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Ammonites of the Cretaceous Taraises and lower Tamaulipas formations in eastern Mexico

Abelardo Cantú-Chapa

Instituto Politecnico Nacional, Mexico, D.F., Mexico

ABSTRACT

The Taraises and lower Tamaulipas formations of the Early Cretaceous (Berriasian–Valanginian) are basinal sedimentary sequences in northeastern and eastern Mexico, respectively. The first unit was penetrated in the San Javier 1 and 2 wells at depths between 1800 and 3200 m (5905 and 10,499 ft), and the second was drilled in the Bejuco 6 and the La Laja 8 wells between 2000 and 2500 m (6562 and 8202 ft). In the Bejuco 6 well, the lower Tamaulipas Formation represents a condensed section. Geophysical logs and ammonites allow the characterization and age dating of these units.

Two important ammonite groups (Ancyloceratoidea and Perisphinctoidea) are described from cores in the four wells and from surface occurrences. Four new genera are proposed, *Misantlites*, *Wiedmannites*, *Parvaites*, and *Parrasites*; new species are *M. reyesi*, *Aegocrioceras eguiluzi*, *Capeloites lajense*, *C. peyroullesense*, *Thurmanniceras kleini*, *Neohoploceras bartolinii*, *Parvaites aguirrei*, *P. leanzai*; and one new subfamily is proposed, Capeloitinae.

INTRODUCTION

Geological Setting and Location

The Taraises and lower Tamaulipas formations were found in petroleum wells in northeastern and eastern Mexico. The core samples with ammonites were correlated with the corresponding well logs to determine the precise depths from which they were obtained. These depths range from 1800 to 3300 m (5905 to 10,827 ft) below sea level (Figure 1). The ammonites from the wells were crushed and fragmented, which made complete systematic determinations difficult.

However, many fragmented specimens recovered from wells are very valuable for stratigraphic purposes and in no case should they be discarded because this paleontologic material is obtained from depth at high cost. A study of this type of material allows a determination of the chronostratigraphic position of the rock in which the fossils are found, particularly with support of specimens from neighboring wells and integration of geophysical logs.

The find in eastern Mexico La Laja 8 well (core 9; 2537–2546 m [8323–8353 ft]) of a specimen with a fine ribbing of olcostephanid type, considered to be *Olcostephanus* sp., is significant, suggesting that the rock from

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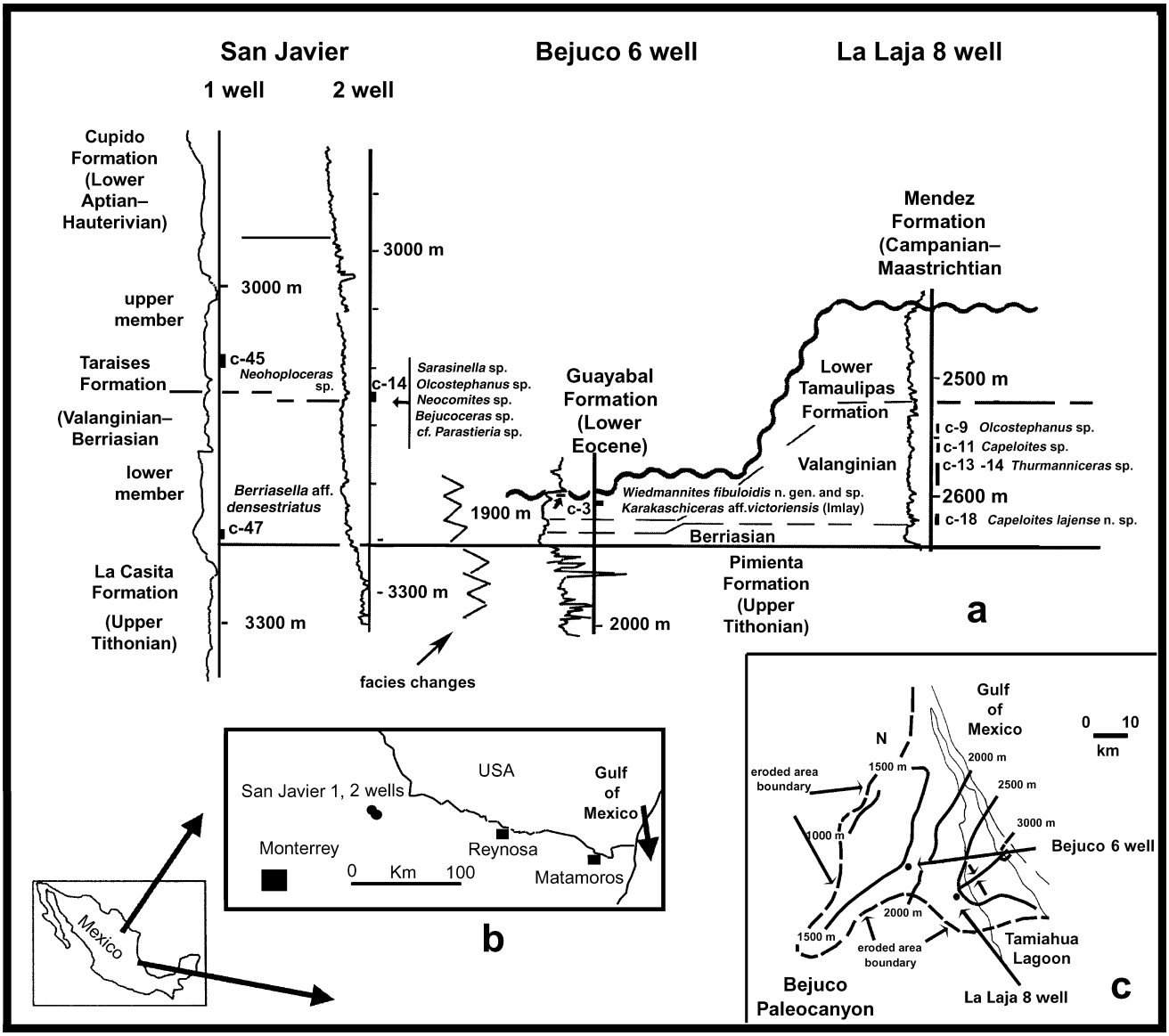

FIGURE 1. Cross-section of the Taraises and lower Tamaulipas formations (Lower Cretaceous) in oil wells in northeastern and eastern Mexico based on gamma-ray logs and ammonites. The stratigraphic datum is top of Tithonian.

which it was recovered is the Valanginian lower Tamaulipas Formation (Figure 2).

THE TARAISES FORMATION (BERRIASIAN–VALANGINIAN) IN THE SAN JAVIER 1 AND 2 WELLS IN NORTHEASTERN MEXICO

These two wells were drilled in the Paras fault system (Cantú-Chapa, 1989), and three ammonite specimens were studied. Some ammonites from the San Javier 1 well were determined by Imlay (1980).

The Taraises Formation consists of alternating beds of shaly limestone and shale subdivided into lower and upper members. This sedimentary sequence is quite recognizable on the gamma-ray log. The Taraises Formation overlies the Tithonian La Casita Formation and underlies the Hauterivian–lower Aptian Cupido Formation in this part of eastern Mexico (Cantú-Chapa, 2001) (Figure 1).

The lower member consists of a dense limestone approximately 140 m (459 ft) thick. A specimen of the ammonite *Berriasella* was recovered from the base of this unit in the San Javier 1 well (core 47; 3199–3207 m [10,495–10,522 ft]). A study of this specimen allowed the characterization of beds containing *Spiticeras* of Berriasian age in this well, as studied in north-central Mexico (Burckhardt, 1930).

FIGURE 2. A fragmented specimen was cut by the borehole in the lower Tamaulipas Formation from the La Laja 8 well (core 9, 2537–2546 m [8323–8353 ft]), eastern Mexico. The specimen shows only a dense ribbing and probably corresponds to *Olcostephanus* sp. from the Valanginian age. Scale = × 1.

The upper member consists of shaly limestone about 130 m (426 ft) thick. This member includes two ammonite associations; the lower containing *Bejucoceras-Sarasinella* and the upper with *Karakaschiceras-Olcostephanus*. These are found at the base and top of this member, respectively (Cantú-Chapa, 2001).

Two fragmented new ammonites were also obtained within the basal upper member of the Taraises Formation in the San Javier 2 well (core 14). These specimens were identified as cf. *Parastieria* sp. and *Sarasinella* sp., suggesting an early Valanginian age because they are associated with previously studied specimens of this age. For chronostratigraphic purposes, these are comparable to similar materials from Europe (Kemper et al., 1981; Company, 1987; Cantú-Chapa, 2001).

A new species of *Neohoploceras* is also described from the upper member of the Taraises Formation in the San Javier 1 well (core 45; 3056–3068 m [10,026–10,066 ft]). This genus characterizes the Valanginian in Argentina, Spain, and France (Company, 1987; Reboulet, 1996; Aguirre-Urreta, 1998).

The lower member of the Taraisas Formation is dated as Berriasian–basal early Valanginian, whereas the upper member is early Valanginian (pertransiens zone) to basal late Valanginian (verrucosum zone). These ages were established in northeastern Mexico from the stratigraphic position of the studied material and by correlation with chronostratigraphic units recognized in Europe (Cantú-Chapa, 2001) (Figure 1).

THE LOWER TAMAULIPAS FORMATION (EARLY CRETACEOUS) IN THE BEJUCO 6 AND LA LAJA 8 WELLS IN EASTERN MEXICO

Both wells were drilled in the Bejuco paleocanyon, which represents an important area of subaqueous erosion that caused the Neocomian–Eocene unconformity. Depths to the unconformity in the studied wells were plotted to show the Bejuco paleocanyon trending from the southwest toward the east. This paleogeographic element trends perpendicular to the modern coast of the Gulf of Mexico and occurs at depths between 1200 and 3000 m (3937 and 9842 ft); the latter depth is toward the Gulf (Cantú-Chapa, 1987) (Figure 1).

Two uncoiled ammonites were obtained from core 3 of the Bejuco 6 well (1907–1919 m, 6256–6296 ft) herein denominated *Wiedmannites* gen. n. from its looped ribbing, which differs from that of similar genera. These fossils are associated with specimens of *Karakaschiceras* in this well and characterize the base of the upper Valanginian according to established comparisons with similar material from France, Spain, Germany, and Poland (Kemper et al., 1981; Company, 1987; Kutek et al., 1989; Reboulet, 1996).

The La Laja 8 well (core 11) provided a specimen of *Capeloites* sp. in the micritic limestone of the lower Tamaulipas Formation of early Valanginian age (Cantú-Chapa, 2001). New specimens from this well are reported herein derived from cores 9 (2537–2546 m, 8323–8353 ft), 11 (2555–2564 m, 8382–8412 ft), 13 (2573–2582 m, 8442–8471 ft), 14 (2582–2591 m, 8471–8501 ft), and 18 (2618–2627 m, 8589–8619 ft). The gamma-ray log curve of this interval is offset to the left and shows little variation representing the massive limestone of this formation (Figure 1).

The lower Tamaulipas Formation in the La Laja 8 well is covered unconformably by marl of the Méndez Formation. The latter formation in this well contains Globotruncanidae foraminifera of Campanian–Maestrichtian age. In a prior study, this unit was considered as part of the Guayabal Formation (middle Eocene), but this has been corrected based on a study of the foraminifera (Cantú-Chapa, 2001).

The La Laja 8 well provides new taxa of the genera *Capeloites* Lissón (1937) and *Thurmanniceras* Cossman (1901). The first genus includes small forms without precise stratigraphic distribution. A Valanginian–early Hauterivian age was considered for similar material in France, Spain, and Peru (Wright et al., 1996).

Some specimens of *Capeloites* in the material from northeastern Mexico were dated as late Valanginian because of their association with *Garcites* Cantú-Chapa

France, and Spain, Company (1987), Reboulet (1996)	Estern Mexico, Bejuco-6 well Cantú-Chapa (1976)	Estern Mexico, La Laja-8 well (this work)	Formation
Lower Valanginian		- - -	
Neocomites campylotoxus (= *Neolissoceras salinarium*)	*Valanginites* sp.	*Olcostephanus* sp. (core 9, 2,539–2,547 m) *Capeloites* sp. (core 11, 2,556–2,562 m)	lower
Thuramanniceras pertransiens	*Thurmanniceras* sp.	*Thurmanniceras kleini* sp. nov. - *Olcostephanus* sp. (core 13, 2,575–2,584 m) cf. *Bejucoceras* sp. (core 14, 2,583–2,592 m)	Tamaulipas
Thurmanniceras otopeta		*Capeloites lajense* (core 18, 2,619–2,628 m)	*pt.*

FIGURE 3. Ammonite distribution in the lower Tamaulipas Formation (Lower Cretaceous), in two oil wells from eastern Mexico, and correlation with zonal schemes from France and Spain.

(2001) and *Karakaschiceras* Thieuloy (1969) (Cantú-Chapa, 2001).

Capeloites lajense n. sp. is described herein from core 18, corresponding to a layer below that containing *Capeloites* sp.; the latter specimen is obtained from core 11 in the La Laja 8 well (Cantú-Chapa, 2001). Therefore, *C. lajense* has an older stratigraphic position than *Capeloites* sp. Both specimens are from the lower Tamaulipas Formation and are separated by approximately 65 m (213 ft) in this well.

C. lajense is older than the *Thurmanniceras kleini* n. sp.-*Olcostephanus* sp. association established from core 13 of the La Laja 8 well (Figures 1, 3). The 72-m (236-ft) thickness of the lower Tamaulipas Formation is herein dated as early Valanginian because of the predominance of *Thurmanniceras*. This thickness is represented in cores 11 to 18 of the La Laja 8 well. In contrast, the age-equivalent unit in the Bejuco 6 well from the same area is represented by a calcareous condensed section only 22 m (72 ft) thick (Figure 1). Some species of *Thurmanniceras* were dated as early Valanginian by Imlay (1937) in outcrops of northeastern Mexico; however, there are doubts concerning this age (Kemper et al., 1981).

Ammonites from Outcrops

Three interesting heteromorphic ammonite specimens of the Family Crioceratitidae were collected at three outcrops of the lower Tamaulipas Formation in northeastern Mexico and are described herein (Figure 4). These are *Misantlites reyesi* n. gen. and sp., *Aegocrioceras eguiluzi* n. sp., and *Crioceratites* sp. The first is from Misantla, Veracruz, eastern Mexico; *Aegocrioceras* was collected in the Sierra de San Francisco, Coahuila; and *Crioceratites* is from Miquihuana, Tamaulipas; both in northeastern Mexico (Figure 4).

Aegocrioceras and *Crioceratites*, described here, represent the first known specimens from Mexico. *Misantlites* is proposed as a new genus distinct from the crioceratids of the rest of the world.

Systematic Considerations

Three Tithonian–early Cretaceous systematic ammonite groups corresponding to the families Olcostephanidae, Berriasellidae, and Neocomitidae are studied here because each includes genera with very contrasting morphologies and insufficient systematic studies as defined in the *Treatise*, part L, by Wright et al. (1996).

CONCLUSIONS

These studies have made four important achievements possible:

1. The stratigraphic position of fragmented and crushed ammonites coming from great depths in Petróleos Mexicanos (PEMEX) wells along the coastal plain of Gulf of Mexico was established.
2. A Berriasian–Valanginian age was determined for several beds in two PEMEX wells.
3. A condensed Valanginian age sequence in the lower Tamaulipas Formation was recognized through the systematic study of ammonites recovered from the PEMEX Bejuco 6 and La Laja 8 wells.
4. A revision of the systematic classifications of the Lower Cretaceous ammonite groups was proposed (crioceraitids, olcostephanids, and berriasellids).

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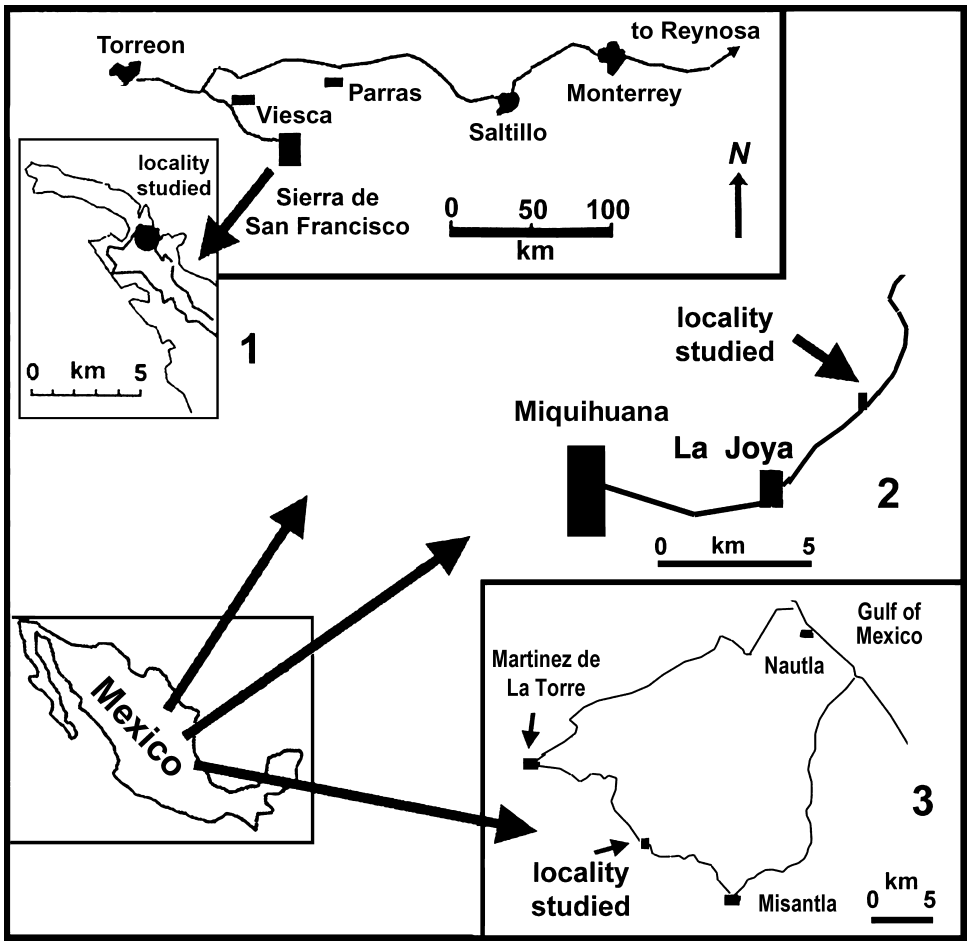

FIGURE 4. Map showing the ammonite localities of the Taraises and lower Tamaulipas formations (Lower Cretaceous). (a) Sierra de San Francisco, Coahuila; (b) Miquihuana, Tamaulipas; (c) Misantla, Veracruz, northeastern and eastern Mexico.

well regions. The author thanks H. Amezcua for the assistance with photography. I express my gratitude to J. Klein and Robert Scott for providing constructive reviews of the manuscript. My special thanks to J. Klein for helping with the bibliographic research. I am grateful to Claudio Bartolini for the translation of the manuscript.

SYSTEMATIC PALEONTOLOGY

The morphological terminology follows Wright et al. (1996). All dimensions are given in millimeters. Described specimens are housed in the Geological Department at the Instituto Politécnico Nacional (IPN), Mexico D.F. 07738, Mexico (Table 1).

TABLE 1. Shell measurements (in millimeters) and proportions of Valanginian–Hauterivian (Cretaceous) ammonites from San Francisco, Coahuila, and San Javier 1 and 2 wells, northeastern Mexico; Misantla, Veracruz; and La Laja 8 and Bejuco 6 wells, eastern Mexico.*

Specimen	*D*	*U*	*(U/D)*	*H*	*W*
Misantlites reyesi n. gen. and sp. IPN-1098	147	97	(0.66)	31	26
Aegocrioceras eguiluzi n. sp. IPN-1097	21	10	(0.47)	6.5	–
Capeloites lajense n. sp. IPN-1102	20	8	(0.40)	8	–
Neohoploceras bartolinii n. sp. IPN-1110	42	11.5	(0.27)	19	–
Thurmanniceras kleini n. sp. IPN-1107	68	23	(0.34)	26	–
Sarasinella sp. A IPN-1112	47	14	(0.30)	19	–

**D = shell diameter; H = whorl height measured from umbilical seam to venter; W = whorl width; and U = umbilical diameter (U/D).*

Order Ammonoidea von Zittel (1884)

Suborder Ancyloceratina Wiedmann (1966)

Superfamily Ancylocerataceae Gill (1871)

Family Protancyloceratidae Breistroffer (1947)

Discussion

Dimitrova (1970) characterized the families Protancyloceratidae and Bochianitidae Spath (1922) by the form of the shells and suture lines. The Protancyloceratidae show an uncoiled shell, simple ribs, and eventually ventral tubercles; the suture line is characterized by an S1 with a large base, irregularly bifid at the top; it is from the Tithonian to Hauterivian (Wright et al., 1996).

The latter has a straight shell; the suture line with S1 and S2 is rectangular, wide, symmetrically divided at the top, with narrow bases; it is known from the Tithonian to lower Aptian.

Wiedmann (1973) proposed the same systematic classification as was pointed out by Dimitrova (1970) but at a subfamily level.

In contrast, Wright et al. (1996) did not analyze the morphological differences between the two heteromorph ammonoides taxa. Without giving any explanation, Wright et al. (1996) included the Subfamily Protancyloceratinae in the Family Bochianitidae.

The Family Protancyloceratidae is here accepted as it was recognized by Dimitrova (1970) and Wiedmann (1973). This family is a useful group that differs from the Family Bochianitidae by its loosely coiled whorls.

Genus *Wiedmannites* new genus

Type Species

Wiedmannites fibuloidis n. gen. and sp. Upper Valanginian, Bejuco 6 well, Veracruz state, eastern Mexico, lower Tamaulipas Formation (Figure 1c).

Including Species

Wiedmannites aff. *fibuloidis* n. sp. from Cuba.

Upper Valanginian, Bejuco 6 well, Veracruz state, eastern Mexico, lower Tamaulipas Formation (Figures 1, 3).

Diagnosis

Small uncoiled whorls. Fine, flexuous looped ribs joined by small, fine ventrolateral spines.

Etymology

In memory of Jost Wiedmann from Germany, who studied the Ancyloceratoidea.

Description

The small shell with flat flanks is ornamented with slightly flexuous looped ribs; they are branched from the internal region of the flank and joined by pair in a small, radial ventrolateral spine; the looped ribs are separated by larger interspaces, but the secondary ribs are separated by narrower spaces. The ventral region is not observed.

Discussion

The proponed genus *Wiedmannites* is distinguished from *Leptoceras* Uhlig (1883) and *Parapedioceras* Collignon (1962) by its looped ribs, which are joined by ventrolateral fine spines. The last two genera have simple, rectiradiate, or rursiradiate ribs; *Wiedmannites* without tubercles and the *Leptoceras* and *Parapedioceras* with feeble inner and ventrolateral tubercles. The upper Valanginian *Juddiceras* Spath (1924) differs from *Wiedmannites* by its irregularly alternating weak and strong ribs and by its inconstant ventral tubercles.

Two small heteromorph specimens with uncoiled shell were described as *Paracrioceras* Spath (1924) from Cuba by Myczynski (1977). They possess similar looped ribbing as *Wiedmannites*, but they do not have other conclusive characteristics.

Wiedmannites fibuloidis new species (Figure 5b, c)

Cf. *Protancyloceras* sp. Cantú-Chapa (1976, p. 65, pl. 6, figure 4, 4a).

Diagnosis

As the genus.

Description

The small specimens show only a flat flank; the whorl height increases moderately. The ventral region and suture line are not observed.

Etymology

Fibula, Latin fibula, plus *oide*, Greek form, alluding to the ribbing.

Type

Holotype, IPN-1095 (Figure 5b); paratype IPN-1096 (Figure 5c).

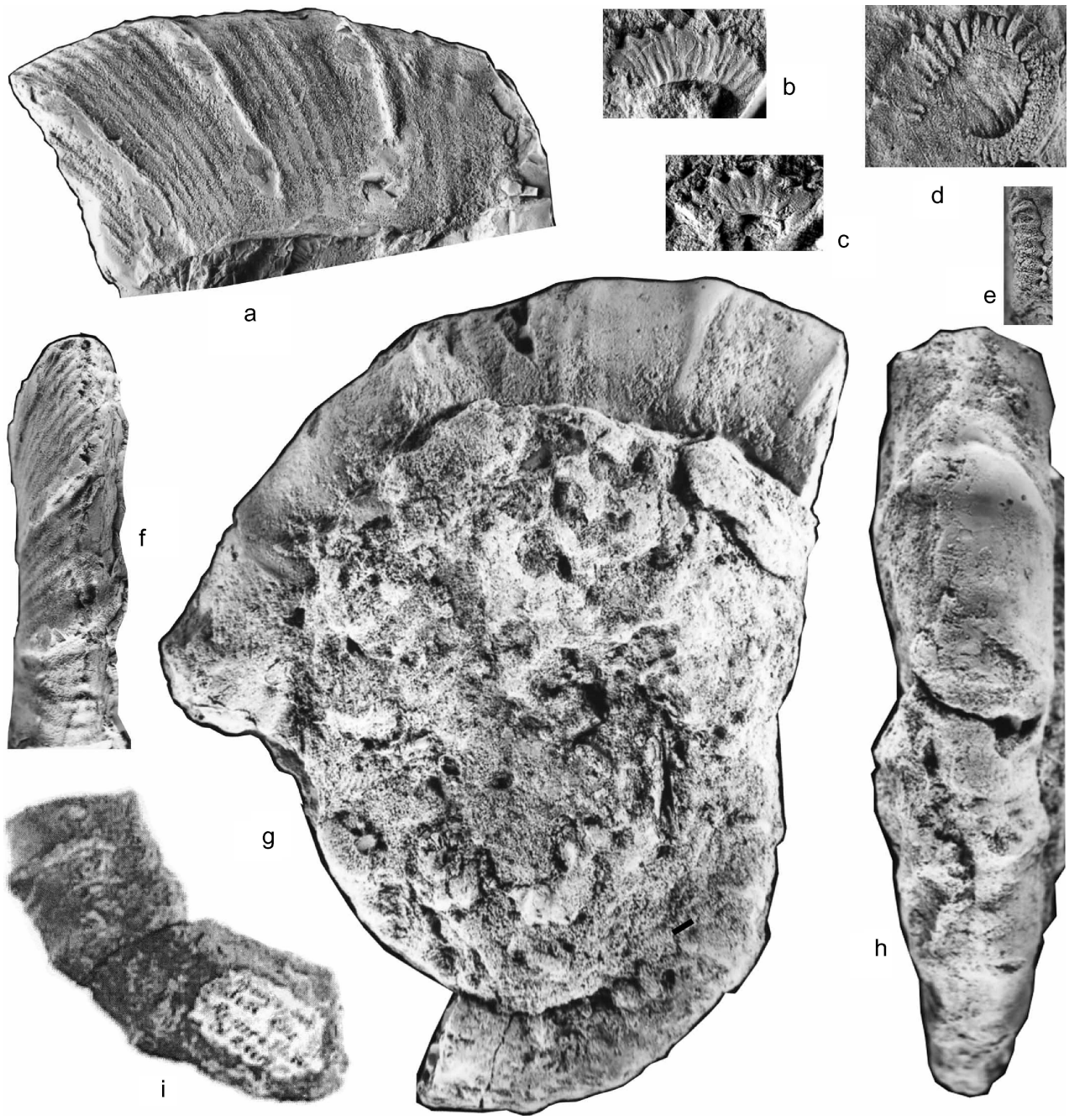

FIGURE 5. (a, f) *Crioceratites* n. sp., lateral and ventral views, IPN-1099. (b, c) *Wiedmannites fibuloides* n. gen. and sp., lateral views: (b) holotype, IPN-1096; (c) paratype, IPN 1095. (d, e) *Aegocrioceras eguiluzi* n. sp., lateral and ventral views, holotype, IPN-1097. (g–i) *Misantlites reyesi* n. gen. and sp., lateral and ventral views, holotype, IPN-1098. Specimens a and f are from Miquihuana; b and c are from the Bejuco 6 well, northeastern and eastern Mexico; d and e are from Sierra de San Francisco; and g–i are from Misantla. Scale = (all specimens except b, c) ×1; (b, c) ×1.5. Specimens are coated with ammonium chloride.

Occurrence

Bejuco 6 well, core 3 (1904–1910 m, 6247–6266 ft), Veracruz state, eastern Mexico; lower Tamaulipas Formation, upper Valanginian (Figure 1).

Discussion

These small, fragmental specimens were previously assigned to cf. *Protancyloceras* sp. (Cantú-Chapa, 1976, p. 65, pl. 6a, figure 4, 4a) on the basis of the resemblance

to the loosely coiled whorls of this genus. It was then noted that the looped ribbing differs from all previously described genera of the Protancyloceratidae.

In addition, two small specimens with uncoiled whorls were assigned to *Paracrioceras* cf. *elegans* (Koenen, 1902) by Myczynski (1977, p. 158, pl. 5, figure 9; pl. 6, figure 1); they are from the Polier Formation in western Cuba. These specimens are similar to the proposed *W. fibuloidis* by their looped ribs and uncoiled whorls. No other ammonites were found with the Cuban specimens; they were, however, dated as Barremian by Myczynski (1977).

Family Ancyloceratidae Gill (1871)

Subfamily Crioceratitinae Gill (1871)

Discussion

The genera of this subfamily are grouped here by the uncoiled whorls (1–5), the straightened shaft (6), and the slightly involute shell (7).

The ornamentation also characterizes them as follows:

1. simple, radial, and nontuberculate ribs cross normally the ventral region such as *Aegocrioceras* Spath (1924), *Parancyloceras* Spath (1924), *Simancyloceras* Kemper (1973), and *Bejucoceras* Cantú-Chapa (1976);
2. simple, radial, and trituberculate ribs such as *Spinocrioceras* Kemper (1973);
3. trituberculate, radial, or slowly flexuous major ribs that are separated by some minor and finer ribs such as *Menuthiocrioceras* Collignon (1949), *Eocrioceratites* Wiedemann (1973), *Crioceratites* Léveillé (1837), and *Acantholytoceras* Spath (1923a);
4. flexuous ribs with ventrolateral tubercles such as *Shasticrioceras* Anderson (1938);
5. radial, simple, or irregularly bifurcate ribs with inconstant inner and ventrolateral tubercles as *Pedioceras* Gerhardt (1897) and *Hemicrioceras* Spath (1924);
6. straightened long shaft with dense, fine, and nontuberculate ribs alternating with constrictions such as *Megacrioceras* Delanoy et al. (1987); and
7. coiled ammonite shells with fine ribs branching from umbilical tubercles such as *Pseudothurmannia* Spath (1923a).

Wright et al. (1996) considered it unnecessary to distinguish *Toxoceras* d'Orbygny (1842) and *Himantoceras* Thieuloy (1965) as different genera of Crioceratitinae because of their very loosely coiled shells; both genera were assimilated by these authors into *C.* (*Crioceratites*). However, this argument is not convincing to invalidate these genera; they must persist as different taxa because of their distinctive uncoiled shells and their stratigraphical distribution.

Genus *Aegocrioceras* Spath (1924)

Type Species

Hamites capricornu Roemer (1841) by original designation.

Discussion

Wright et al. (1996) indicated that *Aegocrioceras* was found in Mexico because they synonymized the Mexican genus *Bejucoceras* with it. The differences between these genera have been already pointed out (Cantú-Chapa, 1976, 2001).

Aegocrioceras eguiluzi new species (Figure 5d, e)

Diagnosis

Uncoiled shell; single, rectiradiate, sharp ribs, separated by narrow interspaces, crossing the venter transversely without interruption.

Description

The whorl shell is moderately compressed, with flat flanks and gently subrounded venter. The whorl height increases moderately in relation to diameter. Twenty ribs are in the adoral half whorl.

Etymology

Named in honor of Samuel Eguiluz Antuñano, engineer for Petróleos Mexicanos, who collected the holotype.

Type

Holotype, IPN-1097.

Occurrence

Sierra de San Francisco, Coahuila state, northeastern Mexico (Figure 4a).

Discussion

This specimen is assigned to *Aegocrioceras* by its uncoiled shell and by its rectiradiate, simple ribs that cross the ventral region transversely.

Rawson (1975) proposed several characters to distinguish *Aegocrioceras* species; they are recognized by the number, size, and lateral direction of the ribbing, as well as by the relative separation of the whorls.

The proposed *A. eguiluzi* n. sp. resembles *A. spathi* Rawson (1975, p. 145, pl. 4, figures 1, 2, 5) and *A. raricostatum* (Rawson, 1975, p. 143, pl. 4, figures 6–10; pl. 5, figures 3, 4, 7) from England by its crioceratitid coiling; it differs from them by its rectiradiate and sharp ribs that are separated by narrower spaces; ribs are curved gently backward over the venter in the two last species.

Genus *Misantlites* new genus

Type Species

Misantlites reyesi n. gen. and sp. by monotype. Probably Hauterivian, lower Tamaulipas Formation; Misantla, Veracruz (Figure 4c).

Diagnosis

Uncoiled in open spiral shell; coarse, single, straight major ribs arise from umbilical bullae, weaken at the flanks, are enlarged at the venter from ventrolateral tubercles, and are separated by minor ventrolateral ribs.

Etymology

After the Misantla village, Veracruz state, eastern Mexico (Figure 4c).

Description

Uncoiled shell in a regular plane spire. The whorl section is subrounded to subquadrate; the whorl height increases moderately, and the flanks and venter are planar to subrounded.

The principal ribs arise from the subrounded edge; they become weakened at the flanks, enlarged across the venter, and are separated by some minor ventrolateral ribs.

Discussion

Menuthiocrioceras, *Eocrioceratites*, *Crioceratites*, and *Acantholytoceras* have trituberculate major ribs alternating with some minor ribs on the flanks and all cross the ventral region normally; although *Misantlites* n. gen. possesses major ribs arising from umbilical bullae, ribs become weakened at the flanks and enlarged across the venter from the ventrolateral tubercles.

The upper Valanginian *Himantoceras* Thieuloy (1965) from France and Morocco differs from *Misantlites* by having major trituberculated ribs that weaken at the ventral region and by its open great uncoiled shell (Thieuloy, 1965; Ettachfini, 2004).

The Hauterivian *Shasticrioceras* from California have flexuous ribs at the flanks and ventrolateral tubercles, and it differs from *Misantlites* in lacking enlarged major ribs at the venter. This last genus is here assigned to the second group of the Crioceratitinae mentioned above.

Age

Its stratigraphic position is unknown. *Misantlites* could be dated as Hauterivian by morphological comparison with the genera of the subfamily Crioceratinae.

Misantlites reyesi new species (Figure 5g–i)

Diagnosis

As the genus.

Description

As the genus.

Etymology

In memory of Eliseo Reyes, engineer for Petróleos Mexicanos, who collected the fossil described.

Type

Holotype, IPN-1098.

Occurrence

Misantla, Veracruz; lower Tamaulipas Formation.

Discussion

As the genus. One incomplete specimen was assigned to *Menuthiocrioceras*? sp. by Cantú-Chapa (1963). Later, the uncoiled specimen IPN-1098 was found in the IMP collections, and it allows a more complete description and reassignment of the fragmented specimen.

Age

Probably Hauterivian.

Genus *Crioceratites* Léveillé (1837)

Type Species

Crioceratites duvalii Léveillé, 1837. By subsequent designation of Diener (1925).

Discussion

The systematic classification of *Crioceratites* was established based on its uncoiled or coiled whorls, its ornamentation, and its suture line (Sarkar, 1955; Thomel, 1964; Wiedmann, 1973; Immel, 1978).

This genus is divided into subgenera by Wright et al. (1996) after the following morphological characteristics:

1. uncoiled whorls with major trituberculated ribs alternating with some minor ribs in *C.* (*Crioceratites*);
2. scarce minor ribs in *C.* (*Paracrioceras*) Spath (1924);
3. major bituberculated ribs on early whorls that became divided at the umbilical edge and are nontuberculate on the outer whorls in *C.* (*Spathicrioceras*) Sarkar (1955); and
4. coiled ammonitic whorls with trituberculated ribs in *C.* (*Sornayites*) Wiedmann (1962). This subgenus is based on an old illustration by Parona (1898), which is not well known; its systematic position is discussed by Thomel (1965).

The *Crioceratites* subgenera are herein considered as genera following Reboulet (1996) and Ettachfini (2004).

Crioceratites sp. (Figure 5a, f)

Description

A fragmental specimen with uncoiled shell, compressed whorl section, flat flanks, subrounded umbilical edge, narrow venter, and dorsal region gradually depressed, and sharp, prorsiradiate, and trituberculate major ribs; the internal and lateral tubercles are radially elongated. The ventral tubercles are inclined forward. One spine is preserved from an internal tubercle.

Major ribs are separated by six or seven fine, prorsiradial, simple ribs; all ribs arise from the subrounded internal shoulder, crossing the ventral region without interruption where they are projected forward.

Material Examined

IPN-1099.

Occurrence

Near Miquihuana, state of Tamaulipas, northeast Mexico; lower Tamaulipas Formation, Hauterivian (Figure 4b).

Discussion

This fragmental specimen shows the distinctive characters from a heteromorphic ammonite with an uncoiled shell that shows its dorsal region; it is assigned to *Crioceratites* sp. by its sharp and trituberculated major ribs alternating regularly with some fine, minor ribs. *Paracrioceras* Spath (1924) differs from *Crioceratites* by having stronger ribs with spines and a smaller number or even an absence of intermediate fine ribs (Kakabadze and Hoedemacker, 2004).

This is the first time that a specimen of *Crioceratites* is described and illustrated from Mexico. Representatives of this genus were mentioned by Burckhardt (1930) from the lower Hauterivian in north-central Mexico; its presence in this country has been successively mentioned by Imlay (1944), Arkell et al. (1957), Wright et al. (1996), and Ettachfini (2004).

Crioceratites sp. indet. from western United States (Imlay, 1960, p. 196, pl. 26, figures 1, 5) resembles our specimen by having trituberculated major ribs alternating with 8 to 9 simple, flexuous minor ribs, but some ribs bifurcate on the outer part of the flanks.

The specimens assigned to *Crioceratites* in the Lower Cretaceous from Cuba by Myczynski (1977, p. 158, pl. 5, figures 7, 8) have constant, dense, fine ribs; they differ from the Mexican specimen herein described by their finer ribbing. The Cuban specimens resemble the upper Hauterivian *C. duvalii* Léveillé from Germany (Kemper, 1992, pl. 57, figures 1, 7) by the fine, flexuous ribs.

This Mexican specimen resembles *C. andinus* (Gerth, 1925, in Aguirre-Urreta, 1993, figure 4.1, 4.2) of the upper Hauterivian from Argentina and Chile by its major ribs. The South American specimens, however, have fewer minor ribs alternating between pairs of major ribs than the Mexican specimen. The outer lateral tubercles of *C. andinus* are not well known so they cannot be fully compared with the Mexican specimen.

The Hauterivian *C. duvalii* Léveillé and *C. nolani* (Kilian, 1907, in Thomel, 1965a) from France have trituberculate major ribs such as the Mexican specimen; but the first differs from the Mexican species by its slightly flexuous minor ribs and the latter by its flexuous and irregularly bifurcated minor ribs.

Suborder Ammonoidea Hyatt (1889)

Superfamily Perisphinctaceae Steinmann (1890)

Family Olcostephanidae Haug (1910)

Subfamily Capeloitinae new subfamily

Type Genus

Capeloites Lissón, 1937.

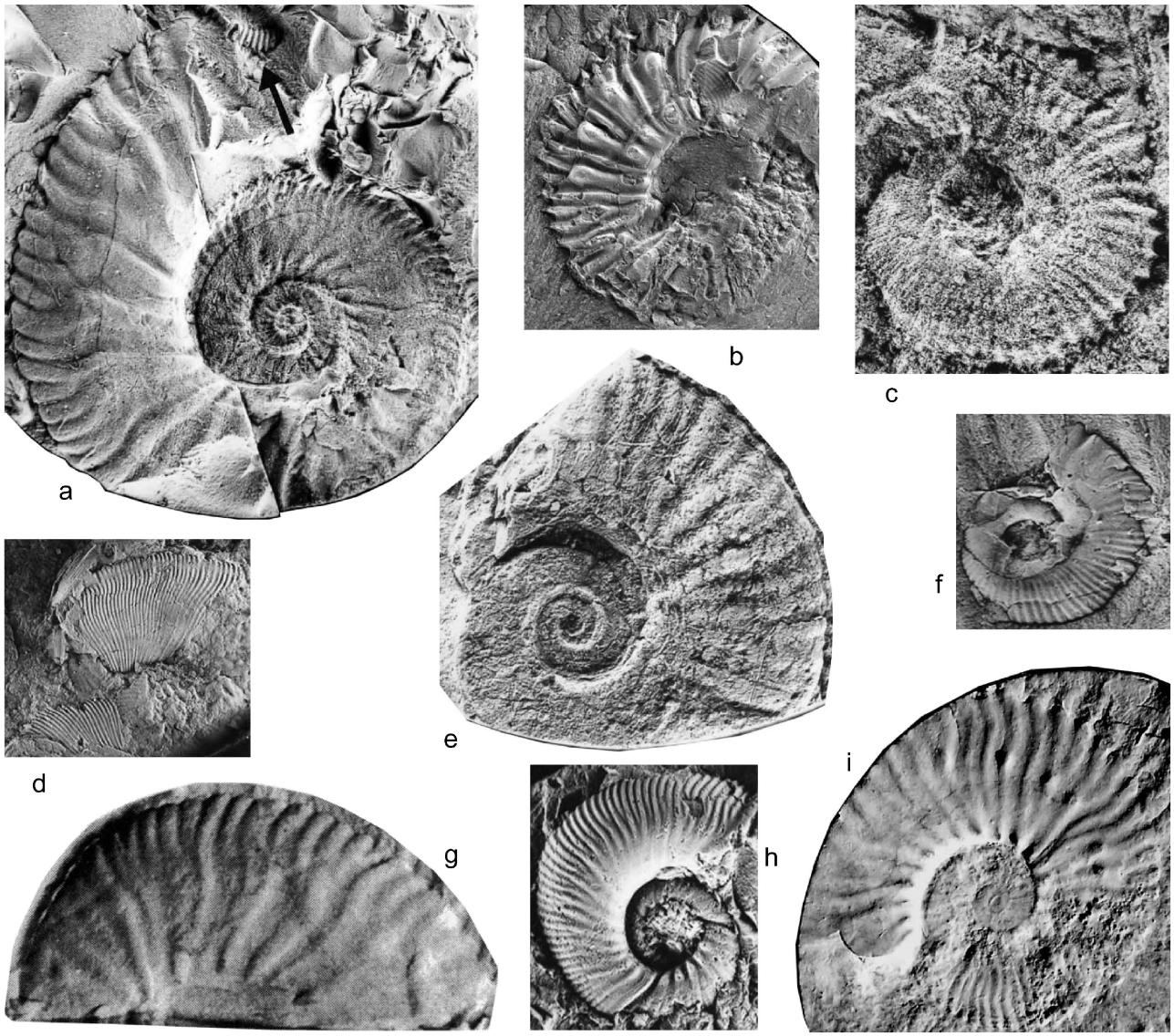

FIGURE 6. (a, g) *Thurmanniceras kleini* sp. nov.; (a) lateral view, holotype, IPN-1107. The arrow shows a small specimen of cf. *Bejucoceras* sp.; (g) paratype, IPN-1108. (b) *Sarasinella* sp. A, lateral view, IPN-1110. (c) *Olcostephanus* sp., lateral views, IPN-1104. (d) *Berriasella* aff. *densestriatus* (Burckhardt, 1912), ventrolateral view, IPN-1106. (e) *Thurmanniceras* sp. A, lateral view, IPN-1109. (f) cf. *Parastieria* sp., lateral view, IPN-1103. (h) *Capeloites lajense* n. sp., lateral views, holotype, IPN-1102. (i) *Neohoploceras bartolinii* n. sp., lateral view, holotype, IPN-1110. Specimens a, c, e, g, and h are from the La Laja 8 well; b and f are from the San Javier 2 well; and d and i are from the San Javier 1 well, northeastern and eastern Mexico. Scale = (all specimens) ×1; (f, h) ×1.5. Specimens are coated with ammonium chloride.

Included Genus

Parastieria Spath, 1923b.

Age

Upper Valanginian–Lower Hauterivian.

Locality

France, Spain, England, Peru, and Mexico.

Diagnosis

Small shell; moderately evolute, compressed whorl section; subrounded venter.

Dimorphic ornamentation in two different positions at the last whorl:

1. Sharp, rectiradiate, or looped and sigmoidal primary ribs with umbilical bullae, ventrolateral tubercles, and inconstant constrictions in the adapical half; fine, dense, bifurcated, or bundled sigmoidal

ribs; inconstant midventral tubercles in the adoral part.

2. Fine, dense, slightly sinuous, closely spaced ribs in the adapical half, and stronger, slightly convex forward, cuneiform, distant ribs in the adoral part; ribs cross normally the ventral region; suture line with long and parallel S1, S2, and L.

Discussion

Ammonites with dimorphic ornamentation on the last whorl are scarce in the Family Olcostephanidae; this type of ornamentation is present in *Capeloites* and *Parastieria* from the Valanginian to the lower Hauterivian.

Both genera were assigned to this family by Kemper et al. (1981) and Wright et al. (1996). Nevertheless, the strong change in the ornamentation on the last whorl in these genera was pointed out by Thieuloy (1969), Kemper et al. (1981), Autran (1989), Bulot (1990), and Cantú-Chapa (2001).

Representatives of the Olcostephanidae possess uniform ornamentation in the last whorl, including genera of the Subfamily Spiticeratinae Spath (1924), which differ from the two genera mentioned above by this type of ornamentation.

The suture line of Capeloitinae genera is only known after *Olcostephanus* (*Subastieria*) *hispanicus* (Mallada, 1882) (= ? *Parastieria*? *hispanica* in Klein, 2005). The suture line was illustrated by Tzankov (1943, in Cooper, 1981, figure 20H, J); it possesses long, narrow, and parallel S1 and S2.

Capeloites and *Parastieria* are herein grouped in the Capeloitinae new subfamily to characterize their dimorphic ornamentation on the last whorl. The former has a widespread geographic distribution from Peru, Mexico, France, and Spain; the latter is only known from England. Both genera are Valanginian and lower Hauterivian in age (Wright et al., 1996).

The position of the dimorphic ornamentation on the last whorl differs in each one of these genera; it generates confusion and produces different opinions because of the position of the dimorphic ornamentation on the last whorl of the shell; this will be discussed farther on.

Genus *Capeloites* Lissón (1937)

Type Species

Capeloites larozai Lissón, 1937. By original designation.

Discussion

Capeloites from Peru was proposed by Lissón (1937); it was later recognized in France and Mexico by Thieuloy (1969), Autran (1989), and Cantú-Chapa (2001). An old illustration of *Ammonite perelegans* (Matheron, 1878) from France was assigned to this genus by Thieuloy (1969).

Capeloites lajense new species (Figure 6h)

Diagnosis

Small, evolute, and dimorphic shell; slightly subrounded flanks and venter. Sharp, rectiradiate, distant primary ribs arise from periumbilical bullae, alternating with one or two fine ribs; two prorsiradial constrictions in the adapical part. Fine, dense, closely spaced, radial to sigmoidal ribs, irregularly bifurcated in the adoral part of the shell.

Description

This small, evolute specimen with dimorphic ornamentation has a subrounded flank. Seven sharp, rectiradiate, and distant primary ribs arise from periumbilical bullae; they are separated by one or two secondary fine ribs. Two prorsiradial constrictions are intercalated in the adapical part of the shell.

The adoral part possesses fine, dense, sigmoidal, closely spaced primary ribs; some ribs are bifurcate, alternating irregularly with simple ribs, which arise from the middle part of the shell. Sixteen primary ribs and 49 secondary ribs exist in the adoral part against 7 primary ribs in the adapical part of the shell.

Etymology

The name refers to the La Laja 8 well.

Type

Holotype, IPN-1102 (Figure 6h).

Occurrence

La Laja 8 well, core 18 (2619–2628 m, 8592–8622 ft); lower Valanginian, lower Tamaulipas Formation; Tampico, eastern Mexico (Figure 1a, c).

Discussion

The proponed *Capeloites lajense* is preserved as a complete shell; with the exception of the ammonite illustrated by Matheron (1878), all other specimens of this genus from France and Peru are preserved as a half whorl (Lissón, 1937; Thieuloy, 1969; Autran, 1989).

C. lajense differs from all species described as *Capeloites* by having two constrictions and rectiradiate, distant primary ribs in the adapical half of the shell; by having fine, dense, sigmoidal, closely spaced, and bifurcated ribs in the adoral part; and by the absence of

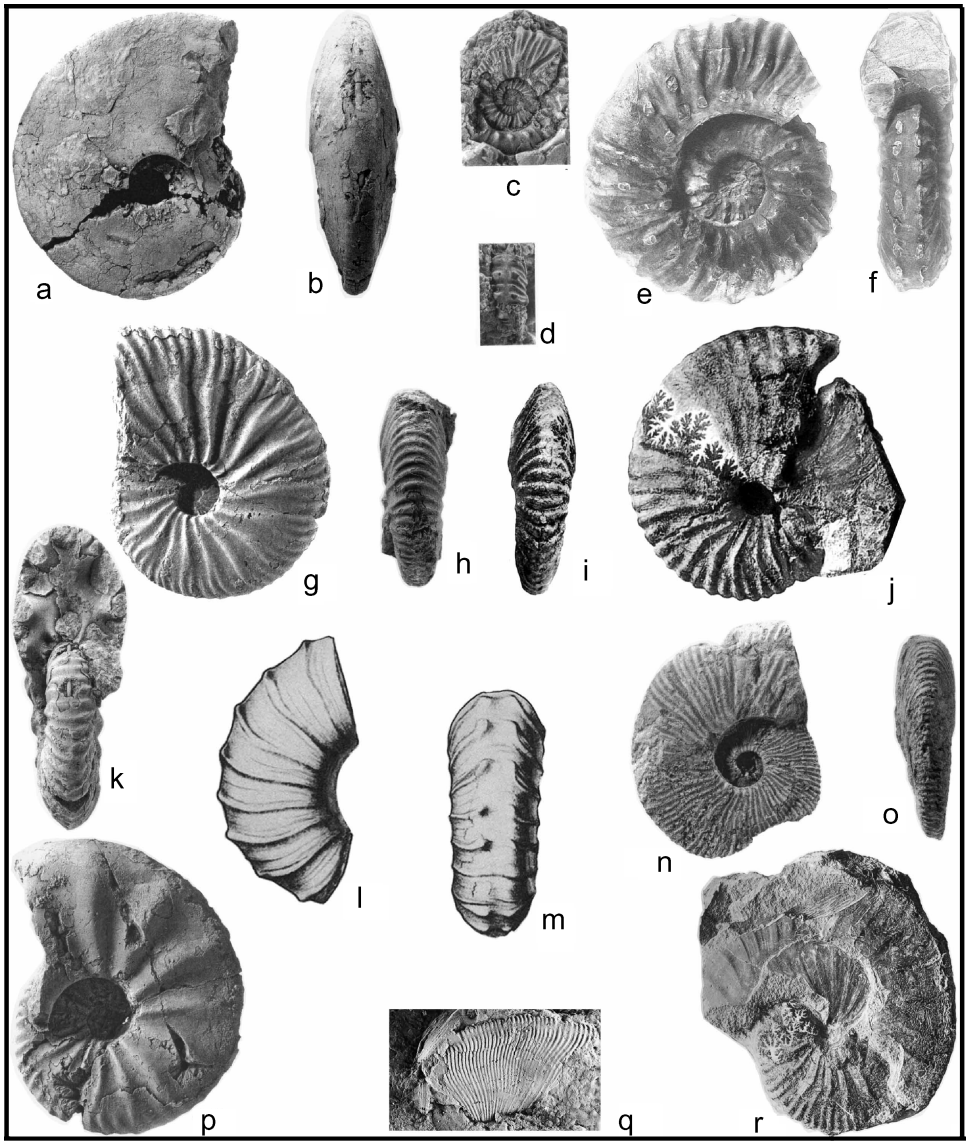

FIGURE 7. Genera and species of the Family Berriasellidae with different ornamentations and form of shells. (a–d) *Banikoceras involutum* Howarth (1992, p. 650, pl. 12, figures 1–4): (a, b) lateral and ventral views; (c, d) internal whorls, lateral and ventral views. (e, f) *Neocosmoceras* aff. *Sayni* Mazenot (1939, p. 183, pl. 29, figure 2a, b), lateral and ventral views. (g, h) *Chigaroceras wetzeli* Howarth (1992, p. 643, pl. 10, figures 4, 5), lateral and ventral views. (i, j, r) *Mazapilites symonensis* Burckhardt (1919–1921, p. 4, pl. 1, figures 2, 3, 9), ventral and lateral views. (k, p) *Chigaroceras banikense* Howarth (1992, p. 643, pl. 10, figures 1, 2), apertural and lateral views. (l, m) *Lythohoplites burckhardti* (Burckhardt 1900, p. 17, pl. 26, figures 1, 2), lateral and ventral views. (n, o) *Tirnovella alpillensis* (Mazenot, 1939) in Howarth (1992, p. 648, pl. 9, figures 3, 4), lateral and ventral views. (q) *Berriasella* aff. *densestriatus* (Burckhardt, 1912), ventrolateral view; this work, IPN-1106. All specimens are without scale.

ventral tubercles at some ribs in the adapical part of the last whorl.

C. neoleonense Cantú-Chapa (2001) from northeastern Mexico differs by the absence of secondary ribs intercalated between the coarse and rectiradiate primary ribs in the adapical half of the shell as *C. lajense* has.

C. perelegans (Matheron, 1878) from France and *C. lajense* are comparable in having a similar type of ribbing on the adapical part of the shell, but *C. perelegans* differs by the absence of constrictions.

C. perelegans (Matheron) differs from *C. perelegans larozai* (Lissón in Thieuloy, 1969, p. 256, figures B1–B3), also from France, by its coarse, radial principal ribs alternating with fine secondaries on the adapical part of the shell.

This later subspecies differs from the former by its convex forward ribbing that is sharp and divided from periumbilical bullae, producing ventral tubercles on the adapical part of the shell; ribs are very dense, fine, and divided on the internal part of the flanks in the adoral half of the shell.

The specimen described by Thieuloy (1969) as *C. perelegans larozai* (Lissón in Thieuloy, 1969, p. 256, figures B1–B3) is here proposed as the holotype of *C. peyroullense* n. sp. It differs from *C. lajense* by its convex ribs at the flanks and from *C. larozai* by the absence of looped ribs on the adapical part of the shell.

C. larozai Lissón (1937) from Peru differs from *C. lajense* by its sigmoidal ribbing; its sharp, looped ribs arising from periumbilical bullae in the adapical part change to very fine, dense, and bifurcated ribs on the adoral part of the shell.

All *Capeloites* species from France, Peru, and Mexico differ from *C. lajense* by the lower ratio of U/D, which varies from evolute (0.40–0.42) in *C. lajense* and

Capeloites sp., respectively, from Mexico to relative involute (0.26–0.36) in *C. peyroullense* and *C. hispanicus* (Mallada in Autran, 1989) from France and *C. neoleonense* (0.25) from Mexico (Cantú-Chapa, 2001).

Genus *Parastieria* Spath (1923b)

Type Species

Acanthoceras? *peltoceroides* Pavlow (1892). By original designation.

Discussion

The dimorphic ornamentation in the last whorl of the shell produces confusion between *Parastieria* and *Capeloites*.

Kemper et al. (1981) pointed out the presence of looped ribs in the adoral part of the shell in one specimen from England; it was not specified which one of these two genera have these structures. The coarse ribbing occurs in the adoral part in *Parastieria wrightae* Rawson from England or in the adapical half of the shell in *Capeloites larozai* Lissón (1937) from Peru.

The specimen mentioned above was assigned to *Parastieria* sp. nov. by Kemper et al. (1981, p. 273, pl. 36, figures 5, 6); its coarse, looped ribs are separated by larger spaces on the adoral part, and it contrasts with the fine ribbing on the adapical half of the shell. Klein (2005) rescues and renames it as *Parastieria wrightae* Rawson (1966) because it was originally proposed by P. F. Rawson (1966).

The position of the dimorphic ornamentation with coarse ribs in the adoral part of the shell characterizes *Parastieria*, but the presence of looped ribs in this part of the shell in *Parastieria* sp. nov. (Kemper et al., 1981) differs from all species assigned previously to *Parastieria*.

This type of ribbing differs from *Parastieria peltoceroides* (Pavlow, 1892, pl. 18 (11), figures 21a, b, in Kemper et al., 1981, p. 273, text, figures 6e–g); its principal ribs became larger and cuneiform on the outer part of the flanks in the adoral half of the whorl.

Autran (1989) differentiated *Parastieria* from *Olcostephanus* by the absence of umbilical tubercles in the former; however, Wright et al. (1996) recognized the presence of slight umbilical bullae in *Parastieria* without specifying in which part of the last whorl they are located.

Cf. *Parastieria* sp. (Figure 6f)

Description

Small and evolute shell, dimorphic ornamentation in the last whorl; inclined and subrounded umbilical wall, slightly subrounded flank.

First whorls are smooth, but the last whorl is ornamented by primary, fine, simple, prorsiradial to slightly flexuous, and closely spaced ribs. They arise freely at the umbilical margin in the adapical part and become strong, slightly convex forward, and distant in the adoral part of the shell.

Material Examined

IPN-1103, negative ammonite mold.

Occurrence

San Javier 2 well, core 14 (3120–3129 m, 10,236–10,266 ft), northeastern Mexico; Taraises Formation, base of the upper member, lower Valanginian (Figure 1a, c).

Discussion

This specimen is assigned to cf. *Parastieria* sp. because of its dimorphic ornamentation in the last whorl; its fine, dense ribbing in the adapical part changes to stronger ribs that are separated by spaces with the same size in the adoral part of the shell.

However, its fragmented condition does not allow a conclusive generic determination. It differs from *P. peltoceroides* (Pavlow, 1892, p. 510, pl. 18 (11), figure 21a–c) in its simple and fine ribs that arise at the umbilical margin in the adapical part and in the presence of coarse, distant ribs in the adoral part of the shell.

Two specimens from Spain were assigned to *Capeloites* by Wilke (1988, pl. 2, figures 3, 4); the dimorphic ornamentation changes from fine ribbing in the adapical part to large, widely spaced ribs in the adoral half of the last whorl; they are herein considered as *Parastieria*.

The specimen from the San Javier 2 well described above resembles the Spanish *P.* aff. *peltoceratoides* Pavlow (1892) in Wilke (1988, pl. 2, figure 4a, b) (= *Capeloites perelegans larozoi*, in Klein, 2005) by its evolute shell; its great number of fine, closely spaced secondary ribs in the adapical part; and its coarse, separated ribs in the adoral part of the shell.

Another Spanish specimen was illustrated by Wilke (1988, pl. 2, figure 3a, b) as *Capeloites perelegans larozoi*; it shows the typical dimorphic ornamentation of *Parastieria*, consisting of fine ribs in the adapical part and coarse ribbing in the adoral part of the shell; this specimen is rather involute, and it is herein considered to be a *Parastieria* sp.

Subfamily Olcostephaninae Haug (1910)

Genus *Olcostephanus* Neumayr (1875)

Type Species

Ammonites astierianus d'Orbigny (1842). By original designation.

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Olcostephanus sp. (Figure 6c)

Description

Small shell, moderately evolute with a convex flank and a lappet at the peristome. The fine, gently convex forward ribs are separated by spaces as large as them. It shows small tubercles near the peristomal area, and very fine striae arise from small tubercles at the adapical part of the shell, corresponding to the eroded rib margins. The umbilical area is partially eroded.

Material Examined

IPN-1104.

Occurrence

La Laja 8 well, core 9 (2539–2547 m, 8330–8356 ft), Tampico, eastern Mexico; lower Valanginian, lower Tamaulipas Formation (Figure 1a, c).

Discussion

This specimen has the distinctive characteristics of *Olcostephanus*, consisting of a gently convex flank with fine ribbing. The most characteristic ornamentation is the small umbilical tubercles and the fine striae, which represent the rest of the eroded ribs at the adapical part of the shell; its whorl section is unknown.

Family Berriasellidae Spath (1922)

Discussion

This family is incorrectly treated as a subfamily of the Family Neocomitidae Salfeld in the *Treatise*. Genera with differently coiled shells and ornamentation are included together; they vary from

1. involute, smooth, and discoidal shells such as *Banikoceras* Howarth (1992) (Figure 7a, b);
2. evolute, with alternating fine and coarse ribs such as *Lytohoplites* Spath (1925) (Figure 7l, m), or with lateral and ventrolateral tubercles, leaving a smooth ventral band such as *Neocosmoceras* Blanchet (1922) (Figure 7e, f);
3. subevolute with fine, closely spaced ribs such as *Tirnovella* Nikolov (1966) (Figure 7n, o);
4. *Banikoceras* possesses umbilical tubercles, looped ribs, and constrictions on the internal whorls (Figure 7c, d).

The diverse set of genera in the Family Neocomitidae (Subfamily Berriasellinae) cannot be retained as having phylogenetic unity because of the great heterogeneity of shells and ornamentation (Figure 7).

For instance, the upper Tithonian *Chigaroceras* Howarth (1992) from Iraq was placed in the Subfamily Berriasellidae in the *Treatise*. Nothing shows that this genus is similar to the *Dalmasiceras* Djanelidzé (1922) to be assigned to this family (Howarth, 1992).

In contrast, *Chigaroceras* must be assigned to the Subfamily Mazapilitinae Spath (1928) according to its involute and compressed shell and its coarse, foldlike, branched ribbing that crosses normally the narrow and subrounded venter.

Chigaroceras is very close to the lower Tithonian *Mazapilites* Burckhardt (1919) from Mexico; in the former, any tubercles are really conspicuous at the umbilical marge and at the midlateral shell, as was pointed out by Howarth (1992). Similar involute and compressed shell and ribbing are present in the both genera, but they occur at different stratigraphic levels through the Tithonian. Compare Figure 7g, h, k, and p (*Chigaroceras*) with Figure 7i, j, and r (*Mazapilites*).

The upper Tithonian–Berriasian (?) *Submazapilites* Cantú-Chapa (1963) from Mexico has an involute shell with an oxycone whorl section. The principal ribs bifurcate from a lateral tubercle and they alternate with two secondaries from the midlateral area; all ribs have ventrolateral tubercles. This genus differs from *Chigaroceras* by its rows of two tubercles.

Chigaroceras and *Mazapilites* are similar in ornamentation and even in their dimorphic ornamentation stages, which are observed in *Ch. banikense* Howarth (1992, p. 643, pl. 10.1-3) and *M. symonensis* Burckhardt (1919, p. 4, pl. 1.1). Both genera have the typical mazapilitinae ribbing in the adapical part of the shell; the former changes to very large, coarse, separated, and rectiradial ribs; the latter varies to very weakened ribs in the adoral half of the shell (Figure 7p, q).

Involute shells with subrounded venter and coarse, foldlike, branched ribbing characterize the Subfamily Mazapilitinae Spath (1928) (*Mazapilites*, *Submazapilites*, and *Chigaroceras*) instead of the Subfamily Berriasellidae where the last genus was included in the *Treatise*.

These genera are here integrated into the Subfamily Mazapilitinae instead in the Subfamily Taramelliceratinae Spath (1928). The presence of one *Mazapilites* specimen in the lower Tithonian beds from Germany (Berckheimer and Hölder, 1959) are not enough to reassign it in the Taramelliceratinae as it was proposed by Donovan et al. (1980).

These subfamilies have different morphological characters and suture lines that allow to separate them.

Another genus with a strange form of shell is the upper Tithonian *Banikoceras* from Iraq (Howarth, 1992); it is included in the Subfamily Berriasellinae in the *Treatise*. The internal whorls are subevolute, the ventral area is smooth, and the looped ribs have umbilical and ventrolateral tubercles; this ornamentation changes to a smooth, involute, and oxyconic shell in the outer whorl (Figure 7a–d).

This specimen is herein assigned to the Subfamily Suaritinae Cantú-Chapa (1998), from the Family Neocomitidae Salfeld (1921) because of its subevolute shell and its looped ribs in the internal whorls.

Family Berriasellidae Spath (1922)

Discussion

This family included genera with fine primary simple ribs that bifurcate at the midflanks; the ribs cross perpendicularly the subrounded ventral region or are interrupted at a smooth or grooved midventral band; exceptionally, the ribs arise from umbilical tubercles as in *Elenaella* Nikolov (1966).

The absence of umbilical tubercles characterize genera such as *Berriasella* Uhlig (1905), *Substeueroceras* Spath (1923), *Parodontoceras* Spath (1939), *Riasanites* Spath (1939), *Andiceras* Krantz (1928), and *Parandiceras* Spath (1939).

The Subfamily Richterellinae Sapunov (1977) differs from the Berriasellinae by its ribbing projected forward at the ventral region and by its suture line (Cantú-Chapa, 1999, 2006).

Genus *Berriasella* Uhlig (1905)

Type Species

Ammonites privasensis Pictet (1867); SD by Roman (1938, p. 324).

Discussion

The systematic concepts of this genus here does not follow the definition of *Berriasella* (*Berriasella*) of Wright et al. (1996). It differs from *B.* (*Elenaella*) by the absence of umbilical tubercles. Both genera were integrated into the former by Wright et al. (1996) but later were separated by Klein (2005). His proposition is followed herein.

Berriasella aff. *densestriatus* (Burckhardt, 1912) (Figure 6d)

1912 *Neocomites densestriatus* Burckhardt, p. 190, figure 45.1–45.15, 45.19.

1964 *Neocomites densestriatus* Burckhardt, in Peña-Muñoz, p. 25, figure 7.6, 7.7.

2005 *Tirnovella? densestriatus* (Burckhardt, 1912) in Klein, p. 255.

Material Examined

One fragmented specimen shows the lateral and ventral ribbing. IPN-1106.

Locality

San Javier 1 well, core 47 (3199–3207 m, 10,495–10,522 ft); Taraises Formation, lower Valanginian; northeastern Mexico (Figure 1a, b).

Description

Shell with a planar to slightly convex flank. Narrow subrounded ventral region, partially with a middle smooth band. Very fine, closely spaced, and slightly flexuous ribs, some of them are bifurcate at different levels from the midflank; secondary ribs are intercalated on the outer half of the flank; all ribs are separated by very fine spaces and weaken at the venter.

Discussion

This specimen is herein assigned to Berriasellinae by its fine ribs arising free from the umbilical shoulder, branching at the middle part of the flanks, and crossing perpendicularly the venter where they weaken.

It resembles *Neocomites densestriatus* Burckhardt (1912, p. 190, pl. 45, figures 1–15, 19) by its slightly planar flank; by its subrounded and narrow venter with a smooth band; and by its very fine, dense, closely spaced ribs that arise free at the umbilical shoulder that bifurcate at the midflank; some secondary ribs are intercalated.

Peña-Muñoz (1964) described a specimen from northern Mexico and assigned it to *Berriasella densestriatus*, but unfortunately the illustration is very bad. This Mexican species is assigned with doubt to *Tirnovella* Nikolov (1966) in the Family Neocomitidae by Klein (2005); this last genus differs from *Berriasella* by its fine and flexuous ribs that born from umbilical tubercles (Figure 7n, o).

B. densestriatus is important to date the Taraises Formation base because it represents the Berriasian beds (zone with *Spiticeras*) from north-central Mexico (Burckhardt, 1912; Imlay, 1944).

Family Neocomitidae Salfeld (1921)

Genus *Thurmanniceras* Cossman (1901)

Type Species

Ammonites thurmanni Pictet and Campiche (1860). By original designation.

Discussion

Some Neocomitidae genera of this family differ from *Thurmanniceras* by the presence of umbilical tubercles such as *Fauriella* Nikolov (1966), *Jabronella* Nikolov

(1966), and *Busnardoites* Nikolov (1966); in contrast, *Thurmanniceras* has periumbilical bullae. *Tirnovella* Nikolov (1966) and *Neocomites* Uhlig (1905) differ from *Thurmanniceras* by their subinvolute shells; *Fauriella* differs also from *Thurmanniceras* by its straight, dense, and fasciculate fine ribbing, contrary to the flexuous angular ribs of the latter genus.

Thurmanniceras kleini new species (Figure 6a, g)

Diagnosis

Evolute shell with slightly convex flank, oblique, low umbilical wall; sharp ribs arising from umbilical bullae, becoming strongly prorsiradiate on the inner flank, producing small swellings at midflank, and dividing irregularly into two or three ribs; all ribs curved forward at the mid-outer part of the flank. Shallow, flexuous, and forward-inclined constrictions irregularly intercalated with the ribs. The ventral region is unknown.

Etymology

Named for Jaap Klein, in recognition of his studies on the Lower Cretaceous ammonites.

Material Examined

Holotype, IPN-1107 (Figure 6a), paratype, IPN-1108 (Figure 6g).

Occurrence

La Laja 8 well, core 13 (2575–2584 m, 8448–8478 ft), Tampico District, eastern Mexico; lower Tamaulipas Formation, lower Valanginian (Figure 1a, c).

Discussion

This specimen is assigned to *Thurmanniceras* Cossman (1901) based on its evolute coiling, slightly convex flank, and oblique umbilical wall; it is ornamented with sharp, falcoid, and furcated ribs arising from umbilical bullae and with forwardly projected constrictions.

Some *Thurmanniceras* species described by Imlay (1937) from northeastern Mexico differ from *T. kleini* by the rectiradiate ribs in *T. angusticostatus* Imlay (1937) and *T. miquihuanense* Imlay (1937) and by the umbilical tubercles in *T. novihispanicus* Imlay (1937); by these structures, this last species is herein assigned to *Busnardoites* Nikolov (1966).

T. jenkinsi Anderson (1938) from western United States was assigned to *Thurmanniceras* instead of *Neocomites* because it lacks umbilical tubercles (Imlay, 1960), but it differs from *T. kleini* by its very fine and closely spaced ribbing.

T. kleini differs from the species of this genus previously described by Böse (1923), Imlay (1937, 1938), and Cantú-Chapa (1963) from Mexico by its ribbing, which is projected strongly forward on the internal part of the flank that becomes irregularly bifurcated or trifurcated at the midflank, and by its falcoid style of curving on the mid-outer part of the flank.

Another specimen from the same core is preserved in a half of whorl (Figure 6g). The specimen is subevolute with gently convex flank; the flexuous primary ribs arising singly or irregularly bifurcated from the inclined umbilical margin are prorsiradiate at the midflank; they are irregularly bifurcated or trifurcated from small swellings at midflank and curve forward on outer flank. All ribs are separated by fine interspaces. This specimen is assigned to *T. kleini* n. sp. The type of its lateral ribbing described above and its subevolute shell allow it to be assimilated to this genus and species.

Thurmanniceras sp. A (Figure 6e)

Material Examined

IPN-1109.

Occurrence

La Laja 8 well, core 13 (2575–2584 m, 8448–8478 ft), Tampico District, eastern Mexico; lower Tamaulipas Formation, lower Valanginian (Figure 1a, c).

Description

A fragment of an evolute shell shows a half of the outer whorl; early whorls are eroded. Flexuous ribs arise free or bifurcate from the umbilical shoulder; they are irregularly bifurcated at the midflank and are separated by narrower spaces on the outer flank.

This specimen differs from *T. kleini* by its slightly flexuous ribbing in contrast to the falcoid ribs from the former. This specimen was previously assigned to *Thurmanniceras* sp. on the basis of its ribbing arising from periumbilical bullae.

Genus *Neohoploceras* Spath (1939)

Type Species

Ammonites sub-Martinii (Mallada, 1882).

Neotype

Kilianella (Neohoploceras) submartini (Mallada) Wiedmann (1966).

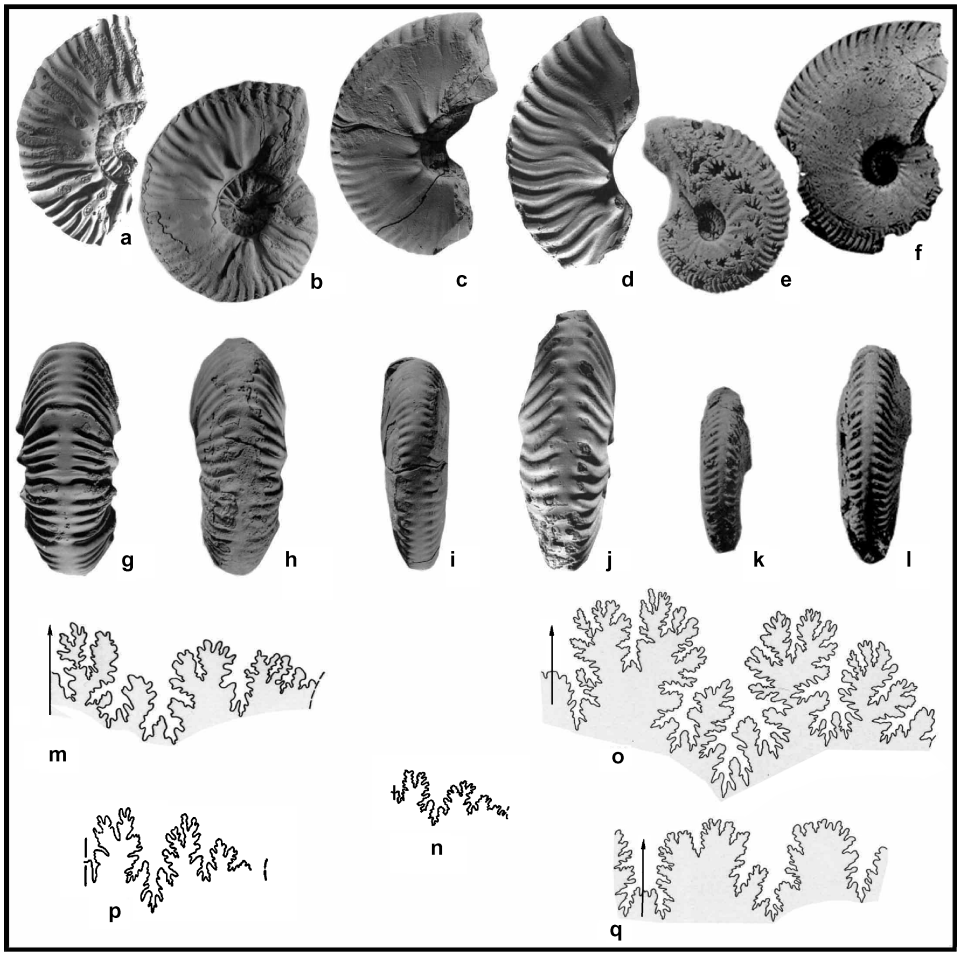

FIGURE 8. Four Neocomitidae genera with different ventral ribbing. (a, g) *Neohoploceras arnoldi* (Pictet and Campiche, 1860) in Aguirre-Urreta (1998, p. 51, figure 12.13, 12.14), lateral and ventral views. (b, h) *Parvaites aguirrei* n. gen. and sp. in Aguirre-Urreta (1998, p. 51, figure 12.3, 12.4), lateral and ventral views. (c, i) *Parvaites leanzai* n. gen. and sp. in Aguirre-Urreta (1998, p. 44, figure 9.3, 9.4), lateral and ventral views. (d, j) *Karakaschiceras neumayri* (Behrendsen, 1892) in Aguirre-Urreta (1998, p. 44, figure 12.15, 12.16), lateral and ventral views. (e, k) *Parrasites flexuosa* (Imlay, 1938, p. 582, figure 11.5, 11.6), lateral and ventral views. (f, l) *Parrasites victoriensis* (Imlay, 1938, p. 581, figure 12.1, 12.2), lateral and ventral views. (m) *Karakaschiceras attenuatus* (Behrendsen, 1892) in Aguirre-Urreta (1998, figure 5.1), suture line. (n) *Parrasites victoriensis* (Imlay, 1938, p. 581, figure 4.11), suture line. (o) *Karakaschiceras pronecostatum* (Felix, 1891) Wiedmann in Kutek et al. (1989, text, figure 5A), suture line. (p) *Parrasites flexuosa* (Imlay, 1938, p. 582, figure 4.10), suture line. (q) *Karakaschiceras subgibbosum* Wiedmann in Kutek et al.(1989, text, figure 5D), suture line. Without scale.

Discussion

Spath (1939, p. 105) applied the name *Neohoploceras* to a group of species assigned to *Leopoldia (Hoplitides)* by Sayn (1907). Spath described this group as Neocomitids with "...rib bundles, starting from umbilical tubercles and bearing lateral tubercles higher up, also single ribs without tubercles between..."

This important morphological character proposed by Spath is not mentioned in subsequent discussions of this genus; its systematic position is based on the dimorphic shell, which is characterized by two or three growth stages according to different authors.

Reboulet (1996) distinguished *Sarasinella* from *Neohoploceras* by its trituberculated ribbing in the inner whorls and by the absence of constrictions. He also pointed out that the latter genus and *Kilianella* have lateral tubercules but without umbilical tubercles in the last one.

Representatives of *Neohoploceras* have been described from fragmented specimens with inconstant bituberculated ribs in half of the last preserved whorl (Koenen, 1902; Gerth, 1925; Arkell et al., 1957; Kemper et al., 1981; Company, 1987; Wright et al., 1996; Aguirre-Urreta, 1998).

Other forms possess inconstant lateral tubercles grouped in a small part of the last whorl (Company, 1987; Reboulet, 1996), and some specimens without lateral tubercles were assigned to this genus by Aguirre-Urreta (1998). This latter distinctive ribbing will be discussed further on.

The dimorphic stages and the position of the bituberculate ribs vary in the last whorl from the adapical half of the shell (*Hoplites* spec., Baumberger, 1906, p. 67, figure 7.5a, b = *Neohoploceras arnoldi* [Pictet and Campiche] in Klein, 2005, p. 333) to the adoral part (*N. submartini* [Mallada, 1987] in Company, 1987, p. 155, figure 13.4; Reboulet, 1996, p. 66, figure 2.8).

The umbilical tubercles are inconsistent in a part of the last whorl and produce single or bifurcate ribs; in the former, they become bifurcate or trifurcate from a lateral tubercle that alternates irregularly with single ribs. This ornamentation is observed in some French, Spanish, and Argentine species (Company, 1987; Reboulet, 1996; Aguirre-Urreta, 1998).

Finally it is recognized that *Neohoploceras* has a widespread geographic distribution and occurs from early Valanginian to early late Valanginian (Reboulet, 1996).

Neohoploceras bartolinii new species (Figure 6i)

Hoplites spec., Baumberger (1906, p. 67, figure 7.5a, b).

Diagnosis

Compressed and evolute shell with shallow umbilicus; inclined and low umbilical wall and flat flank; bifurcated or single, fine, falcoid ribs irregularly arising from umbilical nodes, dividing or resting singly with fine, inconstant nodes at the midflank, curving forward at the outer flank, and ending at ventrolateral small nodes. Shallow and flexuous constrictions. The suture line is unknown.

Etymology

Named in honor of Claudio Bartolini in recognition of his Mexican geological studies.

Material Examined

Holotype, IPN-1110.

Occurrence

San Javier 1 well, core 45 (3056–3068 m, 10,026–10,066 ft), northeastern Mexico; Taraises Formation, lower Valanginian (Figure 1a, b).

Discussion

This specimen is assigned to *Neohoploceras* by its evolute shell with umbilical nodes, from which falcoid and bifurcated or single ribs originate; by its inconsistent midlateral nodes on the middle part of the last whorl; and by its small ventrolateral nodes.

N. imlayi Baraboshkin and Mikhalova (1994) (= *Acanthodiscus bernii* Imlay, 1938, p. 575, pl. 4, figures 7, 9) from northern Mexico is readily distinguished from the proposed *N. bartolinii* by its greater U/D radio (0.46 in the former vs. 0.26 in the latter) and by its radial and strong ribs alternating irregularly with fine ribs; some ribs bifurcate or trifurcate from strong tubercles.

N. submartini (Reboulet, 1996, p. 66, figure 2.8) from France and *N. bartolinii* possess falcoid and fine ribs; the former species differs by its principal, sharp, simple ribs arising from umbilical tubercles, becoming trifurcate from a lateral tubercle; ribs alternate with simple ribs at the adoral part of the preserved shell; the latter species possess inconsistent alternating bifurcate and simple ribs arising from umbilical nodes, some of which have inconsistent lateral nodes on the middle part of the last whorl.

N. bartolinii resembles *Hoplites* spec. (Baumberger, 1906, p. 67, figure 7.5a, b) by its fine ribs, some of which are bituberculate, and by the similar U/D ratio (0.27 in the former, 0.25 in the latter). They differ by the falcoid ribbing style in the Mexican specimen and are rectiradial and slightly inclined forward in the European specimen. However, considering that *Hoplites* spec. (Baumberger) was illustrated by a drawing, these differences are minor; it is here assigned to *N. bartolinii* n. sp.

Klein (2005) assigned *Hoplites* spec. (Baumberger) to *N. arnoldi*, but this species differs by having sharp flexuous ribs and inconsistent umbilical and lateral tubercles that originate as bituberculated ribs in specimens from Spain and Argentina (Aguirre-Urreta, 1998).

Neohoploceras sp. (Kemper et al., 1981, p. 288, figure 41.14, 41.15) (= *N. jacobi* in Klein, 2005 with doubt) from Germany differs from *N. bartolinii* by its lateral tubercles that occur in consecutive ribs; the same tubercles are inconsistent in the Mexican specimen.

N. arnoldi from Spain differs from *Hoplites* spec. (Baumberger) by its stronger lateral tubercles and flexuous ribs (Company, 1987). In addition, *N. arnoldi* from Spain differs from species in Argentina (Company, 1987, figure 13.1, 13.3; Aguirre-Urreta, 1998, p. 51, figure 12.3, 12.4); the former has inconsistent umbilical tubercles and stronger lateral tubercles, the later has inconspicuous lateral tubercles.

The *Neohoploceras* specimens without lateral tubercles that were described by Aguirre-Urreta (1998) from Argentina characterize the following new genus.

Genus *Parvaites* new genus

Type Species

Parvaites aguirrei n. sp. (= *Neohoploceras arnoldi* [Pictet and Campiche, 1860] in Aguirre-Urreta, 1998, p. 51, figure 12.1–4).

Included Species

Parvaites leanzai n. sp. (= *Karakaschiceras neumayri* [Behrendsen, 1892] in Aguirre-Urreta, 1998, p. 42, figure 9.3, 9.4).

Diagnosis

Subevolute shell; whorl section is much higher than wide; subrounded or tabulated venter with a smooth midband; flattened or subrounded flanks; vertical or slightly convex umbilical wall; umbilical tubercles give rise to falcoid, fasciculate, and sharp ribs alternating with simple, bifurcated, or trifurcated ribs at the midflanks, ending perpendicularly at tiny nodes in front of the ventral band or in long and radial tubercles corresponding to the constrictions. The suture line is unknown.

Etymology

After the Cerro La Parva, Neuquen Basin, Argentina (Aguirre-Urreta, 1998).

Occurrence

Idem.

Discussion

The proposed *Parvaites* n. gen. is represented by two shell forms, with subrounded flanks and venter and with constrictions or with planar flanks and venter and without constrictions.

Both forms of *Parvaites* differ from *Neohoploceras* by the absence of lateral tubercles and from the Valanginian *Karakaschiceras* Thieuloy (1971) by its secondary ribs ending perpendicularly at the subrounded or planar venter in front of the midventral band; the ventrolateral tubercles are only on the ribs corresponding to the constrictions (Figure 8b, c, h, i).

In contrast, the *Karakaschiceras* ribbing forms a marked forward flexure that terminates in radial tubercles at the ventrolateral shoulder (Figure 8d, j). Representatives of this genus with this type of ventral tubercles are *K. heteroptychum* (Pavlow, 1892), *K. quadristrangulatum* (Sayn, 1907), and *K. subgibbosum* Kutek et al. (1989, figure 1.1B–1.3B), all from Poland.

Some specimens from Argentina were assigned to *Neohoploceras* by Aguirre-Urreta (1998, figure 12.15, 12.16, 12.22, 12.23); they are here assigned to *Karakaschiceras* because of the forward flexure of the ventrolateral ribbing and the absence of lateral tubercles (Figure 8d, j).

The ventral regions of some representatives of *Karakaschiceras* from Spain, France, and Mexico were not illustrated, so it is not possible to consider them as appertaining to this genus (Kilian, 1905; Cantú-Chapa, 1976, 2001; Contreras, 1977; Company, 1987; Young, 1988; Reboulet, 1996).

In addition, Imlay (1938) described *Leopoldia victoriensis*, *L. flexuosa*, *L. crassicostata*, and *L. bakeri* from Mexico; they were later assigned to *Karakaschiceras* by Young (1987) and Cantú-Chapa (2001). These species do not show this type of ribbing with a ventrolateral flexure that characterizes *Karakaschiceras* (Figure 8e, f, k, l).

This type of ribbing was described by Imlay (1938, p. 582) as "...the ventral terminations are inclined strongly forward at all stages, became swollen on the outer whorls..."; it is present in the species mentioned above and occurs also in *L. victoriensis* (Peña-Muñoz, 1964, p. 28, figure 9.1.2) and cf. *Karakaschiceras* sp. (Cantú-Chapa, 2001, p. 366, figure 8.4, 8.4a). In contrast *L. bakeri* shows this type of ventral terminations only in the specimen illustrated by Imlay (1938, figure 12.6, 12.7).

This last ventral ribbing style characterizes *Parrasites* n. gen., which will be described further; however, it is not observed in representatives of *Karakaschiceras* from South America and Europe (Kutek et al., 1989; Aguirre-Urreta, 1998).

Parvaites aguirrei new genus and species (Figure 8b, h)

Neohoploceras arnoldi (Pictet and Campiche, 1860) in Aguirre-Urreta (1998, p. 51, figure 12.1–4).

Holotype

Specimen studied by Aguirre-Urreta (1998, p. 51, figure 12.1–4) from the lower Agrio Formation (Valanginian), Cerro La Parva, Neuquen Basin, Argentina.

Diagnosis

Subevolute shell with subrounded flanks and venter; subovate whorl section; vertical umbilical wall with subrounded shoulder; principal ribs arising from radial umbilical tubercles, bifurcated or not at the midflanks, alternating irregularly with secondaries, ending perpendicularly at the venter in front of a smooth midband; flexuous and irregular constrictions, some of which produce radial gently ventrolateral tubercles.

Etymology

Named in honor of Beatriz Aguirre-Urreta, in recognition of her studies on Cretaceous ammonites from Argentina.

Occurrence

Idem.

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Discussion

The specimen described above does not have the ventrolateral flexure termination of the ribbing that characterizes *Karakaschiceras*; instead, its ribs end perpendicularly at the venter in front of a smooth midband; it is herein assigned to *Parvaites aguirrei* n. sp. (= *Neohoploceras arnoldi* [Pictet and Campiche, 1860] in Aguirre-Urreta, 1998, p. 51, figure 12.1–4).

Other specimens from the same Argentinian locality are fragmented, so it is impossible to assign them to this genus (Aguirre-Urreta, 1998, figure 12.7–10).

Parvaites leanzai new genus and species (Figure 8c, i)

Karakaschiceras neumayri (Behrendsen, 1892) in Aguirre-Urreta (1998, p. 42, figure 9.3, 9.4).

Holotype

Specimen figured above (Aguirre-Urreta, 1998); paratype figures 9.5, 9.6, after Aguirre-Urreta (1998). All are from the lower Agrio Formation, Valanginian, Arroyo Truquico, Neuquen Basin, Argentina.

Diagnosis

Subevolute shell; plane flanks and venter; subtrapezoidal whorl section is higher than wide; nearly flat flanks; broad, smooth, and slightly convex venter; vertical umbilical wall with a subrounded shoulder. Principal ribs are flexuous arising furcated from umbilical tubercles, irregularly bifurcated, alternating with secondaries at the midflanks, and ending perpendicularly at the venter in radial nodes. The suture line is unknown.

Etymology

Named in honor of Héctor Leanza in recognition of his studies on Lower Cretaceous ammonites from Argentina.

Occurrence

Idem.

Discussion

The proposed *Parvaites leanzai* differs from *P. aguirrai* by its planar flanks and venter and by its homogenous ribs ending perpendicularly at the venter in a small, radial node.

Genus *Parrasites* new genus

Type Species

Leopoldia victoriensis Imlay (1938, p. 581, figure 12.1–4).

Included Species

Leopoldia victoriensis Imlay (1938), *L. flexuosa* Imlay (1938), *L. crassicostata* Imlay (1938), and *L. bakeri* Imlay (1938, p. 583, figure 12.6, 12.7) from Mexico, and with doubt, *K. pruszowskii* Kutek et al. (1989, p. 73, pl. 2, figure 1A–C) from Poland.

Diagnosis

Subevolute shell, vertical umbilical wall, flat flanks; flattened and smooth venter; whorl section is much higher than wide. Ribs arise singly, rarely doubly, from blunt thickenings at the umbilical shoulder; simple ribs intercalate and bifurcate at the midflank, strongly falciform with ventral and weak terminations inclined diagonally forward. Faint constrictions. Suture line with S1 subrectangular, irregularly and superficial bifurcated; S2 long and irregularly bifurcated; L asymmetrically subdivided.

Etymology

After the Sierra de Parras, Coahuila, Northern Mexico.

Occurrence

Idem.

Discussion

Some specimens assigned to *Leopoldia* by Imlay (1938) from northern Mexico were later considered to be *Karakaschiceras* by Young (1987), Cantú-Chapa (2001), and Klein (2005). The above mentioned species described by Imlay (1938) are here grouped in *Parrasites* n. gen. because of their particularly ventrolateral termination of the ribbing.

The new genus differs from *Karakaschiceras* by its flat flanks, by its slightly flat smooth venter, and by its ventral ribbing with diagonally forward-inclined terminations without swellings (Figure 8e, f, k, l).

The suture line of *Karakaschiceras* has been illustrated from some European and Argentinian species; unfortunately, some of these illustrations do not correspond to the respective ventral views from the same specimens to establish the exact comparison (Riccardi et al., 1971; Kutek et al., 1989; Aguirre-Urreta, 1998). Also, it is difficult to compare both elements with those of *Parrasites*.

However, the suture line of *Karkaschiceras* varies from S1 irregularly and deeply bifurcate, with a narrow

base in the Argentinian specimens, to strongly rectangular with superficial divisions at the top and a large base in the Poland specimens (Figure 8o, q); both groups have L irregularly divided with a strong structure at its external base (Kutek et al., 1989; Aguirre-Urreta, 1998).

This type of S1 differs from that of *Parrasites*, which is superficially and irregularly divided at the top. The L is trifurcated with small denticulations (Figure 8m, n, q).

Karakaschiceras pruszowskii Kutek et al. (1989, p. 73, pl. 2, figure 1A–C, text, figure 5C) from central Poland has the same type of ribbing with ventral terminations in its internal whorl, as proposed for *Parrasites* from Mexico.

The suture line of this species, illustrated by these authors, shows that S1 is apparently small, strongly inclined to L, and irregularly divided, and that it is smaller than S2; both are profusely denticulated with narrow bases. The Polish species mentioned above differs from *P. pruszkowskii* by S1, which is rectangular and large.

This latter Polish species has a planar and smooth venter in the internal part of the shell, but it differs from the Mexican *Parrasites* species by its rounded venter and by its flanks that are ornamented with large and swollen primary ribs in the outer whorl. However, it is here doubtfully assigned to *Parrasites*.

Age

Parrasites victoriensis, *P. flexuosa*, *P. crassicostata*, and *P. bakeri* were collected from the Taraises Formation, lower part of the upper member, at locality 58, Sierra de Parras, Coahuila, northern Mexico (Imlay, 1938). They were associated with *Olcostephanus*, *Mexicanoceras*, *Neocomites*, and *Acanthodiscus*; the age of this association was not well constrained to the Valanginian or the lower Hauterivian (Imlay, 1938).

However, *P. pruszkowskii* was dated by Kutek et al. (1989) from the *Saynoceras verrucosum* zone (upper Valanginian) in Poland.

Genus *Sarasinella* Uhlig (1905)

Type Species

Hoplites ambiguus Uhlig (1902). Subsequent designation by Lemoine (1906).

Discussion

Company (1987) pointed out two types of ornamentation on representatives of this genus that are based on the ribbing patterns and in the number and position of the lateral tubercles. The first whorls have rectiradiate ribs, some of them bifurcate from lateral tubercles; the last whorl possesses flexuous and bifurcate ribs arising from umbilical tubercles. Reboulet (1996) separated *Sarasinella* from *Neohoploceras* by its trituberculate ribbing and by the absence of constrictions.

Sarasinella sp. A (Figure 6b)

Material Examined

IPN-1110.

Locality

San Javier 2 well, core 14 (3120–3129 m, 10,236–10,266 ft); Taraises Formation, lower Valanginian; northeastern Mexico (Figure 1a, b).

Description

The fragmented specimen shows the lateral ornamentation, probably of the last whorl; it is evolute with a slightly convex flank.

The ornamentation consists of rectiradiate, sharp, and bifurcate ribs arising from umbilical tubercles; some ribs are bifurcated or trifurcated from a lateral tubercle; these ribs alternate irregularly with one simple and fine rib; all ribs are inclined forward on the external part of the flank and are separated by narrower spaces. The ventral region is not preserved.

Discussion

This fragmented specimen is assigned to *Sarasinella* by this type of ornamentation, consisting of two types of ribs, which bifurcate or trifurcate from lateral tubercles, the ribs alternate irregularly with simple ribs. This specimen corresponds to the species grouped with umbilical and lateral tubercles as pointed out by Company (1987).

This specimen does not show its ventral tubercles because of its incomplete preservation state. It resembles *Sarasinella* aff. *subspinosa* (Uhlig, 1910, in Imlay, 1960, p. 219, pl. 42, figure 16; Imlay and Jones, 1970, p. 50, figure 12.13–15) from California by the same type of irregular ribbing.

Sarasinella eucyrta (Sayn, 1907) described by Company (1987, p. 141, pl. 8, figures 13–15) from the lower Valanginian of Spain is less evolute than the Mexican ammonite described here. It differs also by its principal and trituberculate ribs, which are weaker. Our specimen is considered as *Sarasinella* sp.

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