15

Cantú-Chapa, A., 2001, The Taraises Formation (Berriasian-Valanginian) in northeastern Mexico: Subsurface and outcrop studies, *in* C. Bartolini, R. T. Buffler, and A. Cantú-Chapa, eds., The western Gulf of Mexico Basin: Tectonics, sedimentary basins, and petroleum systems: AAPG Memoir 75, p. 353-370.

The Taraises Formation (Berriasian-Valanginian) in Northeastern Mexico: Subsurface and Outcrop Studies

Abelardo Cantú-Chapa
Instituto Politécnico Nacional, Mexico City, Mexico

ABSTRACT

The Berriasian-Valanginian Taraises Formation in the subsurface of northeastern Mexico consists of an intercalation of argillaceous limestone and shale. This formation is divided into two members, based on lithologic characteristics defined from electric and radioactivity logs from oil wells in northeastern Mexico. In addition, two small ammonite groups of the subfamily Olcostephaninae (upper Valanginian) collected at Potrero de García, Nuevo León, northeastern Mexico, are described: (1) *Capeloites neoleonense* n. sp. and (2) *Garcites potrerensis* n. gen. and sp. and *G. cavernensis* n. gen. and sp. The presence of *Dichotomites* (*Dichotomites*) sp. in the same beds supports an late Valanginian age for these strata. One specimen of *Capeloites* obtained from a core of the La Laja-8 well, south of Tampico City, eastern Mexico, designates an late Valanginian age for the interval drilled (2556-2562 m) in the so-called Lower Tamaulipas Formation in this area. Global geographic distribution of *Capeloites* is restricted to France, Spain, and Peru; its presence in Mexico supports a biogeographic link between Europe and America.

INTRODUCTION

The Taraises Formation was first described in northern Mexico by Imlay (1938) as "a limestone and marl facies with a large cephalopod fauna of Neocomian (Berriasian to lower Hauterivian) age. . . ." He divided this formation into two members. The lower member consists of a compact limestone separated by marly beds. The upper member consists of thin- to medium-bedded limestone and marl.

The contact between these two members is apparently conformable. The lower contact of the Taraises Formation with the underlying Upper Jurassic La Casita Formation is transitional. Its upper contact with the limestone of the Cupido Formation (Hauterivian-lower Aptian) is abrupt. The Taraises Formation represents open-water deposits of the Neocomian sea (Imlay, 1944), into which clay was introduced, probably from the Coahuila block.

Fossils of Berriasian to early Hauterivian age were studied by Burckhardt (1930) and by Böse (1923) in northern Mexico, and some of them were later considered as having been collected from the Taraises Formation. Berriasian to lower Hauterivian ammonites of this formation include the following genera: *Bochianites*, *Spiticeras*, *Olcostephanus*, *Valanginites*, *Mexicanoceras*, *Berriasella*, *Subthurmannia*, *Karakaschiceras*, *Neo-*

comites, *Kilianella*, *Distoloceras*, and *Acanthodiscus* (Imlay, 1937, 1938, 1940, 1944; Cantú-Chapa, 1966, 1972, 1992; Contreras, 1977; Peña-Muñoz, 1964; Young, 1988).

THE TARAISES FORMATION IN NORTHEASTERN MEXICO

In the present study, the Taraises Formation is described from the subsurface of northeastern Mexico using well logs and ammonite biostratigraphy (Figure 1a). New upper Valanginian ammonites of the Taraises Formation are described from outcrops in the Potrero de García, northeastern Mexico (Figure1b). A small specimen of the ammonite *Capeloites* sp. from the La Laja-8 well (core 11, 2556-2562 m) south of Tampico City is also described. The age of this latter specimen is late Valanginian; the core containing the ammonite was cut in the Lower Tamaulipas Formation in this area (Figure 2).

Neocomian ammonites from two oil wells in northeastern Mexico were originally described by the author without using the corresponding well logs. In the Anahuac-1 well, ammonites were incorrectly determined as upper Tithonian. In the Calichoso-1 well, ammonites were assigned to the upper Valanginian (Cantú-Chapa, 1963, 1972). Logs are used to establish the exact stratigraphic position of the fossils, and they are also correlated with logs and specimens of nearby wells, such as the Anahuac-4 and -5, Cadena-3, San Javier-2, Pesquerías-1, and Los Herreras-2 (Figure 1).

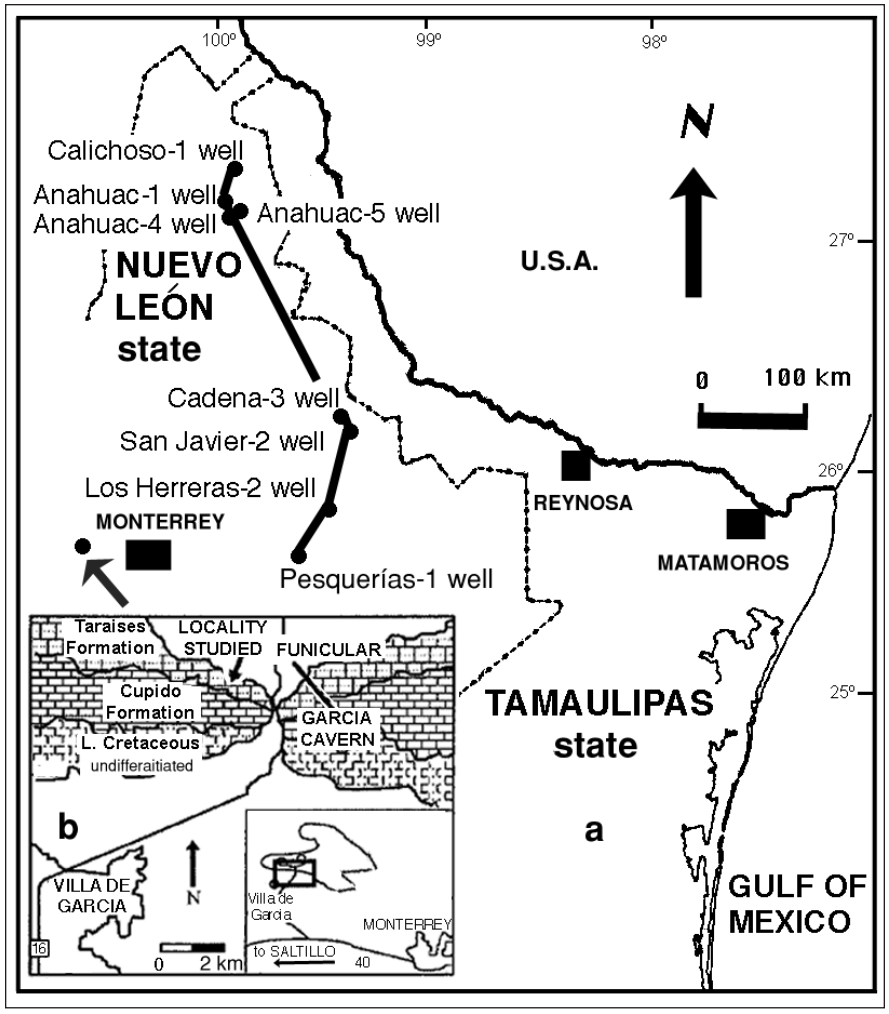

FIGURE 1. (a) Location map showing the oil wells studied. (b) Lower Cretaceous rocks in the Potrero de García, Villa de García, 20 km northwest of Monterrey, northeastern Mexico.

The top of the La Casita Formation (Upper Jurassic) and the bases of the Taraises and Cupido Formations (Lower Cretaceous) are determined with radioactivity logs (Figure 3). They are also correlated with electric logs in sections corresponding to the same formations drilled in the Anahuac-2 and Pesquerías-1 wells. Important biostratigraphic ammonite data are revised from wells where only electric logs are available (Figure 4).

The transitional contact between the Taraises and the La Casita Formations is placed at the decrease in value of the gamma and neutron curves (Figure 3). The spontaneous potential (SP) curve changes in value (south part of the section) in the Cadena-3, Los Herreras-2, and Pesquerías-1 wells. The SP curve is flat in the northern part of the section (Figure 4). This contact corresponds to the Jurassic-Cretaceous boundary in northeastern Mexico (Figures 3 and 4), and it was dated with the late Tithonian ammonites *Proniceras*, *Salinites*, *Substeueroceras*, *Kossmatia*, and *Salinites* in the upper part of the La Casita Formation; specimens were found in several wells of the same area studied here (Cantú-Chapa, 1999). The Taraises-La Casita Formations contact is present at different depths from 3250 m (San Javier-2 well) to 1850 m (Pesquería-1 well) as a result of the Paras fault system in the studied area (Cantú-Chapa, 1989).

The flat SP curve does not allow for a precise determination of the Taraises and Cupido Formations; however, the contact is established utilizing gamma-ray well logs. Radioactivity and resistivity logs decrease in value at the contact (Figures 3 and 4).

Members

The Taraises Formation consists of interbedded limestone, shaly limestone, and shale in the subsurface of northeastern Mexico. It is divided into two members of approximately equal thickness. The lower member consists of approximately 140 m of a dense limestone with a thin, shaly bed near the base. The gamma-ray curve stays uniformly toward the left through this

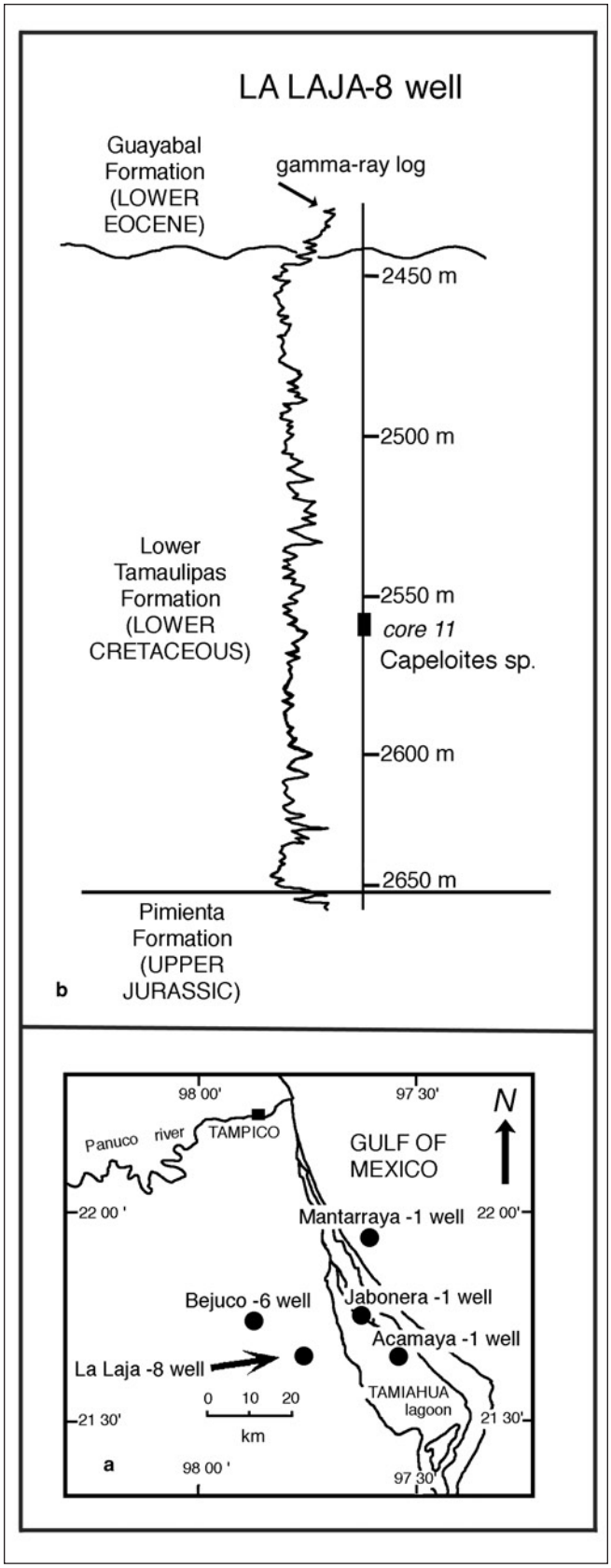

Figure 2. Location map (a) and gamma-ray log (b) showing the Lower Tamaulipas Formation (Lower Cretaceous) in La Laja-8 well, south of Tampico, eastern Mexico (Cantú-Chapa, 2001).

member, but it changes as it cuts across the transitional contact with the La Casita Formation (Figure 3). The SP curve is flat in the lower member and shows a change decreasing in value as it crosses the contact between the La Casita and Taraises Formations (Cadena-3, Los Herreras-2, and Pesquerías-1 wells; Figure 4). The resistivity and radioactivity logs display important value changes, increasing at the contact between the members, thus permitting characterization of the lower member (Figures 3 and 4).

No Berriasian ammonites were found in the cores studied. Possible age-equivalent rocks are inferred by their stratigraphic position. The upper Tithonian (Cantú-Chapa, 1999) and upper Valanginian ammonites in the wells establish the age of the lower member (Figures 3 and 4).

The upper member consists of about 130 m of shaly limestone. Gamma-ray and neutron curves are shifted to the center when recording this lithology in the Anahuac-4 and -5, San Javier-2, and Pesquerías-1 wells. A negative departure is observed in the two microresistivity curves through the upper member. The contact between the Taraises and Cupido Formations is abrupt, as shown by the gamma-ray and neutron curves (Figure 3). The resistivity curve presents an important change in value in the upper member of the Taraises Formation. Ammonites were found in the upper member (Figures 3 and 4).

Age Revision of the Core Number 12 from the Anahuac-1 Well

The stratigraphic study of the Taraises Formation in the Anahuac-1 well shows that the ammonites from core number 12 (2499-2503 m) were erroneously attributed to the upper Tithonian (Cantú-Chapa, 1963). Ammonites found in this core must be restudied. The exact position of core number 12 is here established in a stratigraphic cross section (Figure 4). The comparison of the radioactivity and electric logs of the Anahuac-2 well and the electric logs of the Anahuac-1 well shows that core number 12 of the latter well was taken from the upper member of the Taraises Formation. Also, the systematic position of core number 12 ammonites from the Anahuac-1 well are herein modified.

Protancyloceras anahuacensis Cantú-Chapa, 1963, was proposed as the name for a heteromorph ammonite with a smooth ventral line and simple ribs; it was found in this well and assigned to the upper Tithonian by Cantú-Chapa (1963, p. 28, Plate I, Figures 2-4) (Figure 5.1).

Later, *Bejucoceras* Cantú-Chapa (1976) was proposed as the name for a heteromorph ammonite with characteristics similar to those of *P. anahuasensis*. *Bejucoceras* was found associated with *Leopoldia victoriensis* Imlay in the Bejuco-6 well, (cores 3-5, 1904-1920 m) in eastern Mexico (Figure 2). Both fossils were assigned to the lower Hauterivian by Cantú-Chapa (1976); their age was established by *L. victoriensis* after Imlay (1937). However, the genus *Leopoldia* was restudied, and some forms were considered as belonging to *Karakaschiceras*. The radial

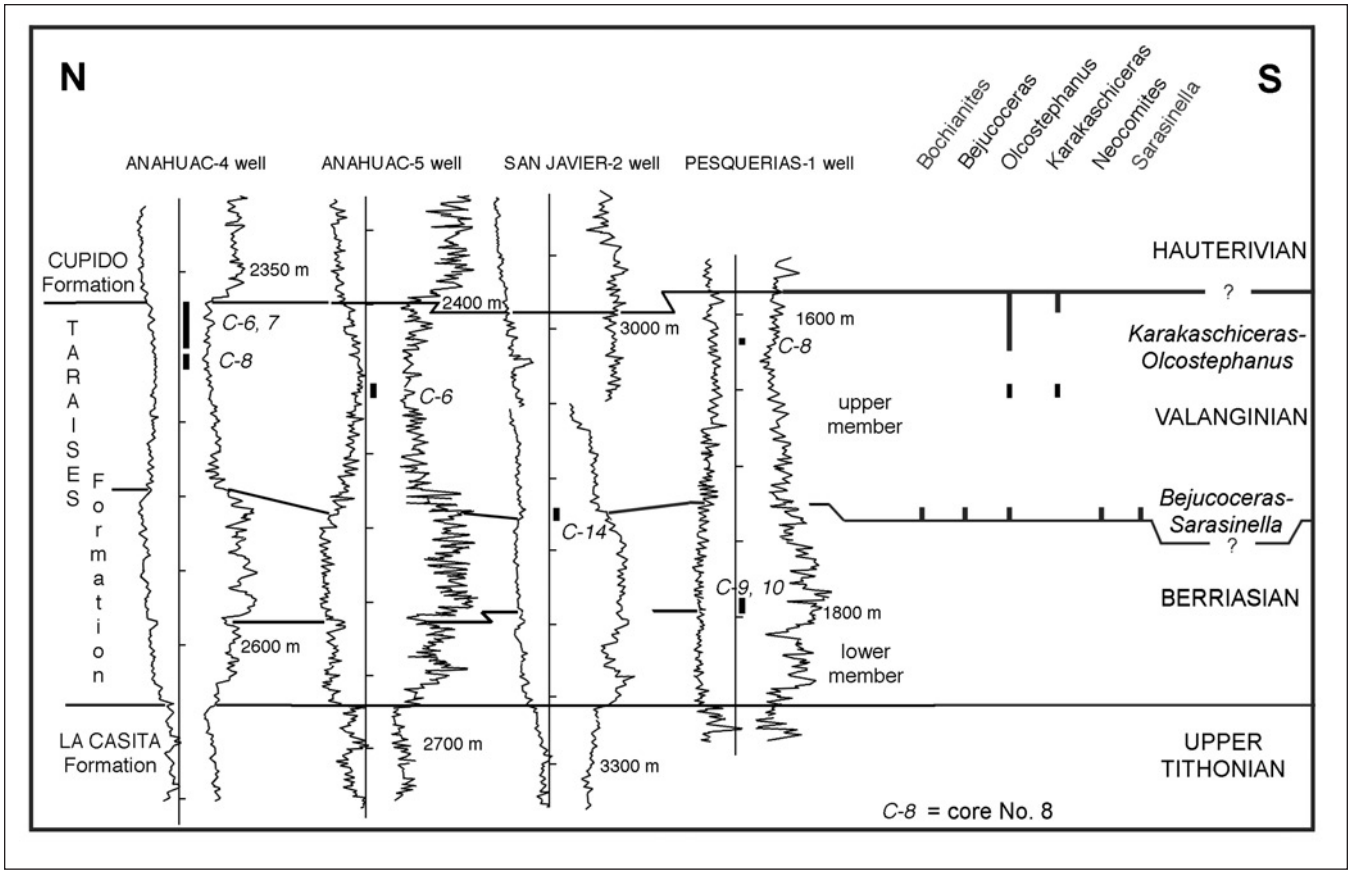

Figure 3. Cross section of the Taraises Formation (Lower Cretaceous) in oil wells in northeastern Mexico, according to radioactivity logs. Stratigraphic datum is top of Tithonian.

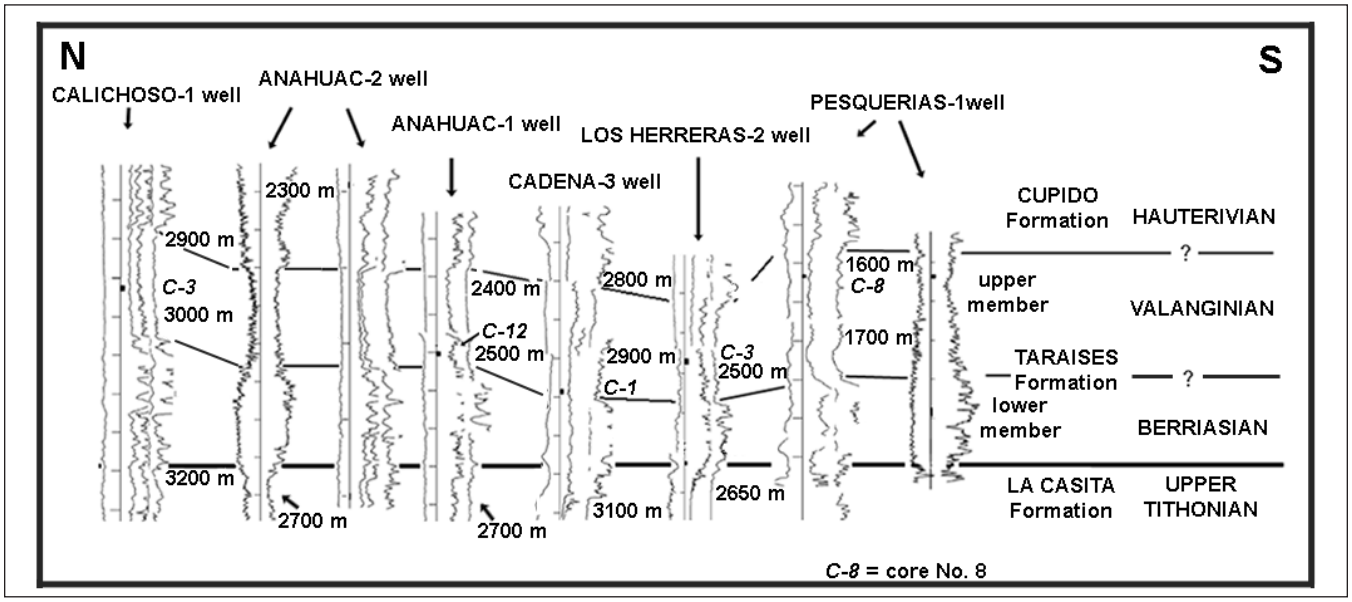

Figure 4. Cross section of the Taraises Formation (Lower Cretaceous) in oil wells in northeastern Mexico, according to radioactivity and electric logs. Stratigraphic datum is top of Tithonian.

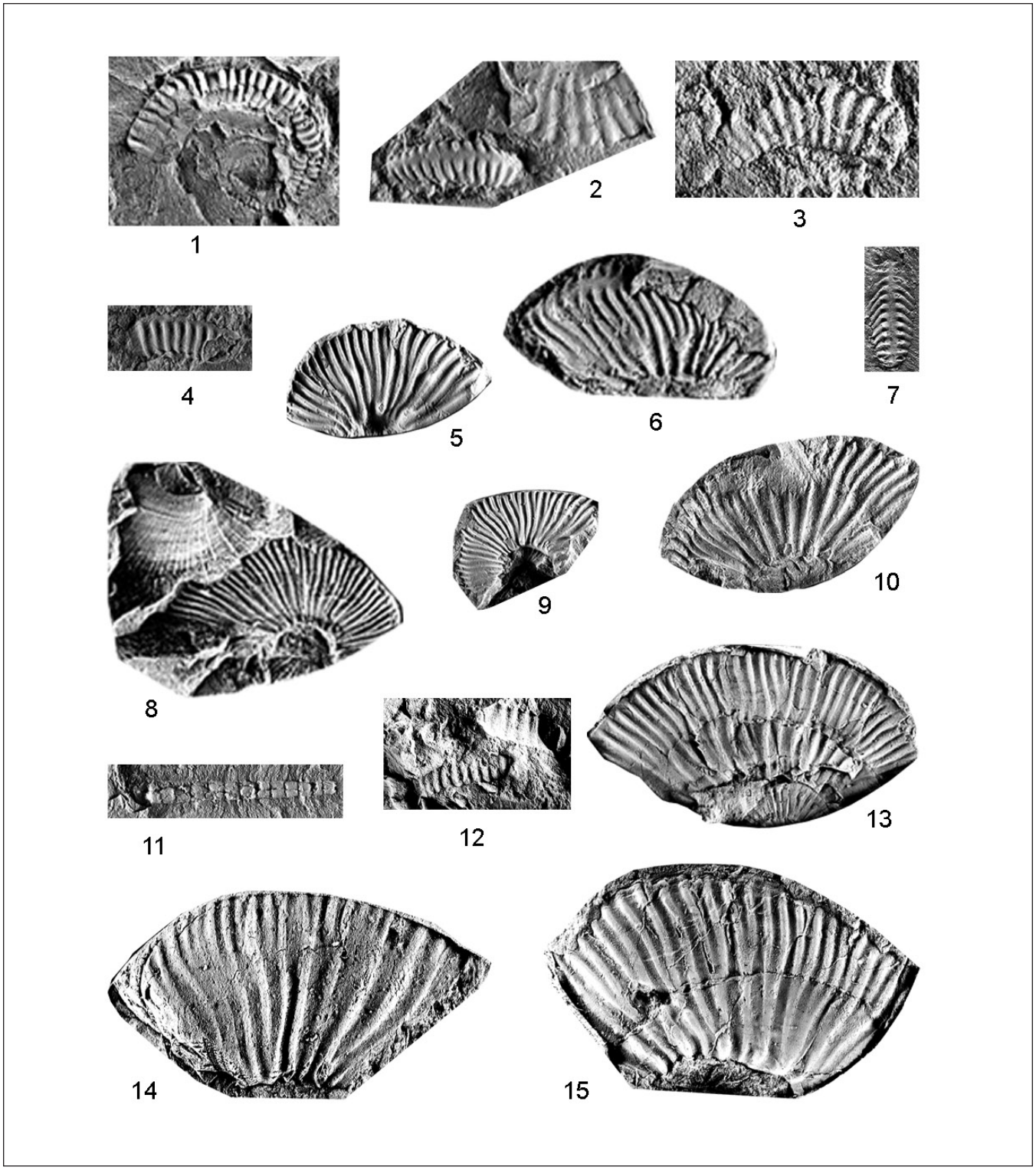

Figure 5. 1. *Bejucoceras simplecostatum* Cantú-Chapa, Anahuac-1 well, core 12 (2499-2503 m), Escuela Superior de Ingenieria y Arquitectura (ESIA)-1032; 2. *Bejucoceras* sp., Cadena-3 well, core 1 (2940-2946 m), ESIA-1033; 3, 4. *Bejucoceras* sp., San Javier-2 well, core 14 (3120-3124 m), ESIA-1034, ESIA-1035; 5, 8, 10. *Neocomites* sp., San Javier-2 well, core 14 (3120-3124 m), 5.8 contains a fragmented pelecypod, ESIA-1036, ESIA-1037, ESIA-1038; 6. Neocomitinae, Anahuac-1 well, core 12 (2499-2503 m), ESIA-1039; 7. Neocomitinae, ventral region, San Javier-2 well, core 14 (3120-3124 m), ESIA-1040; 9. *Neocomites* sp., Cadena-3 well, core 1 (2940-2946 m), ESIA-1041; 11, 12. *Bochianites* sp., Anahuac-5 well, core 6 (2452-2463 m), Los Herreras-2 well, core 3 (2479-2484 m), ESIA-1042, ESIA-1043; 13. Neocomitinae, Los Herreras-2 well, core 3 (2479-2484 m), ESIA-1058; 14, 15. cf. *Sarasinella* sp., Anahuac-1 well, core 12 (2499-2503 m), ESIA-1044, ESIA-1045. Age: Taraises Formation upper member (upper Valanginian), northeastern Mexico. All specimens are x 2.

direction of the ventrolateral tubercle characterizes this last genus (Thieuloy, 1971), which is now dated by the top of the lower Valanginian to the base of the upper Valanginian (Kemper et al., 1981).

The Mexican *Bejucoceras* was recently considered to be *Aegocrioceras* Spath (1924) of the lower Hauterivian from Europe by Wright et al. (1996). This last genus has simple ribs that cross transversely the ventral region (Kemper, 1992; Rawson, 1975). The genera differ by their ventral ribbing and age, which justifies separating them. *Bejucoceras* Cantú-Chapa, 1976, must be recognized as a Valanginian genus, as its smooth midventral band distinguishes it from the lower Hauterivian *Aegocrioceras* (Kemper et al., 1981). *Bejucoceras simplecostatum* Cantú-Chapa (1976, p. 65) must be conserved as the type species of *Bejucoceras*. *P. anahuasensis* (Cantú-Chapa, 1963) of the Anahuac-1 well (core 12), is here considered as a synonym of *B. simplecostatum* Cantú-Chapa, 1976.

Bejucoceras (Figure 5.2) is present in the upper member of the Taraises Formation (as it is found in cores from the three oil-wells studied here). It is associated with *Neocomites* sp. (Figure 5.9) and *Karakaschiceras* sp. (Figure 6.6) in the Cadena-3 well (core 1, 2940-2946 m). *Bejucoceras* sp. (Figure 5.3) is also associated with *Neocomites* sp. (Figure 5.5 and 5.8) and *Olcostephanus* sp. (Figure 6.10) in the San Javier-2 well (core 14, 3120-3124 m); a pelecypod fragment is present in the last core (Figure 5.8). *B. simplecostatum* Cantú-Chapa (Figure 5.1) was found associated with *Bochianites* sp. (Cantú-Chapa, 1963), and cf. *Sarasinella* sp. in the Anahuac-1 well (core 12, 2499-2503 m) (Figures 5.14 and 5.15).

Other Ammonites of the Taraises Formation from Oil Wells in Northeastern Mexico

Three ammonite groups were found in the upper member of the Taraises Formation in oil wells of northeastern Mexico: heteromorphs (*Bejucoceras* and *Bochianites*), neocomitins, and olcostephanins. They allow the Taraises Formation to be dated as Valanginian.

Heteromorph Ammonites

Bejucoceras has been studied previously. *Bochianites* sp. (Cantú-Chapa, 1963, Plate I, Figure 6, p. 29) was found in Anahuac-1 well (core 12), in the Anahuac-5 well (core 6, 2452-2463 m) (Figure 5.11), and the Los Herreras-2 well (core 3, 2479-2484 m) (Figure 5.12). *Bochianites* was studied by Young (1988) in the Taraises Formation in northeastern Mexico.

Neocomitins

Fragmented and involute ammonites are here assigned to *Neocomites* sp. because of their fine, sigmoidal ribs irregularly dividing at the umbilical bullae and in the middle of the flanks (Figure 5.5 and 5.10). They were found in the upper member of the Taraises Formation (Figures 3 and 4) and are associated with *Karakaschicheras* sp. in the San Javier-2 well (core 14). *Neocomites* sp. was also found in the Cadena-3 well (core 1) (Figure 5.9). Our specimens resemble *N. acuticostatus* Imlay (1937, p. 580, Plate 10, Figure 2) with their fine ribbing and irregular division of ribs.

Fragmented specimens of neocomitins were found from the base to the top of the upper member of the Taraises Formation in the Cadena-3 well (core 1) (Figure 6.1 and 6.4) and in the Anahuac-4 well (core 6, 2372-2378 m) (Figure 6.2). Their fine, sigmoidal ribs finishing in ventrolateral bullae and the narrow, flattened, and smooth venter allow identification of these specimens as neocomitins. Two tabulate, smooth ventral regions probably belonging to neocomitins were found in the upper member of the San Javier-2 well (core 14, 3120-3124 m) and Anahuac-4 well (core 6, 2372-2378 m) (Figures 5.7 and 6.5).

Karakaschiceras. Some neocomitins in Mexico were described as *Leopoldia* (Cantú-Chapa, 1976; Contreras, 1977; Imlay, 1938; Peña-Muñoz, 1964) or as *Karakaschiceras* Young (1988). One of them, from Samalayuca, Chihuahua, northern Mexico, was erroneously assigned to *Karakaschiceras* (Young, 1988, Plate 1, Figure 3) (compare Young, 1969); it represents a lower Kimmeridgian *Idoceras* (Cantú-Chapa, 1970).

Two compressed and involute specimens with attenuated ribbing in the middle part of the flanks and a smooth siphonal band were obtained from the studied oil wells. The ribs terminate in a small, ventrolateral radial node. Specimens appear to be somewhat similar to *K. victoriensis* (Imlay, 1938, p. 581, Plate 12, Figures 1, 2) in their lateral and ventrolateral ribbing and whorl section. However, the fragmented preservation does not permit their specific identification, although the ornamentation and presence of the siphonal smooth band permit a generic identification. They were found at the base and top of the upper member of the Taraises Formation in the Anahuac-4 well (core 6, 2372-2378 m) (Figure 6.3) and the Cadena-3 well (core 1, 2940-2946 m) (Figure 6.6).

Sarasinella. Two fragmented and slightly evolute specimens have slightly sigmoidal ribs that are bifurcated at the middle of the sides, some of them starting at a pair of umbilical bullae. The ventral side is not visible (Figure 5.14 and 5.15). The specimens resemble *Sarasinella trezanensis* Lory *in* Baumberger (1923, p. 307, Plate VIII, Figures 2-4) in their lateral ornamentation. Both specimens were found at the base of the upper member of the Taraises Formation in the Anahuac-1 well (core 12, 2499-2503 m). The specimen of Figure 5.15 was determined as *Substeueroceras*? *imlayi* Cantú-Chapa (1963, p. 40, Plate III, Figure 3); it is here assigned as cf. *Sarasinella* sp. because of its ribbing.

One fragmented and crushed specimen was obtained from the Los Herreras-2 well (core 3, 2479-2484 m). It is evolute, and its ribs are bifurcated at the middle of the flank and originate in the umbilical area. Its state of preservation does not allow observation of the umbilical bullae, as only one rib shows this structure (Figure 5.13). This specimen resembles cf. *Sarasinella* sp. of the Anahuac-1 well (Figure 5.15); it is here considered a neocomitin. It was found in the same core associated with a *Bochianites* sp. (Figure 5.12).

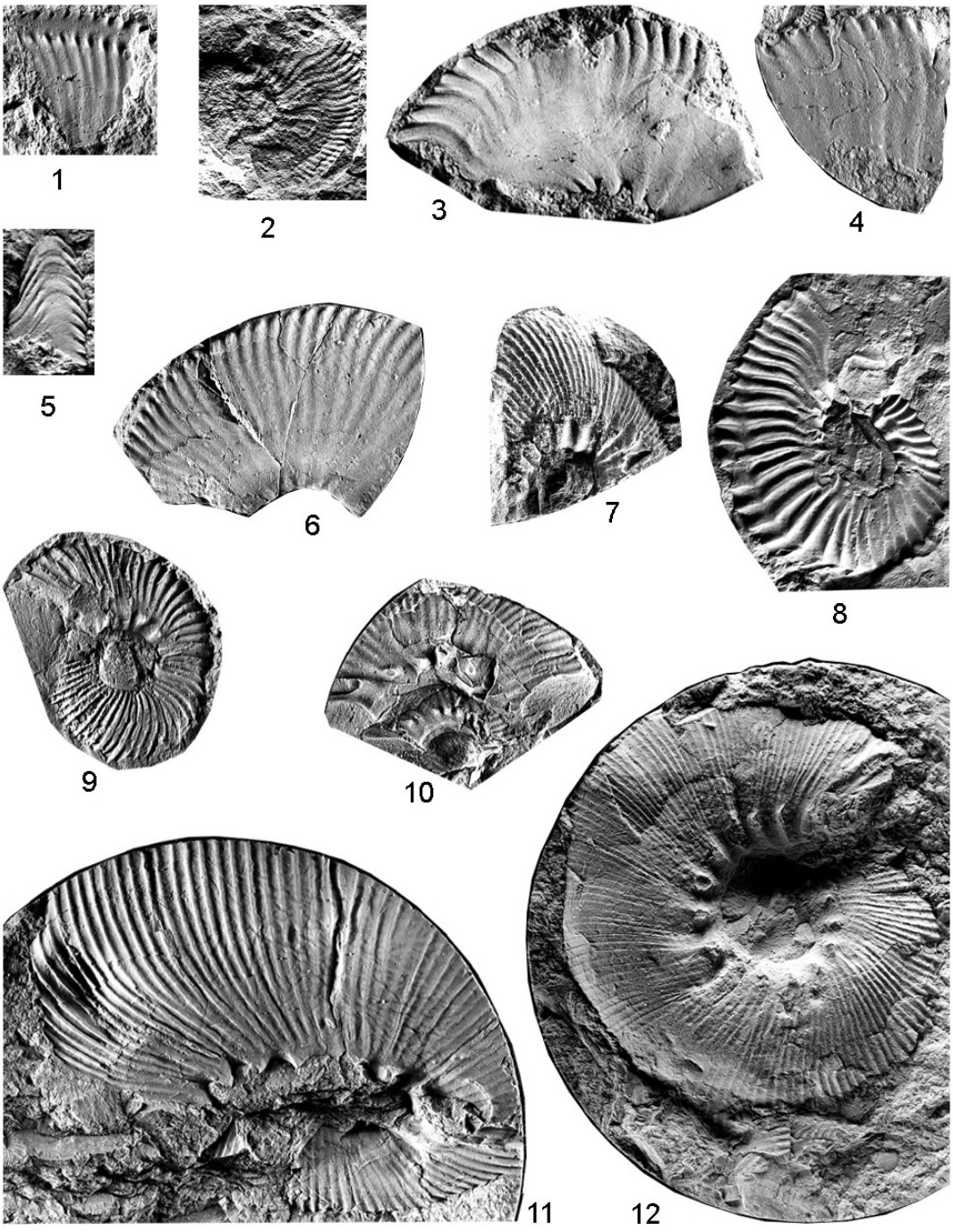

Figure 6. 1, 4. Neocomitinae, Cadena-3 well, core 1 (2940-2946 m), ESIA-1046, ESIA-1047; 2. Neocomitinae, Anahuac-4 well, core 6 (2372-2378 m), ESIA-1048; 3. *Karakaschiceras* sp., Anahuac-4 well, core 6 (2372-2378 m), ESIA-1049; 5. Neocomitinae, ventral region Anahuac-4 well, core 6 (2372-2378 m), ESIA-1050; 6. *Karakaschiceras* sp., Cadena-3 well, core 1 (2940-2946 m), ESIA-1051; 7. *Olcostephanus* sp., Pesquerías-1 well, core 8 (1615-1619 m), ESIA-1052; 8, 9. *Taraisites* sp., Calichoso-1 well, core 3 (2960-2967 m), ESIA-1053, ESIA-1054; 10. *Olcostephanus* sp., San Javier-2 well, core 14 (3120-3124 m), ESIA-1055; 11. *Olcostephanus* sp., Calichoso-1 well, core 3 (2960-2967 m). ESIA-1056; 12. *Olcostephanus* sp., Anahuac-5 well, core 6 (2452-2463 m), ESIA-1057. Age: Taraises Formation upper member (upper Valanginian), northeastern Mexico. All specimens are x 1.

One fragmented and evolute specimen from the Anahuac-1 well (core 12) was previously determined to be *Protacanthodiscus* sp. (Cantú-Chapa, 1963, p. 41. Plate III, Figure 1) (Figure 5.6). Some ribs are irregularly trifurcate at the middle of the flanks from a tubercle, while others are simple and intercalated; all finish at the ventrolateral edge, and a smooth siphonal band is present. This ammonite should not be identified as *Protacanthodiscus*. Its stratigraphic position is in a core from the Lower Cretaceous Taraises Formation. Constrictions were not observed that could identify it as *Kilianella*. It must, therefore, be considered as a neocomitin.

Taraisites and Olcostephanus and Concepts of Sexual Dimorphism in Systematic Paleontology of Ammonites

These two genera are present in the Calichoso-1 (core 3, 2960-2967 m), San Javier-2 (core 14, 3120-3124 m), and Pesquerías-1 (core 8, 1615-1619 m) wells herein studied (Figures 3, 4, and 6.7-6.12). Their systematic position is discussed as follows:

The genus *Taraisites* was proposed by Cantú-Chapa (1966), with its type species *Taraisites bosei* Cantú Chapa, 1966, a species from north-central Mexico described as *Astieria* aff. *Baini* Sharpe, 1856, by Böse (1923, Plate II, Figures 3-6). According to Cantú-Chapa (1966), attribution of this specimen to the genus *Rogersites* (*Olcostephanus* Neumayr, 1875) was erroneous (Imlay, 1937); its features do not agree with the definition of the latter genus. It differs from its type species by its ribbing and whorl section.

Taraisites is a form with two or three secondary and sharp ribs coming from the periumbilical tubercles; they are convex on the flanks and widely spaced on the ventral region. Its whorl section is compressed. Some species have a coiled scaphitoid. *Olcostephanus* is an inflated and involute form, with a dense secondary ribbing coming from the periumbilical tubercles.

Taraisites was not accepted by Riccardi et al. (1971), based on the following terms: "No proper consideration was given to growth stage and morphologic variation which were presumably known to Imlay (1938). Cantú-Chapa omitted the critical evidence that the small paratypes differ from the inner whorls of the large holotypes. . . ." Riccardi et al. (1971) discarded *Taraisites* because of subjective considerations, assuming it to be a different genus from *Olcostephanus*. To this author, the first genus represents a microconch of *Olcostephanus* because of supposed sexual dimorphism. When peristomal lappets and parabolic constrictions are preserved, specimens are implicitly considered as microconch forms.

The arguments of Riccardi et al. (1971) about dimorphic forms in *Olcostephanus* were taken by Cooper (1981), who divided it into four categories based on the dimorphic concepts: macroconchs, microconchs, immature macroconchs, and juvenile forms. Cooper described the first two categories, according to a detailed world study of *Olcostephanus* species. They were not referred to stratigraphic sections.

The classification of *Olcostephanus* species proposed by Cooper (1981) is based on some morphologic characteristics when they happened to be preserved in the form of parabolic constriction and peristomal lappets, thus allowing him to consider them as microconch specimens of the same species. The dimorphic characters in a given species represent a myth in the systematic of ammonites implemented with subjective bases, as indicated by several authors who favor the following concepts:

- "the majority of specimens appears to be macroconchs, specimens . . . are probably microconchs. . . . The dimorphic relationship of the microconch is, therefore, somewhat questionable. . . .¨ (Verma and Westermann, 1973, p. 212, 220).
- "Some macroconchs do not have their equivalent microconchs. . . . There are not enough dimorphic couples established to use them in the systematics of species. . . ." (Enay, 1966, p. 581).
- "The reality of the sexual dimorphism is currently admitted by numerous researchers . . . but . . . in the perisphinctid ammonites it is always difficult to recognize the microconchs if their lappets are not preserved. . . . (Cecca, 1986).

Researchers have expressed different opinions about how to establish the systematic of ammonite dimorphism:

- Place all microconchs specimens in a subgenus (Atrops, 1982).
- Consider certain heteromorph genera of different ages as microconchs because of their small size (Rawson, 1975, p. 138).
- Point out that "the identification of two dimorphic specimens is very difficult, below a certain diameter where the characters are the same. . . ." (Cecca, 1986).
- Some difficulties exist in separating specimens into microconchs and macroconchs (Brochwicz-Lewiński and Rozak, 1976).

The Mexican olcostephanid specimens studied by Imlay (1937) are conserved at the University of Michigan under different numbers. Imlay never indicated that small forms correspond to the first whorls of shell from the same specimen, as was suggested by Riccardi et al. (1971), who determined *Taraisites* to be a synonym of *Olcostephanus*.

Olcostephanid specimens of similar sizes studied here have two sorts of ribbing: (1) A dense ribbing arising from periumbilical tubercles identifies *Olcostephanus*, from the Pesquerías-1 well (core 8, 1615-1619 m) (Figure 6.7), and (2) two or three coarse ribs beginning from a periumbilical tubercle identify *Taraisites huizachense* Cantú-Chapa (1972, p. 88, Plate 1, Figure 6), from the Calichoso-1 well (core 3, 2960-2967 m) (Figure 6.8).

Two large specimens of *Olcostephanus* were found in the Calichoso-1 well (core 3, 2960-2967 m) and in the Anahuac-5

well (core 6, 2452-2463 m) (Figure 6.11 and 6.12). One of them, which is crushed, shows the last umbilical tubercles, from where some fine ribs arise (Figure 6.11). The other one is involute and shows 15 umbilical ribs that terminate in acute and radially elongated tubercles (Figure 6.12). From the tubercles, bundles of five or six very fine ribs arise. This last specimen is somewhat similar to *Olcostephanus bakeri* (Imlay, 1937, p. 560, Plate 70, Figure 1). Our specimen differs by its smaller number of umbilical tubercles and by its finer ribs.

AGE OF THE TARAISES FORMATION IN THE SUBSURFACE OF NORTHEASTERN MEXICO

No ammonites were found in the lower member of the Taraises Formation in the subsurface of northeastern Mexico. The age of this member can be inferred by its stratigraphic position, because it overlies the Tithonian La Casita Formation (Cantú-Chapa, 1999).

However, two groups of ammonites were found in different oil wells from base to top in the upper member of the Taraises Formation. The *Bejucoceras-Sarasinella* association was found in the first 10 m of the upper member in the Anahuac-1 well (core 12, 2499-2503 m), San Javier-2 well (core 14, 3120-3124 m), and Cadena-3 well (core 1, 2940-2946 m) (Figures 3 and 4).

The second group, consisting of *Karakaschiceras* and *Olcostephanus,* was found in the last 60 m before the top of the upper member in the Calichoso-1 well (core 3, 2960-2967 m), Pesquerías-1 well (core 8, 1615-1619 m), Anahuac-4 well (core 6, 2372-2378 m), and Anahuac-5 well (core 6, 2452-2463 m) (Figures 3 and 4).

From subsurface data, there is no biostratigraphic evidence to separate the Berriasian from the lower Valanginian base or to indicate the top of the upper Valanginian deposits in the Taraises Formation. The last two stratigraphic levels are defined by the European *otopeta* and *callidiscus* zones.

The *Bejucoceras-Sarasinella* association can be assigned to the lower Valanginian (*pertransiens* zone) after European chronostratigraphy and stratigraphic position. *Sarasinella* is found in the lower and upper Valanginian rocks of southeastern France (Bulot and Thieuloy, 1993; Bulot et al., 1992; Thieuloy and Bulot, 1992). *Neocomites* shows a similar stratigraphic distribution; it is also known from the base of the lower Hauterivian strata in France and Spain (Company, 1987; Bulot and Thieuloy, 1993).

The *Karakaschiceras-Olcostephanus* association is found at the top of the upper member of the Taraises Formation. *Karakaschiceras* is known only at the lower-upper Valanginian boundary in Europe. Kutek et al. (1989) studied two groups of Valanginian *Karakaschiceras* species in central Poland, but they are separated by a hiatus. A similar distribution of this fossil is observed in the Valanginian rocks in southeastern France (Bulot et al., 1992). This fossil could be assigned to the upper Valanginan base (European *verrucosum* zone), and it overlies the *Bejucoceras-Sarasinella* association in the upper member of the Taraises Formation in the subsurface. *Olcostephanus* has a wide stratigraphic distribution; it is known from the Valanginian to the lower Hauterivian (Autran, 1989; Bulot et al., 1992).

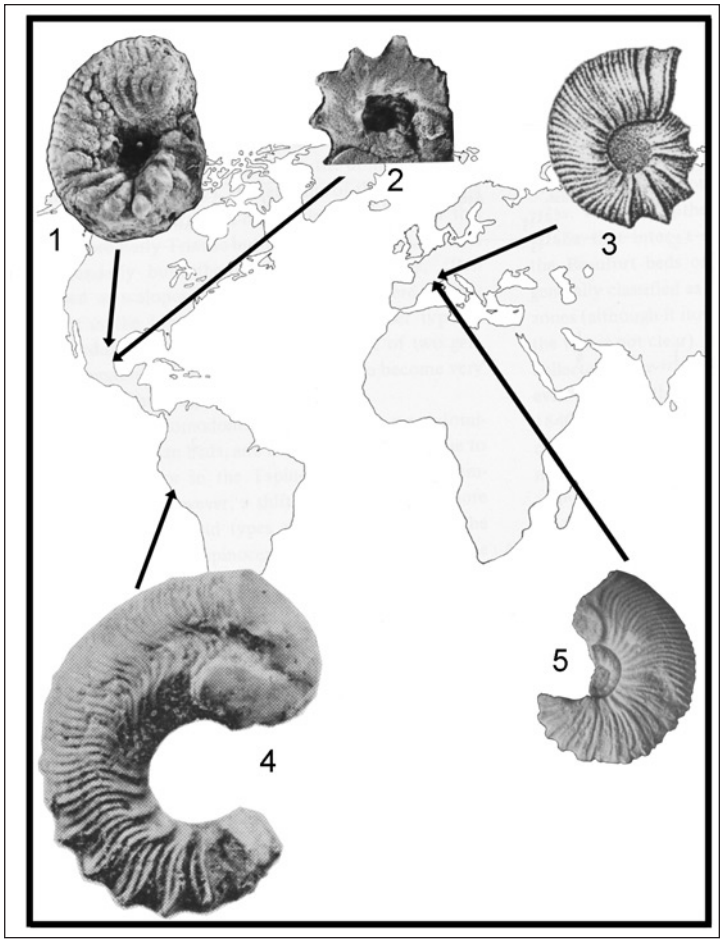

Figure 7. Biogeographic distribution of *Capeloites* (1, 2, 3-5) of the upper Valanginian from France, Peru, and Mexico; after Lissón (1937), Thieuloy (1969), Matheron (1878), and this work. All specimens are x 1.

It is herein considered that the upper member of the Taraises Formation in the subsurface of northeastern Mexico represents the boundary defined by the early-late Valanginian age (*pertransiens-verrucosum* zones), as is well defined with the two ammonite associations *Bejucoceras-Sarasinella* and *Karakaschiceras-Olcostephanus*.

NEW TARAISES FORMATION AMMONITES (UPPER VALANGINIAN) FROM THE POTRERO DE GARCÍA, NORTHEASTERN MEXICO

Dwarf ammonites from calcareous shales in the Taraises Formation at the Potrero de García were, until now, unknown. This locality is found on the southern flank of the El Fraile

anticlinal, 20 km northwest of Monterrey city, Nuevo León, in northeastern Mexico (Wilson and Ward, 1993) (Figure 1b). The ammonites permit the addition of important information to the regional biostratigraphy; we are able to update their international biogeographic distribution and to propose new systematic units.

Ammonites were collected by the writer and his family from the calcareous shales in the lower part of the upper member of the Taraises Formation; some of them are eroded. This member was dated as lower Hauterivian (Imlay, 1944) or upper Valanginian (Young, 1988). Ammonites are associated with dwarf echinoids, all preserved as pyritized internal molds.

ONE AMMONITE OF THE LA LAJA-8 WELL, EASTERN MEXICO

The La Laja-8 well, core 11 (2556-2562 m) provided a fragmented and negative ammonite mold from the micritic limestone of the Lower Tamaulipas Formation (Berriasian-lower Aptian) (Imlay, 1944). The La Laja-8 well was drilled south of the city of Tampico, eastern Mexico (Figure 2).

The position of the core in the compact, brown limestone of Lower Tamaulipas Formation (Lower Cretaceous) was established by the gamma-ray log, which shows a constant straight line. This formation is unconformably overlain by the Guayabal Formation shale (middle Eocene) (Figure 2). The La Laja-8 well is located in a syncline, which represents a major submarine erosional surface forming the Bejuco paleocanyon (Cantú-Chapa, 1987, 2001). The only negative mold of a small ammonite from the La Laja-8 well included in this study was provided by the Department of Subsurface Geology, PEMEX northern region in Tampico.

SYSTEMATIC PALEONTOLOGY

Subfamily OLCOSTEPHANINAE Haug, 1910
Genus *Capeloites* Lissón, 1937
Type species: *Capeloites larozai* Lissón, 1937, by original designation of Lissón (1937, p. 3, Plate I, Figure a).

Discussion. *Capeloites* was proposed by Lissón (1937) to characterize the dimorphic ornamentation present on the last whorl of small specimens collected by him in the El Cascajal, a locality near Lima, Peru. This genus was considered as a synonym of *Olcostephanus* by Arkell et al. (1957), although there is no similarity between them. Recently, Wright et al. (1996) included these two genera in the subfamily Olcostephaninae.

Worldwide distribution of *Capeloites* is known in France, Spain, and Peru (Autran, 1989; Lissón, 1937; Matheron, 1878; Thieuloy, 1969; Wilke, 1988) (Figure 7); its presence in Mexico adds a biogeographic link between these two hemispheres. Autran (1989) found *Capeloites* in the upper Valanginian in southeastern France, and Wilke (1988) collected it in the lower Hauterivian beds in Spain.

Capeloites neoleonense n. sp. (Figure 8.2, 8.2a, 8.3, 8.3a-c)

Diagnosis. Involute, compressed whorl section, tabulated to rounded venter. Three sorts of ornamentation; primary and close-together ribs arise on the umbilical margin in the last whorl. Prominent, rectiradiate, and large primary ribs end in lateral tubercles; coarse and distant ribs cross the tabulated venter in the adapical part. Lateral ribbing and tubercles produce bundles of two or three fine, dense, and sigmoidal secondary ribs that cross transversely the rounded venter in the middle part of the last whorl. Periumbilical, fine, rectiradiate primary ribs originate fine, secondary ribs crossing slightly forward of the rounded venter in the adoral part.

Discussion. The proposed *Capeloites neoleonense* n. sp. differs from *C. larozai* (Lissón, 1937), and *C. perelegans* (Matheron, *in* Thieuloy, 1969) in having a rectiradiate, close-together, coarse ribbing on the flanks; they are distant on the venter of the adapical part. *C. neoleonense* is also considered comparable to *A. perelegans* Matheron (1878), because of the similar coarse, rectiradiate, and prominent primary ribs in the adapical half of both species; however, there are no secondary ribs in the Mexican ammonite (Figure 7).

Capeloites hispanicus (Mallada, *in* Autran, 1989, p. 154, Plate 3, Figure 11; Plate 10, Figure 2) from France has three sorts of ornamentation and does not bear ventral tubercles in the adapical part of the last whorl as does *C. neoleonense*. However, the fine and dense secondary ribs are convex in the adoral part of the French specimens and radial in the Mexican ammonite (Figure 7).

Holotype. Specimen ESIA-1011 (Figures 8.2, 8.2a), two fragmented paratypes, ESIA-1012 (Figures 8.3, 3a-c), ESIA-1059 from the Potrero de García, northeastern Mexico (Figure 1b).

Etymology. The name *neoleonense* is taken from Nuevo León state, where the Potrero de García is located and where the specimens were collected.

Occurrence. The Potrero de García, northeastern Mexico, upper part of the lower member of the Taraises Formation (Lower Cretaceous). Measurements are in Table 1.

Capeloites sp. A (Figure 8.5, 8.5a-c.)

Material. One specimen (ESIA-1014); same locality as *C. neoleonense n. sp.* (Figure 1a).

Description. Dwarf and dimorphic shell with rounded sides and venter, whorl section depressed; the lateral tubercles produce two sorts of ribbing. Coarse ribs alternate with two weakly secondary ribs on the ventral region in the adapical part. Bundles of three or four fine, sigmoidal, and dense ribs arising from a midlateral tubercle cross transversely the broad venter in the adoral part.

Discussion. The proposed *Capeloites* sp. A differs from *Capeloites larozai* (Lissón, 1937), *C. perelegans* (Matheron, *in* Thieuloy, 1969), and *C. neoleonense* n. sp. by its midlateral and rounded tubercles that produce two sorts of ribbing and by its wide venter in the adoral part.

Table 1. Whorl measurements (in mm) of *Capeloites* species from Peru, France, and Mexico; after Lissón (1937), Thieuloy (1969), Autran (1989), and this work. D = whorl diameter, UD = umbilical diameter, U = UD/D.

Specimen	*D*	*UD*	*U*
PERU			
larozai	46	12.0	0.26
FRANCE			
perelegans	25	06.9	0.27
hispanicus	28.5	10.5	0.36
	25	09.5	0.38
MEXICO (Potrero de García)			
neoleonense n.sp.			
holotype, ESIA-1011	27	07.0	0.25
paratype, ESIA-1012	23	06.0	0.26
paratype, ESIA-1058	25	06.0	0.24
Capeloites sp. A			
ESIA-1014	23	-	-
Capeloites sp.	14	06.0	0.42
La Laja 8 well, ESIA-1016			

Occurrence. Same locality and formation as the previously described specimens.

Capeloites sp. (Figure 8.1)

Material. From the La Laja-8 well, southern Tampico District, eastern Mexico, a negative and small ammonite mold was obtained from core 11 (2556-2562 m) (ESIA-1016) (Figure 2).

Description. Dwarf, semievolute shell, dimorphic ornamentation in the last whorl; inclined umbilical wall, sides almost smooth; small periumbilical bullae, inclined slightly forward, and five prominent ventral spines, longitudinally elongated, very distant from one another in the adapical half. Ribs weakly sigmoid, inclined forward on the flank, ending in ventral bullae in the adoral half; a peristomal constriction is present.

Discussion. This specimen may be recognized by the prominence of the ventral spines, very distant from one another in the adapical part, and by its forward inclination of the weak sigmoid ribs near the peristome; this ornamentation contrasts with that of all species of *Capeloites* previously described. Percentage of the umbilicus/whorl diameter (U) varies from *larozoi* and *perelegans* of Peru and France (U = 0.26- 0.27) to *hispanicus* of France (U = 0.36-0.38) and *Capeloites* sp. of the La Laja-8 well of Mexico (U = 0.42) (after Autran, 1989; Lissón, 1937; Thieuloy, 1969; and this work) (Table 1).

Garcites n. gen.

Type species. *Garcites potrerensis* n. gen. and sp.

Diagnosis. Dwarf, involute, sphaerocone, moderately compressed to coronate whorl section; sides slightly subparallel to rounded; deep umbilicus with inclined wall; strong, rectiradiate, cuneiform, prominent, and very close-together primary ribs ending in lateral or ventrolateral tubercles, narrow intercostal spaces; rounded or tabulated venter crossed by distant or close-together, high, and simple ribs arising freely or joined to the tubercles. No suture line is observed. The name alludes to the Villa de García, where the specimens were collected (Figure 1b).

Discussion. *Garcites* n. gen. differs from the upper Valanginian olcostephanins, *Valanginites* (Kilian, 1910), and *Dobrodgeiceras* (Nikolov, 1963) by its ventral ribs separated by very large or moderate spaces, which arise from or in front of rounded and close-together lateral or ventrolateral tubercles. In the last two genera, bundles of three or four ribs arise from a tubercle. *Garcites* n. gen. differs from the last two genera mentioned by its fewer, prominent, large, cuneiform, and rectiradiate primary ribs terminating in tubercles and by its rounded or tabulated venter, not as broad as that of *Dobrodgeiceras* from Peru and *Valanginites* from Europe (Riccardi and Westermann, 1970; Kemper et al., 1981) (Figure 9).

Garcites is also distinguished from *Dobrodgeiceras* by having fewer large primary ribs (approximately 11-14 vs. 18-20 per whorl), and secondary ribs (approximately 12-14 vs. 52 per whorl) (Figure 9.1, 9.2, 9.4, 9.5). *Garcites* presents a simple sculpture, while all previously described Olcostephaninae genera are ornamented with primary ribs terminated in umbilical tubercles, from which arise bundles of some secondary ribs; they cross densely and transversely the ventral region without interruption, with the exception of *Mexicanoceras* (Imlay, 1938).

The absence of midventral tubercles in some *Dobrodgeiceras* specimens from Peru is not considered a special morphologic character that would join them with *Valanginites*; therefore, they persist as different genera (Riccardi and Westermann, 1970). To these authors, species of *Dobrodgeiceras* are separated by the tubercle position; they are lateral in the European specimens and ventrolateral in the Peruvian fossils (Figure 9.4, 9.5).

The secondary ribs arising from ventrolateral tubercles zigzag irregularly on the venter in the Peruvian specimens, but the European forms possess a straight ribbing across the venter (Figure 9.4a, 9.5a). The morphologic features of the two groups of upper Valanginian *Dobrodgeiceras* species are different. The

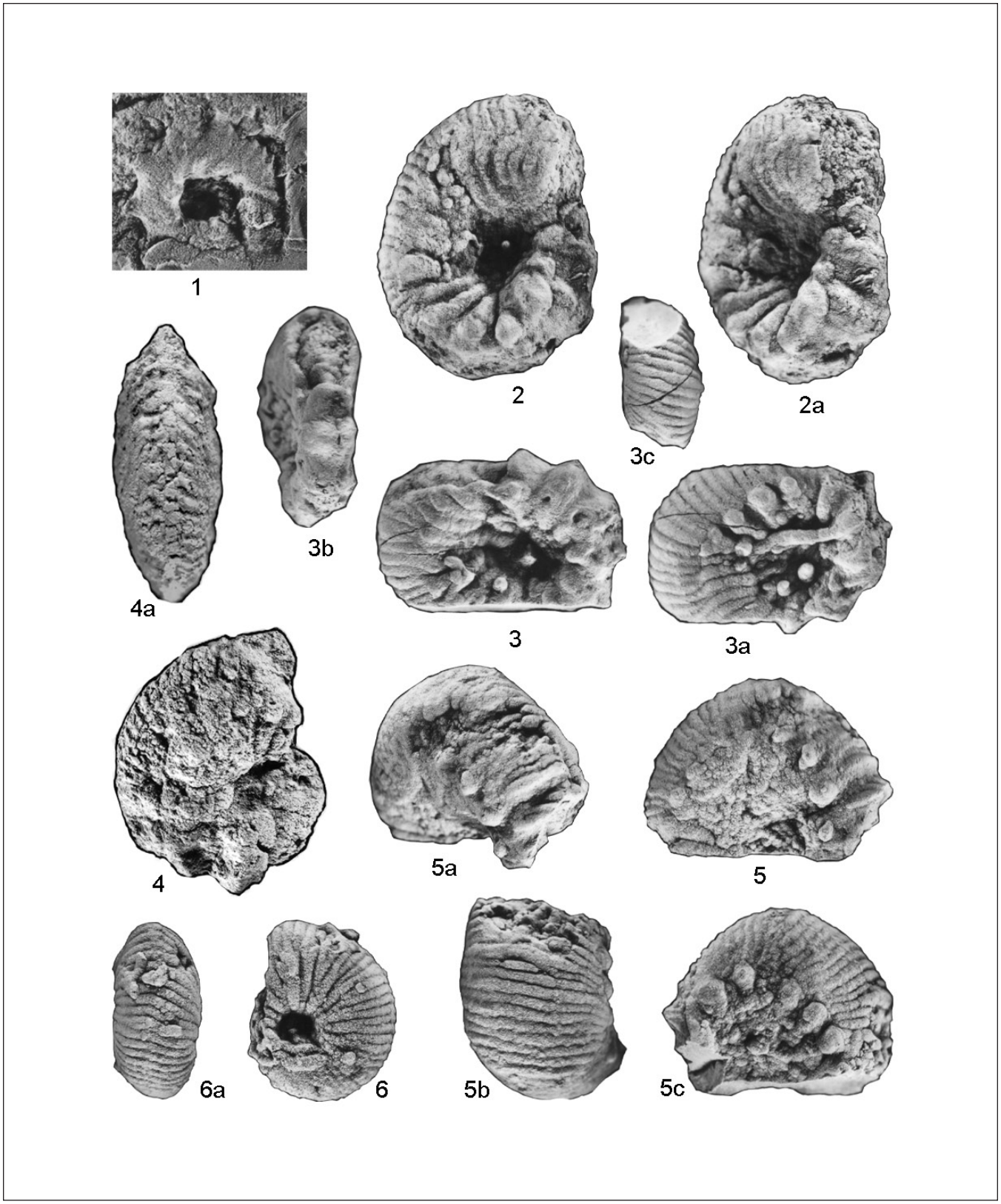

Figure 8. 1. *Capeloites* sp., latex replica of a fragmented specimen (ESIA-1016); 2, 2a, 3, 3a-c. *Capeloites neoleonense* n. sp.; 2, 2a, holotype (ESIA-1011); 3, 3a-c, paratype (ESIA-1012); 4, 4a. cf. *Karakaschiceras* sp. (ESIA-1031); 5, 5a-c. *Capeloites* sp. A (ESIA-1014). 6, 6a. *Dichotomites* (*Dichotomites*) sp., (ESIA-1028). Locality and age: All specimens except 8.1 are from the upper part of the lower member of the Taraises Formation (upper Valanginian), Potrero de García, northwest of Monterrey city, northeastern Mexico. Figure 8.1 is from the La Laja-8 well, core 11 (2556-2562 m), Tampico district, eastern Mexico. All specimens are x 2.

Peruvian forms are larger than the European ones (Figure 9.4a, 9.5a).

Garcites potrerensis n. gen. and sp. (Figure 10.1, 10.1a-b, 10.3, 10.3a)

Diagnosis. Dwarf, involute, sides flattened. Whorl section slightly wider than high, small and deep umbilicus with inclined wall. Eleven rectiradiate, low, wide, and cuneiform ribs, very close together, commencing on the umbilical shoulder and ending in ventrolateral tubercles; very narrow intercostal spaces on the sides; wide and slightly rounded to tabulated venter crossed by very distant, high, and slightly forward ventral ribs; they arise independently and are intercalated between two ventrolateral tubercles.

Discussion. The proposed *Garcites potrerensis* n. gen. and sp. differs from *Olcostephanus beticus* (Mallada, *in* Wilke, 1988, Plate 11, Figures 5a, b) of the upper Valanginian from southeastern Spain by its involute form, its rectiradiate and cuneiform ribs ending in ventrolateral tubercles, and its very distant and high ventral ribs. Percentage of the umbilicus/whorl diameter (U) varies from very involute (U = 0.12-0.13) in *D. wilfride ventrotuberculatum* (Nikolov, *in* Thieuloy and Gazay, 1967) and *D. broggianum* (Lissón, *in* Riccardi and Westermann,1970), from France and Peru, respectively, to relative evolute (U = 0.27-0.30) in *G. potrerensis* (Table 2).

Etymology. The name *potrerensis* is taken from the Potrero de García locality, where the specimens were collected. Holotype, specimen ESIA-1017 (Figure 10.1, 10.1a-b); paratypes, specimen ESIA-1018 (Figures 10.3, 10.3a), ESIA-1060 from the Potrero de García, northeastern Mexico (Figure 1b).

Garcites cavernensis n. gen. and sp. (Figure 10.6, 10.6a, 10.7, 10.7a)

Diagnosis. Dwarf, involute, depressed, and coronate shell. Small and deep umbilicus with inclined wall. Wide and rounded venter, and inclined sides toward the umbilical area. Fourteen large, rectiradiate, cuneiform, and close-together primary ribs commencing on the umbilical wall, ending in ventrolateral tubercles and separated by narrow intercostal spaces. Coarse ventral ribs arise in front of each tubercle, pass straight across the rounded and wide venter, and are separated by spaces as large as the width of the ribs.

Discussion. The proposed *Garcites cavernensis* n. gen. and sp. differs from *G. potrerensis* by its ventral ribbing—the intercostal spaces are as large as the ribs. Ventral ribs are separated by very large spaces in *G. potrerensis*.

Etymology. It is herein proposed that *G. cavernensis* should keep this name, derived from the locality where it was collected near García Cavern, Potrero de García, northeastern Mexico.

Occurrence. Same locality and formation as the previously described specimens. Holotype: specimen ESIA-1025 (Figures 10.6, 10.6a); two paratypes—specimen ESIA-1026 (Figures 10.7, 10.7a) and ESIA-1061; same locality as the previously described specimens (Figure 1b). Measurements are in Table 2.

Garcites sp. A (Figure 10.2, 10.2a, 10.2b, 10.4, 10.4a-b)

Material. Two elliptically coiled specimens (ESIA-1020, ESIA-1021), same locality as the previously described speciman (Figure 1b); their adapical halves are flattened without sides and primary ribs, as if they were crushed, probably by posthumous compression.

Table 2. Whorl measurements (in mm) of *Garcites* n. gen., *Dichotomites* sp., and *Karakaschiceras* sp. from Mexico; *Dobrodgeiceras* from Peru and France (Riccardi and Westermann, 1970; Thieuloy and Garzay, 1967), and *Dichotomites* from France (Thieuloy, 1977). D = whorl diameter, UD = umbilical diameter, U = UD/D.

Specimen	*D*	*UD*	*U*
Garcites potrerensis n. gen. and sp. holotype, ESIA-1017 (holotype)	14.8	4	0.27
ESIA-1018	23.6	7	0.30
Garcites cavernensis n. gen. and sp. ESIA-1025 (holotype)	18.7	3.6	0.19
ESIA-1026	15.7	3.6	0.22
Garcites sp. A. ESIA-1020	19.7	4.3	0.22
EISA-1021	20.8	5.1	0.24
Dobrodgeiceras broggianum (Lissón)	34.6	4.5	0.13
FRANCE *D. wilfridi ventrotuberculatum* (Nikolov)	25.6	3.2	0.12
MEXICO *Dichotomites* (*Dichotomites*) sp. ESIA-1028	17.3	2.6	0.15
cf. *Karakaschiceras* sp ESIA-1031	23.0	3.6	0.15
FRANCE: *Dichotomites* (*D.*) *vergunnorum* Thieuloy	26.2	7.8	0.30

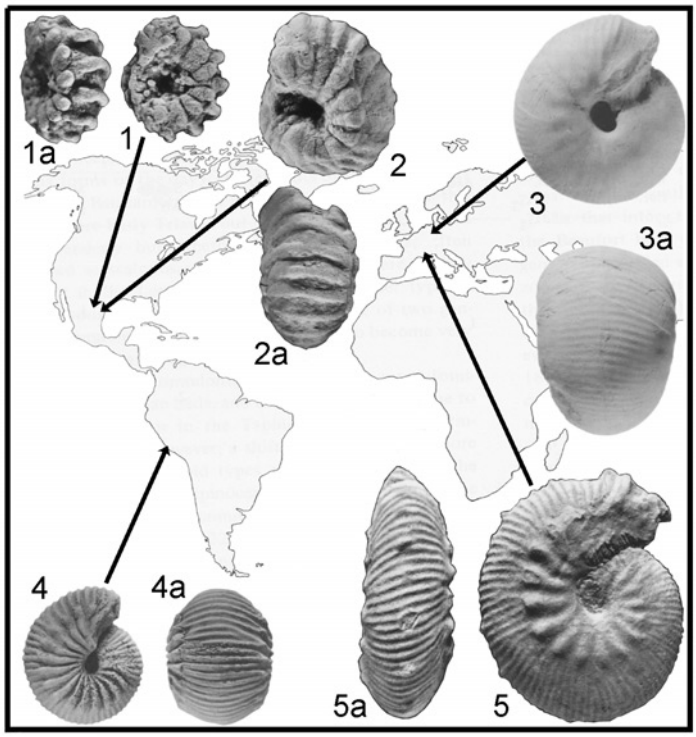

Figure 9. Biogeographic distribution of *Garcites* n. gen. (1-2), *Valanginites* (3), and *Dobrodgeiceras* (4-5) of the upper Valanginian from France, England, Peru, and Mexico, after Kemper et al. (1981), Riccardi and Westermann (1970), Thieuloy and Gazay (1967), and this work. All specimens are x 1.

Description. Adoral part with depressed whorl section, sides flattened; rectiradiate, large, cuneiform, and close-together primary ribs ending in ventrolateral tubercles; slightly rounded venter crossed by distant ribs borne freely in front of the tubercles. Adapical part flattened with only coarse, right, and ventral ribs.

Discussion. The proposed *Garcites* sp. A has similar ornamentation on the adoral part to *Garcites potrerensis*, but it differs by its crushed adapical part that conserves only ventral ribs.

Occurrence. Same locality and formation as the previously described specimen. Measurements are in Table 2.

Garcites sp. (Figures 10.5, 10.5a)

Description. Involute, dwarf shell, deep umbilicus, rounded venter, and compressed whorl section; rectiradiate, large, and close-together primary ribs separated by narrow intercostal spaces on the umbilical area; they finish in lateral tubercles; ribs are separated by wider interspaces on the venter.

Discussion. The proposed *Garcites* sp. is similar to *Garcites potrerensis* n. gen. and sp. in its ventral ribbing separated by large spaces, but it differs in its compressed whorl section (Figure 10.5, 10.5a).

Material. One eroded specimen (ESIA-1022); same locality as the previously described specimens (Figure 1b). Measurements are in Table 2.

Family POLYPTYCHITIDAE Wedekind, 1918
Genus *Dichotomites* Koenen, 1909

Dichotomites (Dichotomites) sp. (Figure 8.6, 8.6a)

Material. One specimen (ESIA-1028) from the Potrero de García, northeastern Mexico (Figure 1b); concretional structures are added to the shell. Two small, fragmented specimens are covered by calcareous material at the umbilical part (ESIA-1029, ESIA-1030).

Description. Small, involute, and compressed shell; narrow, deep umbilicus with vertical umbilical well; suboval whorl section slightly higher than wide; slightly flat sides and rounded venter; fine and rectiradiate ribs freely start on the rounded umbilical shoulder; some of them are irregularly bidichotomous at the middle of the sides, alternating irregularly with bifurcate ribs; fine intercostal spaces; 27 secondary ribs in the adoral half of the last whorl cross slightly forward on the ventral region.

Discussion. *Dichotomites* (*Dichotomites*) sp. might be a juvenile form; because of a difference in size, it could not be compared with the two large species from the upper Valanginian of eastern and northeastern Mexico, *Dichotomites* (*Dichotomites*) *compressiusculus* (Imlay, 1938) and *Dichotomites* (*Dichotomites*) *mantarraiae* Cantú-Chapa (1990).

Thieuloy (1977) described small specimens of *Dichotomites* (*Dichotomites*) *vergunnorum* Thieuloy (1977, Plate 7, Figures 2-8, p. 418) from the upper Valanginian of southeastern France. They are more evolute than our specimen and have a greater number of ribs in the external half of the last whorl, 42 in the French specimen versus 27 in the Mexican *Dichotomites* (*Dichotomites*) sp. Measurements are in Table 2.

Family NEOCOMITIDAE Salfeld, 1921
Genus *Karakaschiceras* Thieuloy, 1971
Type species. *Hoplites biassalensis* Karakasch, 1889, p. 435, Plate 1, Figures 4-5, by original designation of Thieuloy (1971, p. 229).

cf. Karakaschiceras sp. (Figure 8.4, 8.4a)

Material. An eroded specimen (ESIA-1031) from the Potrero de García, northeastern Mexico (Figure 1b). The ornamentation is preserved only in the outer part of the sides and on the ventral region. Measurements are in Table 2.

Description. Compressed, involute, small shell; whorl section much higher than wide, subparallel sides, narrow and tabulated venter; slightly convex fine ribs in the middle, external sides; intercostal spaces narrower than ribs.

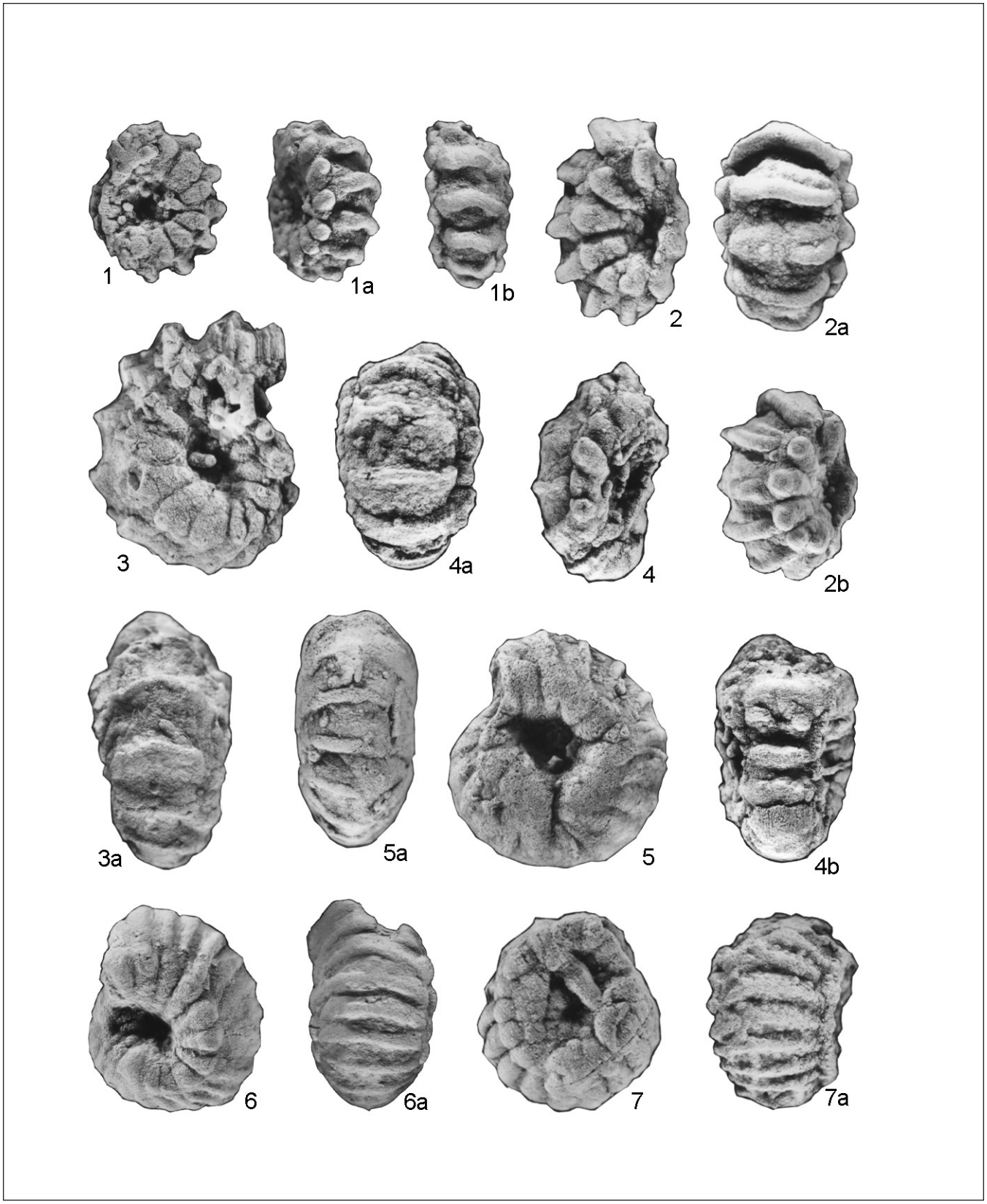

FIGURE 10. 1, 1a-b, 3, 3a. *Garcites potrerensis* n. gen. and sp.; 1, 1a-b, holotype (ESIA-1017); 3, 3a, paratype (ESIA-1018). 2, 2a, 2b, 4, 4a-b. *Garcites* sp. A (ESIA-1020, ESIA-1021). 5, 5a. *Garcites* sp. (ESIA-1022). 6, 6a, 7, 7a. *Garcites cavernensis* n. gen. and sp.; 6, 6a, holotype (ESIA-1025); 7, 7a, paratype (ESIA-1026). Locality and age: All specimens are from the upper part of the lower member of the Taraises Formation (upper Valanginian), from the Potrero de García, northwest of Monterrey City, northeastern Mexico. All specimens are x 2.

Discussion. This eroded and involute specimen is preserved in calcareous concretions in the middle, internal part of the sides; its ribbing is preserved only in the outer part of the sides and in the ventral region of the adoral half of the whorl. It is assigned to *Karakaschiceras* sp. by its tabulated venter and by its radial ribs, which slightly thin along the midventral region. Some species of *Karakaschiceras* from northeastern Mexico were studied by Imlay (1938) and by Young (1988); they are better preserved than the specimen described above.

Occurrence. Same locality and formation as the previously described specimens.

AGE OF THE AMMONITES FROM THE POTRERO DE GARCÍA

Capeloites and *Garcites* are predominant in the ammonite association collected from the lower part of the upper member of the Taraises Formation, approximately 100 m below the upper contact with the Cupido Formation (upper Hauterivian-lower Aptian; Imlay, 1944), from the Potrero de García, 20 km northwest of Monterrey, northeastern Mexico (Figure 1b). *Capeloites* was found in the upper Valanginian from southeastern France (Autran, 1989) and in the lower Hauterivian from Spain (Wilke, 1988); the exact age of this genus is still uncertain in Peru (Lissón, 1937). *Garcites* is a closely related form of *Dobrodgeiceras*, which was found at the base of the upper Valanginian, zone of *verrucosum*, in France (Thieuloy and Gazay, 1967; Thieuloy, 1977). The age of *Dobrodgeiceras* specimens from Peru was documented only as "upper Valanginian" by Riccardi and Westermann (1970).

Ammonites from the Potrero de García are associated with three small specimens of *Dichotomites* (*Dichotomites*) and one eroded specimen of *Karakaschiceras*. The age of *Dichotomites* is restricted to the upper Valanginian base in Germany (Kemper, 1978; Kemper et al., 1981) or to the zone of *trinodosum* (upper Valanginian), in the French small specimens studied by Thieuloy (1977). The age of *Karakaschiceras* is presently being discussed. It is placed at the lower-upper Valanginian boundary (*campylotoxus-verrucosum* zones) in France, Germany, and Poland (Bulot and Thieuloy, 1993; Kemper et al., 1981; Kutek et al., 1989) or at the upper Valanginian base (Kemper, 1992). Because of the cf. *Karakaschiceras-Dichotomites-Garcites* association, the Mexican ammonites here described could belong to the base of the upper Valanginian, as it is known in the Mediterranean area (Hoedemaeker et al., 1993).

AGE OF THE *CAPELOITES* FROM THE LA LAJA-8 WELL

This ammonite, found in the La Laja-8 well, core 11 (2556-2562 m), Tampico district, eastern Mexico, was obtained from limestone of the Lower Tamaulipas Formation (Berriasian-lower Aptian; Imlay, 1944) (Cantú-Chapa, 2001). The specimen can be correlated with ammonites reported here from the base of the upper Valanginian in Potrero de Garcia.

CONCLUSIONS

The Taraises Formation consists of open-water deposits that contain Berriasellids and Olcostephanids ammonites of Valanginian age. In the subsurface of northeastern Mexico, this formation is easily recognized with the aid of electric and radioactivity logs. The Taraises Formation is formed by two members: a lower member consisting of unfossiliferous compact limestone, which could be Berriasian in age, based on its stratigraphic position above the Late Tithonian La Casita Formation; and the upper member, consisting of fossiliferous marly limestone that contains Valanginian ammonites. Ammonites from several oil wells permitted the identification of the lower-upper Valanginian age boundary.

The new upper Valaginian ammonites found in outcrops of the Taraises Formation at Potrero de García, northeastern Mexico, not only represent important biostratigraphic information but also suggest a paleobiogeographic communication between Europe and America (Peru and Mexico). The upper Valanginian *Capeloites* sp. ammonite from the La Laja 8-well in the Lower Tamaulipas Formation is also an important biostratigraphic and biogeographic worldwide element.

REPOSITORY

Specimens described herein are housed in the Department of Geology at the Escuela Superior de Ingeniería y Arquitectura (ESIA), Instituto Politécnico Nacional (IPN), Mexico D. F. 07738, Mexico.

ACKNOWLEDGMENTS

Thanks to my wife, Françoise, and my sons Xochitl, Tonatiuh, and Yaocalli for helping me collect the small specimens from the Potrero de García locality. I also thank Hector Amezcua for his assistance with photographs. I thank Claudio Bartolini for translating the manuscript to English. I express my gratitude to Ryszard Myczynski and James Lee Wilson for providing constructive reviews of the manuscript. I thank Jaap Klein for making literature available.

REFERENCES CITED

Arkell, W. J., B. Kummel, and C. W. Wright, 1957, Mesozoic Ammonoidea, *in* R. C. Moore, ed., Treatise on invertebrate paleontology, part L. mollusca 4, cephalopoda, ammonoidea: Geological Society of America and University of Kansas Press, York and Lawrence, p. L80-L490.

Atrops, F., 1982, La sous-famille des Ataxioceratinae (Ammonitina) dans le Kimméridgien inférieur du Sud-Est de la France. Systématique, Evolution, Chronostratigraphie des genres (*Orthosphinctes* et *Ataxioceras*): Document du Laboratoire Géologique, Lyon 83, 463 p.

Autran, G., 1989, L'évolution de la marge nord-est provençale (Arc de Castelane) du Valanginien Moyen à l'Hauterivien à travers l'analyse biostratigraphique des séries de la région de Peyroules:

Séries condensées, discontinuités et indices d´une tectogenèse distenssive: Paléobiologie,Thèse Doctorat, Faculté des Sciences et Techniques de l'Université de Nice, 232 p.

Baumberger, E., 1923, Beschreibung zweier Valangienammoniten, nebst Bemerkungen über die Fauna des Gemsmätlihorizontes von Suizi im Justistal: Eclogae Geologicae Helvetiae, v. 18, no. 2, p. 303-313.

Böse, E., 1923, Algunas faunas cretácicas de Zacatecas, Durango y Guerrero: Instituto de Geología de México, 42, 219 p.

Brochwicz-Lewiñski, W., and Z. Rozak, 1976, Some difficulties in recognition of sexual dimorphism in Jurassic perisphinctids (Ammonoidea): Acta Palaeontologica Polonica, v. 21, no. 1, p. 97-114.

Bulot, L., and J-P. Thieuloy, 1993, Implications chronostratigraphiques de la révision de l´échelle biostratigraphique du Valanginien supérieur et de l´Hauterivien du Sud-Est de la France: Compte-Rendus de l' Académie des Sciences, Paris, T. 317, série II, p. 386-394.

Bulot, L., J.-P. Thieuloy, E. Blanc, and J. Klein, 1992, Le cadre stratigraphique du Valanginien supérieur et de l´Hauterivien du Sud-Est de la France: Définition des biochronozones et caractérisation de nouveaux biohorizons: Géologie Alpine, t. 68, p. 13-56.

Burckhardt, C., 1930, Étude synthétique sur le Mésozoïque mexicain: Mémoire de la Société Paléontologique Suisse, v. 49-50, 280 p.

Cantú-Chapa, A., 1963, Étude biostratigrafique des ammonites du Centre et de l´Est du Mexique: Société Géologique de France, Mémoire 99, no. 5, 103 p.

Cantú-Chapa, A., 1966, Se propone una nueva subdivisión de la Familia Olcostephanidae (Ammonoidea), del Cretácico Inferior (Taraisitinae subfam. nov. y Taraisites gen. nov.): Ingeniería Petrolera, v. 6, no. 12, p. 15-17.

Cantú-Chapa, A., 1970, El Kimeridgiano Inferior de Samalayuca, Chihuahua: Revista del Instituto Mexicano del Petróleo, v. 2, no. 3, p. 40-44.

Cantú-Chapa, A., 1972, Amonitas del Valanginiano Superior del pozo Calichoso no. 1, Norte de México: Revista del Instituto Mexicano del Petróleo, v. 4, no. 3, p. 88-89.

Cantú-Chapa, A., 1976, El contacto Jurásico-Cretácico, la estratigrafía del Neocomiano, el hiato Hauteriviano Superior-Eoceno Inferior y las amonitas del pozo Bejuco 6 (Centro-Este de México): Boletín de la Sociedad Geológica Mexicana, v. 37, p. 60-83.

Cantú-Chapa, A., 1987, The Bejuco Paleocanyon (Cretaceous-Paleocene) in the Tampico District, Mexico: Journal of Petroleum Geology, v. 10, no. 2, p. 207-218.

Cantú-Chapa, A., 1989, La Peña Formation (Aptian): A condensed limestone-shale sequence from the subsurface of NE of Mexico: Journal of Petroleum Geology, v. 12, no. 1, p. 69-83.

Cantú-Chapa, A., 1990, *Dichotomites* (*Dichotomites*) *mantarraiae* sp. nov., ammonita del Valanginiano Superior del pozo Mantarraya 1, Golfo de México: Revista de la Sociedad Mexicana de Paleontología, v. 2, no. 2, p 43-45.

Cantú-Chapa, A., 1992, *Novoleonites tovarensis* gen. nov. sp. nov. (Ammonoideo Neocomitino) del Valanginiano Superior del NE de México: Revista de la Sociedad Mexicana de Paleontologia, v. 5, no. 1, 37-43.

Cantú-Chapa, A., 1999, Confrontation of stratigraphic methods to define the Jurassic-Cretaceous boundary in eastern Mexico subsurface: Geological Society of America, Special Paper 340, p. 93-103.

Cantú-Chapa, A., 2001, Paleocanyons in the subsurface of eastern Mexico: Facts and uncertainties. This volume, chapter 19.

Cecca, F., 1986, Le genre *Richterella* Avram (Ammonitina, Périsphinctidés) dans le Tithonique inférieur de la bordure ardéchoise (Sud-Est de la France): Dimorphisme et variabilité: Geobios, no. 19, p. 33-44.

Company, M., 1987, Los ammonites del Valanginiense del sector oriental de las Cordilleras Béticas (SE de España): Thesis, Universidad de Granada, Spain, 295 p.

Contreras, M. B., 1977, Bioestratigrafía de las formaciones Taraises y La Peña (Cretácico Inferior), de la Goleta, Coahuila y Minillas, Nuevo León: Revista del Instituto Mexicano del Petróleo, v. 9, no. 1, p. 8-29.

Cooper, M. R., 1981, Revision of the Late Valaginian Cephalopoda from the Sundays River Formation of South Africa, with special reference to the genus *Olcostephanus:* Annals of the South African Museum, v. 83, pt. 7, 366 p.

Enay, R., 1966, L´Oxfordien dans la moitié sud du Jura français: Étude stratigraphique Nouvelles Archives du Muséum d´Histoire Naturelle de Lyon, fasc. 8, T. II, p. 331-624.

Hoedemaeker¸ P. J., and 15 others, 1993. Ammonite zonation for the Lower Cretaceous of the Mediterranean region; basis for the stratigraphic correlations within IGCP-Project 262: Revista Española de Paleontología, v. 8, no. 1, p. 117-120.

Imlay, R. W., 1937, Lower Neocomian fossils from the Miquihuana Region, Mexico: Journal of Paleontology, vol. 11, no. 7, p. 552-574.

Imlay, R. W., 1938, Ammonites of the Taraises Formation of northern Mexico: Bulletin of the Geological Society of America, v. 49, no. 4, p. 539-602.

Imlay, R. W., 1940, Neocomian faunas of northern Mexico: Bulletin of the Geological Society of America, v. 51, p. 117-190.

Imlay, R. W., 1944, Cretaceous formations of Central America and Mexico: AAPG Bulletin, v. 28, p. 1077-1195.

Karakasch, N., 1889, Über einige Neokomablagerungen in der Krim: Sitzungsberichte der kaiserlichen Akademie der Wissenschaften in Wien, Mathematisch-Naturwissenshaftliche Klasse (für 1889), p. 428-438.

Kemper, E., 1978, Einige neue, biostratigraphisch bedeutsame Arten der Ammoniten-Gattung *Dichotomites* (NW-Deutschland, Obervalangin): Geologisches Jahrbuch A45, p. 183-253.

Kemper, E., 1992, Die tiefe Unterkreide im Vechte-Dinkel-Gebiet (westliches Niedersächisisches Becken): Het Staringmonument te Losser, p. 7-95.

Kemper, E., P. F. Rawson, and J.-P. Thieuloy, 1981, Ammonites of Tethysan ancestry in the early Lower Cretaceous of north-west Europe: Palaeontology, 24, p. 251-311.

Kilian, W., 1910, Erste Abteilung: Unterkreide (Palaeocretacicum). Lieferung 2: Das bathyale Palaeocretacicum im südostlichen Frankreich; Valendis-Stufe: Hauterive-Stufe; Barreme-Stufe: Apt-Stufe, *in* Fritz Frech, ed., Lethaea Geognostica II, Das Mesozoicum, 3 (Kreide): E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, p. 169-288.

Kutek, J., R. Marcinowski, and J. Wiedmann, 1989, The Wawal Section, Central Poland—An important link between Boreal and Tethyan Valanginian, *in* J. Wiedmann, ed., Cretaceous of the Western Tethys, Proceedings 3rd International Cretaceous Symposium, Tübingen, 1987: Stuttgart, E. Schweizerbart'sche Verlagsbuchhandlung, p. 717-754.

Lissón, C. I., 1937, Dos Amonites del Perú: Boletín de Minas, Lima, Talleres Gráficos San Miguel, p. 3-9.

Matheron, P., 1878-1880, Recherches paléontologiques dans le Midi de la France: Marseille, 12 p.

Neumayr, M., 1875, Die Ammoniten der Kreide und die Systematik der Ammonitiden: Zeitschrift der Deutschen Geologischen Gesellschaft, v. 27, p. 854-942.

Nikolov, T., 1963, New name for a Valanginian Ammonites genus: Geological Magazine, v. 100, no. 1, p. 94.

Peña-Muñoz, M. G., 1964, Ammonitas del Jurásico Superior y del Cretácico Inferior del extremo oriental del estado de Durango, México: Paleontología Mexicana, no. 20, 33 p.

Rawson, P. F., 1975, Lower cretaceous ammonites from north-east England: The Hauterivian Heteromorph Aegocrioceras: Bulletin of the British Museum, (Natural History) Geology, v. 26, no. 4. p. 131-283.

Riccardi, A. C., and G. E. G. Westermann, 1970, The Valanginian *Dobrodgeiceras* Nikolov (Ammonitina) from Peru: Journal of Paleontology, v. 44, no. 5, p. 888-892.

Riccardi, A. C., G. E. G. Westermann, and R. Levy, 1971, The Lower Cretaceous Ammonitina *Olcostephanus*, *Leopoldia*, and *Favrella* from west-central Argentina: Palaentographica, 136, A, p. 83-121.

Spath, L. F., 1924, On the ammonites of the Speeton Clay and the subdivisions of the Neocomian: Geological Magazine, v. 61, p. 73-89.

Thieuloy, J.-P., 1969, Sur la présence du genre Capeloites Lisson (Ammonoidea) dans le Néocomien des Basses-Alpes et la signification des espèces migratrices transatlantiques: Comptes-Rendus sommaire des Séances de la Société Géologique de France, Fascicule 7, p. 256-258.

Thieuloy, J.-P., 1971, Réflexions sur le genre *Lyticoceras* Hyatt, 1900 (Ammnoidea): Comptes-Rendus des Séances de l'Académie des Sciences, Paris, series D272, p. 2297-3000.

Thieuloy, J.-P., 1977, Les ammonites boréales des formations néocomiennes du sud-est français (province subméditerranéenne): Geobios 10, p. 395-461.

Thieuloy, J.-P., and L. Bulot, 1992, Ammonites du Crétacé Inférieur du Sud-Est de la France: 1. Nouvelles espèces à valeur stratigraphique pour le Valanginien et l'Hauterivien: Géologie Alpine, t. 68, p. 85-103.

Thieuloy, J.-P., and M. Gazay, 1967, Le genre *Dobrodgeiceras* Nikolov en Haute Provence: Travaux du laboratoire de Géologie, Faculté des Sciences, Lyon, Nouvelle Série 14, p. 69-78.

Verma, H. M, and G. E. G. Westermann, 1973, The Tithonian (Jurassic) ammonite fauna and stratigraphy of Sierra Catorce, San Luis Potosí, Mexico: Bulletin of American Paleontology, v. 63, no. 277, p. 105-320.

Wilke, H.-G., 1988, Stratigraphie und Sedimentologie der Kreide im Nordwesten der Provinz Alicante (SE-Spanien): Berliner geowissenschaft 95, 72 p.

Wilson, J. L., and W. C. Ward, 1993, Early Cretaceous Carbonate platforms of northeastern and east-central Mexico, i*n* J. A. Tonisimo, R. W. Scott, and J. P. Masse, eds., Cretaceous carbonate platforms; AAPG Memoir 56, p. 35-49.

Wright, C. W., J. H. Calloman, and M. K. Howarth, 1996, Cretaceous Ammonoidea, *in* R. L. Kaesler, ed., Treatise on invertebrate paleontology, part L, mollusca 4: The Geological Society of America and the University of Kansas, Lawrence, 362 p.

Young, K., 1969, Ammonites zones of Northern Chihuahua, *in* Guidebook of the Border Region: New Mexico Geological Society, 20th Field Conference, p. 97-101.

Young, K., 1988, *Karakaschiceras* and the Late Valanginian of Northern Mexico and Texas, *in* J. Wiedmann and J. Kullmann, eds., Cephalopods—present and past: Stuttgart, E. Schwizerbart'sche Verlagsbuchhandlung, p. 621-632.