The Ammonite *Metengonoceras* Hyatt, 1903, from the Mowry Shale (Cretaceous) of Montana and Wyoming

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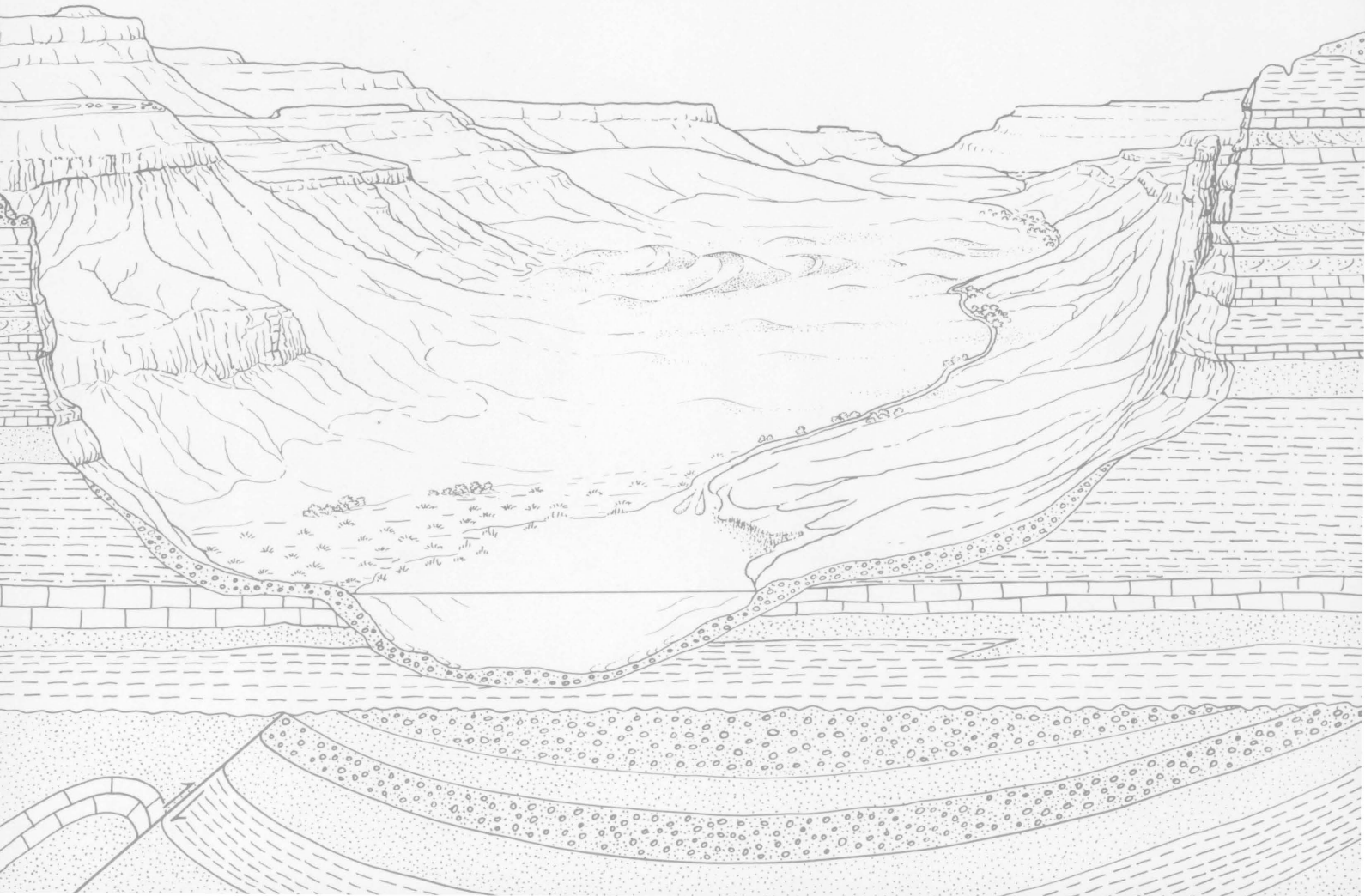

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Chapter L

The Ammonite *Metengonoceras* Hyatt, 1903, from the Mowry Shale (Cretaceous) of Montana and Wyoming

By WILLIAM A. COBBAN and W.J. KENNEDY

A multidisciplinary approach to research studies of
sedimentary rocks and their constituents and
the evolution of sedimentary basins, both ancient and modern

U.S. GEOLOGICAL SURVEY BULLETIN 1787

EVOLUTION OF SEDIMENTARY BASINS—UINTA AND PICEANCE BASINS

DEPARTMENT OF THE INTERIOR
MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY
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CONVERSION FACTORS FOR SOME SI METRIC AND U.S. UNITS OF MEASURE

To convert from	To	Multiply by
Feet (ft)	Meters (m)	0.3048
Miles (mi)	Kilometers (km)	1.609
Pounds (lb)	Kilograms (kg)	0.4536
Degrees Fahrenheit (°F)	Degrees Celsius (°C)	Temp °C=(temp °F-32)/1.8

The Ammonite *Metengonoceras* Hyatt, 1903, from the Mowry Shale (Cretaceous) of Montana and Wyoming

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

Abstract

Pseudoceratitic ammonites of the family Engonoceratidae are locally common in the Mowry Shale in the central and northern parts of the Western Interior of the United States. Most occurrences are of crushed, specifically indeterminate specimens, but occasional collections from concretions have well-preserved, uncrushed material. *Metengonoceras aspenanum* (Reeside and Weymouth) is revised on the basis of uncrushed specimens from a concretion in the *Neogastroplites americanus* zone in the Colorado Shale of Wheatland County, Montana. *Metengonoceras teigenense*, n. sp., is described from abundant material from a concretion in the *Neogastroplites muelleri* zone in the Mowry Member of the Colorado Shale of Petroleum County, Montana. *Metengonoceras aspenanum* seems to be older than *M. teigenense*, n. sp., and both species are believed to be of early Cenomanian age.

INTRODUCTION

The Engonoceratidae is a Tethyan family that has abundant representatives in the upper Albian-lower Cenomanian Washita Group of Texas. Specimens are characterized by a compressed, highly involute shell with a very narrow venter that is flat at some growth stage. The unusual suture line has numerous auxiliary and adventive elements in which the saddles are usually entire and the lobes are subdivided in such a manner as to resemble the Triassic Ceratitidae; hence, the term pseudoceratite has been applied to them.

Engonoceratids have a typically Tethyan distribution, and, therefore, their occurrence in large numbers as far north as Montana is in itself remarkable. During the Albian, engonoceratids were present in a broad belt from Iran through the Middle East and North Africa to Ecuador, Colombia, Peru, Venezuela, Mexico, and Texas (Basse, 1940; Kennedy and Cobban, 1976, fig. 13). In Europe, there are scattered records from the Iberian Peninsula, France as far north as Aube (Amédro and Destombes, 1984), and southern England (Spath, 1924, 1931; Kennedy and Hancock, 1978). There is a single exotic Southern Hemisphere record from northern Australia (Wright, 1963). Aside from *Neolobites*, localities of engonoceratids from Cenomanian and Turonian rocks are much fewer, but there are records from France (Grossouvre, 1912; Kennedy and others, 1981), Tunisia (Pervinquière, 1907), and Nigeria (Furon, 1935; Schneegans, 1943; Barber, 1957; Zaborski, 1987), as well as numerous records from Texas (for example, Adkins, 1928).

Engonoceratids have been known from the Aspen and Mowry Shales of the Western Interior region for the past 57 years, but only one paper dealt with their systematics when Reeside and Weymouth (1931) described *Epengonoceras* [*Metengonoceras*] *aspenanum* from the Aspen Shale of southwestern Wyoming. The specimens occurred flattened in hard, siliceous shale. Later, uncrushed engonoceratids were found in concretions in the Mowry Shale at several localities in Wyoming and Montana. These specimens were assigned to *Metengonoceras*, but none was described (Reeside and Cobban, 1960). The engonoceratids and the associated *Neogastroplites* were considered as latest Albian in age with the reservation that they could be of early Cenomanian age.

The present investigation was undertaken to describe the species of *Metengonoceras* of the Mowry Shale and to relate them to the engonoceratid sequence of the Gulf coastal region with the object of more closely dating the Mowry.

In the course of the present study, only two species of *Metengonoceras* were recognized—*M. aspenanum* (Reeside and Weymouth) and *M. teigenense*, n. sp. Both are well represented by uncrushed material from a few silty concretions.

The erratic occurrences of *Metengonoceras* in the Western Interior present a problem. Aside from the local

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abundance of specimens in two zones of the Mowry Shale, occurrences of *Metengonoceras* are scarce. A single flattened specimen (*Metengonoceras* sp.) was found in the lower part of the Mancos Shale southeast of Socorro, N. Mex., at USGS Mesozoic locality D5777 in the SE1/4 sec. 8, T. 5 S., R. 2 E., Socorro County. This specimen was found a little above beds that contain an *Acanthoceras amphibolum* fauna, and the age of the specimen is probably middle Cenomanian. A large, poorly preserved, flattened specimen, identified as *Epengonoceras dumbli* (Cragin)? by Cobban and Scott (1973, p. 59, pl. 8), was collected 3.3 m above the middle Cenomanian Thatcher Limestone Member of the Graneros Shale near Pueblo, Colo. Sutures are not preserved, and it is possible that this specimen could even be a crushed nautiloid. *Metengonoceras acutum* Hyatt occurs along the east side of the Western Interior seaway in northwestern Iowa (Cobban, 1983, 1987). Associated fossils include *Dunveganoceras pondi* Haas of earliest late Cenomanian age. *Metengonoceras acutum* also occurs a little higher in the late Cenomanian zone of *Metoicoceras mosbyense* in north-central Minnesota (Cobban, 1987). No trace of *Metengonoceras* has been found in these zones in the central and western parts of the seaway. Younger rocks of late Cenomanian age in the Western Interior have not yielded any specimens of this genus, although *M. acutum* is known from rocks as young as the zone of *Sciponoceras gracile* in north Texas.

All specimens described in this report have USNM catalog numbers and are kept in the U.S. National Museum (USNM) of Natural History, Washington, D.C. (formerly U.S. National Museum). Plaster casts of a few of the specimens are in the reference collection of the U.S. Geological Survey at the Federal Center in Denver, Colo. R.E. Burkholder made the photographs. Kennedy acknowledges the financial support of the Natural Environment Research Council (U.K.), the Royal Society, and the Astor Fund (Oxford), and the technical assistance of the staff of the Geological Collection, Oxford University Museum, and the Department of Earth Sciences, Oxford (U.K.).

LOCALITIES OF COLLECTIONS

Localities at which *Metengonoceras aspenanum* (Reeside and Weymouth) and *M. teigenense*, n. sp., have been collected in the northern part of the Western Interior are shown in figure 1. The U.S. Geological Survey (USGS) Mesozoic locality number, names of collectors, year of collection, locality, and stratigraphic assignment are given in table 1.

SYSTEMATIC PALEONTOLOGY

Family ENGONOCERATIDAE Hyatt, 1900
Genus METENGONOCERAS Hyatt, 1903

Type species.—*Metengonoceras inscriptum* Hyatt, 1903, p. 180, pl. 25, figs. 5–9; pl. 26, figs. 1–4, by subsequent designation, Roman, 1938, p. 491, from the middle Albian Fredericksburg Group, Wise County, Tex.

Diagnosis.—The following concise diagnosis was given by Cobban (1987, p. C2). "This genus includes very compressed, almost smooth ammonites that have tiny umbilici and narrow, flattened venters, which may round on the adult body chamber. Ornament consists of falcoid growth lines and, on some specimens, weak arcuate ribs a little above the middle of the flank and rarely faint umbilical bullae. Sutures are very closely spaced and have numerous auxiliary and adventive elements with most saddles undivided and the larger lobes moderately frilled."

Hyatt (1903, p. 179) noted that internal molds may have an acute venter in the early adult growth stage.

Metengonoceras aspenanum (Reeside and Weymouth)

(Plate 1, text figure 3)

1931. *Epengonoceras aspenanum* Reeside and Weymouth, p. 16, pl. 1, fig. 15; pl. 2, figs. 2–5; pl. 3, figs. 5–7.
1951. *Metengonoceras aspenanum* (Reeside and Weymouth). Cobban and Reeside, p. 1893.
1960. *Metengonoceras* A. Reeside and Cobban, p. 26.

Types.—Holotype USNM 73774; hypotypes USNM 420357–420369.

Diagnosis.—A very involute species that has a flat venter on the inner whorls with a midventral threadlike ridge. Ornament consists of falcoid growth lines accentuated a little near the middle of the flank on the outer whorl.

Description.—Reeside and Weymouth's types consist of eight flattened, somewhat distorted internal molds from the Aspen Shale of southwestern Wyoming. The holotype (USNM 73774), about 73 mm in diameter, has an umbilical ratio of 0.07. A flat venter is present at least to a diameter of 70 mm. Falcoid growth lines are the only ornament. The external suture has many narrow lobes separated by broader saddles of which the first four are bifid, the next three are undivided, and the next two are very wide and bifid (Reeside and Weymouth, 1931, pl. 2, figs. 4, 5).

Undistorted specimens that seem referable to *Metengonoceras aspenanum* have been found in a few

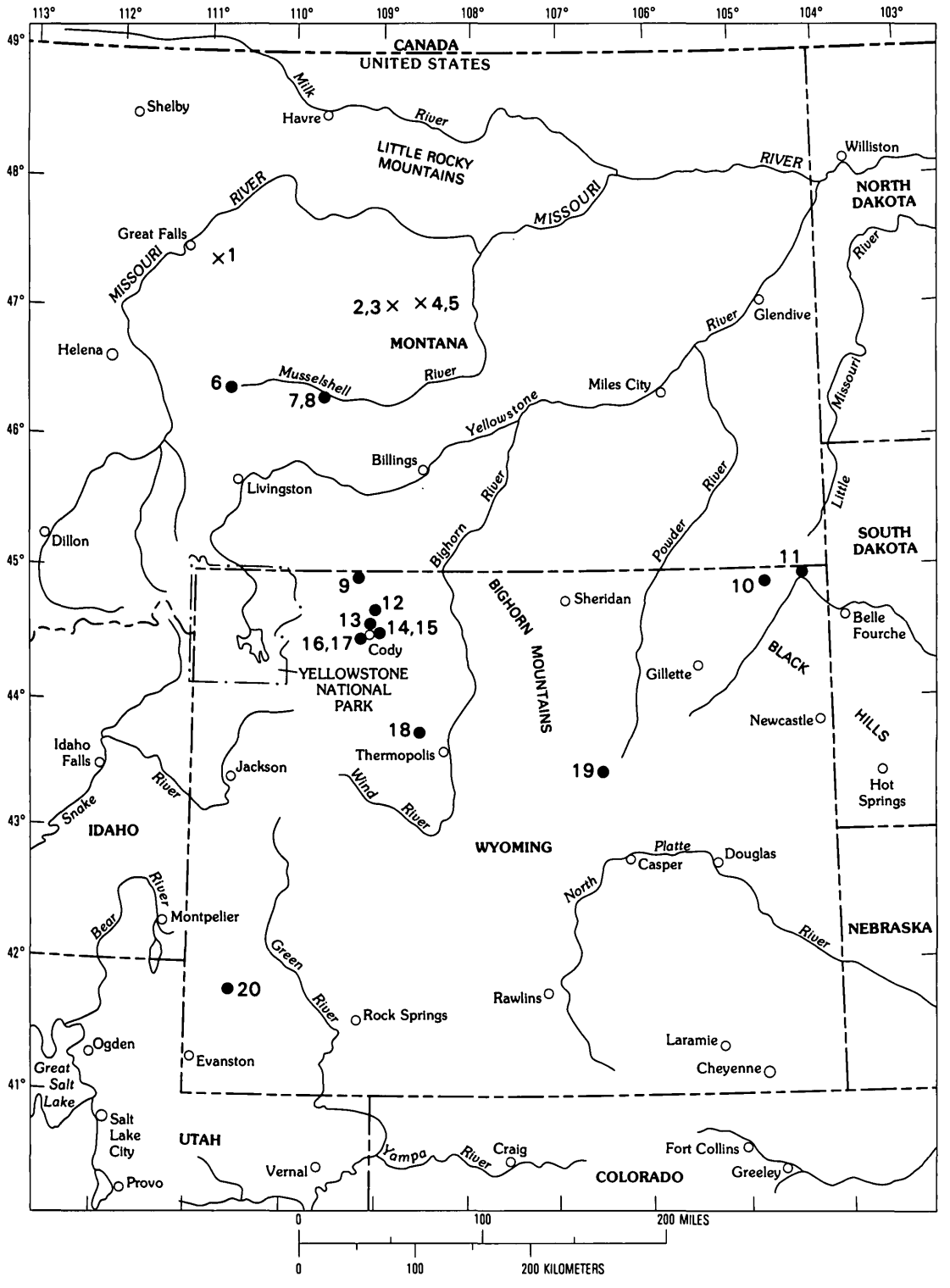

Figure 1. Part of the Western Interior of the United States showing localities of collections of *Metengonoceras teigenense* n. sp. (X) and *M. aspenanum* (Reeside and Weymouth) (solid circle) referred to in the text and in table 1. Base map from Reeside and Cobban (1960, fig. 1).

Table 1. Localities at which *Metengonoceras aspenanum* (Reeside and Weymouth) and *M. teigenense*, n. sp., were collected
[Localities shown by number on figure 1; USGS numbers are Mesozoic locality numbers]

Locality number	USGS number	Collector, year of collection, description, and stratigraphic assignment
1	24705	W.A. Cobban, 1953. South side of Belt Butte in the NW1/4SE1/4 sec. 30, T. 19 N., R. 7 E., Cascade County, Mont. Mowry Member, 12 m above top of Arrow Creek Member of the Colorado Shale.
2	24601	W.A. Cobban, 1953. SW1/4SW1/4 sec. 7, T. 16 N., R. 21 E., Fergus County, Mont. From 23 m above base of Mowry Member.
3	26224	O.O. Mueller, 1956. Due north of Ayers Colony, sec. 15 or 16, T. 15 N., R. 22 E., Fergus County, Mont. From 23 m above base of Mowry Member.
4	24065	O.O. Mueller, 1952. About 4 km southeast of Teigen, center sec. 4, T. 14 N., R. 25 E., Petroleum County, Mont. From a large concretion just below middle of Mowry Member.
5	24418	O.O. Mueller, 1952. Near center of sec. 3, T. 14 N., R. 25 E., Petroleum County, Mont. From a concretion just below middle of Mowry Member.
6	D9004	E.A. Merewether and W.A. Cobban, 1973. NW1/4NW1/4 sec. 14, T. 7 N., R. 8 E., Meagher County, Mont. From concretion in Mowry Member.
7	23042	J.B. Reeside, Jr., and others, 1950. Timber Coulee in center SW1/4 sec. 14, T. 7 N., R. 16 E., Wheatland County, Mont. From unnamed shaly member 35 m below base of Big Elk Sandstone Member of Colorado Shale.
8	24608	O.O. Mueller, 1953. Timber Coulee in N1/2NE1/4 sec. 23, T. 7 N., R. 16 E., Wheatland County, Mont. Same stratigraphic position as 23042.
9	17934	R.P. Bryson, 1938. NE1/4SE1/4 sec. 34, T. 58 N., R. 103 W., Park County, Wyo. Mowry Shale.
10	10415	A.J. Collier, 1920. Railroad cut in sec. 3, T. 48 N., R. 66 W., Crook County, Wyo. Mowry Shale.
11	23465	W.A. Cobban, 1951. Bank of Belle Fourche River in NE1/4 sec. 28, T. 57 N., R. 62 W., Crook County, Wyo. About 18 m below top of Mowry Shale.
12	24565	A. Calderón García and D.W. Taylor, 1953. NE1/4 sec. 3, T. 53 N., R. 102 W., Park County, Wyo. About 60 m above base of Mowry Shale.
13	24554	J.B. Reeside, Jr., and others, 1953. NE1/4 sec. 26, T. 53 N., R. 102 W., Park County, Wyo. About 62 m above base of Mowry Shale.
14	24567	J.B. Reeside, Jr., and others, 1953. SW1/4 sec. 17, T. 52 N., R. 101 W., Park County, Wyo. About 72 m below top of Mowry Shale.
15	24568	D.W. Taylor, 1953. West of locality 24567. About 72 m below top of Mowry Shale.
16	24561	J.B. Reeside, Jr., and others, 1953. SW1/4 sec. 18, T. 52 N., R. 102 W., Park County, Wyo. About 56 m above base of Mowry Shale.
17	24564	J.B. Reeside, Jr., and others, 1953. NE1/4 sec. 19, T. 52 N., R. 102 W., Park County, Wyo. About 62 m above base of Mowry Shale.
18	8535	D.F. Hewett, 1913. Hamilton dome in NE1/4SW1/4NE1/4 sec. 14, T. 44 N., R. 98 W., Hot Springs County, Wyo. Near middle of Mowry Shale.
19	6735	William Mulholland, 1910. Salt Canyon in SE1/4NW1/4 sec. 5, T. 40 N., R. 81 W., Natrona County, Wyo. Middle part of Mowry Shale.
20	14718	A.A. Weymouth, 1929. About 4.8 km southeast of Kemmerer in NW1/4NW1/4 sec. 32, T. 21 N., R. 115 W., Lincoln County, Wyo. Upper part of Aspen Shale.

highly fossiliferous limestone concretions in Montana and Wyoming. The largest collection is from a concretion at USGS Mesozoic locality 23042 near Winnecook in central Montana, where 230 specimens of *M. aspenanum* were found with 1,300 specimens of *Neogastroplites americanus* (Reeside and Weymouth) (Reeside and Cobban, 1954). Diameters at the base of body chambers could be determined for 50 of the *M. aspenanum* from this locality. These measurements revealed a considerable span with most between 15 and 70 mm (fig. 2). Crowded sutures at the end of body chambers were observed on only a few of the larger specimens, and it has not proved possible to demonstrate dimorphism.

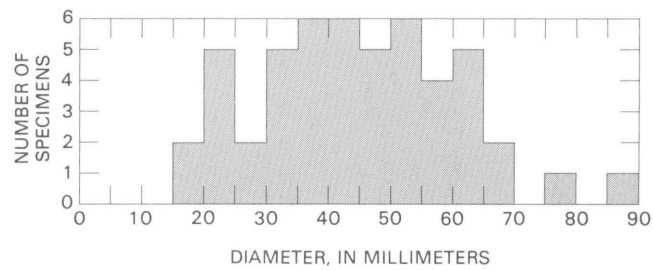

Figure 2. Histogram showing range in size of base of body chambers of 50 specimens of *Metengonoceras aspenanum* (Reeside and Weymouth) from USGS Mesozoic locality 23042 near Winnecook, Mont. (fig. 1).

The earliest whorls of specimens from locality 23042 are about as broad as high and have rounded flanks that grade evenly into the rounded venter. At some diameter between 2.0 and 2.5 mm, the whorls become higher than wide and the venter flattens. At slightly larger diameters, the whorls become very compressed and the flanks flatten; the greatest width is at the umbilical shoulder. On internal molds, the venter is either flat or slightly concave. On specimens that retain their shell

material, a threadlike midventral rib arises at some diameter between 30 and 40 mm. This rib and flattened venter persist on the larger specimens. The largest specimen from locality 23042 is an adult about 94 mm in diameter that has traces of the midventral rib and flattening on the rounded, younger end of the body chamber (pl. 1, figs. 20, 21). Other ornament on the specimens from locality 23042 consists of falcoid growth lines and, on the body chamber and last septate whorl, faint to distinct arcuate ribs on the inner part of the outer half of the flank. These ribs, which usually number 7 or 8 per half whorl, form where the growth lines curve back.

Sutures of the specimens from locality 23042 differ from the two illustrated by Reeside and Weymouth (1931, pl. 2, figs. 4, 5) in that the lobes tend to be longer

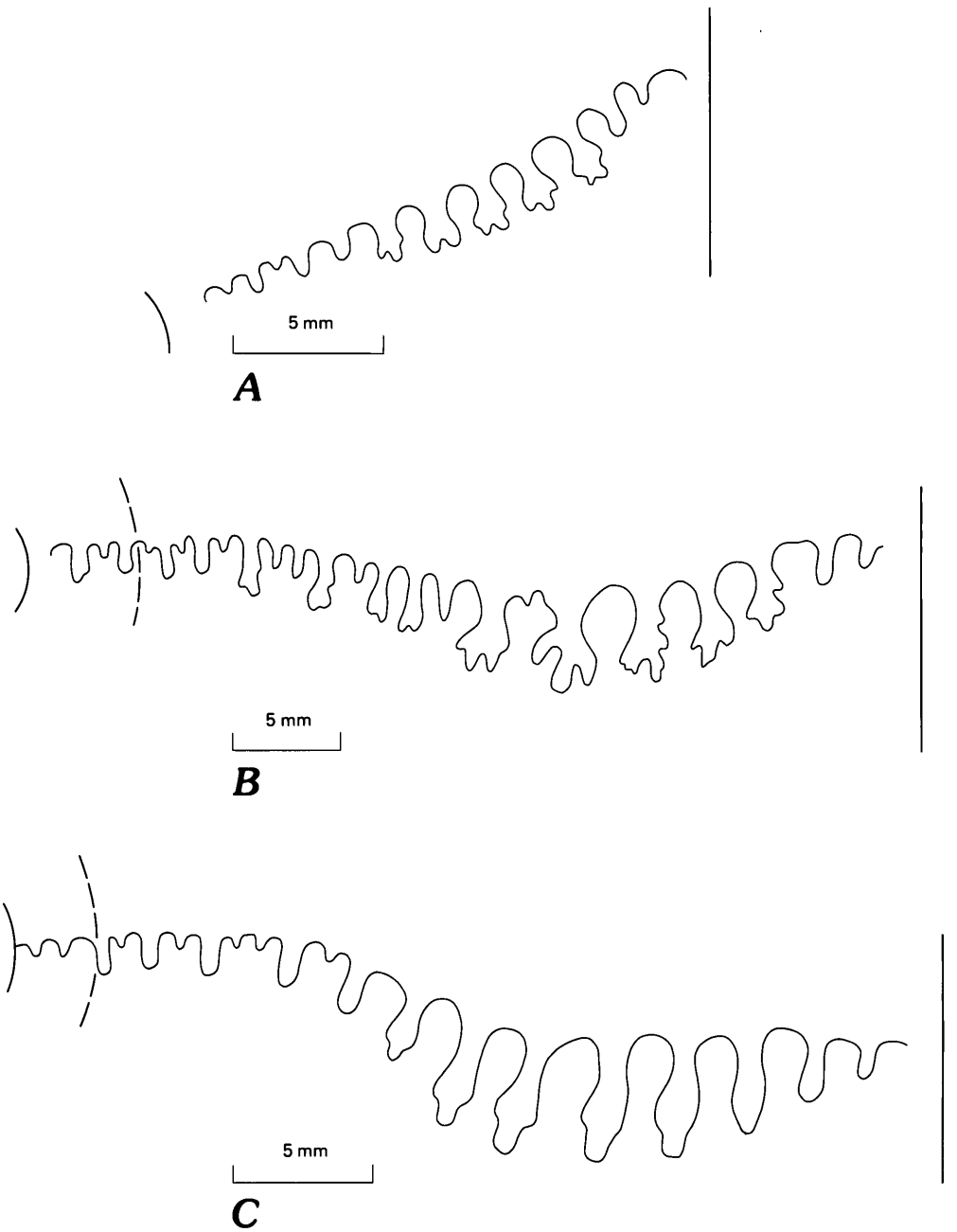

Figure 3. External sutures of *Metengonoceras aspenanum* (Reeside and Weymouth) from USGS Mesozoic locality 23042 near Winnecook, Mont. (fig. 1). *A*, Hypotype USNM 420358 at a whorl height of 18 mm (pl. 5, figs. 3, 4). *B*, Hypotype USNM 420368 at a whorl height of 37 mm. C, Hypotype USNM 420369 at a whorl height of 30 mm. Heavy straight line marks the middle of the venter; curved dashed line marks the umbilical shoulder; solid curved line marks the umbilical seam.

and the saddles broader (fig. 3). Only one specimen (pl. 1, figs. 22, 23) has bifid saddles on the outer part of the flank like those shown by Reeside and Weymouth.

Discussion.—Inner whorls of *M. aspenanum* closely resemble those of the species described by Böse (1928, p. 229, pl. 7, figs. 37–41; pl. 8, figs. 1–8; pl. 12, fig. 8) as *Engonoceras bravoense* from the lower Cenomanian Del Rio Clay of north-central Texas. Inner whorls of both forms are slender with narrow venters and smooth flanks. *Metengonoceras aspenanum* differs chiefly in that it has a slightly smaller umbilicus and a slightly broader venter. The form described from the Cenomanian of Tunisia as *Engonoceras thomasi* by Pervinquière (1907, p. 202, pl. 9, fig. 6a, b; text fig. 77) also resembles *M. aspenanum* in its smooth shell, but the African species has a slightly wider umbilicus and a broader venter. Sutures of *E. thomasi, E. bravoense*, and *M. aspenanum* are much alike. All these species should probably be placed in the same genus—*Metengonoceras*.

Occurrence.—Reeside and Weymouth's types are from 24.4 m below the top of the Aspen Shale at USGS Mesozoic locality 14718 in the NW1/4 sec. 32, T. 21 N., R. 115 W., Lincoln County, Wyo. (fig. 1), where they were associated with *Neogastroplites americanus* (Reeside and Weymouth). The specimens of *Metengonoceras aspenanum* described herein are from the same zone (*N. americanus* zone) 35 m below the base of the Big Elk Sandstone Member of the Colorado Shale at USGS Mesozoic locality 23042 in the SW1/4 sec. 14, T. 7 N., R. 16 E., Wheatland County, Mont. (fig. 1). Other occurrences in Montana and Wyoming are shown in figure 1 and described in table 1.

Metengonoceras teigenense, n. sp.

Plates 2–5, text figure 4

1960. *Metengonoceras* B. Reeside and Cobban, p. 26.

Types.—Holotype USNM 420341, figured paratypes USNM 420342–420356, 33 unfigured paratypes USNM 420357, all from the Mowry Shale Member of the Colorado Shale at USGS Mesozoic locality 24065 in the center of sec. 4, T. 14 N., R. 25 E., Petroleum County, Mont., where they were associated with *Neogastroplites muelleri* Reeside and Cobban.

Origin of name.—From Teigen, Petroleum County, Mont., near which the types were found.

Diagnosis.—A highly, involute, compressed species that has on internal molds a very narrow, flat to concave venter on the early whorls of the phragmocone and a sharp venter on the later whorls of the phragmocone and body chamber. The suture usually has undivided saddles and florid lobes between the external and lateral lobes.

Description.—The holotype (pl. 2, figs. 5–7) is an internal mold of an adult 142 mm in diameter that has an umbilical diameter of 9.9 mm (0.07). The crushed body chamber occupies half a whorl and has a diameter of 103 mm at its base. A sharp venter is present on the entire body chamber as well as on the phragmocone. The uncrushed phragmocone has a very compressed whorl section that is widest at the umbilical shoulder. Ornament other than falcoid growth lines seems to be lacking on the body chamber. A few faint, short, arcuate ribs are visible in oblique lighting on the outer part of the flank on the last quarter whorl of the phragmocone. Septa are closely spaced as in other species of *Metengonoceras*. The lateral lobe and the first four auxiliary lobes between it and the venter are florid, and the intervening saddles are rounded and undivided. Most of the saddles between the lateral lobe and the umbilicus are bifid.

The holotype came from a large, silty, calcareous concretion at USGS Mesozoic locality 24065 near Teigen in central Montana (fig. 1). This concretion yielded 400 specimens of *M. teigenense*, along with 3,800 specimens of *Neogastroplites muelleri* Reeside and Cobban (Reeside and Cobban, 1954). Most of the *Metengonoceras* consist of fragments of less than half a whorl. Only 28 specimens are complete enough for measurements of the diameter at the base of the body chamber. These show a wide range in size that probably indicates both immature and mature growth stages (fig. 4). We are unable to demonstrate dimorphism. The largest phragmocone has a diameter of 168 mm, which is probably also the diameter at the base of the body chamber (pl. 5, figs. 1–3). The largest complete adult, an internal mold, has a diameter of 170 mm (pl. 4, figs. 7, 8). Slightly more than half of the outer whorl is a body chamber that has a diameter of 112 mm at its base. The venter of this internal mold is sharp to the aperture. On this individual, as well as on other adult body chambers, the aperture is normal and follows the shape of the growth lines.

Whorls of specimens 2.0 to 2.5 mm in diameter from locality 24065 are about as high as wide with rounded flanks that grade evenly into rounded venters. At diameters from 2.5 to 3.0 mm, the whorls become higher than wide, and the venter flattens a little. Whorls become progressively higher with growth, and the flanks flatten. At a diameter of 4.5 mm, the height may be twice that of the width with the greatest width at the umbilical shoulder. The venter becomes very narrow and slightly concave on both shelled specimens and internal molds. At some diameter between 30 and 45 mm, the venter on internal molds becomes sharp. Specimens that retain shell material have very narrow flat venters at least to a diameter of about 100 mm. At larger diameters, the flattening may be lost.

Ornament is inconspicuous and usually consists only of falcoid growth lines. Under oblique lighting, faint arcuate ribs that number 8 to 10 per half whorl are discernible just above midflank on some body chambers and

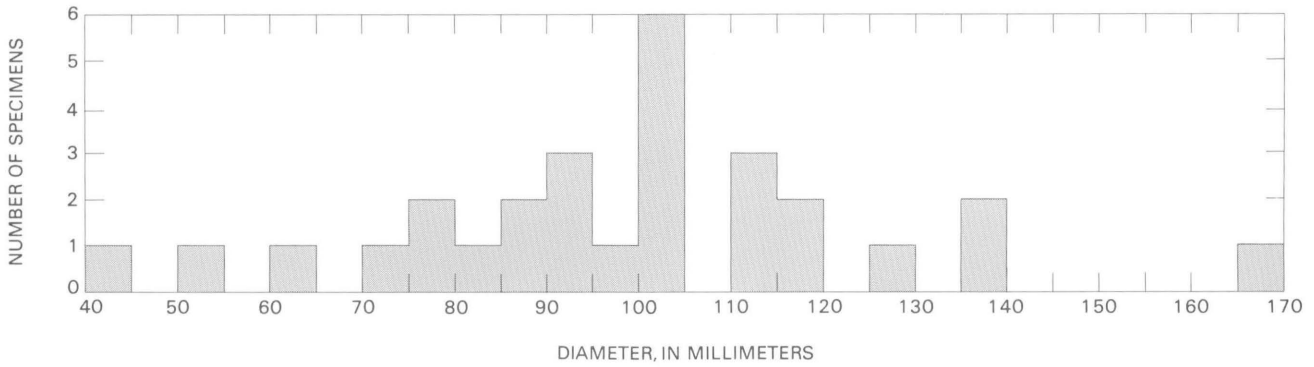

Figure 4. Histogram showing range in size of base of body chambers of 28 specimens of *Metengonoceras teigenense*, n. sp., from USGS Mesozoic locality 24065 near Teigen, Mont. (fig. 1).

outer septate whorls. An occasional septate whorl may have faint prorsiradiate umbilical foldlike ribs that number about 5 per half whorl.

Sutures are distinctive and fairly complex for the genus. Most sutures have narrow-necked lateral and adventitious lobes whose branches may touch one another (figs. *5C, D*). Saddles that separate these lobes are usually round and undivided. Lobes between the lateral lobe and the umbilicus are generally narrow and bifid or undivided. Saddles that separate these lobes vary considerably; some may be undivided (fig. *5B*), some may be bifid (fig. *5A*), and some may be irregularly trifid (fig. *5B*). In this part of the suture, a pair of lobes may be close together and are separated by a narrow, deep saddle (figs. *5B, C*), similar to a pair on a suture of *Engonoceras uddeni* (Cragin) illustrated by Hyatt (1903, pl. 19, fig. 1), as well as a pair on a suture of *Metengonoceras acutum* Hyatt (1903, pl. 27, fig. 2). The short, bowtielike external lobe is centered on the middle of the venter on whorls less than 15 mm in diameter, but, as the whorls enlarge, the lobe usually drifts off center either to the right (figs. *5C, D*) or to the left (figs. *5A, B*). This shifting of the lobe occurs at some diameter from 15 to 35 mm. Observations on 317 specimens larger than 35 mm diameter revealed that only 13 still had the lobe centered on the venter. Of the remainder, 158 had the lobe off to the right, and 146 had it off to the left.

Discussion.—Metengonoceras teigenense, n. sp., seems most closely related to *M. dumbli* (Cragin) of middle and late Cenomanian age and to *M. acutum* Hyatt of late Cenomanian age. All three species are of comparable size and have smooth or nearly smooth shells and similar sutures. *Metengonoceras dumbli* (Cragin, 1893, p. 243, pl. 44, fig. 6), which has been well illustrated from the Cenomanian Woodbine Formation of north Texas by Stephenson (1953, p. 206, pl. 55, figs. 1–4), Kennedy and others (1981, p. 32, pl. 3, figs. 1–5; pl. 7, figs. 4–6; text figs. 4a–g, 5b–f) and Cobban (1987, p. C2, pl. 1, figs. 3–6, 8; pl. 2, figs. 1–3, 9, 10; text fig. 1) differs from *M. teigenense* in that it has a stouter shell and the adventitious lobes of its suture have less deeply divided branches. *Metengonoceras acutum* Hyatt (1903, p. 184, pl. 26, fig. 8; pl. 27, figs. 1, 2), which was described from the Cenomanian and Turonian Eagle Ford Group of north Texas, may differ from *M. teigenense* only in its more acute venter. Hyatt (1903, p. 184) mentioned the presence of broad, foldlike costae near the umbilical shoulder, but this ornament is not present on the few specimens at hand from the Eagle Ford.

Occurrence.—The holotype and paratypes of *M. teigenense* are from a large silty concretion below the middle of the Mowry Member of the Colorado Shale at USGS Mesozoic locality 24065 in east-central Montana. The species is known only from a few localities in central and east-central Montana (fig. 1) in the zone of *Neogastroplites muelleri* Reeside and Cobban.

ORIGIN AND AGE OF THE MOWRY *METENGONOCERAS*

Reeside and Cobban (1960, p. 26, 27) recognized the following five biostratigraphic assemblages (zones) of the ammonite *Neogastroplites* McLearn, 1931, and their interpreted chronostratigraphic sequence in the Western Interior of the United States is:

Neogastroplites maclearni (youngest)
N. americanus
N. muelleri
N. cornutus
N. haasi (oldest)

Metengonoceras was not found in the oldest zone, and only two fragments were observed in the next zone of *N. cornutus*. Only the zones of *N. muelleri* and *N. americanus* contain abundant *Metengonoceras*.

Although Reeside and Cobban (1960, table 1) had 124 collections of Mowry ammonites, specific names could be assigned only to about half of these owing to

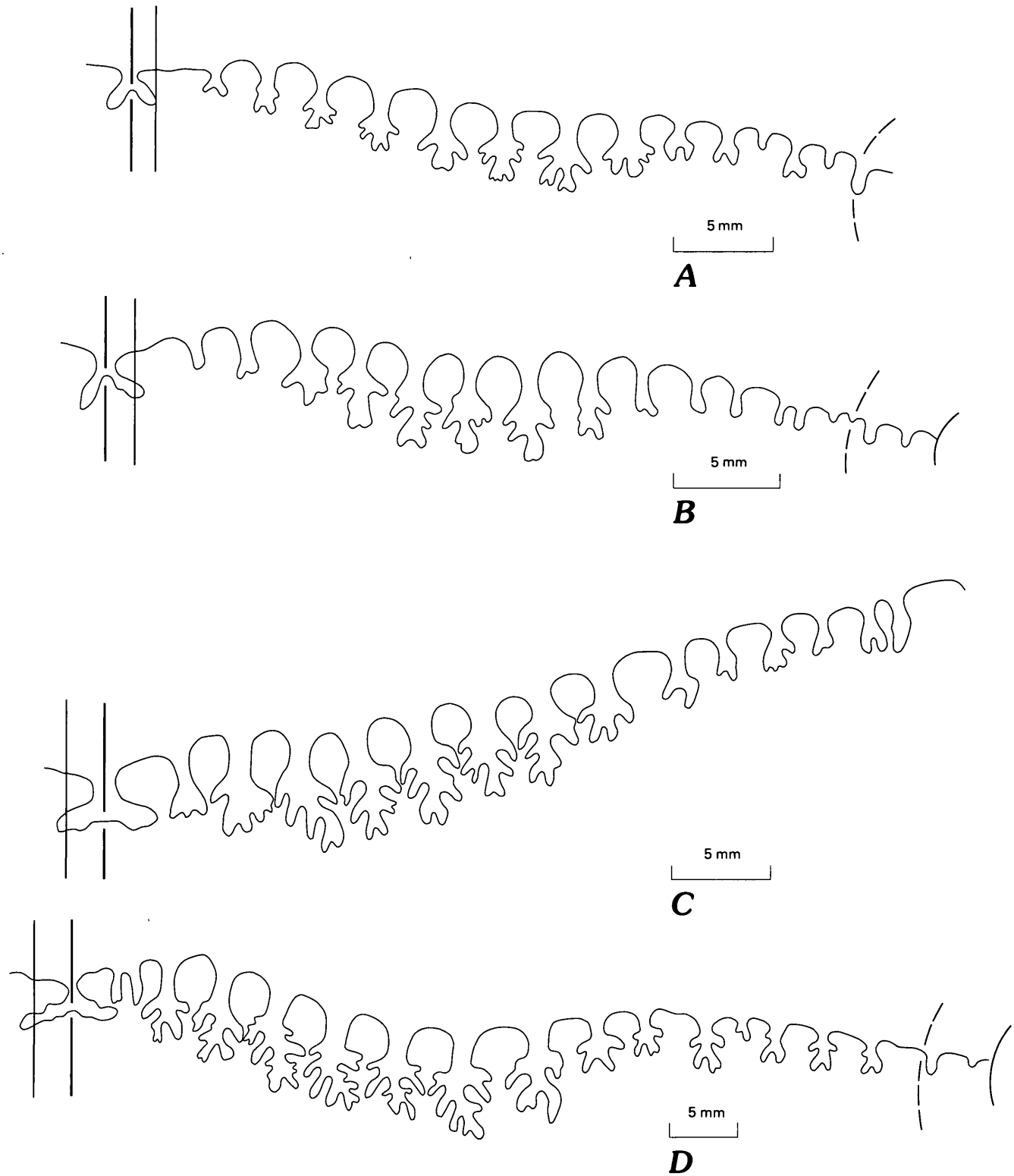

Figure 5. External sutures of *Metengonoceras teigenense*, n. sp., from USGS Mesozoic locality 24065 (fig. 1). *A*, Paratype USNM 420352 at a whorl height of 38 mm. *B*, Paratype USNM 420353 at a whorl height of 57 mm. *C*, Paratype USNM 420354 at a whorl height of 43 mm. *D*, Paratype USNM 420355 at a whorl height of 62.5 mm. Heavy straight line marks middle of external (siphonal) lobe; light straight line marks middle of venter; dashed curve line marks umbilical shoulder; solid curved line marks umbilical seam.

flattened or poorly preserved specimens. Those authors pointed out the difficulties in determining the stratigraphic succession of these geographically widely distributed collections. The present investigation suggests that the zones of *N. muelleri* and *N. americanus* should be reversed in their order. *Metengonoceras aspenanum*, which lies in the zone of *N. americanus*, is stouter and a little more ornamented than *M. teigenense*, n. sp., and in these features *N. aspenanum* more closely resembles the lower Cenomanian species of *Metengonoceras* from Texas than does *M. teigenense* from the *N. muelleri* zone. *Metengonoceras teigenense*, on the other hand, has the smooth-flanked, sharp-ventered appearance of the younger *M. dumbli* and *M. acutum* of the middle and upper Cenomanian.

The Tethyan family Engonoceratidae is well represented in the upper Albian-lower Cenomanian Washita Group of Texas. The presence of numerous specimens of *Metengonoceras* as far north as central Montana is remarkable. Inasmuch as only a few fragments of engonoceratids have been found farther north in central western Alberta (Thorsteinson, 1952, p. 30), the origin of the Mowry *Metengonoceras* seems to be in the Gulf region.

Neither of the Mowry species is known in the Gulf faunas. Both *M. aspenanum* and *M. teigenense* are more involute than any of the Albian and lower Cenomanian species of Texas, which gives the Mowry species a post-Washita Group aspect. The youngest engonoceratids in the USGS collections from the Washita Group are *Engonoceras retardum* Hyatt (1903, p. 160, pl. 19, figs. 15–17) and *Metengonoceras bravoense* (Böse), both found in the Grayson Formation in north Texas. *Engonoceras retardum* is an ornate species that has umbilical and mid-flank tubercles; there is nothing like it in the Mowry faunas. *Metengonoceras bravoense*, however, rather closely resembles *M. aspenanum* and could have given rise to it by becoming more involute and a little stouter.

Metengonoceras may have migrated northwestward across northwestern Texas and eastern New Mexico soon after the close of Grayson time (earliest Cenomanian) and entered the Western Interior seaway in southeastern Colorado. There are no known records of this postulated event. The Grayson Formation of north Texas is overlain disconformably by the middle Cenomanian Woodbine Formation, and the Buda Limestone, of late Grayson age in southwestern Texas, is overlain disconformably by the Boquillas Formation of which the basal beds range in age from early to middle Cenomanian. Two lower Cenomanian ammonoid faunas have been described from strata above the Buda Limestone in southwestern Texas (Young, 1958; Cobban and Kennedy, in press), but engonoceratids have not been recorded. The youngest marine rocks of Washita age in northeastern New Mexico are included in the Pajarito Shale Member of the Purgatoire Formation, where *Lopha quadriplicata* (Shumard) has been recorded (Dobrovolny and others, 1947). This bivalve has a range of upper Albian into lower Cenomanian (Fort Worth, Denton, Weno, and Main Street Formations in north Texas; Adkins, 1928, p. 105). At many places the Pajarito Member is overlain by a crossbedded sandstone unit that has been recently referred to as the Romeroville Sandstone (Kues and Lucas, 1987). The unit is possibly a nonmarine equivalent of the Grayson-Buda sequence. Overlying the Romeroville Sandstone of Kues and Lucas (1987, fig. 3) is the marine Graneros Shale, which consists of lower and upper unnamed shale members separated by the Thatcher Limestone Member. The Thatcher Member contains a middle Cenomanian *Conlinoceras tarrantense* fauna in southeastern Colorado (Cobban and Scott, 1973), but the lower unnamed shale member has not yielded diagnostic fossils. A marine connection between the Western Interior and Gulf coastal basins probably existed at sometime during deposition of the lower shale member, and during that time *Metengonoceras* may have entered the Western Interior basin.

Although the relative stratigraphic position of the two *Metengonoceras* faunas cannot be proven without additional field work, both faunas have a post-Washita appearance, and both are herein considered of early Cenomanian age. The age of the few fragments of *Metengonoceras* in the older zone of *Neogastroplites cornutus* cannot be determined from the material at hand, but the age may well be early Cenomanian.

The age of the *Neogastroplites* faunas has usually been considered as late Albian or late late Albian, but the endemic nature of the faunas has prevented a definite correlation with the type Albian faunas of Europe. Reeside and Cobban (1960), following the Albian assignments by Canadian and British paleontologists (for example, McLearn, 1931, 1932; Spath, 1937; Warren and Stelck, 1958), considered the faunas as latest Albian "with the reservation that they may possibly belong to the earliest Cenomanian" (Reeside and Cobban, 1960, p. 1).

Neogastroplites has been said to occur on the Pacific side of the U.S.S.R., where specimens have been identified as *N. americanus*, *N.* cf. *maclearni*, and *N.* cf. *muelleri* (Pergament, 1977, p. 90). Other ammonites listed from this *Neogastroplites* zone are upper Albian forms. Pergament did not illustrate the *Neogastroplites*, but Avdeiko (1968) had earlier figured a few small specimens as *N.* cf. *muelleri*, *N.* cf. *americanus*, and *N.* cf. *maclearni*. Jeletzky (1980, p. 39), after thoroughly investigating *Neogastroplites* and related genera concluded that *Neogastroplites* is endemic to and confined to the Western Interior basin and that the Soviet records of the genus are questionable.

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PLATES 1–5

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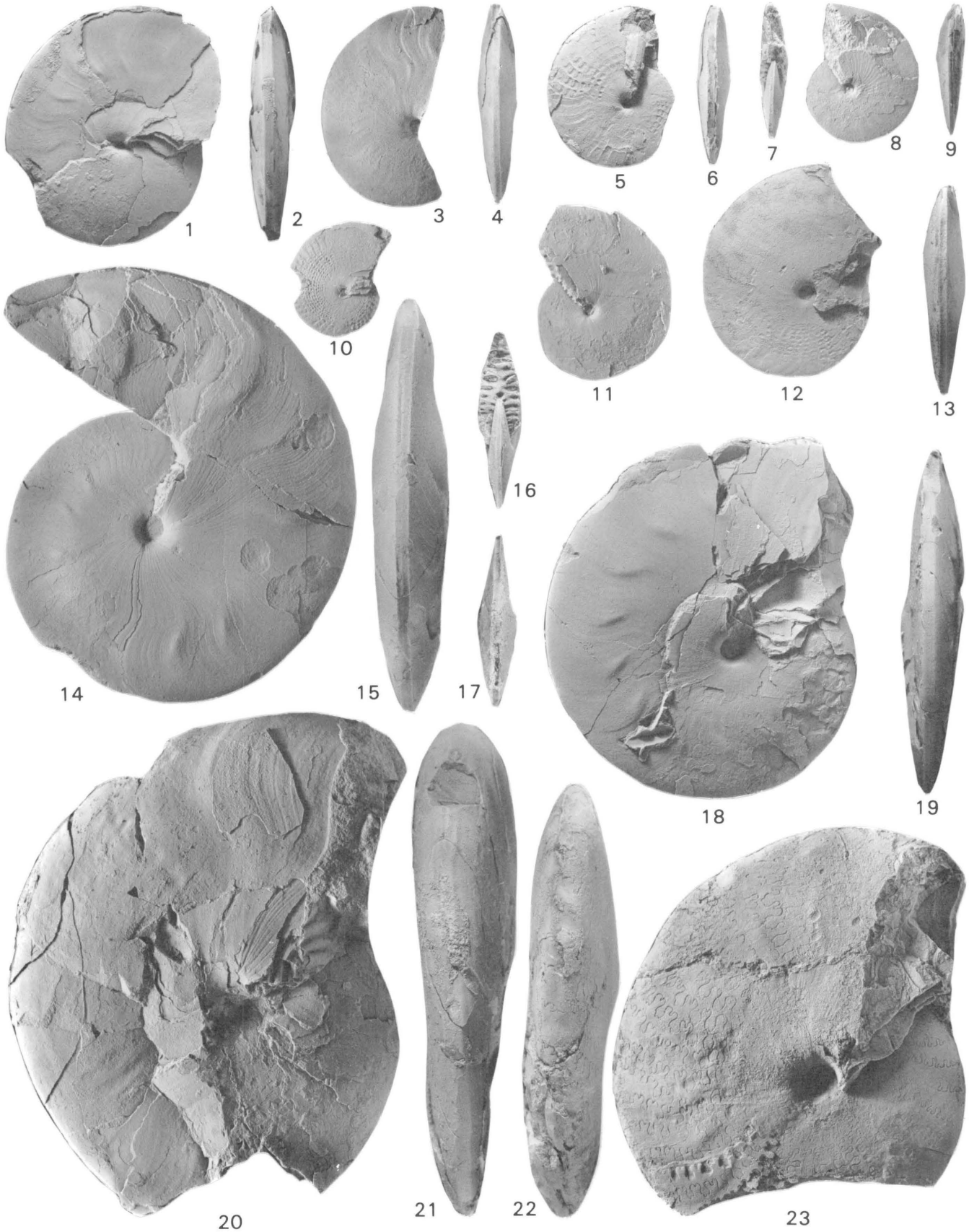
PLATE 1

[All figures natural size. Locality shown on text figure 1]

Metengonoceras aspenanum (Reeside and Weymouth). From the Colorado Shale at USGS Mesozoic locality 23042 near Winnecook, Meagher County, Mont.

Figures 1,2. Hypotype USNM 420357.
3,4. Hypotype USNM 420358. See text figure 5*A* for the suture.
5,6. Hypotype USNM 420359.
7–9. Hypotype USNM 420360.
10. Hypotype USNM 420361.
11, 16, 17. Hypotype USNM 420362.
12, 13. Hypotype USNM 420363.
14, 15. Hypotype USNM 420364.
18, 19. Hypotype USNM 420365.
20, 21. Hypotype USNM 420366.
22, 23. Hypotype USNM 420367.



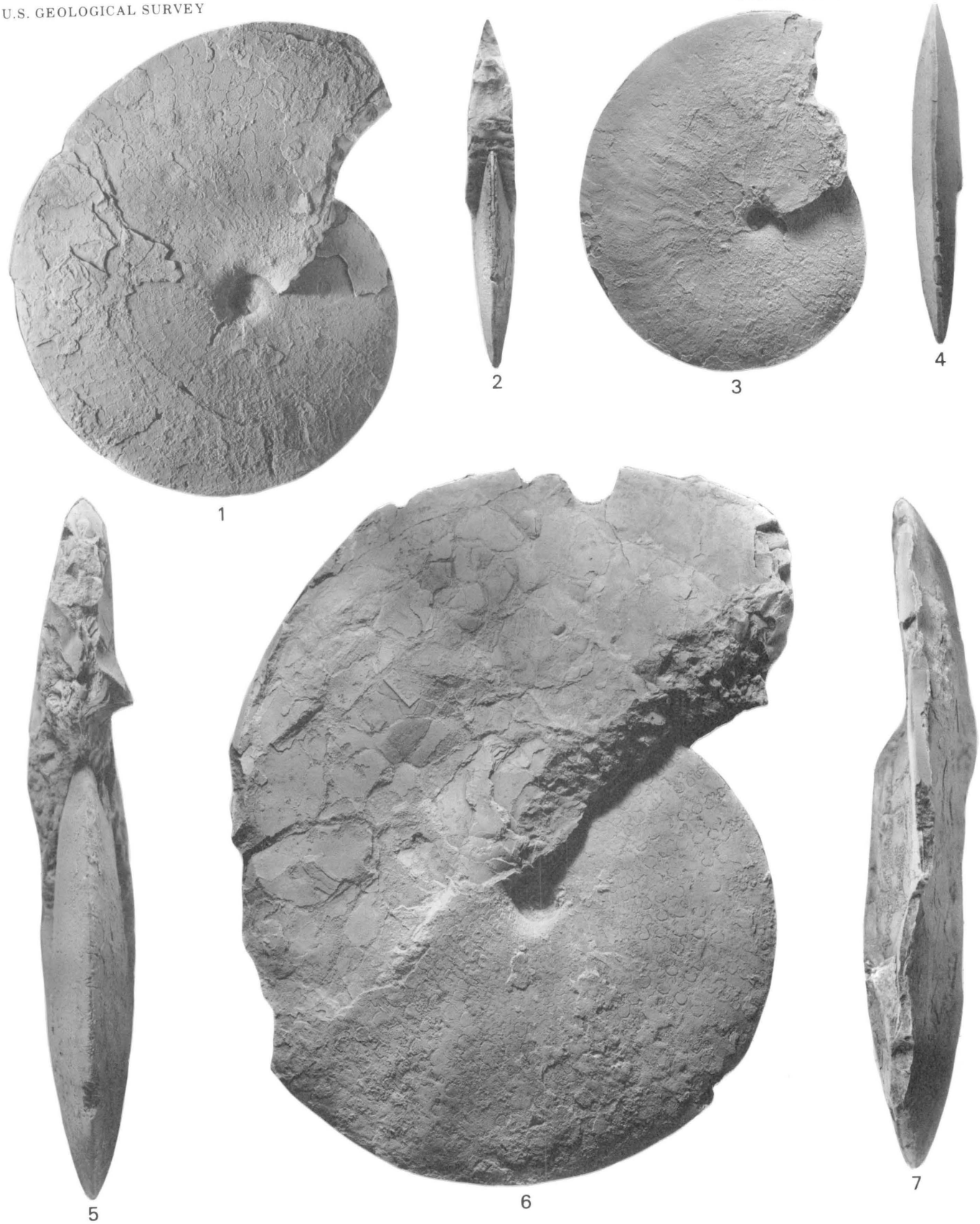
METENGONOCERAS

PLATE 2

[All figures natural size. Locality shown on text figure 1]

Metengonoceras teigenense n. sp. From the Mowry Member of the Colorado Shale at USGS Mesozoic locality 24065 near Teigen, Petroleum County, Mont.

Figure 1. Paratype USNM 420342. See plate 3, figures 1,2, for rear and front views.
2–4. Paratype USNM 420343.
5–7. Holotype USNM 420341.



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METENGONOCERAS

PLATE 3

[All figures natural size. Locality shown on text figure 1]

Metengonoceras teigenense n. sp. From the Mowry Member of the Colorado Shale at USGS Mesozoic locality 24065 near Teigen, Petroleum County, Mont.

Figures 1,2. Paratype USNM 420332. See plate 2, figure 1, for side view.
3–5. Paratype USNM 420344.
6–8. Paratype USNM 420345.

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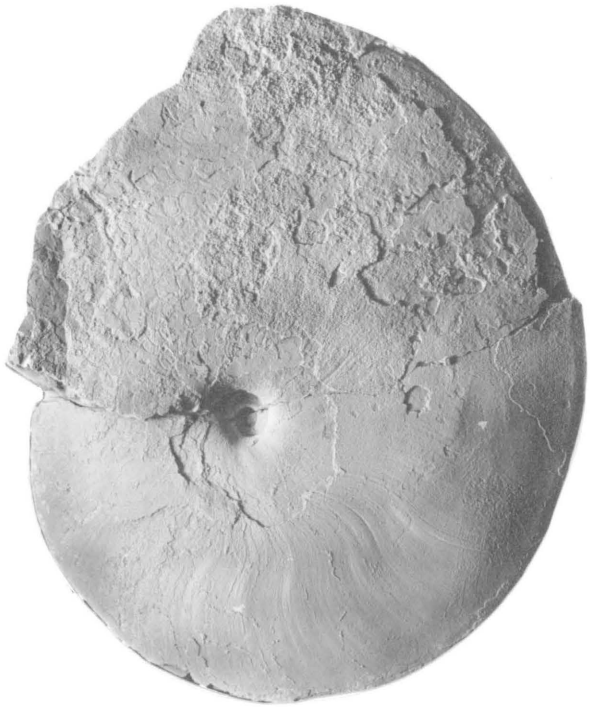

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METENGONOCERAS

PLATE 4

[All figures natural size. Locality shown on text figure 1]

Metengonoceras teigenense n. sp. From the Mowry Member of the Colorado Shale at USGS Mesozoic locality 24065 near Teigen, Petroleum County, Mont.

Figures 1,5,6. Paratype USNM 420349.
2. Paratype USNM 420346.
3. Paratype USNM 420347.
4. Paratype USNM 420348.
7,8. Paratype USNM 420350.

METENGONOCERAS

PLATE 5

[All figures natural size. Locality shown on text figure 1]

Metengonoceras teigenense n. sp. From the Mowry Member of the Colorado Shale at USGS Mesozoic locality 24065 near Teigen, Petroleum County, Mont. Paratype USNM 420351.

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METENGONOCERAS

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Maps

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Geophysical Investigations Maps are on topographic or planimetric bases at various scales; they show results of surveys using geophysical techniques, such as gravity, magnetic, seismic, or radioactivity, which reflect subsurface structures that are of economic or geologic significance. Many maps include correlations with the geology.

Miscellaneous Investigations Series Maps are on planimetric or topographic bases of regular and irregular areas at various scales; they present a wide variety of format and subject matter. The series also includes 7 1/2-minute quadrangle photogeologic maps on planimetric bases which show geology as interpreted from aerial photographs. Series also includes maps of Mars and the Moon.

Coal Investigations Maps are geologic maps on topographic or planimetric bases at various scales showing bedrock or surficial geology, stratigraphy, and structural relations in certain coal-resource areas.

Oil and Gas Investigations Charts show stratigraphic information for certain oil and gas fields and other areas having petroleum potential.

Miscellaneous Field Studies Maps are multicolor or black-and-white maps on topographic or planimetric bases on quadrangle or irregular areas at various scales. Pre-1971 maps show bedrock geology in relation to specific mining or mineral-deposit problems; post-1971 maps are primarily black-and-white maps on various subjects such as environmental studies or wilderness mineral investigations.

Hydrologic Investigations Atlases are multicolored or black-and-white maps on topographic or planimetric bases presenting a wide range of geohydrologic data of both regular and irregular areas; principal scale is 1:24,000 and regional studies are at 1:250,000 scale or smaller.

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