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New Mexico Geology, v. 22, n. 1 pp. 1-7, Print ISSN: 0196-948X, Online ISSN: 2837-6420.
<https://doi.org/10.58799/NMG-v22n1.1>

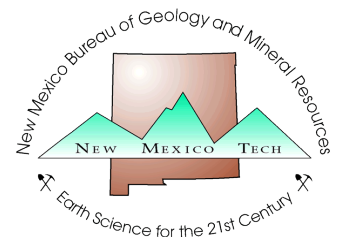
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Late Jurassic ammonites from the northeastern Chiricahua Mountains, southeast Arizona

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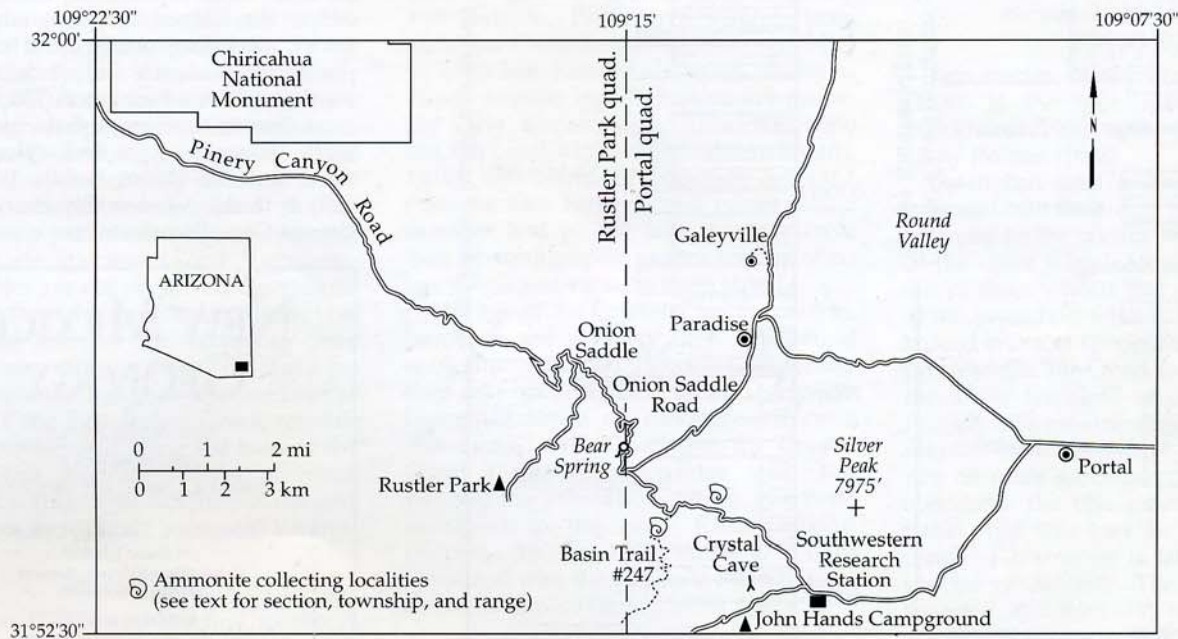


FIGURE 1—Location map of the northeastern Chiricahua Mountains, southeast Arizona.

Abstract

Five ammonite genera and two species, *Idoceras striatum*, *Lytoceras* sp., *Subneumayria ordonezi*, *Ochetoceras?* sp., and *Partschiceras* sp., have been identified from Upper Jurassic strata (Crystal Cave Formation) in the northeastern Chiricahua Mountains, southeast Arizona. This is the first descriptive account of Late Jurassic ammonites west of the Malone Mountains in west Texas. These genera have direct affinities with ammonite taxa described from the United States Gulf Coast and provide an important biostratigraphic link between ammonite taxa in the Chihuahua trough and ancestral Gulf of Mexico. *Idoceras striatum* establishes a minimum age of early Kimmeridgian for the Crystal Cave Formation, providing biostratigraphic correlation with the Haynesville Formation of the U.S. Gulf Coast and La Casita Formation in northern Mexico.

Introduction

An Upper Jurassic stratigraphic section is exposed in the northeastern Chiricahua

Mountains, southeast Arizona, that is unique in the southwestern Cordillera (Olmstead, 1992; Lawton and Olmstead, 1995). Upper Jurassic strata were deposited in a rift basin known as the Bisbee Basin, which is the northwest terminus of the Chihuahua trough that extended from the ancestral Gulf of Mexico across northeastern Mexico and into southern Arizona during Late Jurassic time (Cantu-Chapa, 1976). The objectives of this paper are twofold: to formally document Late Jurassic ammonite taxa west of the Malone Mountains in west Texas (Albritton, 1937; Cragin, 1905) and to place these ammonites in biostratigraphic relation with taxa in Upper Jurassic strata of the U.S. Gulf Coast region and Chihuahua trough of Mexico. All specimens were collected by W. A. Cobban, T. F. Lawton, and G. A. Olmstead in 1991 and 1995.

Repository

The specimens assigned U.S. National

Museum numbers (USNM) are housed in the repository at the Smithsonian Museum of Natural History in Washington, D.C. The remaining specimens are in the repository at the U.S. Geological Survey (USGS) Federal Center in Denver.

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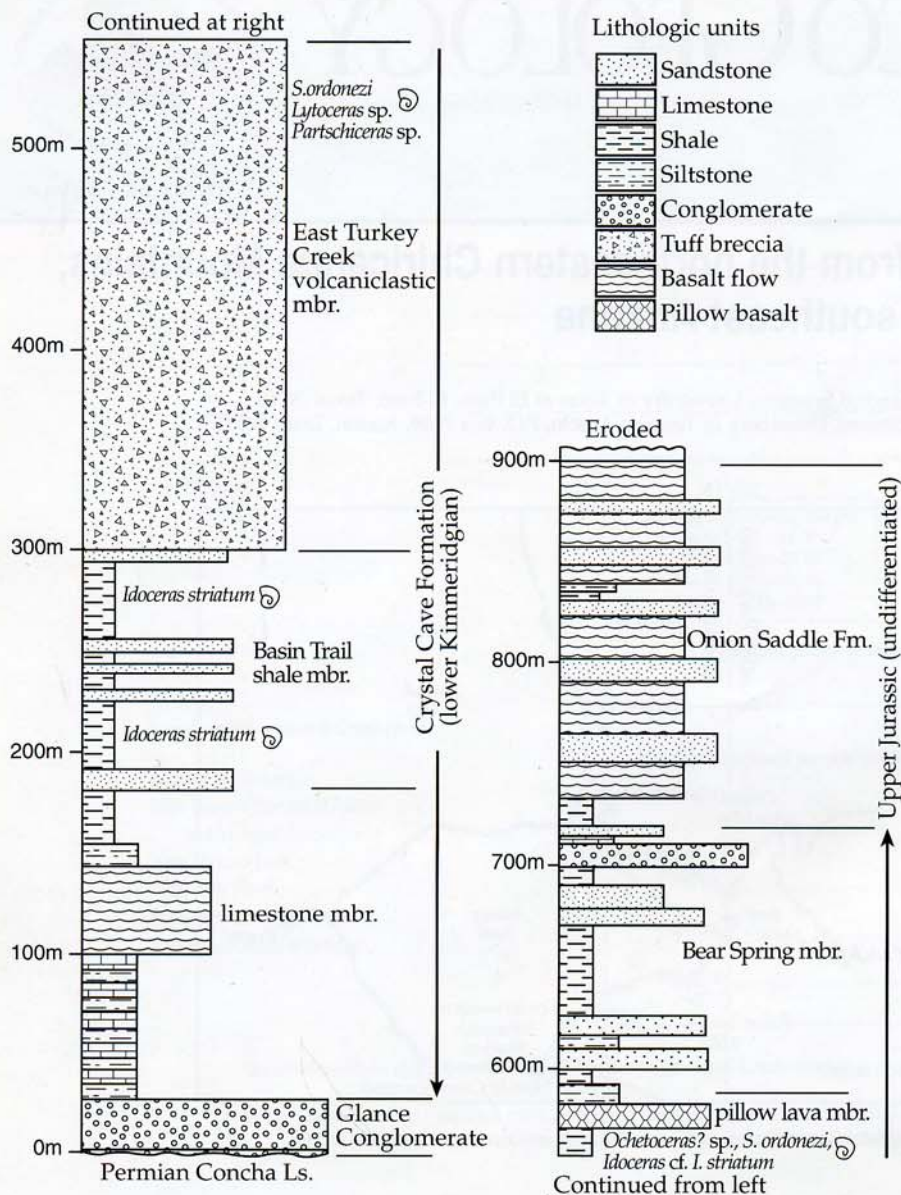


FIGURE 2—Upper Jurassic stratigraphic section and ammonite horizons in the northeastern Chiricahua Mountains, southeast Arizona. Modified after Lawton and Olmstead, 1995; Olmstead, 1998.

Conventions

Rib density or rib index (RD) is the number of ribs per unit of height when counted along the venter at that height in the middle of the section of the venter. It has normally been used with heteromorphs but is convenient to use when comparing fragments of coiled forms. It has nothing to do with umbilical or lateral ribs, and such features must be described separately.

Diameter (D) is recorded in centimeters (cm). Diameter of the umbilicus (U), height of the whorl (H), and width or breadth of the whorl (W) are recorded as percentages of the diameter, except where the diameter is impossible to obtain, in which case they are recorded in cm. H/W is the ratio of the height of the whorl divided by its width. On-the-bedding-

plane-impression dimensions are recorded in centimeters. Because one flank of a specimen is usually much better preserved than the other, whorl sections are usually drawn with one flank as the mirror image of the best-preserved flank.

Locality

The Upper Jurassic stratigraphic section is located in the northeastern Chiricahua Mountains, southeast Arizona (Portal 7½-min topographic quadrangle; Fig. 1). The specimens were collected in the Basin Trail shale member of the Crystal Cave Formation at approximately 2,024 m elevation on the Basin Trail, 750 m southwest of the trail head at the junction with Onion Saddle Road, sec 2 T17S R30E, and in the East Turkey Creek volcanoclastic member and basal pillow lava member of the

Crystal Cave Formation at elevation 1,775 m, 300 m west of the west boundary of the SW¼ sec 31 T17S R31E in the Portal quadrangle.

Stratigraphy

The Upper Jurassic section is approximately 925 m thick and unconformably overlies the Permian Concha Limestone (Fig. 2; Lawton and Olmstead, 1995; Olmstead, 1998). This stratigraphic sequence records progradational deposition from submarine turbidites and volcanoclastics to nonmarine deltaic fluvial sandstones interbedded with subaerial basalt flows. The Jurassic stratigraphic section is divided into three formations in ascending order: the Glance Conglomerate (25 m thick), consisting primarily of clast-supported conglomerate and sandstone beds; the Crystal Cave Formation (730 m thick), consisting of limestone, shale, sandstone, mafic volcanic rocks, and volcanoclastic rock; and the Onion Saddle Formation (200 m thick), conformably overlying the Crystal Cave Formation and consisting of

NEW MEXICO GEOLOGY

Science and Service
ISSN 0196-948X
Volume 22, No. 1, February 2000

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Circulation: 1,000

Printer: University of New Mexico Printing Services

TABLE 1—Measurements (in cm) of *Idoceras striatum* (Imlay).

Specimen figures	Max. diameter	Whorl height	Umbilical diameter
5.1 USNM 501770	4.3	1.2	0.10
5.2 USNM 501771	5.3	1.5	0.15

subaerial mafic volcanic flows interbedded with nonmarine siltstones and sandstones. The Crystal Cave Formation is divided into five informal members, which are in ascending order: 1) limestone member, 2) Basin Trail shale member, 3) East Turkey Creek volcanoclastic member, 4) pillow lava member, and 5) Bear Spring member.

Material

All of the ammonites were collected from black shales and siltstones in the Basin Trail shale member and from the top of the East Turkey Creek volcanoclastic member and along the base of the pillow lava member. Specimens collected from the Basin Trail shale member are mold impressions parallel with bedding. Some of the specimens are deformed, due to post-depositional shortening, and consist of complete specimens and fragments; suture lines are not preserved. Specimens collected from the East Turkey Creek volcanoclastic member are complete casts with poor preservation of sutures. Specimens collected from siltstone beds at the top of the East Turkey Creek volcanoclastic member and along the base of the pillow lava member consist of mold impression fragments lacking sutures and some casts with poorly preserved sutures.

Previous work

Raydon (1952) was the first to report ammonites at this locality, stating only that they are of a paleohoplite type no younger than early Albian age. Olmstead (1992) reported these ammonites, initially identified as Early Cretaceous (Albian) in age (W. A. Cobban, written communication, 1991). Lawton and Olmstead (1995) and Olmstead et al. (1996) reported the ammonites as Late Jurassic in age based on a written communication from K. Young (1994).

Biostratigraphy and correlation

Specimens of *Idoceras striatum* collected from the Basin Trail shale member and *Idoceras* cf. *I. striatum* collected from the

base of the pillow lava member have close affinities with *Idoceras* spp., described by Imlay and Herman (1984) from Texas, Louisiana, and Mississippi and with specimens of *Idoceras striatum* collected by Roberts (1989) from Cerro Los Panales, Chihuahua, Mexico. Burckhardt (1912) described a number of *Idoceras* spp. of Kimmeridgian age from San Pedro del Gallo, Durango, Mexico, that have close similarities to those found in the Basin Trail shale member. *Idoceras* spp. (Imlay and Herman, 1984) have a range from early-late Oxfordian (*P. cautionsgrae* Zone) to early-late Kimmeridgian (*R. mutabilis* Zone). *Idoceras* spp. in Mexico are probably early Kimmeridgian (Roberts, 1989) but not basal Kimmeridgian (Burckhardt, 1912). Specimens of *Lytoceras* collected from the East Turkey Creek volcanoclastic member and pillow lava member have long biostratigraphic ranges and are of no age-diagnostic value to these strata.

The age of the Crystal Cave Formation, based on the presence of *I. striatum*, is early Kimmeridgian. However, the formation may extend back to the early-late Oxfordian based on dinoflagellate cysts (Olmstead, 1998). Therefore, the Crystal Cave Formation correlates with the Haynesville Formation, which has been restricted to the early Kimmeridgian (Kopaska-Merkel, 1998) of the U.S. Gulf Coast and with the La Casita Formation in northern Mexico (Imlay, 1939).

Implications for New Mexico geology

The presence of Upper Jurassic strata in the Chiricahua Mountains is unique in this region of the southwestern Cordillera and shows that the Chihuahua trough during Late Jurassic time extended as far north as southeast Arizona and most probably across southernmost New Mexico (Lawton and Olmstead, 1995). A thick marine and volcanic section that lies beneath Cretaceous Bisbee strata in the Bootheel region of southern New Mexico has been interpreted, based on stratigraphic position and regional relations, as Late Jurassic in age and may be correlative

with the Crystal Cave and Onion Saddle Formations in the Chiricahua Mountains (Lawton and Harrigan, 1998).

ACKNOWLEDGMENTS—I thank T. F. Lawton (New Mexico State University), W. A. Cobban (USGS, Denver), S. G. Lucas (New Mexico Museum of Natural History and Science, Albuquerque) for reviewing the manuscript and W. Cornell (University of Texas at El Paso) for his assistance in the photography. I also thank all the editors whose suggestions were very helpful in improving this manuscript and the NMB-MMR Drafting Department for figure improvements.

Selected systematic descriptions

Idoceras striatum Imlay, 1939
Figs. 5.1–5.2

Type species—*Ammonites planulus* Zieten (1830) is the type species of *Idoceras* Burckhardt (1906), subsequently designated by Roman (1938).

Description—All specimens are mold impressions. Involute, compressed ribs bifurcate on the middle to upper one-third of the outer whorl. Most specimens consist of three whorls that overlap one-half of the preceding whorls. Ribs are densely spaced on most specimens and are gently prosiradiate. Ribs tend to weaken toward the lower one-third of the outer whorl. Primary ribs are strongly defined and outnumber both secondary and intercalary ribs on most specimens. On some of the specimens the ribs almost efface on the flanks, but this may be diagenetic. The conch of *I. striatum* is fairly involute for species of *Idoceras*. The venter is well rounded, and the H/W is about 1.5. Ribs are weaker on the middle half of the flank, and rib density is about 16 (Imlay, 1939). See Table 1 for measurements of figured specimens.

Occurrence—Specimens collected from the Basin Trail shale member are located on the Portal quadrangle at elevation 2,024 m crossing the Basin Trail and 914 m east of the west line of the Portal quadrangle. The specimens figured are very common in the Basin Trail shale member. Localities in Mexico are reported by Imlay (1939) and Roberts (1989). *I. striatum* ranges from upper Oxfordian to lower Kimmeridgian in Tethyan and Pacific realms (Arkell, 1957, Treatise on Invertebrate Paleontology, part L, p. L323).

Genus *Lytoceras* Suess, 1865
Figs. 5.3–5.4

Type species—The type species of *Lytoceras* Suess is *Ammonites fimbriatus* Sowerby, 1817, designated ICZN Opinion 130.

Description—Internal cast, evolute, slight overlap of whorls, poor preservation of ribs on venter. Maximum diameter = 11.0 cm, umbilical outer diameter = 3.0 cm, umbilical inner diameter = 1.0 cm, whorl height = 4.5 cm, whorl breadth = 3.5 cm.

TABLE 2—Whorl measurements (in cm) of *Subneumayria ordonezi* (Burckhardt) as compared to Burckhardt (1906). D = diameter; diameter of the umbilicus (U), height of the whorl (H), and width or breadth of the whorl (W) are recorded as percentages of the diameter. H/W is the ratio of the height of the whorl divided by its width. RD = rib density or rib index.

Specimen	D	U	H	W	H/W	RD
5.7–8 USNM 501774	10.32	2.58	4.12	3	1.37	0
D13216	8.17	2.51	3.35	1.91	1.75	1.2
D13218	15	3.44	4.38	2.27	1.92	2.5
Burckhardt (1906, pl. 1, figs. 6, 7)	10.6	2.09	4.17	2.86	1.46	1.35
Burckhardt (1906, pl. 2, figs. 1–3)	5.39	2.45	4.68	3.25	1.44	*1.0±

* at D = 4.0 cm

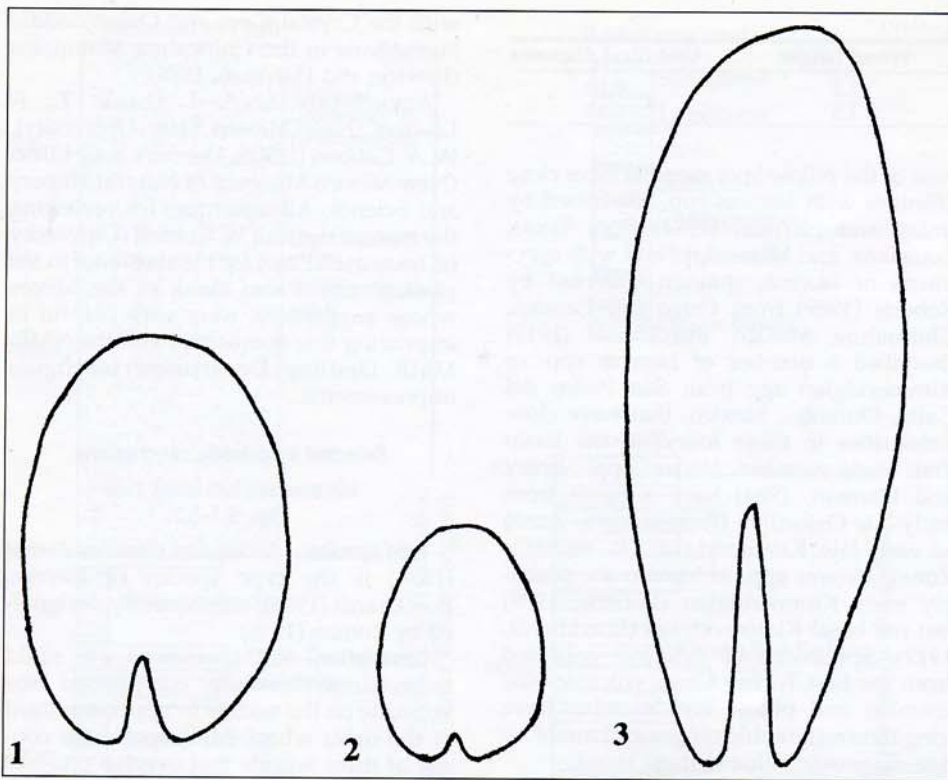
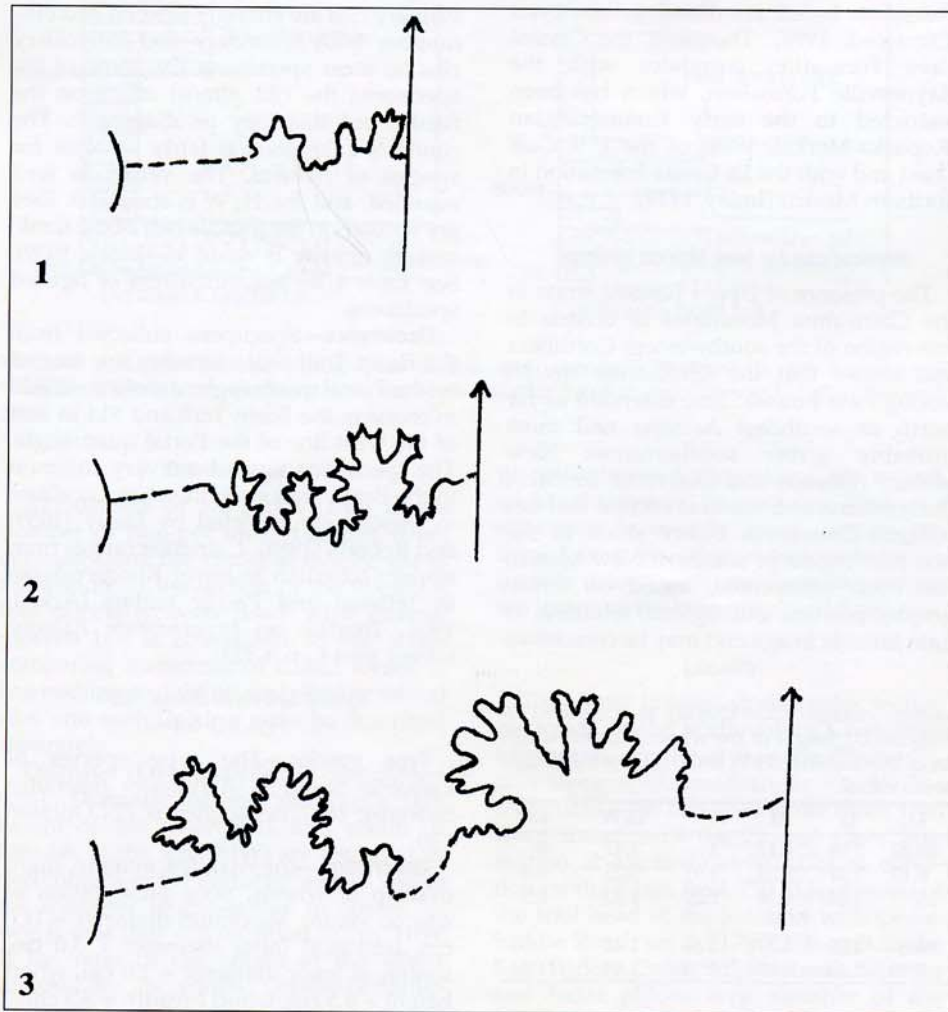


FIGURE 3—Whorl cross sections. 1. *Subneumayria ordonezi*, (x 1.0), 2. *Partschiceras* sp., (x 1.0), 3. *Ochetoceras?* sp. (x 1.0).



Occurrence—Only one specimen was recovered from the East Turkey Creek volcaniclastic member, USGS locality CNE¼ SE¼ sec 36 T17S R30E on the Portal quadrangle. *Lytoceras* ranges from Lower Jurassic to Upper Cretaceous worldwide (Arkell, 1957, Treatise on Invertebrate Paleontology, part L, p. L194).

Genus *Partschiceras* Fucini, 1923
Figs. 5.5–5.6

Type species—The type species of *Partschiceras* is *Ammonites partschi* Stur, 1851 (non Klipstein, 1843) = *P. monestieri* Breistroffer 1947, subsequently designated by Spath, 1927.

Description—Internal cast, involute, poorly defined ribbing on venter, poor preservation of sutures. Diameter = 6.0 cm, umbilical diameter = 1.5 cm, whorl height = 4.0 cm, whorl breadth = 1.5 cm, whorl cross section (Fig. 3.2), suture pattern (Fig. 4.1).

Occurrence—Only two specimens were recovered from the East Turkey Creek volcaniclastic member and pillow lava member. USGS localities CNE¼SE¼ sec 36 T17S R30E, NE¼NW¼SE¼ sec 36 T17S R30E, and NE¼NW¼SW¼ sec 31 T17S R31E on Portal quadrangle. *Partschiceras* ranges from Upper Jurassic to Upper Cretaceous worldwide; abundant in Tethyan and Pacific realms, not in Boreal realm unless stated (Arkell, 1957, Treatise on Invertebrate Paleontology, part L, p. L187).

Subneumayria ordonezi (Burckhardt, 1906)
Figs. 5.7–5.8

Type species—*Neumayria ordonezi* Burckhardt (1906) is the type species of *Subneumayria* by the original designation of Spath (1924, p. 17).

Lectotype—Burckhardt (1906) did not designate a type. Gonzalez-Arreola and del Carmen Perrilliat (1989, pp. 244–245) reillustrated a syntype but did not designate a lectotype. The specimen they reillustrated is Burckhardt's (1906, pl. 1, figs. 6–7). This specimen has part of a body chamber and shows the typical ornamentation of the phragmacone and the absence or near absence of ornamentation on the body chamber. It is herein designated the lectotype.

Description—Listed in Table 2. Whorl cross section (Fig. 3.1), suture pattern (Fig. 4.2)

Discussion—Burckhardt (1906) described two species, *Neumayria ordonezi* and *N. profulgens*, as belonging to *Neumayria* Nikitin (1881) (non Bayle, 1871). Both *Neumayria* Nikitin and *Neumayria* Bayle are homonyms of *Neumayria* de Stefano (1877). *Neumayria* Bayle was renamed *Taramelliceras* by del

FIGURE 4—External ammonitic suture patterns. 1. *Partschiceras* sp. (x 1.2), 2. *Subneumayria ordonezi* (x 1.45), 3. *Ochetoceras?* sp. (x 1.0).

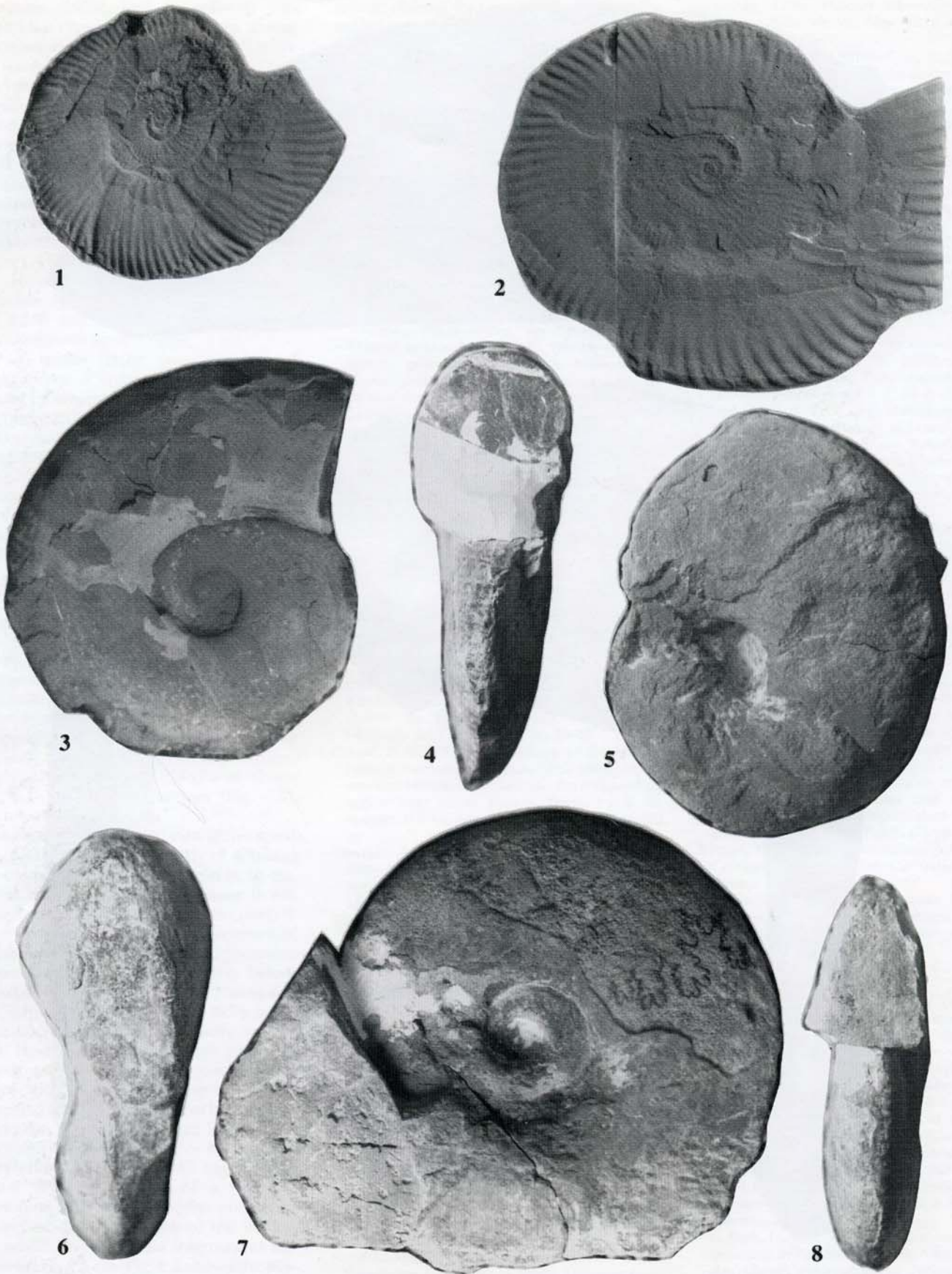


FIGURE 5—1-2. *Idoceras striatum* (Imlay). Lateral views of mold impressions (1. x 1.3, 2. x 1.5) USNM 501770, USNM 501771; 3-4. *Lytoceras* sp.(Suess). Lateral and apertural views (3. reduced by 27%; 4. x 1.8) USNM 501773; 5-6. *Partschiceras* sp.(Fucini). Lateral and apertural views (5. x 1.5, 6. x 1.9) USNM 501772; 7-8. *Subneumayria ordonezi* (Burckhardt). Lateral and apertural views (7. x 1.0, 8. x 1.7) USNM 501774. Specimens coated with ammonium chloride.

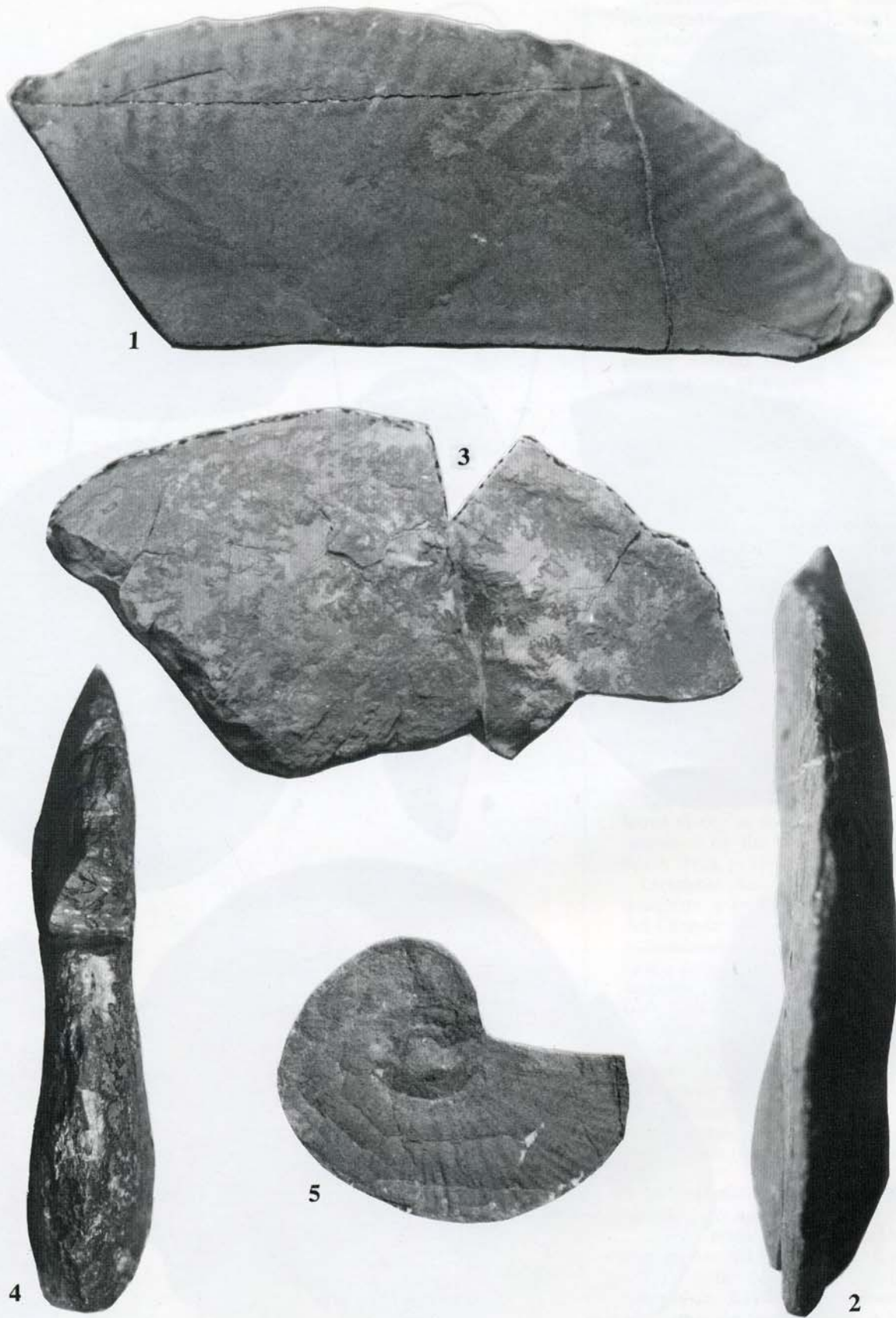


FIGURE 6—1-5. *Ochetoceras?* spp. (Haug). 1-2. Lateral view of partial whorl section and ventral view (x 2.1) USNM 501777; 3-4. lateral and ventral views (3. x 0.5, 4. reduced by 40%) USNM 501775; 5. lateral view of mold impression (x 1.7) USNM 501776. Specimens coated with ammonium chloride.

Campana (1905), and *N. ordonezi* was named the type species of his new genus, *Subneumayria*, by Spath (1924, p. 17) without reference to *Neumayria* (Nikitin, 1884) of which the only species were *N. fulgens* (Trautschold) and "*Oxynoticeras*" *subfulgens* Nikitin. Haupt (1907) described two species of *Neumayria*, *N. cf. zitteli* Burckhardt and *N. pseudolithica* Haupt (1907), but said that they belonged to *Neumayria* Burckhardt, not *Neumayria* Nikitin, believing, probably correctly, that Nikitin's and Burckhardt's *Neumayrias* were generically distinct. However, *N. zitteli* Burckhardt is the type species of *Pseudolissoceras*. Therefore, *N. cf. zitteli* (Haupt, 1907, pl. 7, figs. 2a-c) and *N. pseudolithica* belong to *Pseudolissoceras* Spath (1925).

This leaves only two species of *Subneumayria*, *S. ordonezi* and *S. profulgens*, neither of which has been mentioned in the literature on the Jurassic faunas of Mexico since Burckhardt (1906), except for the reillustration of the types by Gonzalez-Arreola and del Carmen Perrilliat (1989).

Occurrence—Three specimens were recovered from the East Turkey Creek volcaniclastic member at USGS locality CNE $\frac{1}{4}$ SE $\frac{1}{4}$ sec 36 T17S R30E on Portal 7 $\frac{1}{2}$ -min quadrangle.

Genus *Ochetoceras?* Haug, 1885
Figs. 6.1-6.5

Type species—The type species of *Ochetoceras* Haug (1885) is *Ammonites canaliculatum* von Buch (1832) subsequently designated by Munier-Chalmas (1892).

Description—Partial whorl section of cast (Fig. 6.3) with poorly preserved sutures, poorly preserved keel, discoid in shape (Fig. 6.4), whorl cross section (Fig. 3.3), suture pattern (Fig. 4.3).

Discussion—The specimen illustrated (Fig. 6.3) is about one-fourth of a whorl and the height at the larger end is 10 cm, and at the smaller end the venter is not preserved. The height of this specimen is much greater than published specimens of *Ochetoceras*. Most canaliculate specimens of the genus lose the canal long before reaching such large diameters. This specimen is poorly preserved and lacks ornamentation, and the keel is badly weathered. Thus, the genus, although probably *Ochetoceras*, must remain in question, and no specific characters are discernable. The general conformation approaches that of *Ochetoceras contancia* Sanchez-Roig (1951, pl. 7) and that of *Ochetoceras sanlazarensis* Imlay (1939, pl. 1, figs. 1-4). Fig. 6.1 is a partial whorl fragment of a juvenile *Ochetoceras?* showing poorly preserved ribbing on the outer flank of the venter. The whorl height of this fragment at the larger end is 2.5 cm. Fig. 6.2 shows the distinctive discoid shape in ventural view. Fig. 6.5 is a mold impression of another juvenile *Ochetoceras?* with poorly pre-

served ribbing that diminishes toward the umbilicus. The diameter of this specimen is 3.5 cm with a maximum whorl height of 2.0 cm.

Occurrence—Three specimens were recovered from the basal pillow lava member in the SW $\frac{1}{4}$ sec 31 T17S R31E on the Portal 7 $\frac{1}{2}$ -min quadrangle.

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