Characteristic Marine Molluscan Fossils From the Dakota Sandstone and Intertongued Mancos Shale, West-Central New Mexico

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Characteristic Marine Molluscan Fossils From the Dakota Sandstone and Intertongued Mancos Shale, West-Central New Mexico

By WILLIAM A. COBBAN

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Brief descriptions, illustrations, and stratigraphic sequence of the more common fossils at the base of the Cretaceous System

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CHARACTERISTIC MARINE MOLLUSCAN FOSSILS FROM THE DAKOTA SANDSTONE AND INTERTONGUED MANCOS SHALE, WEST-CENTRAL NEW MEXICO

By WILLIAM A. COBBAN

ABSTRACT

Molluscan fossils are abundant in marine rocks of early Late Cretaceous age (Cenomanian) on the south and southeast flanks of the San Juan Basin in northwestern New Mexico. Here the Cenomanian rocks are characterized by generally eastward-pointing tongues of Dakota Sandstone separated in part by westward-pointing tongues of Mancos Shale. From bottom to top, the sequence consists of the Oak Canyon Member of the Dakota Sandstone, Cubero Sandstone Tongue of the Dakota Sandstone, Clay Mesa Shale Tongue of the Mancos Shale, Paguate Sandstone Tongue of the Dakota Sandstone, Whitewater Arroyo Shale Tongue of the Mancos Shale, and Twowells Sandstone Tongue of the Dakota Sandstone. The lower part of the Oak Canyon Member consists of rocks of fluviatile and brackish-water origin; the strata of the rest of the member and of all the overlying intertongued Dakota Sandstone and Mancos Shale are dominantly of shallow-water open-marine origin.

Molluscan fossils occur in all the members. Most specimens are found in silty limestone concretions, in calcareous siltstone or sandstone concretions, and in very fine grained sandstone and siltstone beds. The upper part of the Oak Canyon Member and the Paguate Sandstone Tongue contain the greatest variety of fossils. Fifty-two kinds of bivalves, 38 gastropods, and 15 ammonoids from these two units are present in the collections of the U.S. Geological Survey.

INTRODUCTION

The basal part of the Cretaceous System in west-central New Mexico consists of a generally transgressive sequence of intertongued sandstone, siltstone, and shale. The stratigraphic framework and terminology of this sequence was summarized in two recent papers by Landis, Dane, and Cobban (1973a, b). Many of the characteristic molluscan fossils were recorded, but no attempt was made to show either stratigraphic ranges or geographic distributions. This paper has been prepared as a paleontologic supplement to the stratigraphic work of Landis, Dane, and Cobban. However, this paper is not intended as a detailed systematic study of the fauna, but rather as a generalized guide to the common fossils and their distribution. No new species are formally described and named herein. Synonomies include only the original paper in which a species was named and, generally, one or two later papers that have important nomenclature changes or good illustrations.

ACKNOWLEDGMENTS

The photographs in this report were made by Robert E. Burkholder, of the U.S. Geological Survey. All illustrated specimens are stored in the National Museum of Natural History in Washington, D.C. The rest of the fossils, as well as some plaster casts of illustrated specimens, are kept in the U.S. Geological Survey's Mesozoic invertebrate collections at the Federal Center, Denver, Colo.

Dr. Annie Dhondt, Institut royal des Sciences naturelles de Belgique, kindly examined photographs of *Neithea* from the Paguate Sandstone Tongue of the Dakota Sandstone and *Camptonectes* from the Twowells Sandstone Tongue of the Dakota, and she offered suggestions regarding their specific names.

STRATIGRAPHIC SUMMARY

Landis, Dane, and Cobban (1973a, b) observed that the intertonguing of the Dakota Sandstone and Mancos Shale was formed best in the Grants-Laguna area in the southern part of the San Juan Basin (fig. 1). Here the sequence, from oldest to youngest, consists of Oak Canyon Member of the Dakota Sandstone, Cubero Sandstone Tongue of the Dakota Sandstone, Clay Mesa Shale Tongue of the Mancos Shale, Paguate Sandstone Tongue of the Dakota Sandstone, Whitewater Arroyo Shale Tongue of the Mancos Shale, and Twowells Sandstone Tongue of the Dakota Sandstone. Northwestward from Grants, the lower part of the sequence (Oak Canyon Member and Cubero, Clay Mesa, and Paguate Tongues) grades into a dominantly sandstone unit identified as the main body of the Dakota Sandstone (fig. 2).

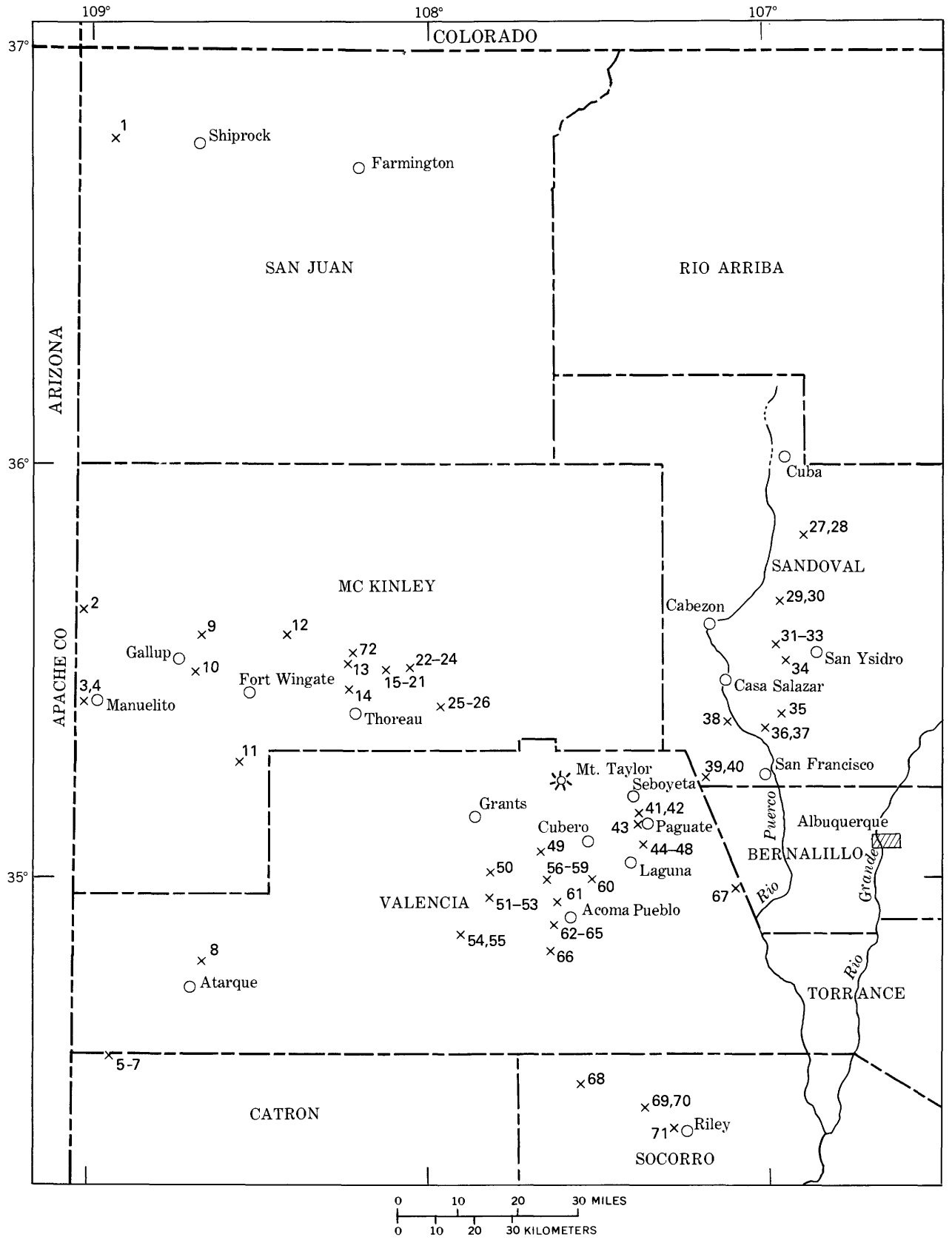

FIGURE 1.—Part of northwestern New Mexico showing localities of mollusk collections referred to in the text and in table 4.

Southeastward from Grants, the Cubero and Paguate Sandstone Tongues grade into shale referred to as the lower part of the Mancos Shale. The nomenclature of the Grants-Laguna area is applicable northeastward from Laguna for about 50 miles (80 km) to north-central Sandoval County where the Cubero and Paguate Sandstone Tongues disappear into the lower part of the Mancos Shale, which overlies a thick main body of the Dakota Sandstone and underlies a very thin Twowells Sandstone Tongue of the Dakota Sandstone (fig. 3).

AGE OF THE INTERTONGUED DAKOTA SANDSTONE AND MANCOS SHALE

The oldest molluscan fossils occur in dark-brown-weathering ferruginous silty to sandy concretionary beds above the middle of the Oak Canyon Member. An ammonite, described from the Woodbine Formation of Texas as *Acanthoceras wintoni* by Adkins (1928, p. 234, pl. 25, figs. 2, 3), occurs sparsely in the ferruginous concretions in the Oak Canyon Member. This ammonite is middle Cenomanian in age.

The youngest fossils are found in the upper part of the Twowells Sandstone Tongue. Among the ammonites are *Calycoceras obrieni* Young and fragments of *Metoicoceras* resembling *M. defordi* Young and *M. muelleri* Cobban, which are of late Cenomanian age. In Wyoming, these ammonites occur with *Dunveganoceras conditum* Haas, a guide to the first ammonite zone older than that of *Sciponoceras gracile* (Shumard), which is of latest Cenomanian age.

EARLIER RECORDS OF FOSSILS

Fossil mollusks of Cretaceous age have been recorded from west-central New Mexico in many papers during the past century. Most authors, however, have made only passing remarks such as noting the local abundance of *"Exogyra columbella"* or *"Gryphaea newberryi."*

C. A. White was probably the first person to describe Cretaceous mollusks from west-central New Mexico. He reported on the collections made in connection with the geographical and geological explorations and surveys west of the 100th meridian. The new bivalve species *Pinna petrina* was described, but not illustrated, by White in 1874. His specimens came from 1 mile (1.6 km) south of Pajuate (Paguate). In 1877, White illustrated this species and also described a new gastropod, *Lispodesthes lingulifera*, from the same locality. Both species are probably from the Paguate Sandstone Tongue of

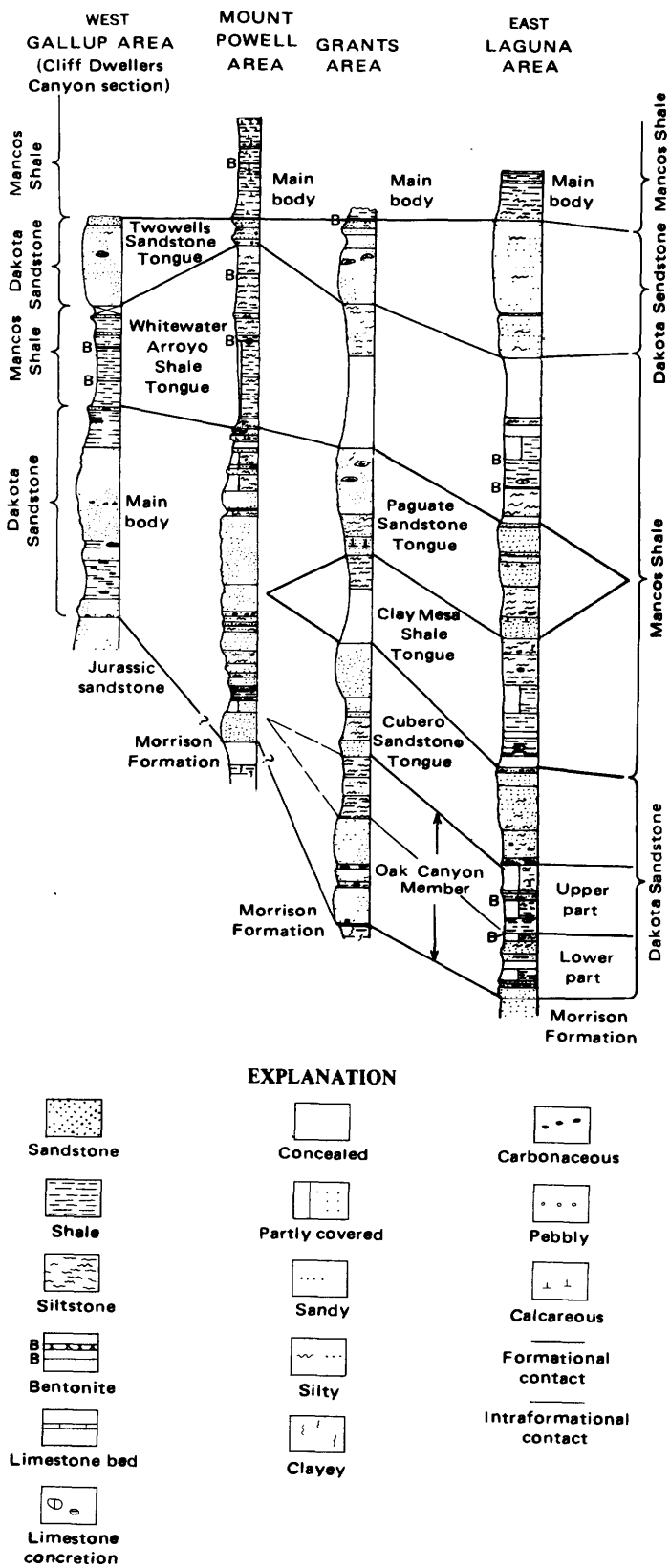

FIGURE 2.—East-west stratigraphic changes in Dakota Sandstone and intertongued Mancos Shale. From Landis, Dane, and Cobban, 1973a, fig. 3.

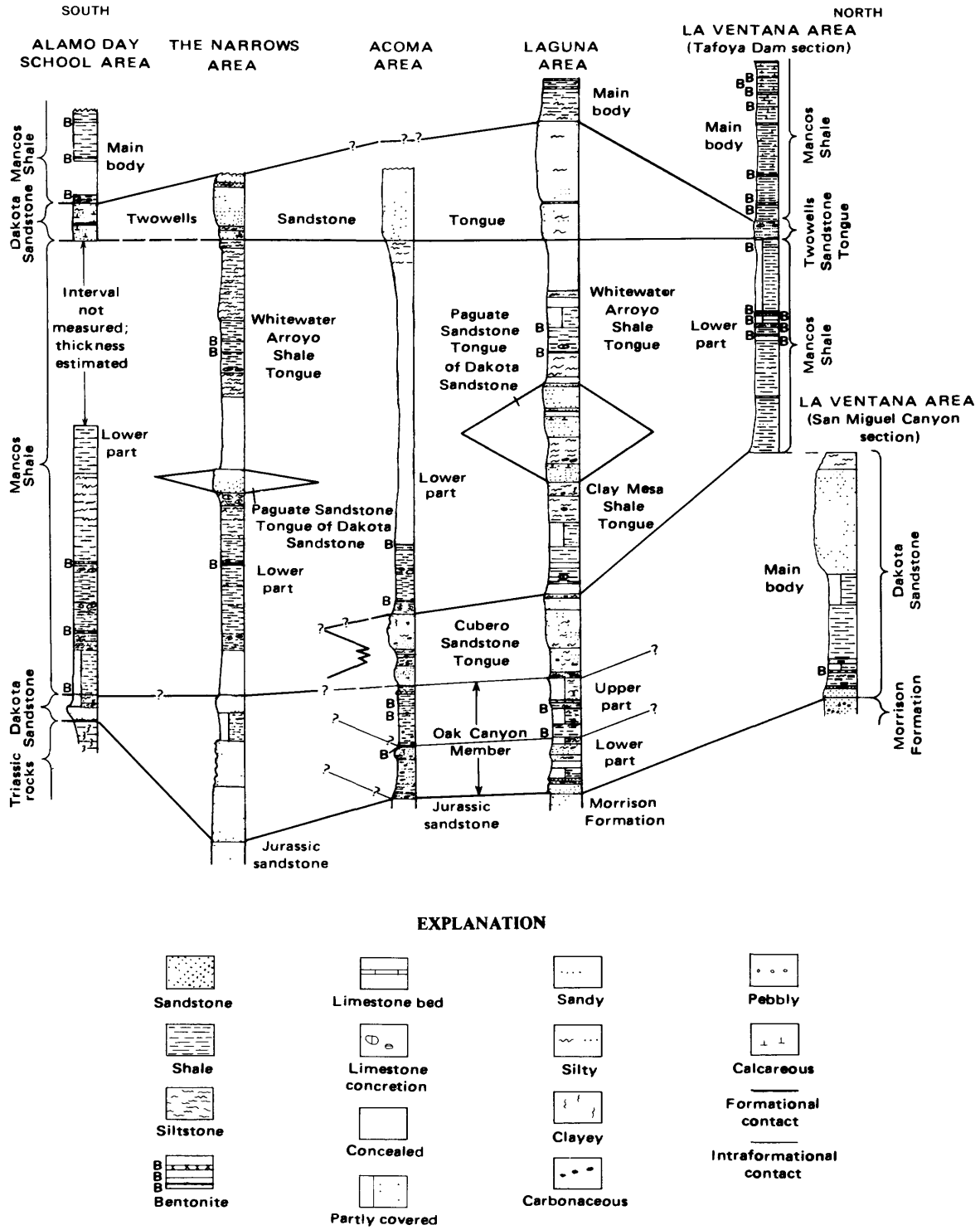

FIGURE 3.—North-south stratigraphic changes in Dakota Sandstone and intertongued Mancos Shale. From Landis, Dane, and Cobban, 1973a, fig. 4.

the Dakota Sandstone, inasmuch as that unit crops out 1 mile south of Paguate (sandstone bed 2 of the Mancos Shale of Moench, 1963). White (1877, p. 174, 183, pls. 17, 18) also described and illustrated the new bivalves *Exogyra costata* Say var. *fluminis* and *Idonearca depressa* from the east bank of the Rio Puerco 6 miles (9.6 km) south of Casa Salazan (Casa Salazar). The *Exogyra* was later assigned to

E. columbella Meek by Stanton (1893, p. 63). The geologic map of the Casa Salazar area by Hunt (1936, pl. 19) does not show any outcrops along the Rio Puerco 6 miles south of Casa Salazar, but the Dakota Sandstone and lower part of the Mancos Shale are shown a mile or two to the south and west of the fossil locality.

In a short paper, White (1881) described *Pinna stevensoni* as a new species from "about 1½ miles southwestward from Fort Wingate, Northern New Mexico." Stanton (1893, p. 89) interpreted White's specimen to be an unusually large example of *P. petrina*.

Meek (1876) reported on the collections of fossils obtained by the exploring expedition of Capt. J. N. Macomb from Santa Fe to the junction of the Grand [Colorado] and Green Rivers. The new bivalve species, *Exogyra columbella* and *Plicatula arenaria* were described and illustrated; they were said to have come from Covero, which is the present day Cubero. Cubero is located on Water Canyon less than a mile north of an east tributary that exposes a highly fossiliferous ferruginous bed in the Oak Canyon Member of the Dakota Sandstone, which is probably the source of Meek's fossils (C. H. Maxwell, oral commun., 1975).

Lists of fossils from well-defined stratigraphic levels were not published until 1900 when Herrick and Johnson (1900, p. 187–188) listed 14 mollusks mostly from the strata presently included in the intertongued Dakota Sandstone and Mancos Shale. A highly fossiliferous "gasteropod zone" was described about 40 feet (12 m) above the Dakota Sandstone. In terms of the present nomenclature, the "gasteropod zone" lies in the upper part of the Oak Canyon Member of the Dakota Sandstone, where the fossils usually occur in dark-brown-weathering ferruginous concretions of calcareous siltstone or very fine grained sandstone. In southeastern Colorado, a dark-brown-weathering ferruginous concretionary limestone bed, the Thatcher Limestone Member of the Graneros Shale, contains *Plicatula arenaria, Exogyra columbella,* and other fossils known from the Oak Canyon Member and the basal part of the overlying Cubero Sandstone Tongue. This fauna will be referred to as the Thatcher fauna.

Darton (1910, p. 60) briefly described a stratigraphic section 2 miles northeast [northwest] of Laguna. "Beds were numbered 1 to 13 from the top to the base. Darton's bed 8, 5 feet (1.5 m) of "Sandstone, hard, red, irony," and the overlying bed 7, 60 feet (18 m) of "Shale, dark gray to gray-green, sandy layers, fossiliferous," can both be assigned to the Oak Canyon Member. Darton listed 16 mollusks from his bed 7 (Thatcher fauna). Bed 6, 40 feet (12 m) of "Sandstone, massive, hard, light buff," is the Cubero Sandstone Tongue, and the overlying bed 5, 60 feet (18 m) of "Shales with sandstone layers, very fossiliferous," represents the Clay Mesa Tongue and lower part of the Paguate Sandstone Tongue. Darton listed eight mollusks from his bed 5, all of which probably came from the lower part of the Paguate Sandstone Tongue. He mentioned the abundance of *Exogyra columbella* in this bed. However, this study will show that *E. columbella* is restricted to the Oak Canyon Member and basal part of the Cubero Sandstone Tongue and that the higher records of this species are based on a somewhat similar species, *E. levis* Stephenson, originally described as *E. columbella levis* Stephenson (1952, p. 77, pl. 18, figs. 1–3) from the Templeton Member of the Woodbine Formation of northeastern Texas. Darton (1910, p. 57) also mentioned that "*Exogyra columbella* Meek [*E. levis* Stephenson] is a very abundant species" in a section that he briefly described 3 miles (4.8 km) east of Gallup.

Lee (1912, p. 622–623) presented a section near San Francisco (now ruins) in the Rio Puerco valley and listed 16 mollusks from the "Gastropod zone" (Thatcher fauna) and 13 mollusks from a 50-foot (15 m) shaly sandstone (Paguate) 105 feet (32 m) higher. Two ammonites recorded from this sandstone as *Prionotropis* sp. and *Acanthoceras*? sp. are probably *Acanthoceras amphibolum* Morrow. Later, Lee (in Lee and Knowlton, 1917, p. 194–195) presented a section near Casa Salazar in which he listed *Exogyra columbella* and six other bivalves and gastropods (Thatcher fauna) from a 55-foot (17 m) sandy to nonsandy shale unit, the base of which is 26 feet (8 m) above the Upper Jurassic Morrison Formation. Above this shale unit (upper part of Oak Canyon Member), Lee measured a 37-foot (11 m) sandstone unit (Cubero Sandstone Tongue) in which he listed *E. columbella* and seven other kinds of mollusks (Thatcher fauna). A 48-foot (15 m) dark shale unit (Clay Mesa Shale Tongue) overlies the sandstone. Above the shale, Lee measured a 66-foot (20 m) yellow sandstone unit (Paguate Sandstone Tongue) containing seven species of mollusks.

Pike (1947) briefly described some sections in the intertongued Dakota Sandstone and Mancos Shale, but very few fossils were recorded other than "*Gryphaea newberryi*" and "*Exogyra columbella.*" Most of these records probably should read *Pycnodonte* aff. *P. kellumi* (Jones) and *Exogyra levis*

TABLE 1.—*Distribution of molluscan fossils in the Clay*
[Approximate stratigraphic position of single occurrences in the members is indicated by an

Species	Clay Mesa Shale Tongue	Paguate Sandstone Tongue
Class Bivalvia:		
Idonearca blanpiedi Stephenson		
Pinna petrina White		
Phelopteria cf. *P. linguaeformis* (Evans and Shumard)		
Phelopteria? cf. *P. aquilerae* (Böse)		
Pseudoptera sp.		×
Inoceramus arvanus Stephenson		
rutherfordi Warren		
Camptonectes sp.		
Neithea cf. *N. sexcostata* (Woodward)		×
Plicatula sp.		
Pycnodonte cf. *P. kellumi* (Jones)		
Exogyra trigeri Coquand		
cf. *E. oxyntas* (Coquand)		
levis Stephenson		
Ostrea beloiti Logan		
Granocardium enstromi (Bergquist)		
trite (White)		
Cymbophora emmonsi (Meek)		
Tellinimera sp.		
Veniella sp.	×	
Pharodina sp.		×
Aphrodina cf. *A. munda* (Stephenson)		
sp.		
Legumen ellipticum Conrad		
Caryocorbula? aff. *C.*? *ovisana* Stephenson		×
Pholadomya n. sp.		
Psilomya aff. *P. concentrica* (Stanton)		×
Psilomya? sp.	×	
Class Gastropoda:		
Turritella shuleri Stephenson ?		
n. sp.		
Perissoptera aff. *P. prolabiata* White		×
Cassiope turriformis (Stephenson)		

Stephenson. The uppermost sandstone tongue (Twowells) of the Dakota Sandstone was named by Pike (1947, p. 36) who reported *Inoceramus labiatus*? in it. "*Gryphaea newberryi*," "*Exogyra columbella*," and a few other bivalves and gastropods were listed by Pike from the underlying shale (Whitewater Arroyo Shale Tongue).

Landis, Dane, and Cobban (1973a, b) recorded

Mesa Shale Tongue and Paguate Sandstone Tongue

×, and the stratigrapric range of each species, based on several occurrences, is shown by a line|

Species	Clay Mesa Shale Tongue	Paguate Sandstone Tongue
Helicaulax? sp.		×
Vascellum mundum Stephenson		×
Anchura aff. *A. turricula* Stephenson		×
n. sp.		—
Lispodesthes panda Stephenson		×
aff. *L. patula* Stephenson		×
aff. *L. lirata* Stephenson		×
Lispodesthes? sp.		×
Paleopsephaea cf. *P. patens* Stephenson		—
sp.		×
Carota dalli (Stanton)		—
aff. *C. dalli* (Stanton)		—
cf. *C.*? *nodosa* Stephenson		×
sp.		—
Avellana n. sp.		×
Hillites? sp.		×
Euspira? sp.		×
Gyrodes tramitensis Stephenson		×
cf. *G. tramitensis* Stephenson		—
sp.		—
Ringicula sp.		—
Fictoacteon cf. *F. humilispira* Stephenson		×
sp.		—
Class Cephalopoda:		
Turrilites acutus americanus Cobban and Scott		—
Desmoceras aff. *D. japonicum* Yabe		—
Paracompsoceras landisi Cobban		—
Tarrantoceras rotatile Stephenson	—	—
Acanthoceras alvaradoense Moreman	—	
amphibolum Morrow		—
Plesiacanthoceras aff. *P. wyomingense* (Reagan)		—
Euomphaloceras aff. *E. cunningtoni* (Sharpe)	—	—
Pseudocalycoceras n. sp.		—
Borissiakoceras reesidei Morrow		×
Eutrephoceras? sp.		—

many mollusks from the intertongued Dakota Sandstone and Mancos Shale. Ammonites were found in all the members of these two formations. (Previous papers seldom recorded the presence of ammonites.) Two unusual specimens, however, have been noted. Northrop (1962, p. 63) mentioned the discovery of a very large "*Mantelliceras canitaurinum* Haas" from the Rio Puerco valley, and Owen (1969, p. 91)

TABLE 2.—*Distribution of molluscan fossils in the Oak Canyon Member and Cubero Sandstone Tongue of the Dakota Sandstone*

[Approximate stratigraphic position of single occurrences in the member is indicated by an ×, and the stratigraphic range of each species, based on several occurrences, is shown by a line]

Species	Oak Canyon Member	Cubero Sandstone Tongue
Class Bivalvia:		
Nuculana sp.	—	—
Barbatia? tramitensis Stephenson	×	
Modiolus cf. *M. santaanaensis* Jones	—	
Pinna petrina White	—	—
Plesiopinna n. sp.	—	
Gervillia sp.	×	
Phelopteria cf. *P. linguaeformis* (Evans and Shumard)	×	
Inoceramus eulessanus Stephenson	—	—
cf. *I. macconnelli* Warren	—	—
Camptonectes symmetricus Herrick and Johnson	—	
Plicatula arenaria Meek	—	—
Anomia subquadrata Stanton	—	
Limatula sp.	—	
Pycnodonte cf. *P. kellumi* (Jones)	—	
Exogyra columbella Meek	—	—
aff. *E. columbella* Meek	—	—
aquillana Stephenson	—	—
sp. A		—
Ostrea beloiti Logan	—	
Astarte sp.	—	—
Opis? sp.	×	
Mediraon sp.	—	
Granocardium n. sp.		×
cf. *G. productum* (Sowerby)	—	—
sp.	—	—
"*Cardium*" n. sp.	—	—
Cymbophora emmonsi (Meek)	—	—
Leptosolen angustus Stephenson	×	
Tellinimera sp.	—	—
Protodonax cf. *P. elongatus* Vokes		×
Aphrodina sp.	×	
Cyprimeria sp.	—	
Parmicorbula sp.	—	—
Pholadomya aff. *P. goldenensis* Stephenson	×	
Laternula sp.	×	
Psilomya levis Stephenson?	—	
aff. *P. concentrica* (Stanton)	—	—
Class Gastropoda:		
Turritella cf. *T. shuleri* Stephenson	×	
sp.	—	
Cerithium n. sp.	—	
Graciliala aff. *G. umbrana* (Stephenson)	—	
Arrhoges modesta (Cragin)?	—	—
Euspira humilis (Cragin)?	×	
Gyrodes sp.	—	
Sigaretus textilis Stanton?	×	
Actaeon n. sp.	—	
Ringicula arlingtonensis Stephenson	×	
Nonactaeonina? sp.	×	
Class Cephalopoda:		
Turrilites acutus Passy	—	—
Desmoceras sp.	×	
Calycoceras tarrantense (Adkins)	—	—
Borissiakoceras compressum Cobban	×	
Johnsonites sulcatus Cobban	×	

TABLE 3.—*Distribution of molluscan fossils in the Whitewater Arroyo Shale Tongue and Twowells Sandstone Tongue*

[Approximate stratigraphic position of single occurrences in the member is indicated by an ×, and the stratigraphic range of each species, based on several occurrences, is shown by a line]

Species	Whitewater Arroyo Shale Tongue	Twowells Sandstone Tongue
Class Bivalvia:		
Nuculana sp.	×	
Idonearca depressa White	—	—
Pinna petrina White		—
Pinna sp.	—	—
Phelopteria sp.		×
Pseudoptera sp.		×
Inoceramus cf. *I. mesabiensis* Bergquist	×	
prefragilis Stephenson	—	—
ginterensis Pergament		×
Camptonectes ex gr. *C. virgatus* (Nilsson)		×
sp.	—	—
Plicatula cf. *P. ferryi* Coquand	—	—
Pycnodonte cf. *P. kellumi* (Jones)	—	
aff. *P. kellumi* (Jones)		—
Exogyra trigeri Coquand	—	—
cf. *E. oxyntas* Coquand	—	
levis Stephenson	—	—
aff. *E. levis* Stephenson	×	
Ostrea beloiti Logan	—	
Lopha staufferi (Bergquist)		—
Lucina sp.	—	—
Astarte sp.	×	
Granocardium enstromi (Bergquist)	—	
trite (White)	—	—
"*Cardium*" sp.		×
Cymbophora emmonsi (Meek)		×
Leptosolen sp.	×	
Aphrodina sp.	—	—
Parmicorbula? sp.		×
Pholadomya sp.		×
Laternula? sp.		×
Class Gastropoda:		
Cerithiopsis sp.		×
Anchura sp.	×	×
Crommium utahensis (White)?	×	
Class Cephalopoda:		
Turrilites n. sp.	×	
Stomohamites sp.	×	
Tarrantoceras? sp.	×	
Calycoceras? *canitaurinum* (Haas)	—	—
cf. *C.*? *canitaurinum* (Haas)	—	—
Calycoceras obrieni Young		×
Metoicoceras aff. *M. praecox* Haas	—	—
aff. *M. latoventer* Stephenson	×	
spp.	—	—

recorded "*Turrilites* cf. *T. costatus* Lamarck" from the upper part of the Dakota near the southwest corner of Sandoval County.

RÉSUMÉ OF FOSSIL OCCURRENCES

Molluscan fossils are present in all members of the intertongued Dakota Sandstone and Mancos Shale. The fossils usually occur in silty limestone concretions, siltstone or sandstone concretions, concretionary siltstone or sandstone beds, or along bedding surfaces of very fine grained sandstone or siltstone beds. Exogyras, however, are often found as free specimens in silty shale, and pycnodonts may form coquinal beds. Large ammonites in septarian limestone concretions are usually fragmented and distorted.

The Paguate Sandstone Tongue contains the largest variety of mollusks. Most of the species are listed on table 1, which shows 25 bivalves, 27 gastropods, and 10 ammonoids in the Paguate. The upper part of the Oak Canyon Member also has a large and varied molluscan fauna; 34 bivalves, 11 gastropods, and 5 ammonoids from this member are listed on table 2. The Clay Mesa Shale Tongue of the Mancos Shale contains the fewest species; only 12 are listed on table 1. The Whitewater Arroyo Shale Tongue, which is a more widespread unit than the Clay Mesa Tongue, contains a much larger fauna; 19 bivalves, 2 gastropods, and 8 ammonites listed on table 3 are found in this unit.

GEOGRAPHIC DISTRIBUTION

The fossils illustrated in plates 1–21 are from 76 localities in west-central New Mexico and one locality in the northwest corner of the State. The general localities of 72 of the collections are shown in figure 1; table 4 further describes these localities, gives the stratigraphic position of the fossils, and names the collectors in each case.

CHARACTERISTIC FOSSILS

Idonearca blanpiedi Stephenson

Plate 8, figures 1–3

1953. *Idonearca blanpiedi* Stephenson, U.S. Geol. Survey Prof. Paper 242, p. 63, pl. 11, figs. 1–4 [1952 imprint].

Idonearca blanpiedi is a very stout bivalve that has a subtrapezoidal outline and a very convex cross section. The shell is fairly smooth except for growth lines of irregular height and spacing and a few obscure radial ribs. The elongate triangular

TABLE 4.—*Localities where fossils were collected*

Locality (fig. 1)	U.S. Geol. Survey Mesozoic locality	Collector, year of collection, description of locality, and stratigraphic assignment
1	D6200	E. R. Landis and W. A. Cobban, 1967. Near Red Wash, 2 miles southeast of Bitlabito, San Juan County. Top of Twowells Sandstone Tongue.
2	D6191	Cobban, 1967. South side of Tse Bonita Wash, in the SW¼ sec. 2, T. 16 N., R. 21 W., McKinley County. Lower part of Twowells Sandstone Tongue.
3	D6187	Landis, 1967. Surrender Canyon, in the SW¼ sec. 23, T. 14 N., R. 21 W., McKinley County. Main body of the Dakota Sandstone.
4	D9240	Cobban, 1967. Near Manuelito, in the SE¼ sec. 19, T. 14 N., R. 20 W., McKinley County. Twowells Sandstone Tongue, from brown-weathering sandstone concretions.
5	D6182	Cobban, 1967. NW¼ sec. 15, T. 4 N., R. 20 W., Catron County. Middle of Paguate Sandstone Tongue.
6	D6183	Cobban, 1967. Same locality as D6182. Top of Paguate Sandstone Tongue.
7	D6184	Cobban, 1967. Same locality as D6182. Whitewater Arroyo Shale Tongue, from concretionary limestone bed about 3 ft above base.
8	D6137	Landis and Cobban, 1967. East of State Highway 32 and 4½ miles (7 km) north of Atarque Creek, in the western part of T. 7 N., R. 17 W., Valencia County. Whitewater Arroyo Shale Tongue.
9	D5764	Landis and Cobban, 1967. Northeast of Gallup, in the NE¼ sec. 30, T. 16 N., R. 17 W., McKinley County. Paguate Sandstone Tongue.
10	D2077	Cobban, 1959. Four miles (6.4 km) east-southeast of Gallup, McKinley County. Twowells Sandstone Tongue, from brown-weathering sandstone concretions.
11	D6164	C. H. Dane and Landis, 1967. SE¼ SW¼ sec. 7, T. 12 N., R 16 W., McKinley County. Twowells Sandstone Tongue.
12	D5762	Cobban, 1967. Near common corner of secs. 27, 28, 33 and 34, T. 16 N., R. 15 W., McKinley County. Whitewater Arroyo Shale Tongue, about middle.
13	D5754	Cobban, 1967. NW¼NW¼ sec. 20, T. 15 N., R. 13 W., McKinley County. Float from basal part of Twowells Sandstone Tongue.
14	D7338	Landis, Cobban, J. F. Robertson, and M. W. Green, 1969. Mount Powell, in the E½NW¼ sec. 8, T. 14 N., R. 13 W., McKinley County. Whitewater Arroyo Shale Tongue, about 15 ft (4.6 m) above base.

TABLE 4.—*Localities where fossils were collected*—Continued

Locality (fig. 1)	U.S. Geol. Survey Mesozoic locality	Collector, year of collection, description of locality, and stratigraphic assignment
15	D5759	Landis and Cobban, 1967. SW¼SE¼ sec. 24, T. 15 N., R. 13 W., McKinley County. Whitewater Arroyo Shale Tongue, about 10 ft. (3 m) below top.
16	D5760	Cobban, 1967. SE¼NE¼ sec. 31, T. 15 N., R. 12 W., McKinley County. Cubero Sandstone Tongue, from 6-ft bed of olive-gray sandstone and overlying brown-weathering sandstone concretions.
17	D5756	Cobban, 1967. SW¼NE¼ sec. 28, T. 15 N., R. 12 W., McKinley County. Cubero Sandstone Tongue, from brown-weathering sandstone concretions.
18	D7332	Landis, Cobban, J. F. Robertson, and M. W. Green, 1969. Drainage ditch east of State Highway 56, near center of sec. 5, T. 14 N., R. 12 W., McKinley County. Paguate Sandstone Tongue.
19	D7333	Landis, Cobban, Robertson, and Green, 1969. Same locality as D7332. Paguate Sandstone Tongue, from dark-brown-weathering sandstone concretions.
20	D7334	Landis, Cobban, and Robertson, 1969. SW¼SE¼ sec. 32, T. 15 N., R. 12 W., McKinley County. Paguate Sandstone Tongue.
21	D7335	Landis, Cobban, Robertson, and Green, 1969. SE¼SE¼ sec. 31, T. 15 N., R. 12 W., McKinley County. Twowells Sandstone Tongue.
22	D5750	Landis and Cobban, 1967. SW¼SW¼ sec. 25, T. 15 N., R. 12 W., McKinley County. Paguate Sandstone Tongue, from brown-weathering sandy limestone concretions.
23	D5753	Landis and Cobban, 1967. Casamero Lake, in the NW¼NE¼ sec. 30, T. 15 N., R. 11 W., McKinley County. Twowells Sandstone Tongue.
24	D7328	Landis, Cobban, J. F. Robertson, M. W. Green, and T. L. Britt, 1969. NE¼NE¼ sec. 25, T. 15 N., R. 12 W., McKinley County. Upper part of Paguate Sandstone Tongue.
25	D5742	Dane, Landis, and Cobban, 1967. Head of Rincón Canyon, in the NW¼NE¼ sec. 35, T. 14 N., R. 11 W., McKinley County. Oak Canyon Member, from brown-weathering calcareous sandstone concretions in upper part.
26	D5743	Dane, Landis, and Cobban, 1967, NE¼NE¼ sec. 25, T. 14 N., R. 11 W., McKinley County. Near top of Twowells Sandstone Tongue.

TABLE 4.—*Localities where fossils were collected*—Continued

Locality (fig. 1)	U.S. Geol. Survey Mesozoic locality	Collector, year of collection, description of locality, and stratigraphic assignment
27	D5392	Landis and Cobban, 1967. SW¼SW¼ sec. 36, T. 19 N., R. 1 W., Sandoval County. Twowells Sandstone Tongue.
28	D5819	Cobban, 1967. Same locality as D5392. Twowells Sandstone Tongue.
29	D5377	Cobban, 1966. About 9/10 mile (1.4 km) southeast of Soda Spring on Arroyo Cachulie, in T. 17 N., R. 1 W., Sandoval County. Oak Canyon Member, from gray silty limestone concretions 62 ft (18.9 m) above base.
30	D5380	Dane, Landis, and Cobban, 1966. About ½ mile south of Chamisa Vega Spring, in T. 17 N., R. 1 W., Sandoval County. Clay Mesa Shale Tongue, from unit of dark-brown-weathering siltstone concretions.
31	D5372	Dane, Landis, and Cobban, 1966. About 500 ft (152 m) west of Ojito Spring, in the NW¼NW¼ sec. 29, T. 16 N., R. 1 W., Sandoval County. Lower part of Paguate Sandstone Tongue.
32	D5812	Cobban, 1967. Ojito Spring, in the NW¼NW¼ sec. 29, T. 16 N., R. 1 W., Sandoval County. Paguate Sandstone Tongue.
33	D5815	Cobban, 1967. About 1½ miles (2.4 km) N. 30° E. of Ojito Tank, in T. 16 N., R. 1 W., Sandoval County. Oak Canyon Member.
34	D5806	Cobban, 1967. Bernalillito Arroyo, in the SW¼ sec. 21, T. 15 N., R. 1 W., Sandoval County. Oak Canyon Member, from dark-brown-weathering calcareous sandstone bed.
35	D5325	Landis and Cobban, 1966. NW¼NE¼ sec. 33, T. 15 N., R. 1 W., Sandoval County. Paguate Sandstone Tongue, from brown sandstone concretions at top.
36	D5321	Cobban, 1966. SE¼SE¼ sec. 12, T. 13 N., R. 2 W., Sandoval County. Oak Canyon Member, from dark-brown-weathering calcareous sandstone concretions.
37	D5324	Landis and Cobban, 1966. NW¼NW¼ sec. 7, T. 13 N., R. 1 W., Sandoval County. Paguate Sandstone Tongue.
38	D5383	Dane and Landis, 1966. About ¼ mile (0.4 km) south and 1½ miles (2.4 km) east of the northwest corner of Puerco Dam quadrangle, Sandoval County. Paguate Sandstone Tongue.
39	D5366	Dane and Landis, 1966. NE¼ sec. 29, T. 12 N., R. 3 W., Sandoval County. Oak Canyon Member, from brown-weathering sandy limestone concretions 66 ft (20 m) above base.

TABLE 4.—*Localities where fossils were collected*—Continued

Locality (fig. 1)	U.S. Geol. Survey Mesozoic locality	Collector, year of collection, description of locality, and stratigraphic assignment
40	D4018	Dane, 1963. Center of sec. 29, T. 12 N., R. 3 W., Sandoval County. Paguate Sandstone Tongue.
41	D5344	Cobban, 1966. Bottom of arroyo just east of State Highway 279, in the NW¼NE¼ sec. 29, T. 11 N., R. 5 W., Valencia County. Whitewater Arroyo Shale Tongue, from glauconitic calcareous sandstone concretions 46–51 ft (14–15.5 m) below top.
42	D5345	Dane, Landis, and Cobban, 1966. Same locality as D5344, but on east side of arroyo. Near base of Twowells Sandstone Tongue.
43	D5347	Dane, Landis, and Cobban, 1966. SW¼NW¼ sec. 4, T. 10 N., R. 5 W., Valencia County. Lower part of Paguate Sandstone Tongue.
44	D5336	Dane, Landis, and Cobban, 1966. West end of South Oak Canyon Mesa, in the NW¼NW¼ sec. 15, T. 10 N., R. 5 W., Valencia County. Oak Canyon Member, from silty limestone concretions 25 ft (7.6 m) below top.
45	D7080	Cobban, 1969. NE¼SE¼ sec. 20 and SW¼NW¼ sec. 21, T. 10 N., R. 5 W., Valencia County. Oak Canyon Member, from dark-brown-weathering silty limestone concretions 56–58 ft (17–17.7 m) above base.
46	D7081	Cobban, 1969. Same locality as D7080. Oak Canyon Member, from ledge of hard gray silty limestone 72 ft (22 m) above base.
47	D7084	Landis, Cobban, and C. H. Maxwell, 1969. Three miles north of Laguna, in the SE¼NE¼ sec. 20, T. 10 N., R. 5 W., Valencia County. Paguate Sandstone Tongue, from brown-weathering sandstone concretions.
48	D7086	Cobban and Maxwell, 1970. NE¼SE¼ sec. 20 and SW¼NW¼ sec. 21, T. 10 N., R. 5 W., Valencia County. Twowells Sandstone Tongue.
49	D5741	Cobban, 1967. Sharp road bend southwest of McCartys in the SE¼SW¼ sec. 27, T. 10 N., R. 8 W., Valencia County. Whitewater Arroyo Shale Tongue, from a limestone concretion in upper part.
50	D5737	Dane, Landis, and Cobban, 1967. Las Ventanas Ridge, in the NW¼NE¼ sec. 17, T. 9 N., R. 9 W., Valencia County. Whitewater Arroyo Shale Tongue, from basal part.
51	D6130	Landis, Dane, and Cobban, 1967–69. North of Little Narrows, about 15 miles (24 km) south of Grants, in the SW¼ sec. 6 and NW¼ sec. 7, T. 8 N., R. 9 W., Valencia County. Paguate Sandstone Tongue, from brown-weathering sandstone concretions in lower part.
52	D6781	Landis and Cobban, 1968. Same locality as D6130. Clay Mesa Shale Tongue, from dark-brown-weathering limestone concretions.
53	D7326	Landis, Cobban, and C. H. Maxwell, 1969. NE¼NW¼ sec. 5, T. 8 N., R. 9 W., Valencia County. Clay Mesa Shale Tongue, from septarian limestone concretions.
54	D6131	Dane and Landis, 1967. NE¼ sec. 4, T. 7 N., R. 10 W., Valencia County. Base of Twowells Sandstone Tongue.
55	D6133	Dane and Landis, 1967. Same locality as D6131. Top of Twowells Sandstone Tongue.
56	D2048	Dane, Cobban, and G. H. Bachman, 1959. Near McCartys-Acoma Pueblo road, in the NE¼ sec. 23, T. 9 N., R. 8 W., Valencia County. Cubero Sandstone Tongue.
57	D2049	Dane and Cobban, 1959. West side of Canipa Mesa, in the NW¼SE¼ sec. 14, T. 9 N., R. 8 W., Valencia County. Paguate Sandstone Member.
58	D2051	Cobban, 1959. West side of Canipa Mesa, in the SE¼SE¼ sec. 14, T. 9 N., R. 8 W., Valencia County. Twowells Sandstone Tongue, from lower part.
59	D5365	Dane and Landis, 1966. West side of Canipa Mesa, in the NE¼NE¼ sec. 23, T. 9 N., R. 8 W., Valencia County. Float from Twowells Sandstone Tongue.
60	D6800	C. H. Maxwell, 1970. Seama Mesa, in the SW¼NW¼ sec. 19, T. 9 N., R. 6 W., Valencia County. Lower part of Cubero Sandstone Tongue.
61	D2053	Dane, Landis, and Cobban, 1966. Deadmans Rock, about 3½ miles (5.6 km) north-northwest of Acoma Pueblo, in the NE¼NE¼ sec. 7, T. 8 N., R. 7 W., Valencia County. Oak Canyon Member, from dark-brown-weathering ferruginous sandstone concretions.
62	D5329	Landis and Cobban, 1966. SE¼ sec. 36, T. 8 N., R. 8 W., Valencia County. Oak Canyon Member, from brown-weathering calcareous siltstone concretions 62½ ft (19 m) above base.
63	D5330	Landis and Cobban, 1966. Same locality as D5329. Lower part of Cubero Sandstone Tongue.

TABLE 4.—*Localities where fossils were collected*—Continued

Locality (fig. 1)	U.S. Geol. Survey Mesozoic locality	Collector, year of collection, description of locality, and stratigraphic assignment
64----	D5332	Landis and Cobban, 1966. Same locality as D5329. Clay Mesa Shale Tongue, from limestone concretions 25 ft (7.6 m) above base.
65----	D7364	C. H. Maxwell, 1970. Two miles west of Acoma Pueblo, in the SE¼SW¼ sec. 30, T. 8 N., R. 7 W., Valencia County. Clay Mesa Shale Tongue, from a gray septarian limestone concretion 10 ft (3 m) above base.
66----	D6794	Cobban, 1968. North side of Paradise Canyon, in the SW¼NW¼ sec. 24, T. 7 N., R. 8 W., Valencia County. Oak Canyon Member, from brown-weathering silty limestone concretions 80 ft (24 m) above base.
67----	D6218	Dane and Landis, 1967. About 1 mile southeast of Miranda windmill and east of Arroyo de Miranda on the South Garcia 15-minute quadrangle, Valencia County. Oak Canyon Member.
68----	D5771	Cobban, 1967. SE¼SE¼ sec. 11, T. 3 N., R. 7 W., Socorro County. Mancos Shale, from sandstone concretions 72 ft (22 m) above base of Dakota Sandstone.
69----	D5785	Cobban, 1967. SE¼ sec. 33, T. 3 N., R. 5 W., Socorro County. Mancos Shale, from white-weathering baked shale 105 ft (32 m) above base.
70----	D5787	Cobban, 1967. Same locality as D5785. Mancos Shale, float from gray septarian limestone concretions within 25 ft (7.6 m) of base of Twowells Sandstone Tongue.
71----	D5795	Cobban, 1967. About 2½ miles (4 km) west of Riley, in the SW¼ sec. 16 and NW¼ sec. 21, T. 2 N., R. 4 W., Socorro County. Top of Twowells Sandstone Tongue.
72----	D7345	Landis, Cobban, Robertson, and Green, 1969. NE¼SE¼ sec. 8, T. 15 N., R. 13 W., McKinley County. Top of sandstone underlying Whitewater Arroyo Shale Tongue.

cardinal area covered by fine chevron-shaped ligamental grooves and the narrow hinge and conspicuous dentition are characteristic of the genus.

Stephenson's types are from the Templeton Member of the Woodbine Formation of Texas. The species is common in very fine grained calcareous sandstone concretions in the Paguate Sandstone Tongue.

Types.—Hypotypes, USNM 239606, 239607.

Idonearca depressa White

Plate 16, figures 20–24; plate 19, figures 10–12

1877. *Idonearca depressa* White, U.S. Geog. and Geol. Expl. Surveys W. of 100th Meridian (Wheeler), v. 4, pt. 1, p. 183, pl. 18, figs. 13a, b.

1894. *Trigonarca depressa* (White). Stanton, U.S. Geol. Survey Bull. 106, p. 93, pl. 19, fig. 2 [1893 imprint].

This species differs from *Idonearca blanpiedi* Stephenson by having conspicuous radial ribbing over all the shell. The holotype came from "Strata of the Cretaceous period; east bank of Rio Puerco, 6 miles below Casa Salazan [Casa Salazar], New Mexico" (White, 1877, p. 183). Most specimens from west-central New Mexico are larger than the holotype, and some attain lengths of 56 to 62 mm. The species is fairly common in the Twowells Sandstone Tongue and in sandstone beds in the Whitewater Arroyo Shale Tongue.

Types.—Hypotypes, USNM 239608–239611.

Pinna petrina White

Plate 1, figures 2, 4; plate 3, figure 8; plate 15, figure 21

1874. *Pinna petrina* White, U.S. Geog. and Geol. Expl. Surveys W. of 100th Meridian (Wheeler), v. 4, p. 182, pl. 13, figs. 7a, b.

1881. *Pinna stevensoni* White, U.S. Natl. Mus. Proc., v. 3, p. 47.

1894. *Pinna petrina* White. Stanton, U.S. Geol. Survey Bull. 106, p. 88, pl. 19, fig. 4; pl. 20, fig. 1 [1893 imprint].

Pinna petrina is easily recognized by its long and narrow shell whose side view has a triangular appearance. The hingeline is very long and moderately straight, and the beaks are terminal. A ridge extends along the middle of each valve but disappears in the late growth stage. About 8 to 10 weak to strong narrow radial ribs are present on the ventral half of the shell, and that many or a few more weaker radial ribs are present on the dorsal half. All radial ribs tend to disappear in the late growth stages; the valves then are characterized by conspicuous, closely spaced, irregular growth lines (Stanton, 1893, pl. 19, fig. 4). The species attains lengths of 150–160 mm.

Pinna petrina is present in very fine grained sandy beds in the upper part of the Oak Canyon Member and in the Cubero, Paguate, and Twowells Sandstone Tongues. All specimens in the collections from west-central New Mexico are incomplete even though they usually include both valves. Most specimens are internal molds that have patches of brown shell material.

The holotype came from "east of Mount Taylor, 1 mile south of Pajuate, New Mexico." The specimen

probably came from the Paguate Sandstone Tongue, which crops out 1 mile (1.6 km) south of Paguate, where it is fossiliferous and contains *Pinna*.

Types.—Hypotypes, USNM 239612–239615.

Plesiopinna sp.

Plate 1, figures 1, 3

The bivalve genus *Plesiopinna* is characterized by its subtrigonal shell, terminal umbo, inflated posteroventral part, and long straight edentulous hingeline. Ornamentation on the type species, *P. antriniformis* Amano (1956, p. 71, pl. 1, figs. 1–5), consists of weak concentric folds and weak radial ribs.

Two specimens from the upper part of the Oak Canyon Member seem assignable to this genus. These specimens differ from the type species in having more conspicuous radial ribbing and in having the ribbing over all but the posterior part of the shell.

Figured specimens.—USNM 239616, 239617.

Phelopteria? cf. P.? aguilerae (Böse)

Plate 7, figures 8, 9

Large pteroid bivalves in the Paguate Sandstone Tongue resemble, in their shape and smoothness of their shell, the genera *Phelopteria* and *Panis* described by Stephenson, (1952, p. 67–70) from the Woodbine Formation of Texas. The cardinal area of the Paguate specimens differs considerably, however, from that of the Woodbine genera. In the Paguate specimens, the cardinal area is massive and thick shelled like that of *Panis*, but the three ligamental pits of that genus are missing. If the cardinal area of the Paguate specimens had less breadth, it would be more like that of *Phelopteria*. The Paguate specimens, which are much larger than specimens of *Phelopteria* and *Panis* from Texas, attain a height of as much as 10 cm. Most specimens are about as long as high. The species described by Böse (1918, p. 227, pl. 20, figs. 1, 2, 11, 12) as *Avicula aguilerae*, from the lower Turonian of Coahuila, Mexico, closely resembles the Paguate species in its shape, but nothing has been published regarding the cardinal area of the Mexican form.

Figured specimen.—USNM 239618.

Inoceramus eulessanus Stephenson

Plate 3, figures 3, 4

1953. *Inoceramus eulessanus* Stephenson, U.S. Geol. Survey Prof. Paper 242, p. 65, pl. 44, fig. 2 [1952 imprint].

The narrow sharp beak projecting above the hingeline is the most characteristic feature of this slightly convex species. Most specimens are suberect, and the angle between the axis of the shell and the hingeline is large. The height is greater than the length, and the outline is elongate-ovate. The hingeline is moderately long and straight. The anterior margin is broadly rounded, the ventral margin is more sharply rounded, and the posterior margin is very gently rounded to almost straight. Ornamentation consists of concentric undulations of irregular strength and spacing. The species is rather small; none of the specimens in the collections from west-central New Mexico exceed 10 cm in height.

Inoceramus eulessanus occurs sparsely in the upper part of the Oak Canyon Member. In the Thoreau area, a thin very fine grained calcareous sandstone bed that seems to be an equivalent of some part of the Cubero Sandstone Tongue, contains numerous specimens of *I. eulessanus*.

The holotype of *I. eulessanus* is from the Woodbine Formation of Texas. Specimens referable to this species occur in the Thatcher Limestone Member of the Graneros Shale in southeastern Colorado (Cobban and Scott, 1972, p. 8, 27).

Types.—Hypotypes, USNM 239619, 239620.

Inoceramus cf. I. macconnelli Warren

Plate 2, figure 3; plate 3, figures 5–7

Small inoceramids from very fine grained sandstone slightly above the middle of the main body of the Dakota Sandstone show affinities with *Inoceramus macconnelli* Warren (1930, p. 60, pl. 4, figs. 1–3) in having narrow sharp beaks that are curved anteriorly. The hingeline, which is posterior to the beak, is straight and moderately long. Ornamentation on most specimens consists of concentric undulations of unequal strength and spacing. The cotypes of *I. macconnelli* consist of a left valve and a right valve which are more weakly ornamented than those of the New Mexico specimens.

Inoceramus cf. *I. macconnelli* was found only in the Thoreau area in association with *I. eulessanus*. Locally specimens are numerous (pl. 2, fig. 3).

Figured specimens.—USNM 239621–239624.

Inoceramus rutherfordi Warren

Plate 7, figures 4, 10–14

1930. *Inoceramus rutherfordi* Warren, Alberta Research Council Geol. Survey Rept. 21, p. 59, pl. 7, figs. 1–3.
1965. *Inoceramus rutherfordi* Warren. Hattin, Kansas Geol. Survey Bull. 178, pl. 4, figs. C, E, F, H.

The squarish outline, well-defined posterior auricle, and conspicuous posterior fold easily identify this inoceramid. The posterior fold is sharply delineated by a deep posterior auricular sulcus and,

on its anterior side, by a shallow sulcus. The shallow sulcus is bounded on its anterior side by a weak fold. The shell is ornamented by moderately conspicuous rugae of irregular strength.

Inoceramus rutherfordi is widely distributed in the western interior of the United States. The types are from the Dunvegan Formation in central western Alberta. In west-central New Mexico, *I. rutherfordi* is common in very fine grained sandstone concretions in the Paguate Sandstone Tongue. Most individuals are from 50 to 70 mm in height. *Ostrea beloiti* Logan encrusts many specimens.

Types.—Hypotypes, USNM 239625–239629.

Inoceramns arvanus Stephenson

Plate 6, figure 27

1953. *Inoceramus arvanus* Stephenson, U.S. Geol. Survey Prof. Paper 242, p. 65, pl. 12, figs. 6–9 [1952 imprint].

1955. *Inoceramus arvanus* Stephenson. Stephenson, U.S. Geol. Survey Prof. Paper 274–C, p. 55, pl. 4, figs. 1–3.

This species gave rise to and closely resembles *Inoceramus rutherfordi* Warren. Both species have a quadrate form, folds and sulci, well defined posterior auricle, and similar ornamentation. The only difference is in the weaker folds and sulci of *I. arvanus*. In large collections of *I. rutherfordi*, some specimens have weaker folds and sulci than others and could easily pass for *I. arvanus*.

A few inoceramids from silty limestone concretions in the upper part of the Clay Mesa Shale Tongue have only weak folds and sulci; these specimens are assigned to *I. arvanus*.

The holotype of *I. arvanus* came from the Lewisville Member of the Woodbine Formation in northern Texas. Stephenson (1955, pl. 4, figs. 1–3) illustrated several specimens from the basal part of the Eagle Ford Shale of Texas. In the western interior region, *I. arvanus* has been found at a few places in association with *Acanthoceras alvaradoense* Moreman.

Type.—Hypotype, USNM 239630.

Inoceramns prefragilis Stephenson

Plate 19, figures 1, 2, 4

1953. *Inoceramus prefragilis* Stephenson, U.S. Geol. Survey Prof. Paper 242, p. 64, pl. 12, figs. 10–12; pl. 13, figs. 1, 2 [1952 imprint].

This is a medium-sized, moderately inflated inoceramid whose height is much greater than its length. Beaks are prominent, slightly curved, and located at the dorsoanterior corner of the shell. The hingeline is long and straight, and an inconspicuous posterior auricle is present. The anterior side of the shell slopes steeply. Ornamentation consists of low closely spaced concentric folds that tend to be of uniform height. A few irregularly spaced rugae are present.

Inoceramus prefragilis is present in silty limestone concretions in the Whitewater Arroyo Shale Tongue and in fine-grained sandstone concretions in the lower and middle parts of the Twowells Sandstone Tongue.

The types of *I. prefragilis* are from the Lewisville Member of the Woodbine Formation of Texas. The species is widely distributed in the western interior region in the lower part of the Greenhorn Limestone and equivalent rocks.

Types.—Hypotypes, USNM 239631–239633.

Inoceramus ginterensis Pergament

Plate 19, figure 3

1966. *Inoceramus ginterensis* Pergament, Akad. Nauk SSSR Geol. Inst. Trans., v. 146, p. 50, pl. 25, fig. 5; pl. 26, figs. 1, 2; pl. 27, figs. 1, 2; pl. 28, figs. 1, 2; pl. 29, fig. 1.

This species resembles *Inoceramus prefragilis* in size, shape, and convexity. Ornamentation differs, however, inasmuch as *I. ginterensis* has numerous irregularly spaced rugae and lacks the evenly spaced concentric folds of the other species.

Inoceramus ginterensis was originally described from specimens collected from Cenomanian rocks in northwestern Kamchatka and southern Sakhalin, U.S.S.R. The species is abundant in the western interior region in the Hartland Shale Member of the Greenhorn Limestone and in the equivalent part of the Frontier Formation. In west-central New Mexico, *I. ginterensis* occurs in fine-grained sandstone concretions in the upper part of the Twowells Sandstone Tongue.

Type.—Hypotype, USNM 239634.

Camptonectes symmetricus Herrick and Johnson

Plate 3, figure 1; plate 5, figures 4–7

1900. *Camptonectes symmetricus* Herrick and Johnson, Denison Univ. Sci. Lab. Bull., v. 11, art. 9, p. 209.

This pectinid is abundant in silty limestone concretions and calcareous siltstone beds in the upper part of the Oak Canyon Member. Herrick and Johnson, unfortunately, did not illustrate any specimens; their description is as follows:

Shell small, not over three fourths of an inch in length; broadly oval in outline; hingeline imperfectly seen, apparently longer than half of the width of the shell; valves convex; cardinal slopes from the beak forming with each other nearly a right angle, straight; surface of valves marked

by very fine, numerous, irregular, hair-like radiating striae which curve strongly upward toward the margin, and also by fine concentric striae.

In the gasteropod zone below the Tres Hermanos sandstone in the Rio Puerco valley.

Camptonectes symmetricus may be a synonym for some one of the camptonectids described earlier from the European Cretaceous. Until the American forms are revised, Herrick and Johnson's name is accepted.

Types.—Hypotypes, USNM 239731–239735.

Camptonectes ex gr. C. virgatus (Nilsson)

Plate 19, figure 7

Medium-sized specimens of *Camptonectes* that have dense radial striae occur in the Twowells Sandstone Tongue. None is well enough preserved for positive specific determination, but they belong to the group of *C. virgatus* (Nilsson) according to Dr. Annie V. Dhondt (written commun., 1975), who examined a latex cast of the specimen illustrated here (pl. 19, fig. 7).

Figured specimen.—USNM 239742.

Neithea cf. N. sexcostata (Woodward)

Plate 10, figures 1, 2

This pectinid has been found only in very fine grained sandstone in the Paguate Sandstone Tongue. The species has 6 main radial ribs separated by deep intercostal areas that bear 4 or 5 weaker ribs of variable width. The Paguate form closely resembles the specimen of *Neithea sexcostata* (Woodward) figured by Dhondt (1973, p. 44, pl. 5, figs. 2a, b) from the Campanian rocks of Belgium.

Figured specimen.—USNM 239741.

Plicatula arenaria Meek

Plate 1, figures 5, 6

1876. *Plicatula arenaria* Meek, *in* Macomb, J. N., Report of the exploring expedition from Santa Fe * * * in 1859, U.S. Army Eng. Dept., p. 126, pl. 1, figs. 5a–c.

1894. *Plicatula arenaria* Meek. Stanton, U.S. Geol. Survey Bull. 106, p. 70, pl. 9, figs. 3, 4 [1893 imprint].

The small size, conspicuous radial ribs, and sparseness of concentric folds characterize this bivalve. The broadly ovate to subtrigonal outline is like that of most members of the genus. Meek (1876, p. 127) illustrated two specimens of similar size and gave their dimensions as 0.5 inch in height and 0.43 inch in length. He noted that each valve was ornamented by 18 to 20 "rather sharply-elevated plications, only about half of which extend to the beaks, while the intermediate ones usually extend from one-third to one-half way from the free margins."

Plicatula arenaria is a common species (pl. 1, fig. 5) in calcareous and ferruginous siltstone or very fine grained sandstone in the upper part of the Oak Canyon Member. None of the specimens in the collections exceeds 11 mm in height. Meek's types came from "Covero," which is now the village of Cubero, 23 miles (37 km) east of Grants, N. Mex. According to C. H. Maxwell (oral commun., 1975), of the U.S. Geological Survey, the upper part of the Oak Canyon Member of the Dakota Sandstone is well exposed and very fossiliferous in a small canyon 1 mile (1.6 km) south of Cubero, in the SE¼SE¼ sec. 24, T. 10 N., R. 7 W., Valencia County (Cubero 7½-minute quad.).

Outside west-central New Mexico, occurrences of *P. arenaria* are sparse. A few specimens have been found in the Thatcher Limestone Member of the Graneros Shale in southeastern Colorado (Cobban and Scott, 1972, p. 8).

Types.—Hypotypes, USNM 239635, 239636.

Plicatula cf. P. ferryi Coquand

Plate 9, figure 9; plate 16, figures 6–12; plate 19, figures 5, 6

Plicatula ferryi Coquand (1862, p. 221, pl. 16, figs. 7–9) is distinguished in attaining a moderately large size and in having numerous and conspicuous radial ribs and concentric rugae. Coquand's types are from the Santonian of Algeria. The species has been recorded from the Turonian to the Maestrichtian, mostly from Africa.

Specimens that could be *P. ferryi* occur in sandstone beds in the Paguate Sandstone Tongue, in silty limestone concretions in the Whitewater Arroyo Shale Tongue, and in the Twowells Sandstone Tongue. All are fragments; none is complete enough for a total rib count. The largest fragments suggest that the shells attained heights of about 40 mm. Two specimens, preserved on a thin layer of pale-brown fibrous calcite from the Twowells Tongue, have color bands; the radial ribs are dark brown and the interspaces light brown (pl. 19, fig. 5).

Figured specimens.—USNM 239637–239646.

Plicatula sp.

Plate 9, figures 4–8

Small specimens of *Plicatula* characterized by conspicuous growth interruptions occur in the lower part of the Mancos Shale in northwestern Socorro County. The fossils lie on bedding surfaces of hard noncalcareous silty shale. A Paguate age is indicated by the presence of *Inoceramus rutherfordi* Warren, *Ostrea beloiti* Logan, and *Turrilites acutus americanus* Cobban and Scott.

Figured specimens.—USNM 239647–239651.

Limatula sp.

Plate 5, figure 8

Silty limestone concretions and calcareous siltstone beds in the upper part of the Oak Canyon Member contain a small species of *Limatula* that seems to be more weakly ribbed than other American Cretaceous species. None of the specimens exceeds 13 mm in its longest dimension.

Figured specimen.—USNM 239736.

Pycnodonte cf. P. kellumi (Jones)

Plate 6, figures 21–26; plate 12, figures 1–9; plate 15, figures 17–20; plate 16, figures 1–5

Jones (1938, p. 107, pl. 3, figs. 3–5) described *Gryphaea washitaensis* var. *kellumi* as a new form from the Indidura Formation of Coahuila, Mexico. Two specimens, both left valves, were illustrated. These specimens differ from *Pycnodonte washitaensis* (Hill, 1889, p. 4; Hill and Vaughan, 1898, p. 59, pls. 19–23) by having less convexity, a longer hingeline, and a broader umbo. Jones' form is herein regarded as a separate species, and the larger of his figured specimens is designated the lectotype (Jones, 1938, pl. 3, figs. 3, 4, Univ. Michigan 16127). In a table (Jones, 1938, table 3) that gives the geographic distribution and stratigraphic range of the invertebrate fossils from the areas in Coahuila investigated by Jones, *P. kellumi* is listed (as *Gryphaea washitaensis* var. *kellumi*) with fossils of Albian, Cenomanian, and Turonian age.

Dr. L. B. Kellum, University of Michigan, Ann Arbor, kindly loaned me several of the collections of *P. kellumi*, collected by T. S. Jones from Coahuila. Some of the collections were identified as *Gryphaea washitaensis* Hill by Jones, but all specimens seem referable to his variety *kellumi*. Many individuals have lengths from 30–34 mm, which is more than that of the types. Most specimens have a poorly defined posterior auricle that, on some individuals, is bounded by a low sulcus.

Pycnodonts that closely resemble *P. kellumi* are present in sandy limestone concretions in the upper part of the Oak Canyon Member, Clay Mesa Shale Tongue, and lower half of the Whitewater Arroyo Shale Tongue, as well as in sandstone concretions and very fine grained sandstone beds in the Paguate Sandstone Tongue. Most specimens are larger than *P. kellumi*, and many have lengths of 30–40 mm. Faint growth lines and growth squamae give the shells a smooth appearance. Chomata are present but not conspicuous. The posterior auricle and sulcus, which is inconspicuous in the specimens from the Clay Mesa Tongue, tend to become a little more pronounced on the Paguate specimens. The right valves of some specimens from the Paguate Sandstone Tongue have conspicuous radial color bands that are dark brown and wider than the interspaces (pl. 15, figs. 17, 20).

Figured specimens.—USNM 239652–239661.

Pycnodonte aff. P. kellumi (Jones)

Plate 20, figures 1–15

1927. *Ostrea* (*Gryphaea*?) *patina* Meek and Hayden. Reagan, Indiana Acad. Sci. Proc., v. 36, p. 119, text figs. 15–26.

This species differs from *Pycnodonte* cf. *P. kellumi* (Jones) in attaining a slightly larger size and in having a more distinct posterior auricle bounded by a more clearly defined sulcus. The left valve of *P.* aff. *P. kellumi* ordinarily attains a height of 40–45 mm and a length of 43–49 mm. Growth squamae are usually conspicuous, and many specimens have irregular concentric wrinkles on the umbo. Most adults have a large broad umbo set apart from the rest of the shell by either a change in slope or by a depression. Chomata (small ridgelets and pits along the anterior and posterior margins of the valves) are vermiculate and as much as 5 mm long.

Color bands that radiate from the beaks on both valves are present on a few individuals. The bands are dark brown and variable in width but wider than the light-brown interspaces. Similar color bands were observed on a specimen of *P. newberryi* (Stanton) (Stokes and Stifel, 1964).

The valves of *P.* aff. *P. kellumi* are thick, and some have cirripede and sponge borings like those described and illustrated for a Jurassic *Gryphaea* by Hallam (1963, p. 563, text fig. 5). A fine vesicular structure is visible on a few weathered specimens.

Pycnodonte aff. *P. kellumi* could just as well be referred to as *P.* aff. *P. newberryi* (Stanton) because of its intermediate character between *P.* cf. *P. kellumi* and *P. newberryi*. The species described by Stanton (1893, p. 60, pl. 5, figs. 1–5) as *Gryphaea newberryi* is a younger pycnodont that has a narrower shell, a more convex left valve, and a smaller umbo. Many records in the literature of "*Gryphaea newberryi* Stanton" are probably *Pycnodonte* aff. *P. kellumi*. The " '*Gryphaea*' *newberryi* (broad form)" of Landis, Dane, and Cobban (1973a, p. J4, J9, J25, J28, J31, J32, J36) is *P.* aff. *P. kellumi*. The specimens of *P.* aff. *P kellumi* described and illustrated as examples of *Ostrea* (*Gryphaea*?) *patina* Meek

and Hayden by Reagan (1927, p. 119, text figs. 15–26), are from the Dakota Sandstone at Steamboat, on the southeastern side of Black Mesa, Apache County, Ariz.

Outside the Black Mesa–San Juan Basin area, occurrences of *P.* aff. *P. kellumi* are uncommon. A few specimens have been found in the upper part of the Frontier Formation in the Bighorn and Powder River Basins of Wyoming in association with *Inoceramus ginterensis* Pergament, *Metoicoceras muelleri* Cobban, and *M. defordi* Young. Farther north, in central Montana, *P.* aff. *P. kellumi* occurs in the Mosby Sandstone Member of the Greenhorn Formation.

Figured specimens.—USNM 239662–239666.

Exogyra columbella Meek

Plate 5, figures 14–22

1876. *Exogyra columbella* Meek, *in* Macomb, J. N., Report of the exploring expedition from Santa Fe * * * in 1859, U.S. Army Eng. Dept., p. 124, pl. 1, figs. 3a–d.

1877. *Exogyra costata* Say var. *fluminis* White, U.S. Geog. and Geol. Surveys W. of 100th Meridian (Wheeler), v. 4, pt. 1, p. 174, pl. 17, figs. 3a–d.

1953. *Exogyra columbella* Meek. Stephenson, U.S. Geol. Survey Prof. Paper 242, p. 77, pl. 17, figs. 4–6 [1952 imprint].

This is a moderate-sized species characterized by conspicuous radial ribs that extend over all or much of the left valve and by the presence of a prominent umbonal ridge in the early growth stages. The types came from "Covero," which is now the village of Cubero, 23 miles (37 km) east of Grants, N. Mex. The specimens are probably from the same beds in the upper part of the Oak Canyon Member that yielded the types of *Plicatula arenaria* Meek.

Meek (1876, p. 125) gave the height of the holotype as 1 inch (25 mm). Strong ribs that radiate from the beak completely cover this specimen. Three specimens were illustrated by White (1877, pl. 17, figs. 3a, b) as *Exogyra costata* Say var. *fluminis*, and later as *E. columbella* Meek (White, 1884, pl. 55, figs. 5, 6). The largest of these is an adult. This individual reveals that the adults attain heights of nearly 40 mm and that costation disappears on the outer surface of the shell in the later growth stages. However, an internal mold of a large unfigured adult in White's type lot shows that ribbing reappears along the ventral margin of the anterior side of the left valve at a late growth stage.

Well-preserved examples of *E. columbella* occur in silty limestone concretions, very fine grained calcareous sandstone concretions, and concretionary ferruginous very fine grained sandstone beds in the upper part of the Oak Canyon Member and lower part of the Cubero Sandstone Tongue. Outside the west-central New Mexico area, *E. columbella* has been found at many localities as far north as the Black Hills in northeastern Wyoming and westernmost South Dakota. In Texas, *E. columbella* occurs in the Lewisville Member of the Woodbine Formation (Stephenson, 1952, p. 77, pl. 17, figs. 5, 6).

Types.—Hypotypes, USNM 239667–239671.

Exogyra aff. E. columbella Meek

Plate 5, figures 9–13

Exogyras that resemble *Exogyra columbella* in having costation over much of the left valve occur in silty limestone concretions and very fine grained sandstone beds in the upper part of the Oak Canyon Member and in the overlying Cubero Sandstone Tongue. The shells, however, tend to be smaller and more convex, and the ribs are thinner and more numerous. Most lack an umbonal ridge on the left valve. Some individuals have costation only on the beak and umbo.

Figured specimens.—USNM 239672–239674.

Exogyra aquillana Stephenson

Plate 2, figures 1, 2

1953. *Exogyra aquillana* Stephenson, U.S. Geol. Survey Prof. Paper 243–E, p. 60, pl. 13, figs. 5–8.

The small size and smooth shell are distinctive features of this species. Stephenson observed that most specimens are less than 17 mm in height. The types are from the Woodbine Formation of Texas.

Exogyra aquillana is present in very fine grained calcareous sandstone and in silty limestone concretions in the upper part of the Oak Canyon Member and lower part of the Cubero Sandstone Tongue of the Dakota Sandstone. Many specimens attain heights of 18–20 mm.

Types.—Hypotypes, USNM 239675, 239676.

Exogyra levis Stephenson

Plate 15, figures 1–16; plate 20, figures 16–18

1953. *Exogyra columbella levis* Stephenson, U.S. Geol. Survey Prof. Paper 242, p. 77, pl. 18, figs. 1–3 [1952 imprint].

This species differs from *Exogyra columbella* Meek in attaining a slightly larger size, in lacking an umbonal ridge, and in only occasionally possessing costae on the umbo. The holotype and figured paratype are from the Templeton Member of the Woodbine Formation of Texas.

Exogyra levis is a common species in the Paguate Sandstone Tongue, Whitewater Arroyo Shale

Tongue, Twowells Sandstone Tongue, and in the basal part of the overlying part of the Mancos Shale. One collection from the top of the Cubero Sandstone Tongue may represent the oldest occurrence of the species. Specimens of unusually large size were collected from a very fine grained olive-gray sandstone bed just beneath the Whitewater Arroyo Shale Tongue near Manuelito, N. Mex. (USGS D6187; pl. 15, figs. 11–16).

The exogyras from the upper part of the Dakota Sandstone of the Black Mesa area of northeastern Arizona, figured by Reagan (1927, p. 125–127, figs. 3–9) as *E. columbella* Meek and *E. laeviuscula* Roemer, are probably costate and noncostate specimens of *E. levis*. Some of the records of *E. columbella* in west-central New Mexico are probably based on costate specimens of *E. levis* (for example, Darton, 1910, p. 57).

In the western interior region, *E. levis* is common only in northwestern New Mexico, northeastern Arizona, and southern Utah. Although the species has not been found in Wyoming, it does occur farther north in central Montana in association with *Metoicoceras muelleri* Cobban in the Mosby Sandstone Member of the Greenhorn Formation.

Types.—Hypotypes, USNM 239677–239684.

Exogyra sp. A

Plate 5, figure 23–28

This species, which has been found only in the Cubero Sandstone Tongue, attains a large size and has a smooth, very convex left valve. Adults attain heights of 60–75 mm. The species resembles *Exogyra levis* Stephenson in its form and in its smoothness of shell, but species A is twice as large and umbonal costae are lacking. Small specimens cannot be distinguished from similar-sized noncostate individuals of *E. levis*.

Exogyra sp. A resembles *Rhynchostreon* Bayle as defined and illustrated by Stenzel (1971, p. N1122, fig. J97). Both forms have a strongly coiled beak and a nearly smooth shell that lacks costae, but the Cubero species has a broader umbo and lacks a radial sulcus.

Figured specimens.—USNM 239685–239687.

Exogyra aff. E. levis Stephenson

Plate 17, figures 1, 2, 4; plate 18, figures 1, 2

Some exogyras from the Whitewater Arroyo Shale Tongue and from the basal part of the Mancos Shale overlying the Twowells Sandstone Tongue resemble *Exogyra levis* Stephenson in their shape and general sculpture, but they differ mainly in having exceptionally thick shells. The umbonal area on the left valve has radial ribs, and on some specimens, the ribbing is very fine. Specimens that have both valves have not been found, but certain right valves in the collections probably belong to this species (pl. 17, figs. 1, 2, 4). These valves have weak growth squamae crossed by delicate radial ribs. Complete left valves are lacking in the collections, but the fragments suggest an adult size a little larger than most adults of *E. levis*. Color bands radiating from the umbo are present on the left valves of some individuals. The bands are dark brownish gray and about as wide as the lighter gray interspaces.

Figured specimens.—USNM 239688–239691.

Exogyra cf. E. oxyntas (Coquand)

Plate 10, figures 7–9, 11

Fragments of large very thick-shelled costate exogyras from the Paguate Sandstone Tongue and the Whitewater Arroyo Shale Tongue may represent *Exogyra oxyntas* Coquand (1869, p. 140, pl. 44, figs. 1–9; pl. 46, figs. 14, 15). Coquand's species is a large form that has numerous closely spaced ribs covering all of the left valve. Reeside (1929, p. 268–270), after reviewing the published record of the *E. oxyntas–E. olisiponensis* group of species, concluded that it represented one variable species—*E. olisiponensis* Sharpe (1850, p. 185, pl. 19, figs. 1, 2). Most illustrations of *E. olisiponensis* show a form that has widely spaced costae which are much narrower than the interspaces. Specimens like these occur at the top of the Dakota Sandstone in southern Utah associated with pycnodonts and other fossils that suggest an age slightly younger than the Twowells Sandstone Tongue of west-central New Mexico. The fragments of *Exogyra* from the older Paguate and Whitewater Arroyo Tongues have the closely spaced costae like that of *E. oxyntas* and, until better material is available, these fragments seem best compared to Coquand's species.

Figured specimens.—USNM 239692–239695.

Exogyra trigeri (Coquand)

Plate 9, figures 10–20; plate 16, figures 16–19; plate 17, figures 3, 5–10; plate 18, figures 3–9; plate 20, figures 19, 20

1869. *Ostrea trigeri* Coquand, Monographie du genre *Ostrea*; Terrain crétacé: p. 199, pl. 51, figs. 1, 2.
1971. *Exogyra trigeri* (Coquand). Stenzel, *in* Moore, R. C., ed., Treatise on invertebrate paleontology, Part N, v. 3, Mollusca 6, Bivalvia, p. N1116, figs. 2a, b.

A left valve of low convexity ornamented by numerous rough growth squamae crossed by weak radial ribs characterizes this moderately large spe-

cies. Coquand's type came from the upper Cenomanian of France.

Exogyra trigeri is a common species in very fine grained thin sandstone layers in the Whitewater Arroyo Shale Tongue, where some individuals attain heights of as much as 10 cm. The species has a considerable stratigraphic range; it is found as low as the Clay Mesa Shale Tongue and as high as the basal part of the Mancos Shale above the Twowells Sandstone Tongue of the Dakota.

Attachment areas on the left valves of *E. trigeri* vary greatly in size. The specimens were attached to *Inoceramus, Exogyra, Pycnodonte, Plicatula, Camptonectes, Granocardium,* and *Turritella.* Many shells have sponge borings, and a few have cirripede borings.

Specimens from the Paguate Sandstone Tongue and some from the Whitewater Arroyo Shale Tongue have more erect left valves, greater convexity, and weaker and sparser radial ribs than the typical form. Some very massive thick shells that are much distorted by large attachment areas may be unusual representatives of this species in the Whitewater Arroyo Shale Tongue.

Types.—Hypotypes, USNM 239696–239712.

Ostrea beloiti Logan

Plate 7, figures 4–7

1899. *Ostrea beloiti* Logan, Field Columbian Mus. Geol. Ser., v. 1, no. 6, p. 214, pl. 25, figs. 7, 8.

1965. *Ostrea beloiti* Logan. Hattin, Kansas Geol. Survey Bull. 178, pl. 4, figs. A, B, D, G, I.

This is a small, mostly smooth oyster that tends to be elongated and gently curved. The shape, however, is considerably varied. The left valve is convex, and the right is almost flat. Chromata are numerous and conspicuous. A few inconspicuous radial ribs are present on the ventroanterior part of the left valve of some individuals.

Ostrea beloiti is widely distributed in the western interior region of the United States and Canada (McNeil and Caldwell, 1974). In west-central New Mexico, the species is common in very fine grained sandstone concretions in the Paguate Sandstone Tongue. Some specimens are attached to valves of *Inoceramus rutherfordi* Warren (pl. 7, fig. 4). A few specimens of *O. beloiti* occur in silty limestone concretions in the Whitewater Arroyo Shale Tongue and in the upper part of the Clay Mesa Shale Tongue. The species ranges up into the basal part of the Twowells Sandstone Tongue and possibly down as low as the upper part of the Oak Canyon Member.

Types.—Hypotypes, USNM 239713–239716.

Lopha staufferi (Bergquist)

Plate 19, figures 8, 9

1944. *Ostrea (Alectryonia) staufferi* Bergquist, Jour. Paleontology, v. 18, no. 1, p. 15, pl. 9, figs. 1–10.

Bergquist described *Lopha staufferi* as a small- to medium-sized oyster that curves toward the rear and is ornamented by conspicuous plications that generally number 10 to 12 along the anterior side of the right valve. The adductor muscle scar is "large, broad below, narrowest and indented above, situated close to posteroventral area." The holotype is 55 mm high.

A few plicate oysters from the lower part of the Twowells Sandstone Tongue are assigned to *Lopha staufferi.* Most are internal molds 50–85 mm in height.

Plicate oysters are common in the Cretaceous rocks of Europe and Africa, and many species have been described. *Lopha staufferi* resembles several of these species and may be one of them, such as *L. diluviana* (Linné), which was illustrated by Coquand (1869, pl. 40, figs. 1–4) and Roman and Mazeran (1920, pl. 9, fig. 6; pl. 10, figs. 1, 2) from the Cenomanian and Turonian of France.

Types.—Hypotypes, USNM 239717, 239718.

Granocardium trite (White)

Plate 21, figures 1–4, 7

1879. *Cardium trite* White, U.S. Geol. and Geog. Survey Terr. (Hayden), 11th Ann. Rept. p. 291, pl. 5, figs. 4a, b.

1894. *Cardium trite* White. Stanton, U.S. Geol. Survey Bull 106, p. 100, pl. 22, figs. 7, 8 [1893 imprint].

White (1879, p. 292) gave the dimensions of the holotype as 35 mm high and 36 mm long. His drawing shows about 73 almost equally spaced fine radial ribs. White observed that every third rib had many small nodes or short spines. The type specimen, an internal mold of light-gray very fine grained sandstone, came from "Cretaceous strata, probably equivalent with the lower portion of the Colorado Group; head of Waterpocket Cañon, Southern Utah." Latex casts of the impressions of two incomplete specimens in the lot from which White selected his type are shown on plate 21, figures 4, 7.

Marine rocks older than the Twowells Sandstone Tongue are unknown in southern Utah. The Dakota Sandstone and the overlying Mancos Shale crop out along the east flanks of the Waterpocket fold (Hackman and Wyant, 1973), where Gregory and Moore, (1931, p. 100) recorded *Cardium* [*Granocardium*] *trite* from sandstone just above the Dakota Sandstone. Fred Peterson, of the U.S. Geological

Survey, has recently collected *G. trite* associated with *Metoicoceras defordi* Young from the uppermost 3 or 4 feet of the Dakota Sandstone about 30 miles (48 km) south of the Waterpocket fold exposures (U.S. Geol. Survey Mesozoic locs. D5239 and D5240, in the NW¼ sec. 24, T. 41 S., R. 8 E., Kane County. Utah). Peterson's specimens, although few in number, are very finely ribbed, but none has as great a rib count as indicated on White's drawing of the holotype.

Specimens that seem assignable to *G. trite* occur in the Twowells Sandstone Tongue and possibly in the Paguate Sandstone Tongue in west-central New Mexico. The rib densities are comparable to those of the specimens collected by Peterson from southern Utah.

Types.—Hypotypes, USNM 239719–239722.

Granocardium enstromi (Bergquist)

Plate 8, figures 4–7, 10, 11

1944. *Cardium enstromi* Bergquist, Jour. Paleontology, v. 18, no. 1, p. 22, pl. 1, figs. 6, 7, 12.

Granocardium enstromi is a common species in the Paguate Sandstone Tongue. The species closely resembles *G. trite* (White), but it has fewer ribs and, in most parts of the shell, every other rib is tuberculate. On some individuals (pl. 8, figs. 4, 5), the tubercles attain a large size. Ribs number about 53.

The holotype is from northern Minnesota. Elsewhere in the western interior region, *G. enstromi* is known only from west-central New Mexico.

Types.—Hypotypes, USNM 239723–239726.

Granocardium (Criocardium) cf. G. productum (Sowerby)

Plate 3, figure 2

A few internal molds of an inflated quadrate species from the Oak Canyon Member and Cubero Sandstone Tongue could be the species named by J. de C. Sowerby (cited in Sedgwick and Murchison, 1835, p. 417, pl. 39, fig. 15) as *Cardium productum*. An impression of part of a valve in the very fine-grained sandstone matrix from one of the localities clearly reveals the ornamentation. Ribs are numerous, narrow, and smooth, and the intercostal space is occupied by closely spaced tubercles. On part of the surface, every other row of tubercles is larger than the intervening one.

Figured specimen.—USNM 239727.

Aphrodina cf. A. munda (Stephenson)

Plate 7, figures 1–3

Very fine grained sandstone concretions in the upper half of the Paguate Sandstone Tongue contain a few bivalves that might be *Aphrodina munda* (Stephenson, 1952, p. 106, pl. 26, figs. 14–19). The Paguate specimens tend to have a slightly more elongate shape than Stephenson's types, which are from the Templeton Member of the Woodbine Formation of Texas.

Figured specimens.—USNM 239737, 239738.

Legumen ellipticum Conrad

Plate 9, figures 1–3

1858. *Legumen ellipticus* Conrad, Acad. Nat. Sci. Philadelphia Jour., 2d ser., v. 3, p. 325, pl. 34, fig. 19.

Specimens that seem assignable to Conrad's species are present in very fine grained sandstone in the Paguate Sandstone Tongue. Conrad's sketch of the holotype shows narrower anterior and posterior margins than those of the Paguate specimens, but the topotype and hypotypes illustrated by Stephenson (1941, pl. 42, figs. 13–19) are more like the Paguate forms. This elongate, narrow bivalve seems to have a great stratigraphic range inasmuch as the holotype came from the Ripley Formation of Mississippi, the age of which is probably very late Campanian and very early Maestrichtian.

Types.—Hypotypes, USNM 239739, 239740.

Pholadomya aff. P. goldenensis Stephenson

Plate 5, figure 3

A few pholadomyids from the upper part of the Oak Canyon Member resemble *Pholadomya goldenensis* Stephenson (1952, p. 87, pl. 21, figs. 19–22) in their elongate form and in their concentric folds crossed by conspicuous radial ribs. The Oak Canyon specimens, however, are smaller and have about 12 radial ribs, whereas the types have about 14. Stephenson's types are from the Templeton Member of the Woodbine Formation of Texas.

Figured specimen.—USNM 239728.

Psilomya aff. P. concentrica (Stanton)

Plate 5, figures 1, 2

Several collections of fossils from the upper part of the Oak Canyon Member and lower part of the Cubero Sandstone Tongue contain a species of *Psilomya* resembling *P. concentrica* (Stanton, 1893, p. 119, pl. 26, figs. 8–10). The New Mexico specimens differ in having finer and more closely spaced concentric folds on the umbonal part of the shell. Stanton's types are from the middle Turonian Codell Sandstone Member of the Carlile Shale of south-central Colorado. The species occurs in older rocks, however, inasmuch as Stephenson (1952, p. 92, pl. 22, figs. 13–20) found it in the Woodbine Formation (Cenomanian) of Texas. *Homomya casei* Jones

(1938, p. 111, pl. 4, figs. 14, 18, 19), from the Indidura Formation of Coahuila, Mexico, resembles the New Mexico specimens in its general shape and convexity, but it attains a larger size and may have coarser sculpture.

Figured specimens.—USNM 239729, 239730.

Turritella shuleri Stephenson?

Plate 8, figure 10

1953. *Turritella shuleri* Stephenson, U.S. Geol. Survey Prof. Paper 242, p. 153, pl. 36, figs. 14–19 [1952 imprint].

High-spired gastropods that are probably *Turritella shuleri* Stephenson (N. F. Sohl, written commun., 1970) occur in very fine grained sandstone in the Paguate Sandstone Tongue. The piece of fossiliferous sandstone illustrated in plate 8, figure 10, has several small ends of a *Turritella* that has four primary rows of beaded spiral ribs similar to those on the small end of one of the paratypes figured by Stephenson (1952, pl. 36, fig. 18).

Type.—Hypotype, USNM 239725.

Arrhoges modesta (Cragin)?

Plate 2, figure 4

1893. *Anchura modesta* Cragin, Texas Geol. Survey 4th Ann. Rept. for 1892, p. 18.

1953. *"Anchura" modesta* Cragin. Stephenson, U.S. Geol. Survey Prof. Paper 242, p. 179, pl. 39, figs. 7–11 [1952 imprint].

This nearly smooth gastropod occurs in great numbers in very fine grained calcareous sandstone and siltstone and silty limestone in the upper part of the Oak Canyon Member. The abundance of this species is the source of the "Gasteropod zone" terminology of Herrick and Johnson (1900, p. 187). Cragin's specimens are from the Woodbine Formation of Grayson County, Texas.

Type.—Hypotype, USNM 239743.

Turrilites (Turrilites) acutus Passy

Plate 4, figures 4, 5

1832. *Turrilites acutus* Passy, Description géologique du Département de la Seine-Inférieure, atlas, p. 9, pl. 16, figs. 3, 4.

1972. *Turrilites (Turrilites) acutus* Passy. Cobban and Scott, U.S. Geol. Survey Prof. Paper 645, p. 52, pl. 14, fig. 6, text fig. 20.

This helical ammonoid has three equal rows of tubercles connected by ribs that obliquely cross the flank of the whorls. Two rows of nearly equal sized tubercles lie on the flank of the whorls, and a row of smaller ones is present at the base of the whorls.

Turrilites acutus is present sparsely in the upper part of the Oak Canyon Member and lower part of the Cubero Sandstone Tongue. In southeastern Colorado, the species occurs in the Thatcher Limestone Member of the Graneros Shale.

Types.—Hypotypes, USNM 239744, 239745.

Turrilites (Turrilites) acutus americanus Cobban and Scott

Plate 10, figures 3–6, 10, 12

1972. *Turrilites (Turrilites) acutus* Passy *americanus* Cobban and Scott, U.S. Geol. Survey Prof. Paper 645, p. 53, pl. 11, figs. 1–11; text fig. 21.

This chronologic subspecies differs from *Turrilites acutus* Passy chiefly in having smaller and weaker tubercles at the base of the whorls. In west-central New Mexico, *Turrilites acutus americanus* has been found only in the Paguate Sandstone Tongue or in age-equivalent shale, in association with *Inoceramus rutherfordi* Warren and *Acanthoceras amphibolum* Morrow. In southeastern Colorado, the subspecies occurs in concretionary limestone at the top of the Graneros Shale (Cobban and Scott, 1972, p. 7).

Types.—Hypotypes, USNM 239746–239750.

Desmoceras (Pseudouhligella) sp.

Plate 4, figure 7

The subgenus *Pseudouhligella* differs from *Desmoceras* in having a wider umbilicus and more compressed whorls. The age range is late Albian-Turonian.

A large laterally crushed specimen from the upper part of the Oak Canyon Member is shown on plate 4. This specimen is unusual because it is septate at a diameter of 100 mm. Most illustrated specimens of *Pseudouhligella* have smaller phragmocones.

Figured specimen.—USNM 239751.

Desmoceras (Pseudouhligella) aff. D. japonicum Yabe

Plate 11, figures 1–6, 9, 10

This species seems to differ from *Desmoceras (Pseudouhligella) japonicum* Yabe (1904, p. 35, pl. 5, figs. 3, 4) only in the form of the constrictions. On the New Mexico species, the constrictions crossing the venter are narrow and nearly V-shaped, whereas on *D. (P.) japonicum* they are broader and U-shaped. The occurrences in west-central New Mexico are in the middle and upper part of the Paguate Sandstone Tongue.

Figured specimens.—USNM 239752, 239753.

Calycoceras (Conlinoceras) tarrantense (Adkins)

Plate 3, figure 9; plate 4, figures 1–3, 6

1928. *Metacalycoceras? tarrantense* Adkins, Texas Univ. Bull. 2838, p. 241, pl. 28, fig. 3; pl. 29, fig. 1.

1928. *Acanthoceras wintoni* Adkins, Texas Univ. Bull. 2838, p. 243, pl. 25, figs. 2, 3.

This robust ammonite is characterized by sparse ribs that alternate in length and either lack umbilical tubercles or just show a slight thickening where the tubercules would be. All ribs on specimens less than 80–100 mm in diameter have lower and upper ventrolateral tubercles and a clavate midventral tubercle.

Adkins' specimens are from the Lewisville Member of the Woodbine Formation of Texas. The species is an uncommon fossil in the upper part of the Oak Canyon Member and in the lower part of the Cubero Sandstone Tongue.

Types.—Hypotypes, USNM 239762–239764.

Calycoceras? canitaurinum (Haas)

Plate 21, figure 17

1949. *Mantelliceras canitaurinum* Haas, Am. Mus. Nat. History Bull., v. 93, art. 1, p. 9, pls. 1–3; p. 4, figs. 1, 2, 4; text figs. 1–4.

This is a large stout ammonite that is slightly evolute and has a squarish whorl section. Ribs alternate in length, and the longer ones rise from tubercles at the umbilical shoulder. On the adult whorls, all ribs rise into blunt tubercles at the ventrolateral margin and cross the venter as low, broad, flat ribs. Ribs on the innermost whorls are narrow and closely spaced, and have pointed umbilical, lateral, ventrolateral, and siphonal tubercles.

Some fragments of large ammonites in the Whitewater Arroyo Shale Tongue and Twowells Sandstone Tongue seem assignable to *Calycoceras? canitaurinum*. Other fragments have more widely spaced ribs and are referred to as *Calycoceras*? cf. *C.? canitaurinum* on table 3. One of the latter forms has a diameter of 490 mm.

The types of *C.*? cf. *C.*? *canitaurinum* are from the basal part of the Cody Shale near Greybull, Wyo. The species has been found in the upper part of the Frontier Formation at many localities in Wyoming (for example, Rawlins area, described in Cobban and Reeside, 1952, p. 1944). Fragments of a large ammonite that might be this species were found much farther north in northwestern Montana (Cobban, 1951, p. 2184).

Type.—Hypotype, USNM 239754.

Tarrantoceras rotatile Stephenson

Plate 6, figures 8–10, 28, 29; plate 11, figures 7, 8, 11–16; plate 12, figures 13, 14; text figure 4

1955. *Tarrantoceras rotatile* Stephenson, U.S. Geol. Survey Prof. Paper 274–C, p. 59, pl. 5, figs. 1–10; also *T. stantoni* Stephenson, p. 60, pl. 5, figs. 11–21, *T. lillianense* Stephenson, p. 60, pl. 5, figs. 22–27, and *?T. multicostatum* Stephenson, p. 61, pl. 6, figs. 21–23.

Tarrantoceras Stephenson (1955, p. 59) has a fairly wide umbilicus and flattened flanks. Numerous ribs cross the flanks and venter, and support nodate umbilical and lower ventrolateral tubercles and clavate upper ventrolateral and siphonal tubercles. The genus seems to differ from *Eucalycoceras* Spath (1923, p. 144) only in having a much simpler suture (fig. 4).

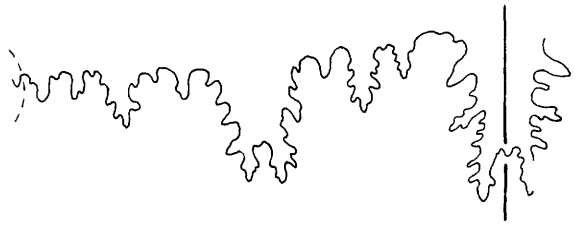

FIGURE 4.—External suture (× 2) of *Tarrantoceras rotatile* Stephenson (pl. 6, figs. 8–10) at a whorl height of 21 mm. Heavy line marks the middle of the external lobe; dashed line marks the umbilical margin. Hypotype, USNM 239755.

The types of *Tarrantoceras rotatile* came from the basal part of the Eagle Ford Shale of Texas. The species is variable, ranging from finely ribbed and weakly tuberculate to coarsely ribbed and strongly tuberculate. Ammonites assignable to *T. rotatile* occur in the Clay Mesa Shale Tongue and Paguate Sandstone Tongue.

Types.—Hypotypes, USNM 239755–239761, 239783.

Acanthoceras amphibolum Morrow

Plate 8, figures 8, 9; plate 12, figures 10–12, 15–23; text figure 5

1935. *Acanthoceras? amphibolum* Morrow, Jour. Paleontology, v. 9, no. 6, p. 470, pl. 49, figs. 1–4, 6; pl. 51, figs. 3, 4; text fig. 4.

The inner whorls of *Acanthoceras amphibolum* have nodate umbilical and lower ventrolateral tubercles, and clavate upper ventrolateral and siphonal tubercles. Upper ventrolateral and siphonal tubercles, which are located on broad ridges that cross the venter, are usually asymmetrically clavate, the steep side being forward. Adult whorls have ventrolateral horns and a broadly arched venter that supports a low midventral ridge. The suture (fig. 5) is about as incised as those of most illustrated specimens that have been assigned to *Acanthoceras.*

The holotype of *A. amphibolum* is from the uppermost part of the Graneros Shale of Kansas. In west-central New Mexico, the species has been found only in the Paguate Sandstone Tongue of the Dakota Sandstone. *Acanthoceras amphibolum* has been collected at many localities in Colorado, Kansas, Wyo-

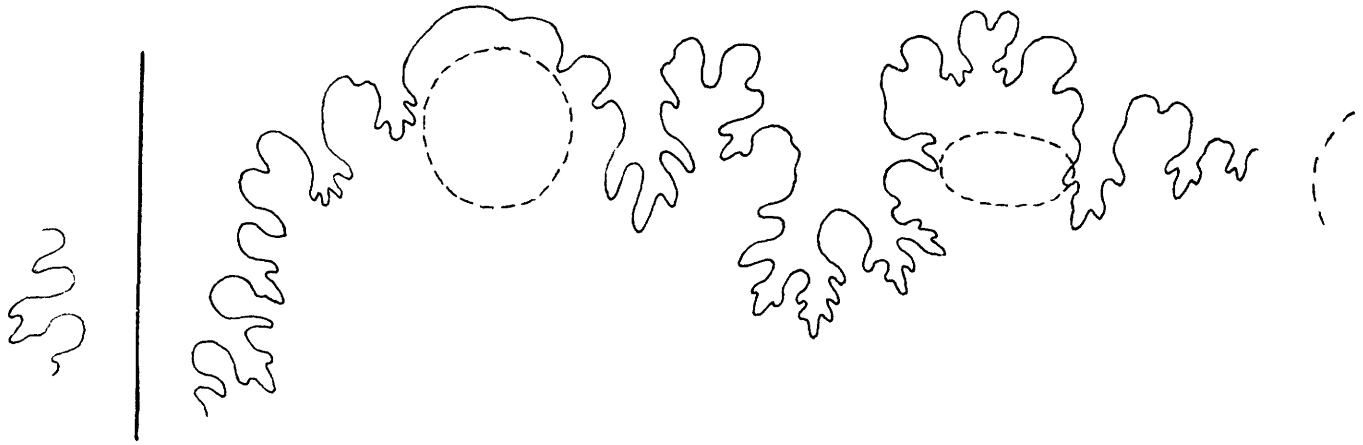

FIGURE 5.—External suture (× 3) of *Acanthoceras amphibolum* Morrow (pl. 12, figs. 22, 23) at a diameter of 77 mm. Heavy line marks the middle of the external lobe; curved dashed line marks the umbilical margin; and closed dashed lines mark the position of tubercles on the shell. Hypotype, USNM 239770.

ming, South Dakota, and Montana in association with *Ostrea beloiti* Logan and *Inoceramus rutherfordi* Warren.

Types.—Hypotypes, USNM 239765–239770.

Acanthoceras alvaradoense Moreman

Plate 6, figures 1–7, 11–20; text figure 6

1942. *Acanthoceras alvaradoense* Moreman, Jour. Paleontology, v. 16, no. 2, p. 205, pl. 32, fig. 6; text figs. 2*O*, 2*T*.

1955. *Euomphaloceras alvaradoense* (Moreman). Stephenson, U.S. Geol. Survey Prof. Paper 274–C, p. 63, pl. 7, figs. 1–9.

The adults of this species resemble the adults of *Acanthoceras amphibolum* Morrow. The chief difference between these species is in the inner whorls. The earliest whorls of *A. alvaradoense* usually have periodic constrictions, and the upper ventrolateral and siphonal tubercles are not as elongate as those of *A. amphibolum*. In addition, some specimens of *A. alvaradoense* have a few extra siphonal tubercles in various places, and therefore the species shows some resemblance to *Euomphaloceras* Spath (1923, p. 144).

A complete suture is shown in figure 6. The first lateral saddle is very broad and asymmetrically bifid much like that of *A. amphibolum* Morrow (fig. 3).

Acanthoceras alvaradoense was collected from septarian limestone concretions in the Clay Mesa Shale Tongue in the Acoma area southeast of Grants. Moreman's type came from the basal part of the Eagle Ford Shale of Texas. The species has been found at very few places in the western interior region.

Types.—Hypotypes, USNM 239771–239773.

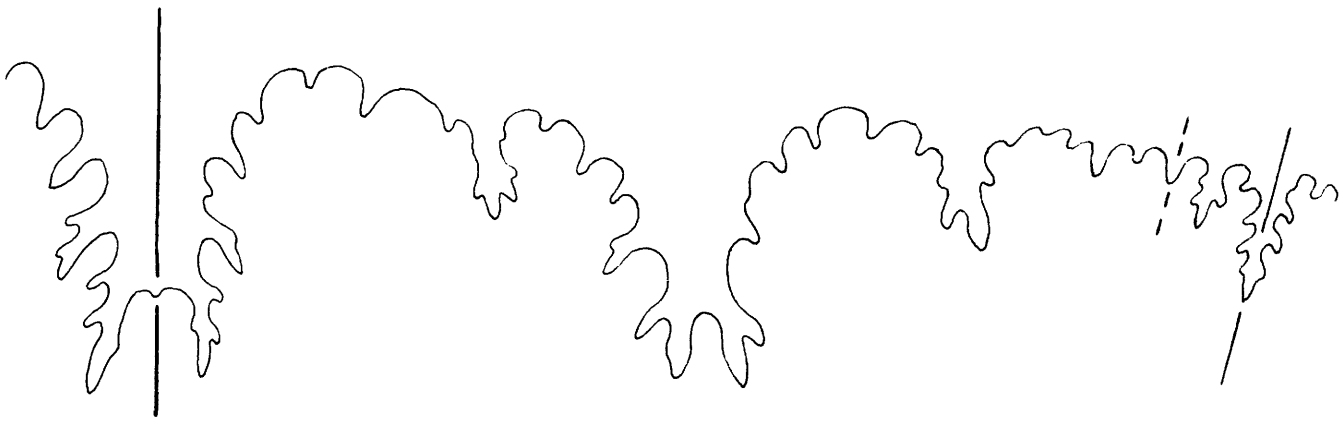

FIGURE 6.—Suture (× 3) of *Acanthoceras alvaradoense* Moreman (pl. 6, figs. 19, 20) at a whorl height of 30 mm. Heavy line marks the middle of the external lobe; light straight line marks the middle of the internal lobe; dashed line marks the umbilical shoulder. Hypotype, USNM 239773.

Plesiacanthoceras aff. P. wyomingense (Reagan)

Plate 13, figures 1, 2

A few large ammonites from the Paguate Sandstone Tongue resemble *Plesiacanthoceras wyomingense* (Reagan, 1924, p. 181, pl. 19, figs. 1, 2) because they are about the same size, because they retain double ventrolateral tubercles out to a large diameter, and because their adult whorls have conspicuous ventrolateral horns. The Paguate specimens differ, however, in tending to have a raised midventral ridge similar to that on some specimens of *Acanthoceras amphibolum* Morrow (1935, p. 472).

Figured specimen.—USNM 239774.

Euomphaloceras aff. E. cunningtoni (Sharpe)

Plate 11, figures 17, 18

Euomphaloceras resembles *Acanthoceras* in having umbilical, lower and upper ventrolateral, and siphonal tubercles, but *Euomphaloceras* differs mainly in having more siphonal tubercles than ventrolateral ones. A few incomplete ammonites from the Paguate Sandstone Tongue have affinities with *E. cunningtoni* (Sharpe, 1854, p. 35, pl. 15, figs. 2a–c) in their sparse tuberculation, but the siphonal tubercles are not as small and numerous as on Sharpe's type.

Figured specimen.—USNM 239775.

Paracompsoceras landisi Cobban

Plate 14

1972. *Paracompsoceras landisi* Cobban, U.S. Geol. Survey Prof. Paper 699, p. 10, pl. 2, figs. 24–26; pls. 6–8; pl. 9, figs. 5–8; text figs. 9–11 [1971 imprint].

Paracompsoceras landisi is a large stout ammonite that attains a diameter of as much as 310 mm. The species is moderately involute and has umbilical ratios of 25–30 percent. The early whorls are quadrangular in cross section and ornamented by ribs and tubercles. Each rib has a lower and an upper ventrolateral tubercle, and every other rib extends to the umbilicus, where it rises into a bullate tubercle. Each rib is matched on the venter by a low clavate siphonal tubercle. As the shell enlarges, all tubercles and the short ribs disappear, and the flanks and venter flatten. The longer ribs persist to the base of the body chamber; they are strongest on the lower half of the whorl. The adult body chamber is smooth, and its cross section is rounded.

The types of *P. landisi* are from the Paguate Sandstone Tongue of the Grants-Laguna area (Cobban, 1971, p. 12). In west-central New Mexico, *P. landisi* has been found only in the Paguate Tongue.

Type.—Holotype, USNM 166360.

Metoicoceras cf. M. praecox Haas

Plate 16, figure 25; plate 21, figures 8, 9

Fragments of ammonites from the Whitewater Arroyo Shale Tongue and the basal part of the Twowells Sandstone Tongue resemble *Metoicoceras praecox* Haas (1949, p. 15, pls. 5–7; text figs. 5–9). Haas' form is a compressed species that has umbilical tubercles on the inner whorls and none on the adult body chamber. Ribs are conspicuous on the inner whorls, cross the flanks and venter, and support ventrolateral tubercles. The innermost whorls of some specimens have weak clavate siphonal tubercles. Ribbing weakens on the body chamber but becomes strong again near the aperture. Haas' types were associated with *Dunveganoceras pondi* Haas in the basal part of the Cody Shale near Greybull, Wyo. The fragments from New Mexico that might be *M. praecox* consist of parts of body chambers preserved as internal molds of very fine grained sandstone.

Figured specimens.—USNM 239776, 239777.

Metoicoceras aff. M. latoventer Stephenson

Plate 16, figures 13–15; text figure 7

A few robust inner whorls of *Metoicoceras* from the Whitewater Arroyo Shale Tongue resemble the inner whorls of *M. latoventer* Stephenson (1952, p. 209, pl. 53, figs. 1–9; pl. 54, figs. 9–11) in their general appearance, but the lower row of ventrolateral tubercles is barely discernible. The suture (fig. 7) is about as incised as those visible on Stephenson's figured specimens. *Metoicoceras latoventer* has been recorded only from the Woodbine Formation of northern Texas.

Figured specimen.—USNM 239778.

Metoicoceras spp.

Plate 21, figures 5, 6, 10–16

Poorly preserved ammonites from the Twowells Sandstone Tongue show some resemblance to *Metoi-*

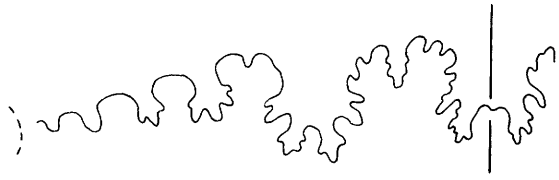

FIGURE 7.—External suture (× 3) of *Metoicoceras* aff. *M. latoventer* Stephenson (pl. 16, figs. 13–15) at a diameter of 28 mm. Heavy line marks the middle of the external lobe; dashed line marks the umbilical margin. Figured specimen, USNM 239778.

coceras muelleri Cobban (1953, p. 49, pl. 6, figs. 15, 16; pl. 8, figs. 1–7; pl. 9) and *M. defordi* Young (1957, p. 1169, pl. 149, figs. 1–8; text fig. 1*a*, *e*, *g*, *i*). A small specimen (pl. 21, figs. 5, 6) resembles *M. muelleri* in its slender cross section and fine ribbing, but its umbilicus is too wide. A larger specimen (pl. 21, figs. 15, 16), 93 mm in diameter, resembles *M. defordi* in the width of its umbilicus, in the number of ribs per whorl, and in the presence of well defined bullate umbilical tubercles, but the venter appears to round at too small a diameter. Other specimens, such as those shown on plate 21, figures 10–14, seem different from any described species.

Figured specimens.—USNM 239779–239782.

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PLATES 1-21

Contact photographs of the plates in this report are available, at cost, from U.S. Geological Survey Library, Federal Center, Denver, Colorado 80225

PLATE 1

[All figures natural size]

FIGURES 1, 3. *Plesiopinna* sp. (p. 14).

Right and left valves of two specimens from USGS localities D6794 and D2053 (text fig. 1, locs. 66, 61). USNM 239616, 239617.

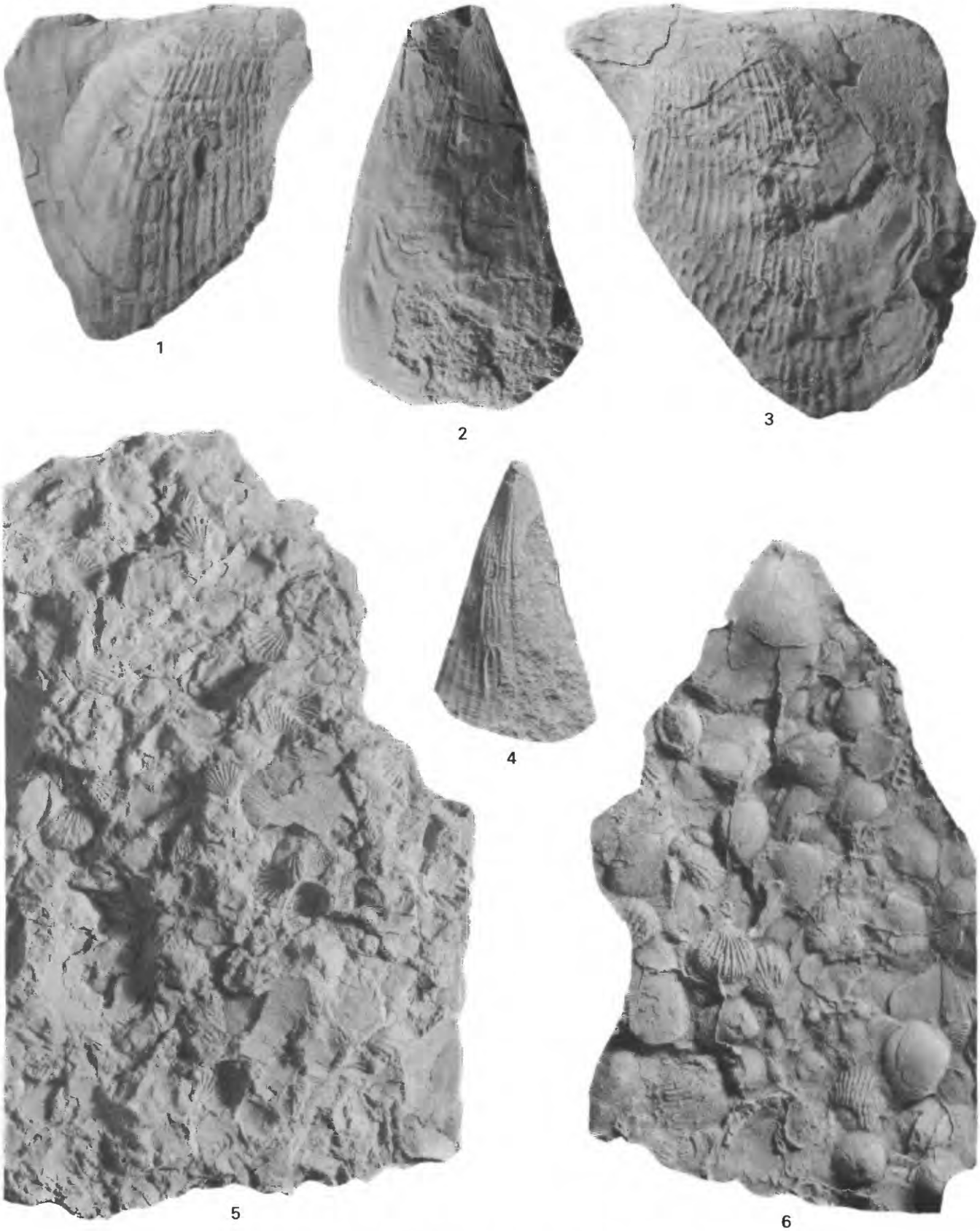
2, 4. *Pinna petrina* White (p. 13).

Two incomplete specimens from USGS localities D7080 and D7081 (text fig. 1, locs. 45, 46). USNM 239612, 239613.

5, 6. *Plicatula arenaria* Meek (p. 16).

5. Slab of very fine grained sandstone that contains numerous specimens of *Plicatula arenaria* and a few bits of *Pinna* shells from USGS locality D6794 (text fig. 1, loc. 66). USNM 239635.

6. Latex cast of a slab of very fine grained sandstone that contains several specimens of *P. arenaria* as well as representatives of *Camptonectes* (a), *Mediraon* (b), *Granocardium* (c), and other bivalves, from USGS locality D2053 (text fig. 1, loc. 61). USNM 239636.



MOLLUSKS FROM THE OAK CANYON MEMBER

PLATE 2

[All figures natural size]

FIGURES 1, 2. *Exogyra aquillana* Stephenson (p. 18).

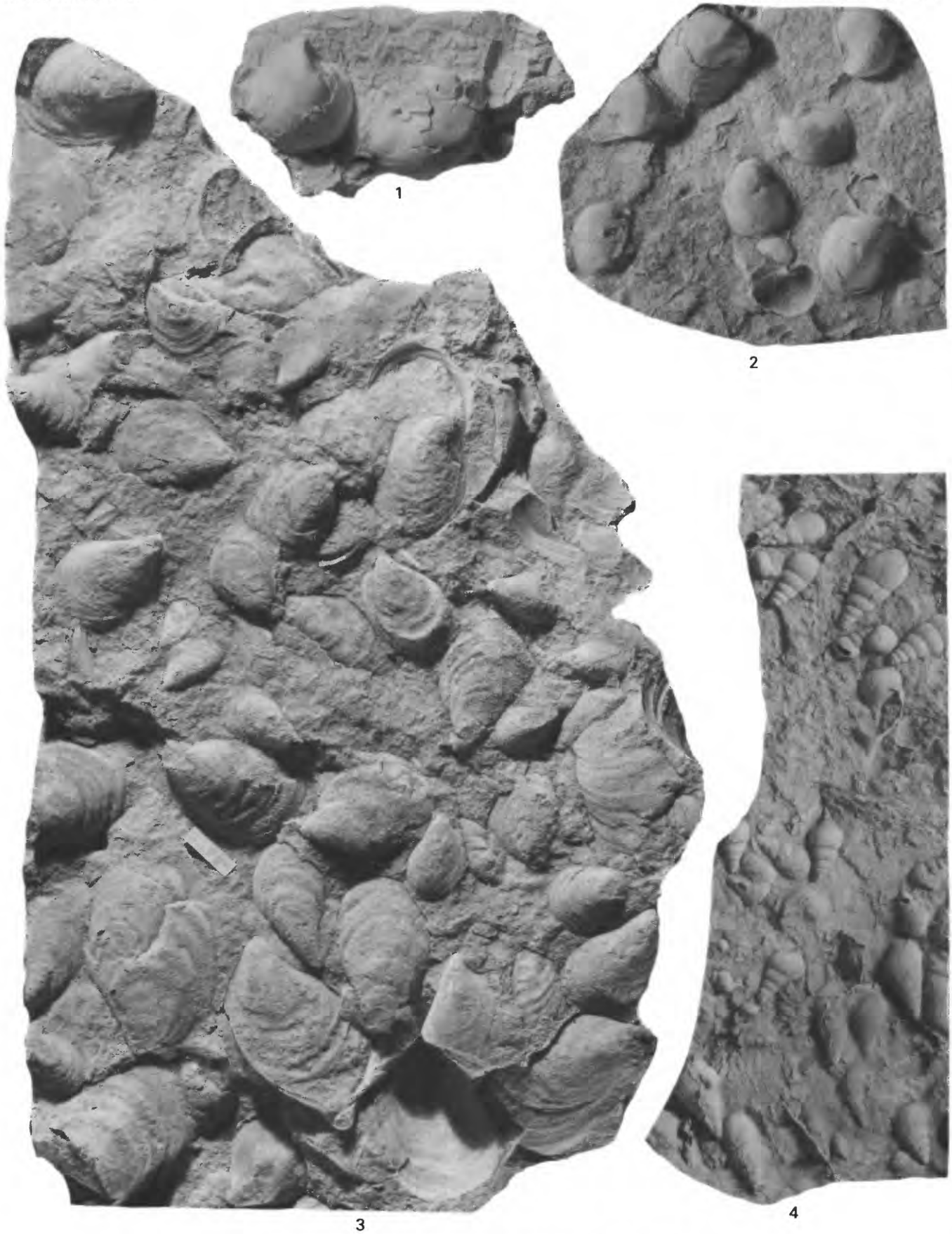
1. Two left valves from USGS locality D5377 (text fig. 1, loc. 29). USNM 239675.
2. Latex cast of a piece of very fine grained sandstone that has impressions of several left valves from USGS locality D5815 (text fig. 1, loc. 33). USNM 239676.

3. *Inoceramus* cf. *I. macconnelli* Warren (p. 14).

Numerous specimens in a slab of very fine grained sandstone from USGS locality D5756 (text fig. 1, loc. 17). USNM 239621.

4. *Arrhoges modesta* (Cragin)? (p. 22).

Latex cast of many specimens in a slab of very fine grained sandstone from locality D5806 (text fig. 1, loc. 34). USNM 239743.



MOLLUSKS FROM THE OAK CANYON MEMBER

PLATE 3

[All figures natural size]

FIGURE 1. *Camptonectes symmetricus* Herrick and Johnson (p. 15).
Latex cast of a piece of very fine grained sandstone that has examples of this pectinid (a) as well as *Plicatula* (b), *Astarte* (c), *Parmicorbula* (d), and other bivalves, from USGS locality D5336 (text fig. 1, loc. 44). USNM 239735.

2. *Granocardium (Criocardium)* cf. *G. productum* (Sowerby) (p. 21).
Latex cast of an impression of part of a shell in very fine grained sandstone from USGS locality D5742 (text fig. 1, loc. 25). USNM 239727.

3, 4. *Inoceramus eulessanus* Stephenson (p. 14).
Latex casts of two specimens from USGS locality D5760 (text fig. 1, loc. 16). USNM 239619, 239620.

5–7. *Inoceramus* cf. *I. macconnelli* Warren (p. 14).
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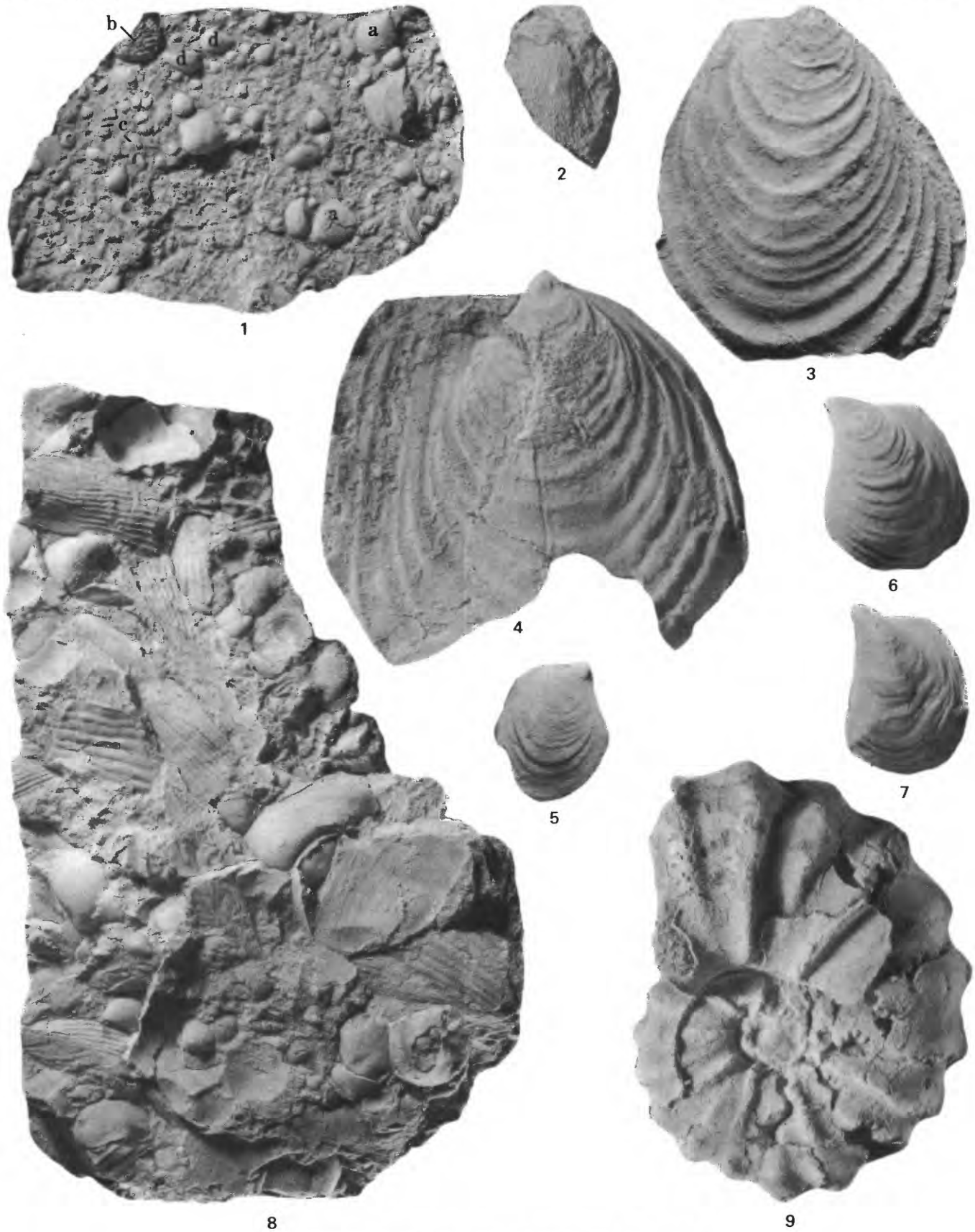
9. *Calycoceras (Conlinoceras) tarrantense* (Adkins) (p. 22).
Side view of a phragmocone from USGS locality D2053 (text fig. 1, loc. 61). USNM 239762.



MOLLUSKS FROM THE OAK CANYON MEMBER

PLATE 4

[All figures natural size]

FIGURES 1–3, 6. *Calycoceras (Conlinoceras) tarrantense* (Adkins) (p. 22).

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MOLLUSKS FROM THE OAK CANYON MEMBER AND CUBERO SANDSTONE TONGUE

PLATE 5

[All figures natural size except as indicated]

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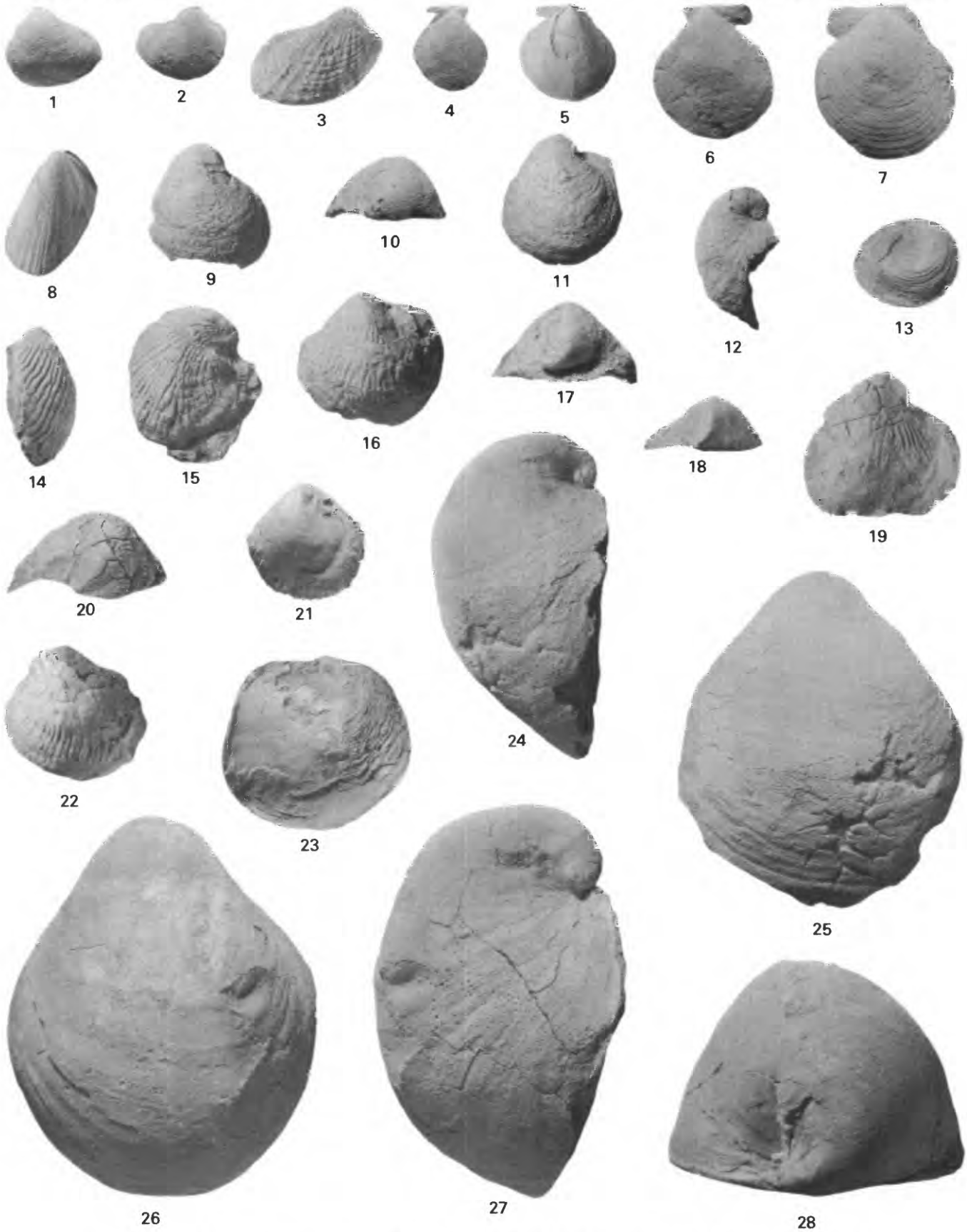
24, 25. Left valve from USGS locality D2048 (text fig. 1, loc. 56). USNM 239686.
26–28. Left valve from the same locality. USNM 239687.



MOLLUSKS FROM THE OAK CANYON MEMBER AND CUBERO SANDSTONE TONGUE

PLATE 6

[All figures natural size]

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27. *Inoceramus arvanus* Stephenson (p. 15).

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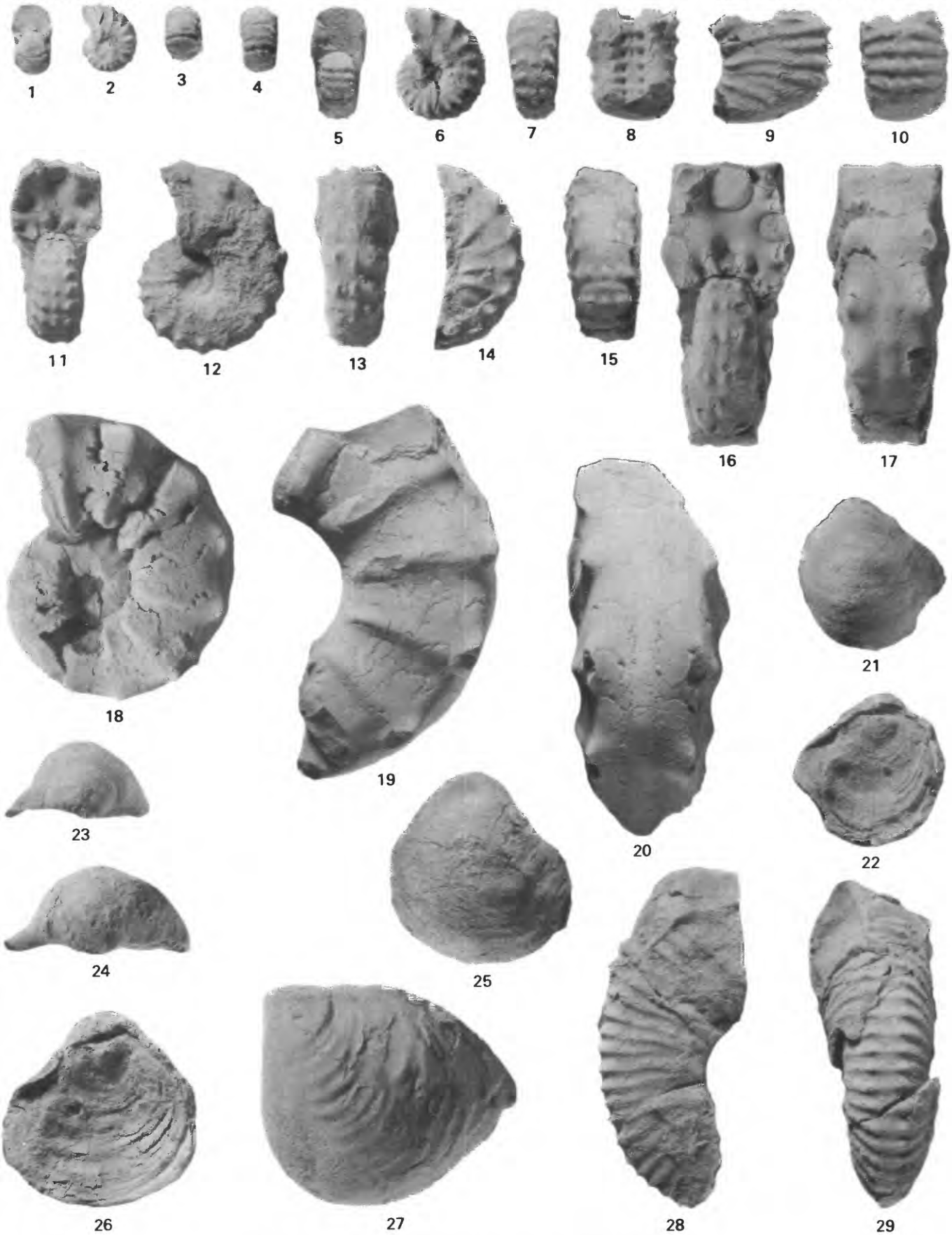

MOLLUSKS FROM THE CLAY MESA SHALE TONGUE

PLATE 7

[All figures natural size]

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3. Exterior of a left valve from USGS locality D5325 (text fig. 1, loc. 35). USNM 239738.

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5. Interior of a left valve from USGS locality D5324 (text fig. 1, loc. 37). USNM 239714.

6. Internal mold of a left valve from USGS locality D7328 (text fig. 1, loc. 24). USNM 239715.

7. Internal mold of a right valve that retains some of the shell material from the same locality as figure 5. USNM 239716.

8, 9. *Phelopteria*? cf. *P.*? *aguilerae* (Böse) (p. 14).

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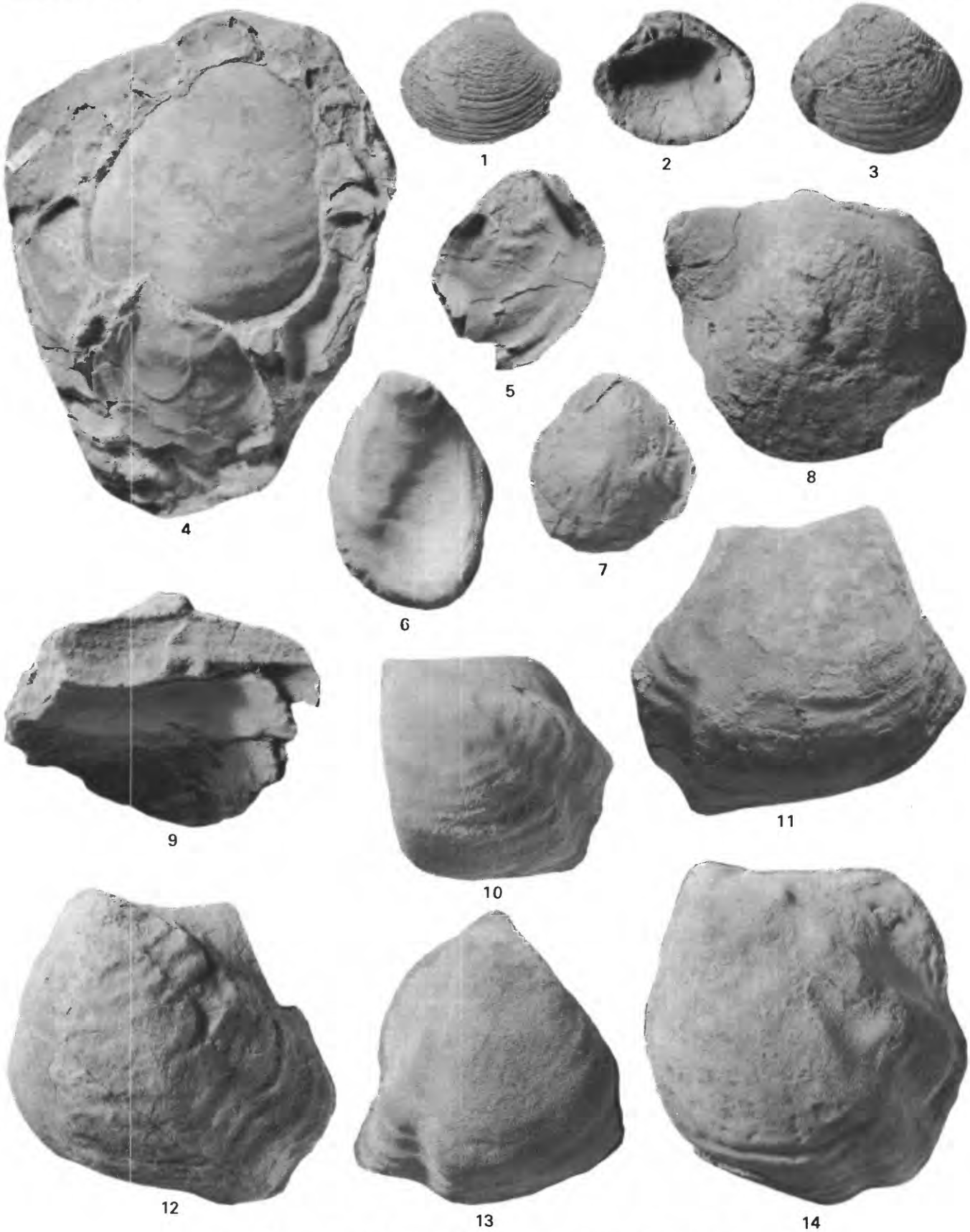
10–14. *Inoceramus rutherfordi* Warren (p. 14).

10, 11. Internal molds of left and right valves from USGS locality D7328 (text fig. 1, loc. 24). USNM 239625, 239626.

12–14. Internal molds of two left valves and a right valve from USGS locality D5750 (text fig. 1, loc. 22). USNM 239627–239629.



MOLLUSKS FROM THE PAGUATE SANDSTONE TONGUE

PLATE 8

[All figures natural size]

FIGURES 1–3. *Idonearca blanpiedi* Stephenson (p. 10).

Left and right valves from USGS locality D7084 (text fig. 1, loc. 47). USNM 239606, 239607.

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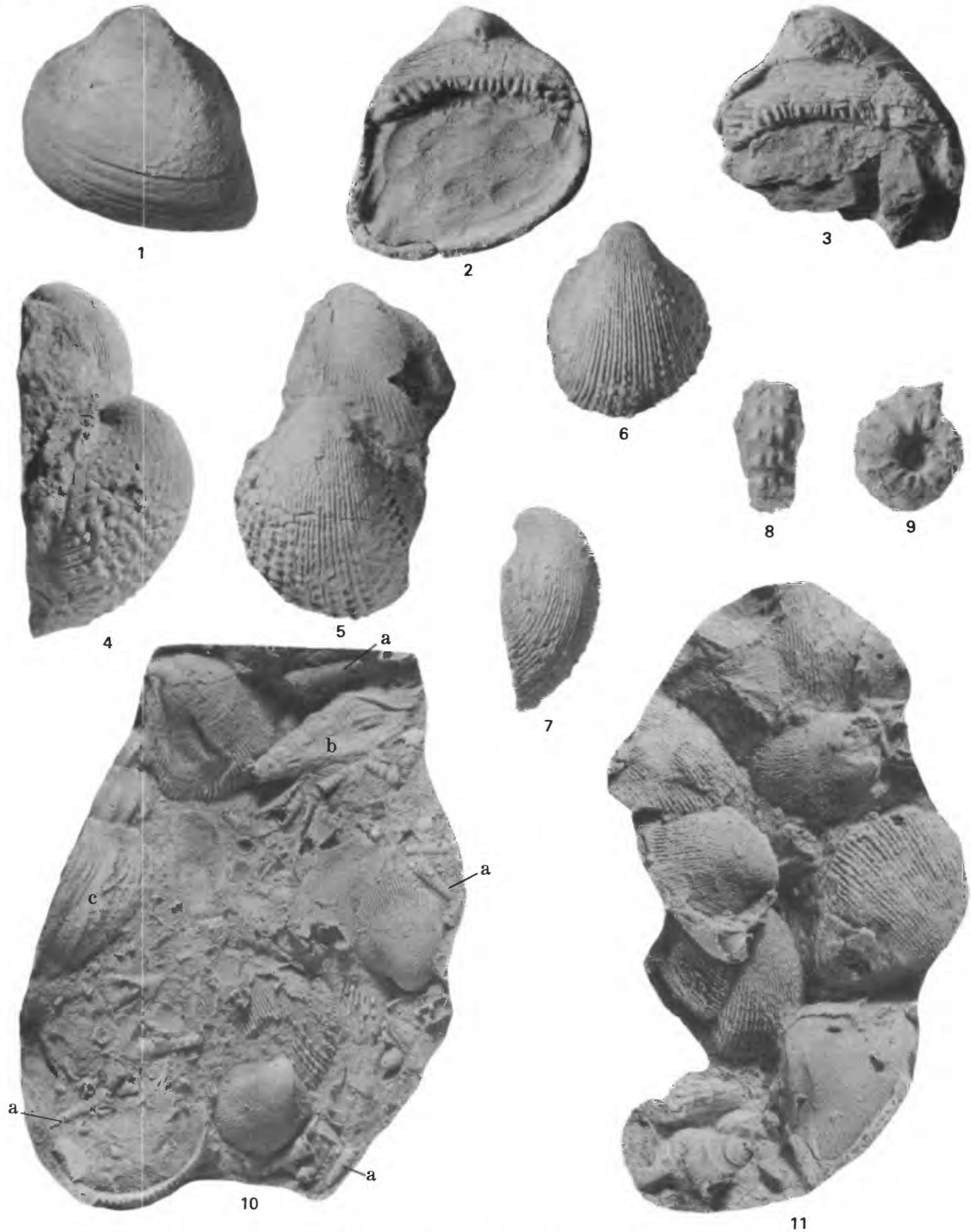
10, 11. Latex casts of impressions in fine-grained sandstone from USGS locality D7345 (text fig. 1, loc. 72). Gastropods include (a) *Turritella shuleri* (Stephenson)?, (b) *Helicaulax*? sp., and (c) *Paleopsephaea* sp. USNM 239725, 239726.

8, 9. *Acanthoceras amphibolum* Morrow (p. 23).

Rear and side views of an internal mold of a small specimen from USGS locality D7333 (text fig. 1, loc. 19). USNM 239765.



MOLLUSKS FROM THE PAGUATE SANDSTONE TONGUE

PLATE 9

[All figures natural size]

FIGURES 1–3. *Legumen ellipticum* Conrad (p. 21).

1, 2. Two views of a specimen collected by W. T. Lee in 1911 from USGS locality 7192 one-half mile west of San Francisco, Sandoval County. USNM 239739.

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4–8. *Plicatula* sp. (p. 16).

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5, 8. Latex casts of two specimens from USGS locality D5795 (text fig. 1, loc. 71). USNM 239648, 239651.

9. *Plicatula* cf. *P. ferryi* Coquand (p. 16).

Latex cast of an impression in very fine grained sandstone from USGS locality D7334 (text fig. 1, loc. 20). USNM 239646.

10–20. *Exogyra trigeri* (Coquand) (p. 19).

10, 11. Side view of left valve and view of right valve of same specimen from USGS locality D6130 (text fig. 1, loc. 51). USNM 239696.

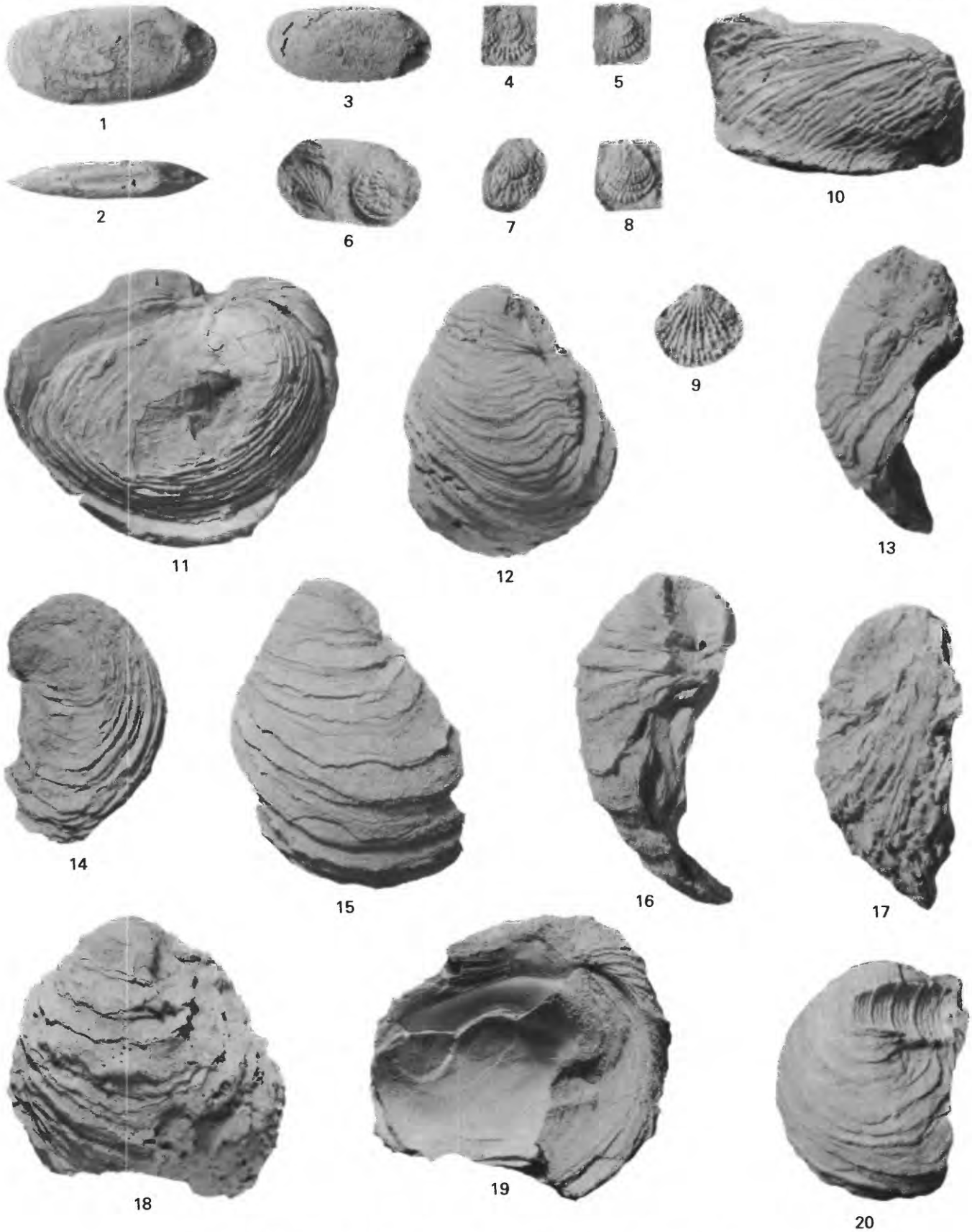
12, 13. Views of a left valve that was attached to a turritellid from USGS locality D6183 (text fig. 1, loc. 6). USNM 239697.

14. Right valve from the same locality. USNM 239698.

15, 16. Views of a left valve that was attached to a turritellid from the same licality. USNM 239699.

17–19. Left valve of another specimen that was attached to a turritellid from the same locality. USNM 239700.

20. Left valve from the same locality. USNM 239701.



MOLLUSKS FROM THE PAGUATE SANDSTONE TONGUE

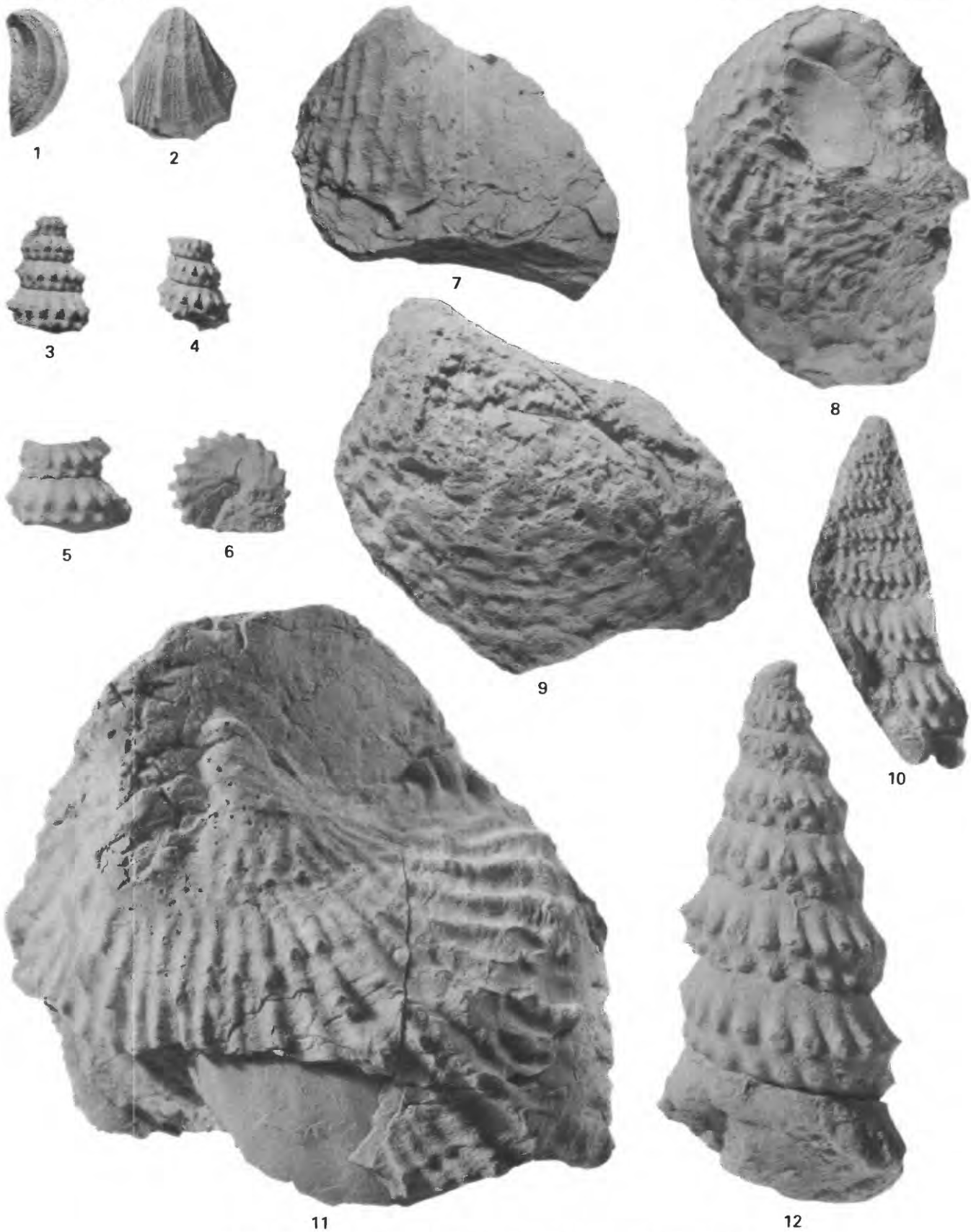
PLATE 10

[All figures natural size]

FIGURES 1, 2. *Neithea* cf. *N. sexcostata* (Woodward) (p. 16).
Two views of a right valve from USGS locality D7332 (text fig. 1, loc. 18). USNM 239741.

3–6, 10, 12. *Turrilites (Turrilites) acutus americanus* Cobban and Scott (p. 22).
3, 4. Small spires consisting of several whorls from USGS locality D7328 (text fig. 1, loc. 24). USNM 239746, 239747.
5, 6. Side and bottom views of parts of two whorls that have a wide apical angle from the same locality. USNM 239748.
10. Latex cast of an impression in baked shale from USGS locality D5795 (text fig. 1, loc. 71). USNM 239749.
12. Large specimen from USGS locality D7084 (text fig. 1, loc. 47). USNM 239750.

7–9, 11. *Exogyra* cf. *E. oxyntas* (Coquand) (p. 19).
7. Fragment of a left valve from USGS locality D5347 (text fig. 1, loc. 43). USNM 239692.
8, 9. Fragments of left valves from USGS locality D2049 (fig. 1, loc. 57). USNM 239693, 239694.
11. Large left valve from USGS locality D7084 (text fig. 1, loc. 47). USNM 239695.



MOLLUSKS FROM THE PAGUATE SANDSTONE TONGUE

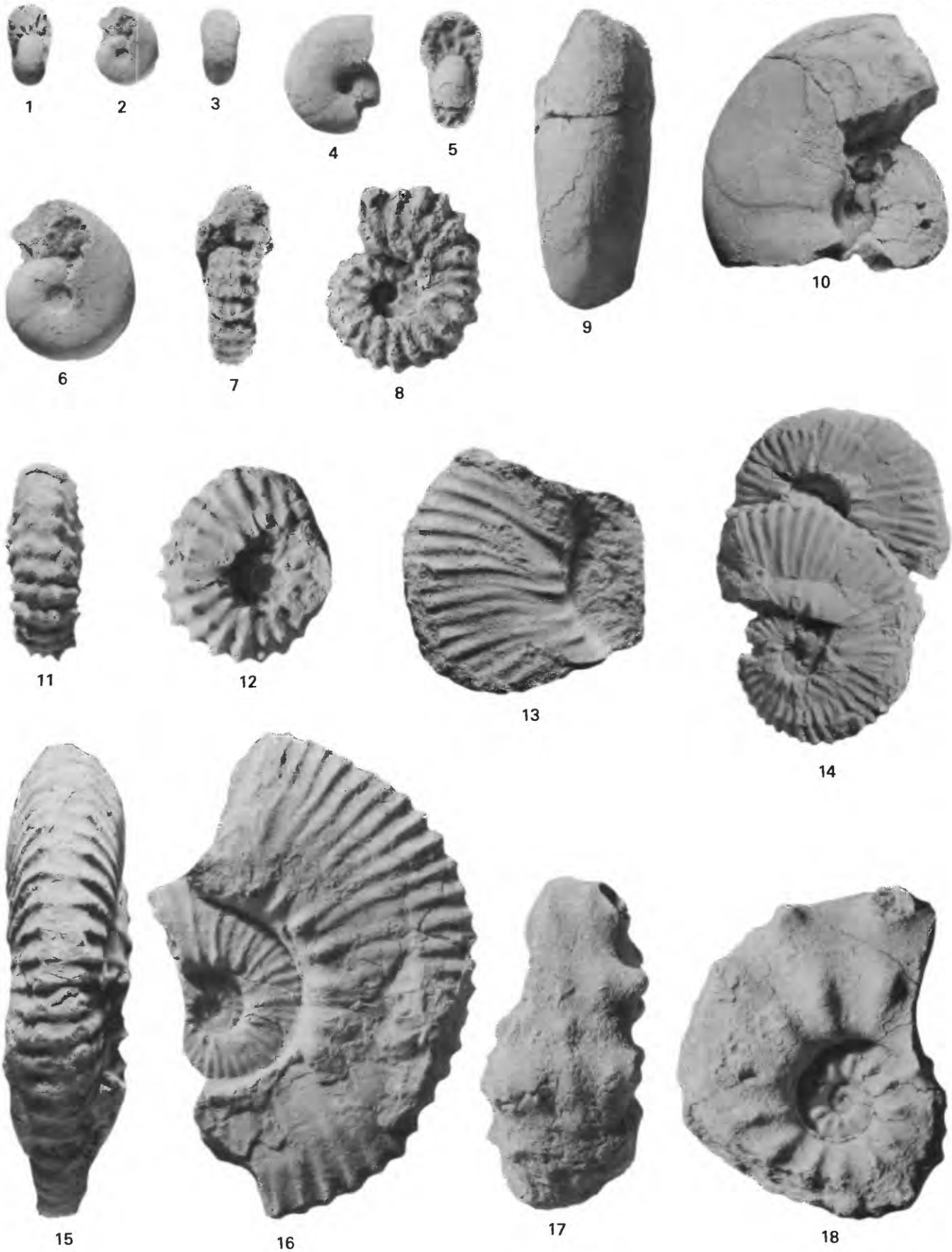
PLATE 11

[All figures natural size except as indicated]

FIGURES 1–6, 9, 10. *Desmoceras (Pseudouhligella)* aff.. *D. japonicum* Yabe (p. 22).
From USGS locality D7328 (text fig. 1, loc. 24).
1–3, 6. Front, side, and rear views and side view (× 2) of a small septate specimen. USNM 239752.
4, 5, 9, 10. Side and front views (figs. 4, 5) of the inner whorls of a large mostly septate specimen (figs. 9, 10). USNM 239753.

7, 8, 11–16. *Tarrantoceras rotatile* Stephenson (p. 23).
7, 8. Front and side views of a coarsely ribbed specimen like *T. stantoni* Stephenson (1955, pl. 5, figs. 11–21), from USGS locality D7084 (text fig. 1, loc. 47). USNM 239757.
11, 12. Rear and side views of another coarsely ribbed specimen from USGS locality D5380 (text fig. 1, loc. 30). USNM 239758.
13. Fragment of a fine-ribbed body chamber resembling *T. multicostatum* Stephenson (1955, pl. 6, figs. 21–23), from USGS locality D5372 (text fig. 1, loc. 31). USNM 239759.
14. Two fine-ribbed specimens from theh same locality as figures 11 and 12. USNM 239760.
15, 16. Rear and side views of a large specimen collected southwest of San Ysidro, Sandoval County, by Mr. Gregg Perry, formerly at the University of New Mexico, Albuquerque. USNM 239783.

17, 18. *Euomphaloceras* aff. *E. cunningtoni* (Sharpe) (p. 25).
Rear and side views of an internal mold from USGS locality D5812 (text fig. 1, loc. 32). USNM 239775.



AMMONITES FROM THE PAGUATE SANDSTONE TONGUE

PLATE 12

[All figures natural size]

FIGURES

1–9. *Pycnodonte* cf. *P. kellumi* (Jones) (p. 17).

1–3. Left valve from USGS locality D7084 (text fig. 1, loc. 47). USNM 239654.

4–6. Left valve from USGS locality D5383 (text fig. 1, loc. 38). USNM 239655.

7, 8. Left valve from USGS locality D6182 (text fig. 1, loc. 5). USNM 239656.

9. Exterior views of three right valves from USGS locality D5372 (text fig. 1, loc. 31). USNM 239657.

10–12, 15–23. *Acanthoceras amphibolum* (Morrow) (p. 23).

10–12. Rear, side, and front views of unusually stout inner whorls from USGS locality D7333 (text fig. 1, loc. 19). USNM 239766.

15, 16. Side and rear views of normal inner whorls from USGS locality D7328 (text fig. 1, loc. 24). USNM 239767.

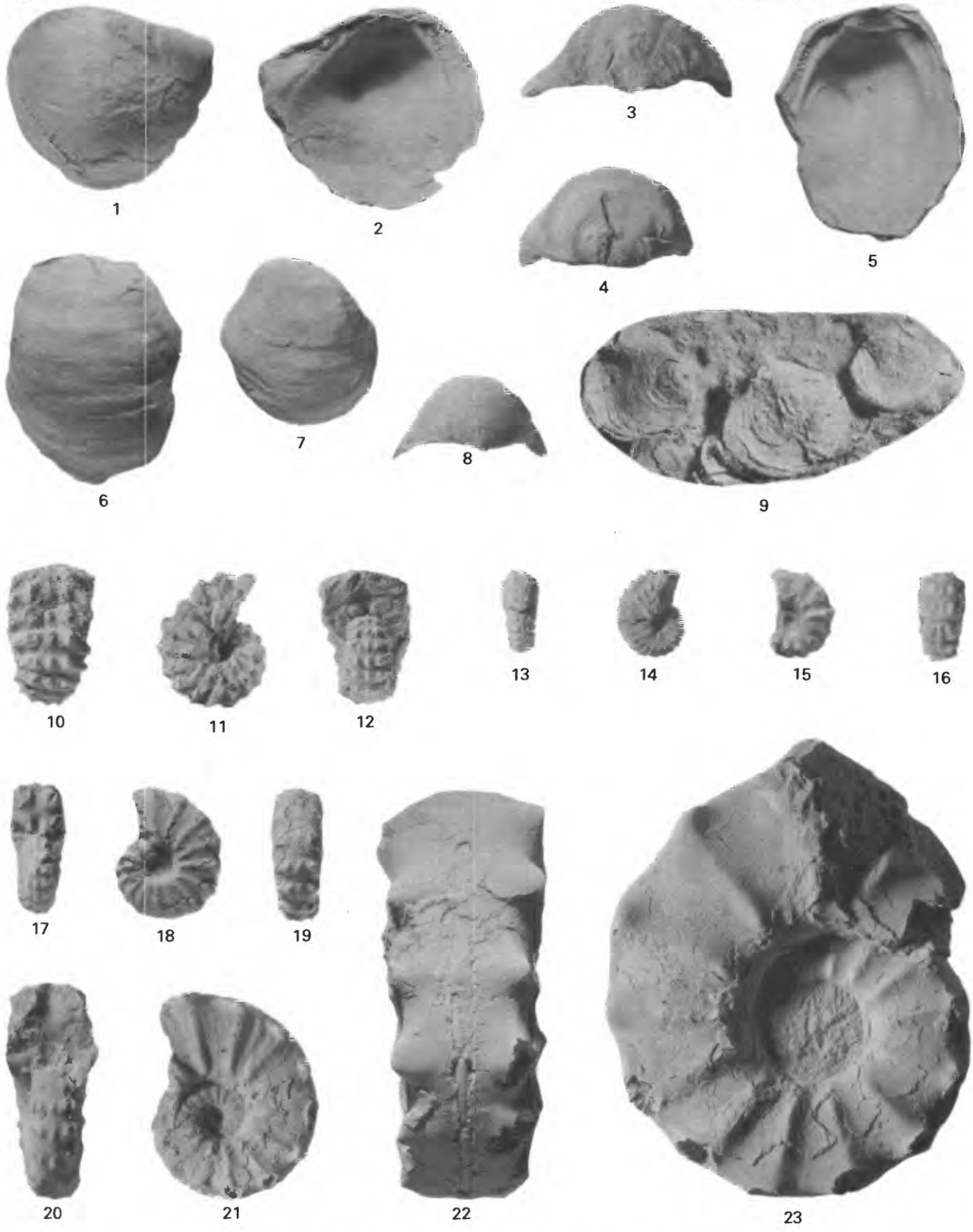
17–19. Front, side, and rear views of inner whorls from the same locality as figures 10–12. USNM 239768.

20, 21. Front and side views of a larger septate coil from the same locality as figures 1–3. USNM 239769.

22, 23. Rear and side views of the phragmocone of an adult from the same locality. See text figure 5 for the suture. USNM 239770.

13, 14. *Tarrantoceras rotatile* Stephenson (p. 23).

Rear and side views of the inner whorls of a specimen from USGS locality D5372 (text fig. 1, loc. 31). USNM 239761.

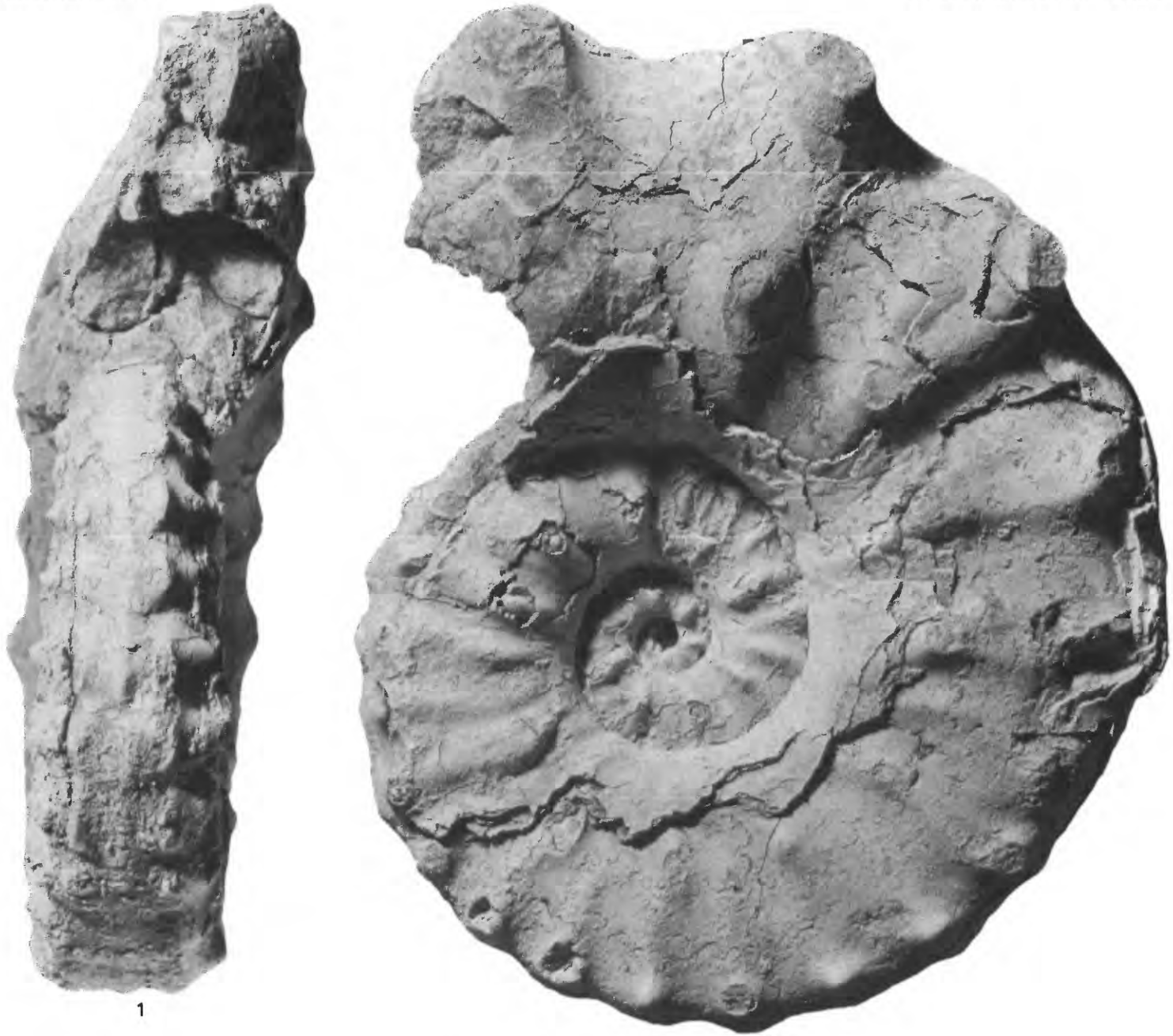


MOLLUSKS FROM THE PAGUATE SANDSTONE TONGUE

PLATE 13

[All figures natural size]

FIGURES 1, 2. *Plesiacanthoceras* aff. *P. wyomingense* (Reagan) (p. 25).
Front and side views of the phragmocone of an adult from USGS locality D6130 (text fig. 1, loc. 51). USNM 239774.



1 2

PLESIACANTHOCERAS CF. *P. WYOMINGENSE* (REAGAN) FROM PAGUATE SANDSTONE TONGUE

PLATE 14

Paracompsoceras landisi Cobban (p. 25).

Side view of most of an adult (× 8/10) from USGS locality D7084 (text fig. 1, loc. 47). USNM 166360.

PARACOMPSOCERAS LANDISI COBBAN FROM PAGUATE SANDSTONE MEMBER

PLATE 15

[All figures natural size]

FIGURES 1–16. *Exogyra levis* Stephenson (p. 18).

1, 2. Left valve from USGS locality D5764 (text fig. 1, loc. 9). USNM 239677.

3, 4, 7. Left valve from the same locality. USNM 239679.

5, 6, 8. Left valve from the same locality. USNM 239678.

9, 10. Left and right valves from USGS locality D7332 (text fig. 1, loc. 18). USNM 239680.

11–13. Left valve of an unusually large specimen that seems to be this species from USGS locality D6187 (text fig. 1, loc. 3). USNM 239681.

14–16. Another unusually large left valve from the same locality. USNM 239682.

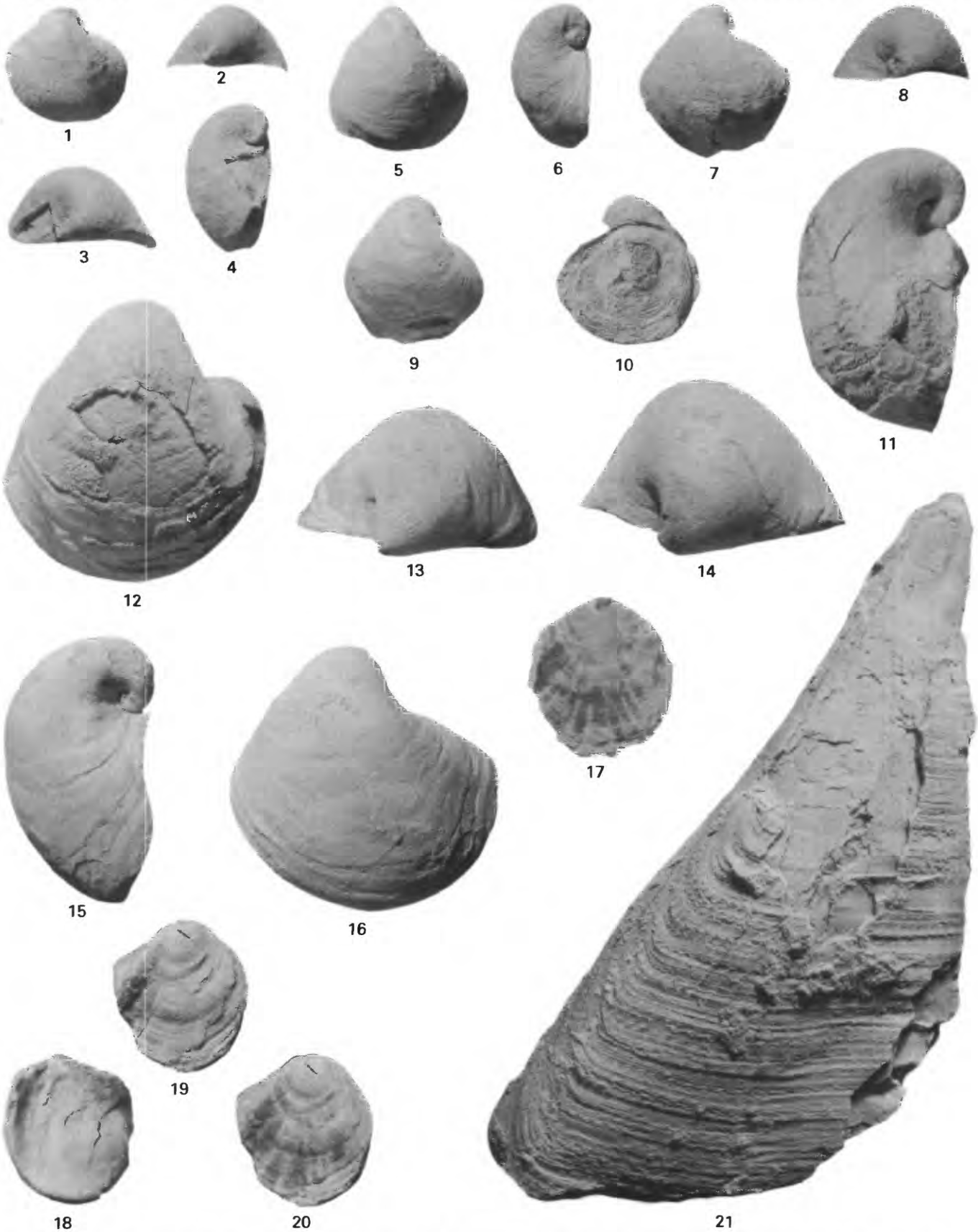
17–20. *Pycnodonte* cf. *P. kellumi* (Jones) (p. 17).

17. Right valve (uncoated) that has radial color bands from USGS locality D6182 (text fig. 1, loc. 5). USNM 239658.

18–20. Interior and exterior views of a right valve from the same locality. Figure 20 is uncoated to show color bands. USNM 239659.

21. *Pinna petrina* White (p. 13).

Large specimen retaining much of the shell material from USGS locality D5344 (text fig. 1, loc. 41). USNM 239615.



MOLLUSKS FROM THE PAGUATE SANDSTONE TONGUE AND WHITEWATER ARROYO SHALE TONGUE

PLATE 16

[All figures natural size]

FIGURES 1–5. *Pycnodonte* cf. *P. kellumi* (Jones) (p. 17).
From USGS locality D6184 (text fig. 1, loc. 7).
1, 2. Exterior and interior views of a small right valve. USNM 239660.
3–5. Small left valve. USNM 239661.

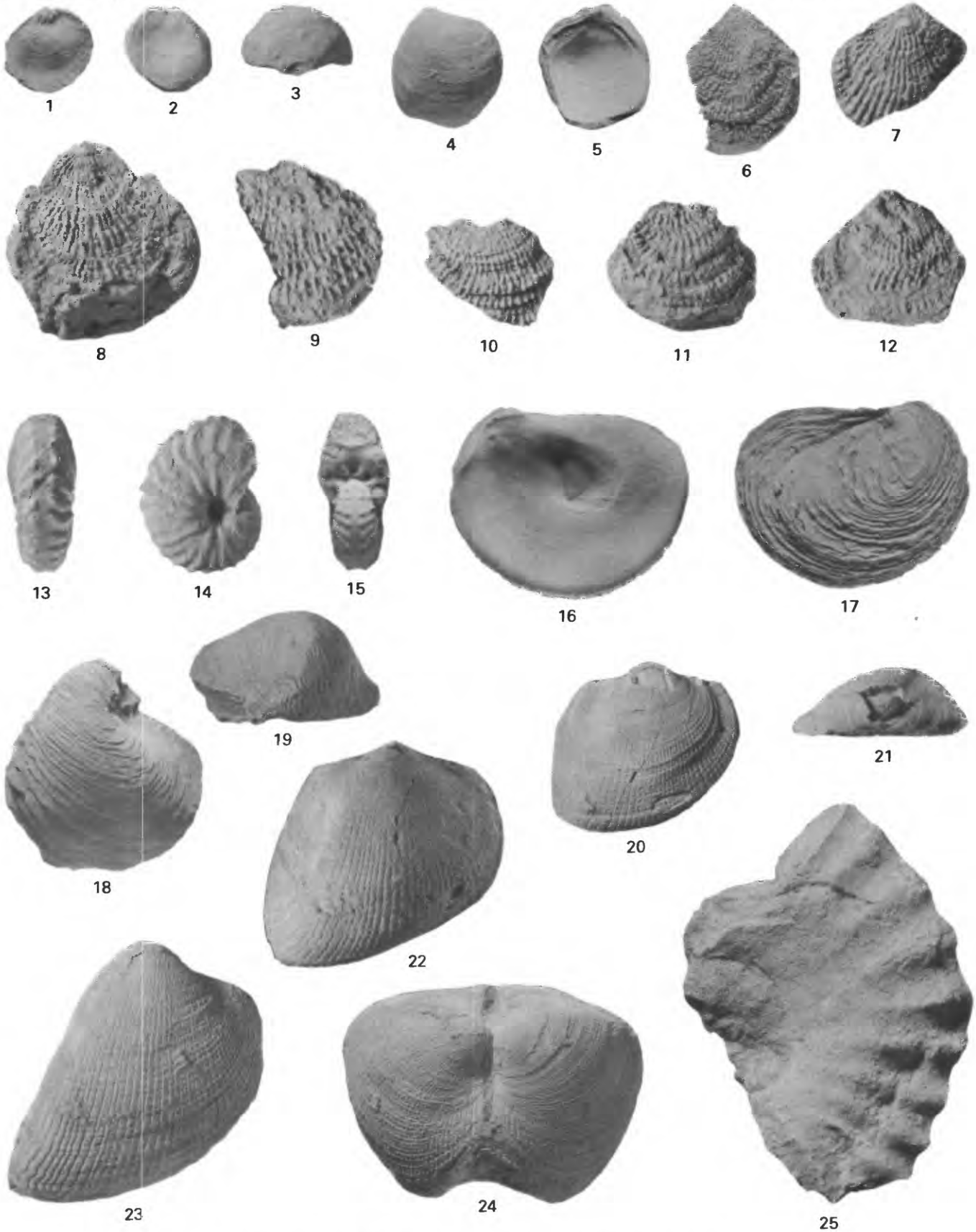
6–12. *Plicatula* cf. *P. ferryi* Coquand (p. 16).
6–8, 10–12. Exterior views of specimens from the same locality as figures 1–5. USNM 239637–239642.
9. Latex cast of an impression in silty limestone from USGS locality D6137 (text fig. 1, loc. 8). USNM 239643.

13–15. *Metoicoceras* aff. *M. latoventer* Stephenson (p. 25).
Rear, side, and front views of the internal mold of a phragmocone from USGS locality D5787 (text fig. 1, loc. 70). See text figure 7 for the suture. USNM 239778.

16–19. *Exogyra trigeri* (Coquand) (p. 19).
From USGS locality D7338 (text fig. 1, loc. 14).
16, 17. Interior and exterior views of a right valve. USNM 239702.
18, 19. Left valve that was attached to a turritellid. USNM 239703.

20–24. *Idonearca depressa* White (p. 13).
From USGS locality D5344 (text fig. 1, loc. 41).
20, 21. Exterior views of a small right valve. USNM 239608.
22. A larger right valve. USNM 239609.
23, 24. Views of a specimen that is missing much of the posterior part. USNM 239610.

25. *Metoicoceras* cf. *M. praecox* Haas (p. 25).
Internal mold from USGS locality D5819 (text fig. 1, loc. 28). USNM 239776.



MOLLUSKS FROM THE WHITEWATER ARROYO SHALE TONGUE

PLATE 17

[All figures natural size]

FIGURES 1, 2, 4. *Exogyra* aff. *E. levis* Stephenson (p. 19).

From USGS locality D5762 (text fig. 1, loc. 12).

1, 2. Interior and exterior views of an unusually large right valve. USNM 239690.

4. Exterior view of a smaller right valve. USNM 239691.

3, 5–10. *Exogyra trigeri* (Coquand) (p. 19).

3. Exterior view of a right valve from USGS locality D5759 (text fig. 1, loc. 15), USNM 239704.

5. Fragment of a left valve that was attached to a turritellid from USGS locality D7338 (text fig. 1, loc. 14). USNM 239705.

6. Another left valve that was attached to a turritellid from USGS locality D5737 (text fig. 1, loc. 50). USNM 239706.

7, 8, 10. Three views of a large left valve from the same locality as figure 3. USNM 239707.

9. Fragment of a left valve that was attached to a *Plicatula* from the same locality as figure 6. USNM 239708.

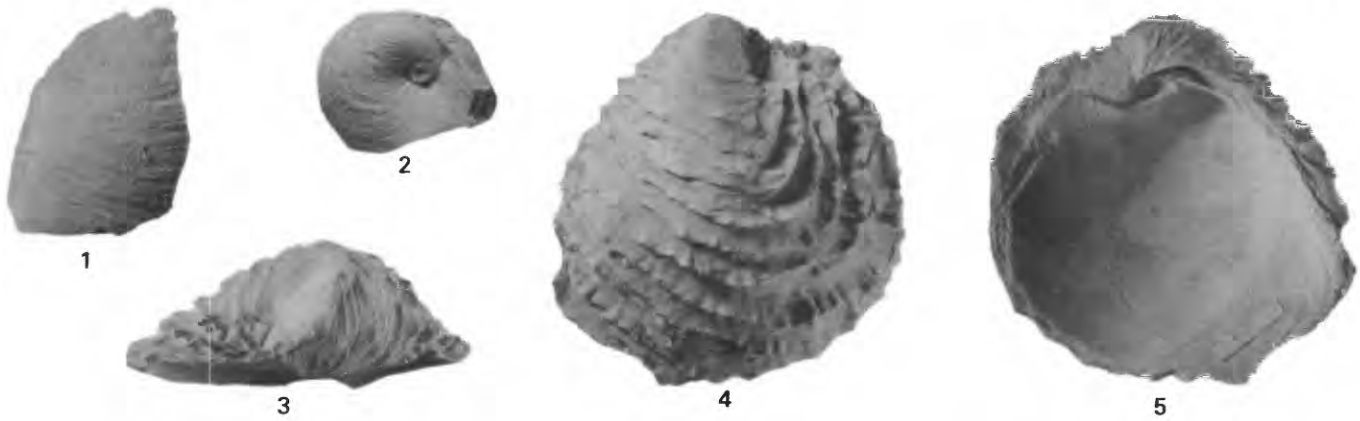
MOLLUSKS FROM THE WHITEWATER ARROYO SHALE TONGUE

PLATE 18

[All figures natural size]

FIGURES 1, 2. *Exogyra* aff. *E. levis* Stephenson (p. 19).
Parts of left valves from USGS locality D5762 (text fig. 1, loc. 12). USNM 239688, 239689.

3–9. *Exogyra trigeri* (Coquand) (p. 19).
From USGS locality D5759 (text fig. 1, loc. 15).
3–5. Views of a left valve. USNM 239709.
6, 7. Exterior and interior views of a large right valve. USNM 239710.
8, 9. Exterior and interior views of a left valve. USNM 239711.



MOLLUSKS FROM THE WHITEWATER ARROYO SHALE TONGUE

PLATE 19

[All figures natural size]

FIGURES 1, 2, 4. *Inoceramus prefragilis* Stephenson (p. 15).
All internal molds of very fine grained sandstone.
1, 2. Right valves from USGS locality D9240 (fig. 1, loc. 4). USNM 239631, 239632.
4. Fragment from USGS locality D2077 (text fig 1, loc. 10). USNM 239633.

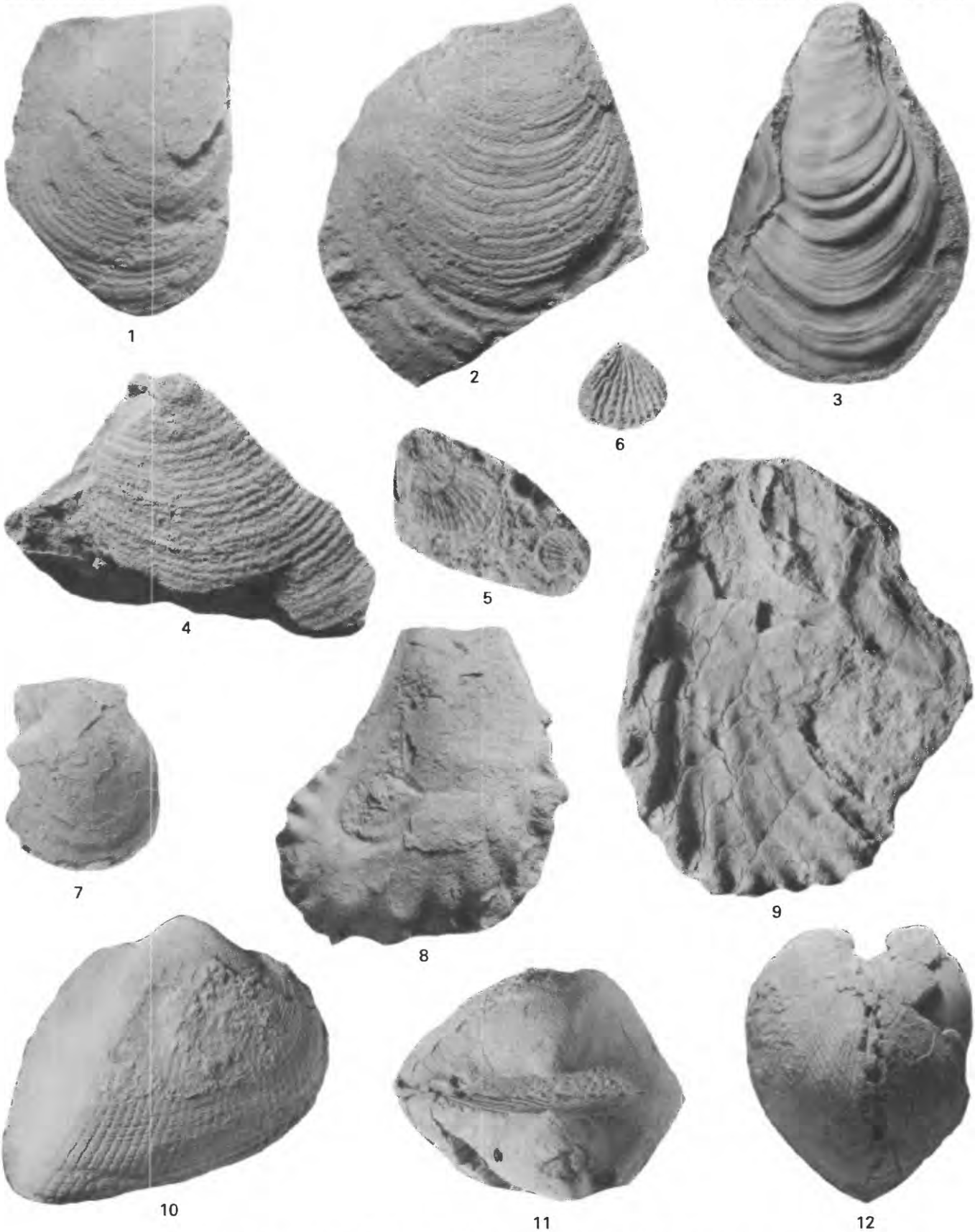
3. *Inoceramus ginterensis* Pergament (p. 15).
Latex cast of an impression of a right valve in very fine grained sandstone from USGS locality D5392 (text fig. 1, loc. 27). USNM 239634.

5, 6. *Plicatula* cf. *P. ferryi* Coquand (p. 16).
5. Two specimens (uncoated) showing radial color bands from USGS locality D7086 (text fig. 1, loc. 48). USNM 239644.
6. Specimen from USGS locality D6200 (text fig. 1, loc. 1). USNM 239645.

7. *Camptonectes* ex gr. *C. virgatus* (Nilsson) (p. 16).
Latex cast of an impression in very fine grained sandstone from USGS locality D5345 fig. 1, loc. 42). USNM 239742.

8, 9. *Lopha staufferi* (Bergquist) (p. 20).
8. Internal mold of a right valve from USGS locality D2051 (fig. 1, loc. 58). USNM 239717.
9. Interior view of a right valve from USGS locality D5365 (fig. 1, loc. 59). USNM 239718.

10–12. *Idonearca depressa* White (p. 13).
Three views of a large specimen from the same locality as figure 8. USNM 239611.



MOLLUSKS FROM THE TWOWELLS SANDSTONE TONGUE

PLATE 20

[All figures natural size]

FIGURES 1–15. *Pycnodonte* aff. *P. kellumi* (Jones) (p. 17).

1–4. Left valve from USGS locality D6133 (fig. 1, loc. 55). USNM 239662.

5–7. Two views of the left valve and one of the right valve from USGS locality D6191 (text fig. 1, loc. 2). USNM 239663.

8, 9. Interior and exterior views of a right valve from USGS locality D7335 (text fig. 1, loc. 21). USNM 239664.

10–13. Left valve from the same locality. USNM 239665.

14, 15. Exterior and interior views of a right valve from the same locality. USNM 239666.

16–18. *Exogyra levis* Stephenson (p. 18).

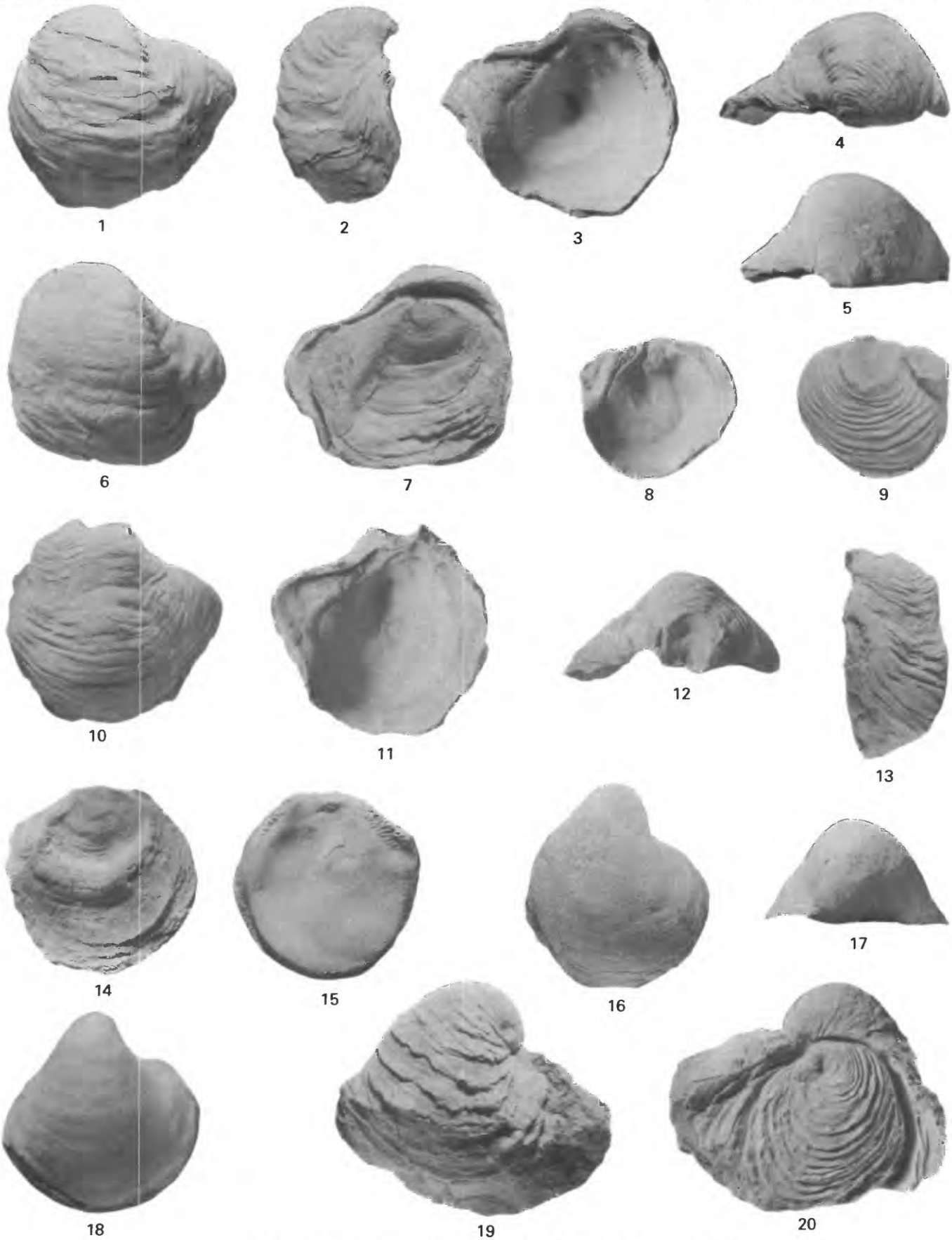
From the same locality as figures 1–4.

16. Left valve. USNM 239683.

17, 18. Left valve. USNM 239684.

19, 20. *Exogyra trigeri* (Coquand) (p. 19).

Left and right valves of an incomplete specimen from USGS locality D5753 (fig. 1, loc. 23). USNM 239712.



MOLLUSKS FROM THE TWOWELLS SANDSTONE TONGUE

PLATE 21

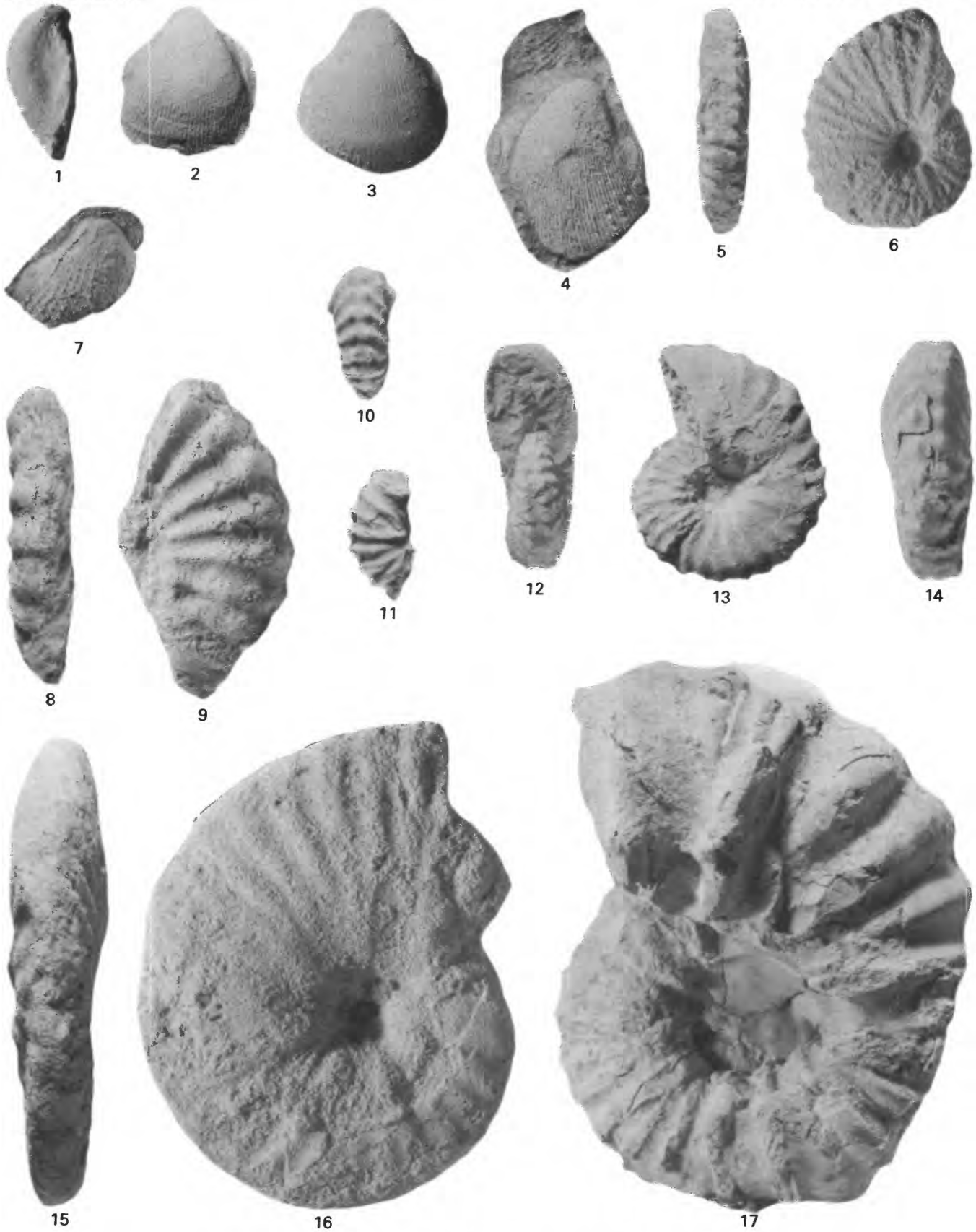
[All figures natural size except as indicated]

FIGURES 1–4, 7. *Granocardium trite* (White) (p. 20).
From USGS locality D6131 (text fig. 1, loc. 54).
1, 2. Views of an internal mold of a left valve. USNM 239719.
3. Internal mold of a left valve. USNM 239720.
4, 7. Latex casts of impressions in very fine grained sandstone of right and left valves in White's type lot from "head of Waterpocket canyon, southern Utah" (White, 1879, p. 291). USNM 239721, 239722.

5, 6, 10–16. *Metoicoceras* spp. (p. 25).
5, 6. Rear and side views of an internal mold from USGS locality D5392 (fig. 1, loc. 27). USNM 239779.
10, 11. Rear and side views of a strongly ornamented fragment from USGS locality D5743 (fig. 1, loc. 26). USNM 239780.
12–14. Front, side, and rear views of an internal mold from USGS locality D6164 (fig. 1, loc. 11). USNM 239781.
15, 16. Rear and side views of an internal mold from USGS locality D5754 (text fig. 1, loc. 13). USNM 239782.

8, 9. *Metoicoceras* cf. *M. praecox* Haas (p. 25).
Rear and side views of part of a whorl from USGS locality D5819 (text fig. 1, loc. 28). USNM 239777.

17. *Calycoceras*? *canitaurinum* (Haas) (p. 23).
Side view (× ½) of a phragmocone from USGS locality D5741 (text fig. 1, loc. 49). USNM 239754.



MOLLUSKS FROM THE TWOWELLS SANDSTONE TONGUE