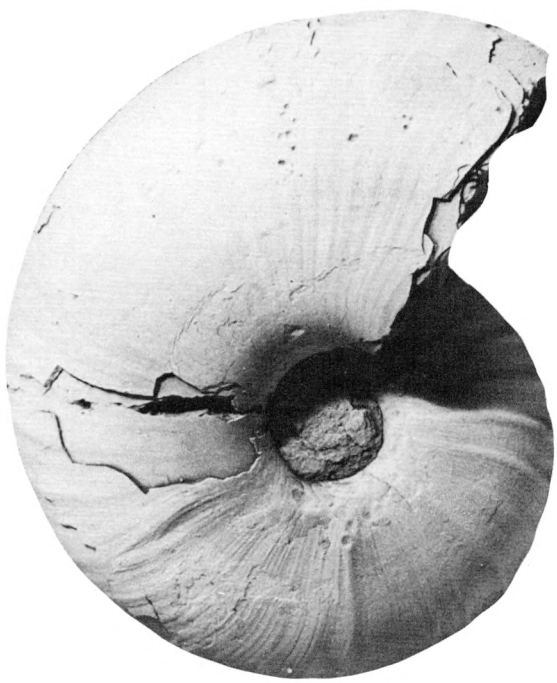

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MENUITES ORALENSIS

PLATE 11

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

Figures 1–11. *Menuites oralensis* n. sp. (p. 9).

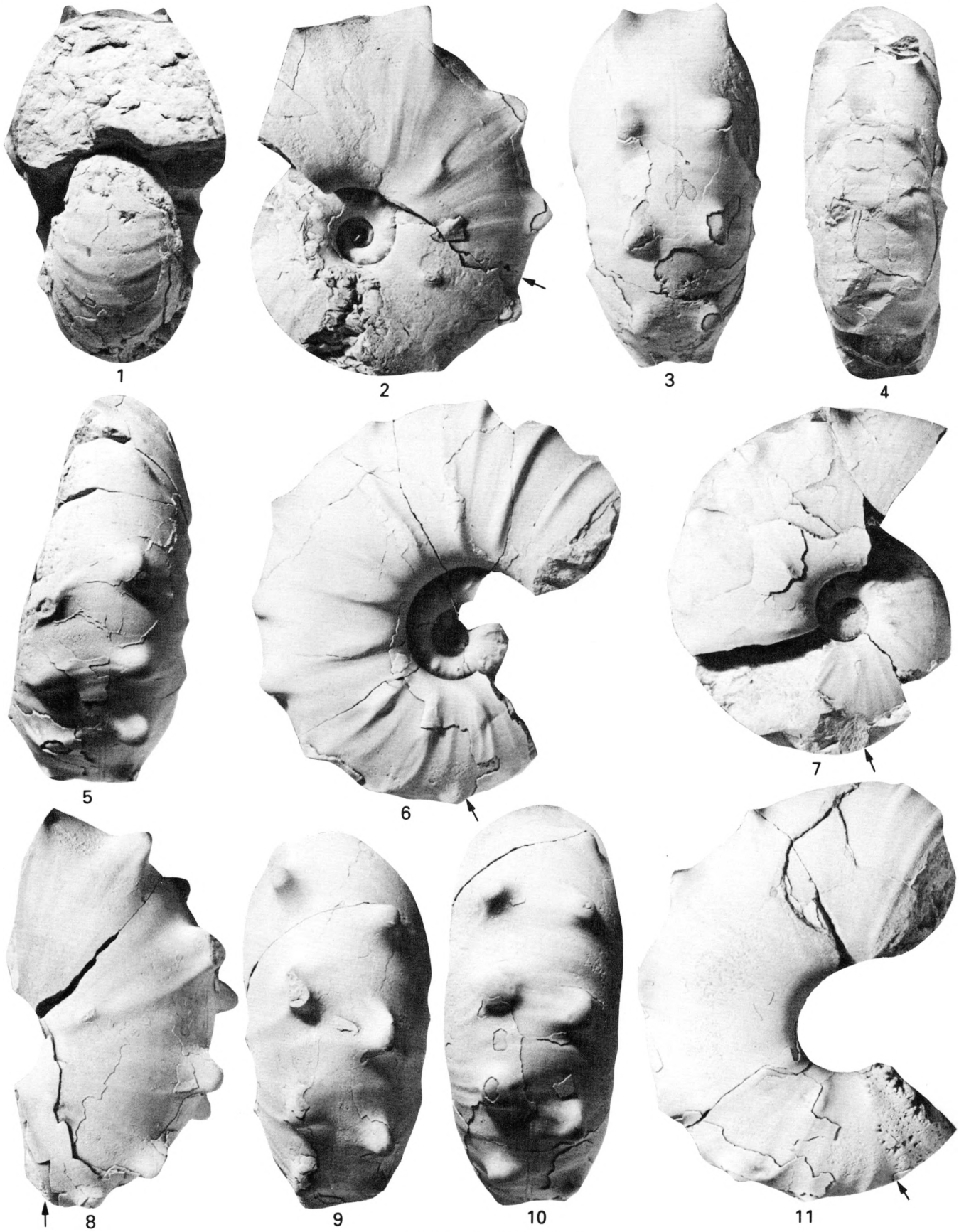
1–3. Paratype USNM 456684, from USGS Mesozoic locality D903 (text fig. 1, loc. 5).

4, 7. Paratype USNM 456685, from USGS Mesozoic locality D1411 (text fig. 1, loc. 6).

5, 6. Paratype USNM 456686, from the same locality as figures 1–3.

8, 9. Paratype USNM 456687, from the same locality.

10, 11. Paratype USNM 456684, from the same locality.



MENUITES ORALENSIS

PLATE 12

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

Figures 1–6. *Menuites oralensis* n. sp. (p. 9).

1–3. Paratype USNM 456689, from USGS Mesozoic locality D903 (text fig. 1, loc. 5).

4. Paratype USNM 456690, from USGS Mesozoic locality D715 (text fig. 1, loc. 20). See plate 13, figures 1 and 2 for other views.

5, 6. Paratype USNM 456691, from USGS Mesozoic locality D13159 (text fig. 1, loc. 8).

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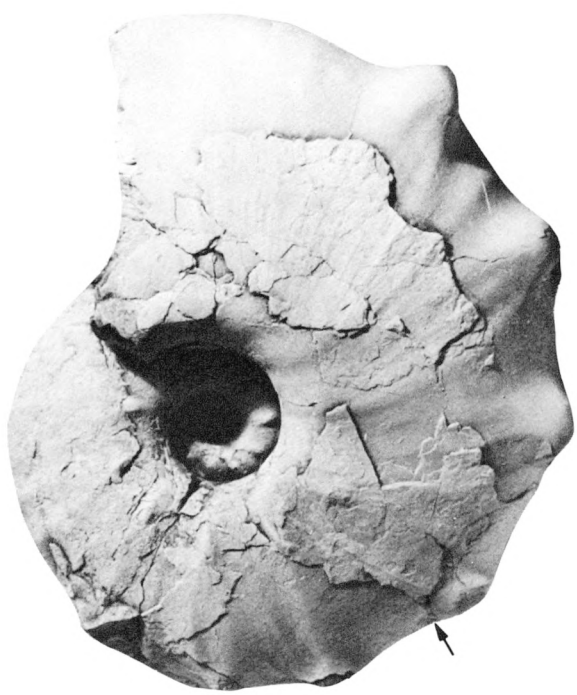

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MENUITES ORALENSIS

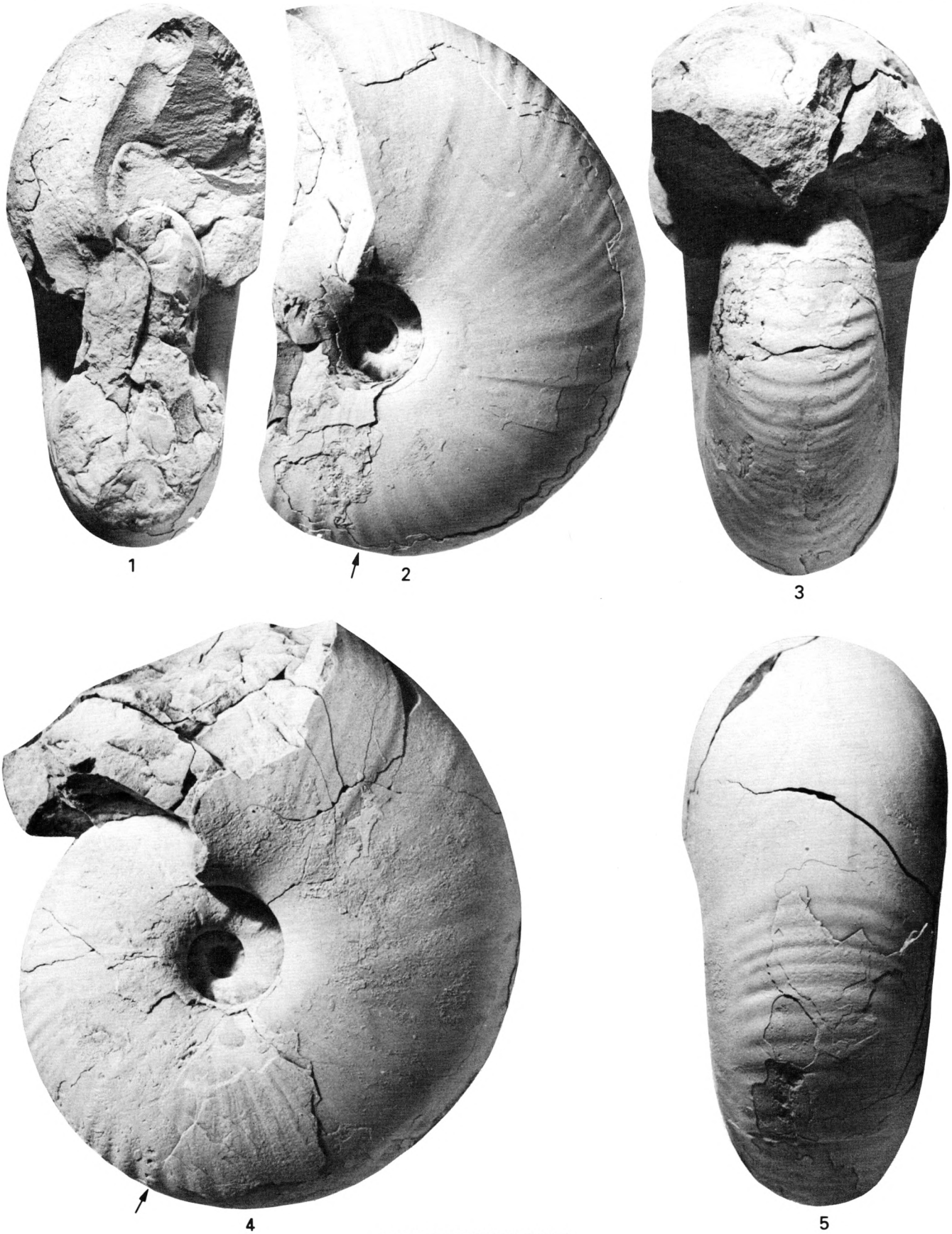
PLATE 13

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

Figures 1–5. *Menuites oralensis* n. sp. (p. 9).

1, 2. Paratype USNM 456690, from USGS Mesozoic locality D715 (text fig. 1, loc. 20). See plate 12, figure 4 for other view.

3–5. Paratype USNM 456692, from USGS Mesozoic locality D903 (text fig. 1, loc. 5).



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MENUITES ORALENSIS

PLATE 14

[Figure natural size]

Menuites oralensis n. sp. (p. 9).
Paratype USNM 456693, from USGS Mesozoic locality D903 (text fig. 1, loc. 5).

MENUITES ORALENSIS

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