Towards a standard ammonite zonation for the Aptian (Lower Cretaceous) of northern Mexico

Ricardo Barragán-Manzo* and Ana Laura Méndez-Franco

Instituto de Geología, Universidad Nacional Autónoma de México,
Ciudad Universitaria, 04510 México, D. F., Mexico.
** ricardor@geologia.unam.mx*

ABSTRACT

Detailed data on twenty-seven species of ammonites identified in three stratigraphic sections of northern Mexico, allow further refinement of the Aptian ammonite biozonations of previous authors. Four formal ammonite biozones are proposed. Dufrenoyia justinae Taxon-Range-Zone for the uppermost part of the lower Aptian (Bedoulian), Epicheloniceras cf. subnodosocostatum/Acanthohoplites acutecosta Interval Zone representative of the middle Aptian (Gargasian), and Acanthohoplites aschiltaensis and Hypacanthoplites cf. leanzae Taxon-Range-Zones, spanning the upper Aptian (Clansayesian). The ammonite zonation proposed represents the advancements on the development of a standard scheme towards a reliable correlation with the biozonal scheme of England and the ammonite zonal standard of the Mediterranean area.

Key words: biostratigraphy, ammonites, Aptian, Mexico.

RESUMEN

Estudios detallados de veintisiete especies de ammonites provenientes de tres secciones estratigráficas del norte de México, permiten redefinir los esquemas biozonales del Aptiano, establecidos previamente por otros autores para el área, con base en la distribución vertical de estos macrofósiles. En este trabajo se proponen cuatro biozonas formales de ammonites. La Zona de Rango Dufrenoyia justinae para la parte terminal del Aptiano inferior (Bedouliano), la Zona de Intervalo Epicheloniceras cf. subnodosocostatum/Acanthohoplites acutecosta representativa del Aptiano medio (Gargasiano) y las Zonas de Rango Acanthohoplites aschiltaensis e Hypacanthoplites cf. leanzae, características del Aptiano superior (Clansayesian). La biozonación de ammonites propuesta representa los avances en el desarrollo de un esquema estandarizado con miras a realizar correlaciones más precisas con los esquemas biozonales desarrollados para Inglaterra y el área Mediterránea.

Palabras clave: bioestratigrafía, ammonites, Aptiano, México.

INTRODUCTION

The Lower Cretaceous stages were first defined in southern France by d'Orbigny (1840), who also developed a correlation based on ammonite assemblages. The Aptian stage was characterized on the basis of two assemblages of ammonites from two stratigraphic sections, one at Apt, near the town of Gargas, and the other near the hamlet of La Bédoule. The section at Apt is composed of marls, whereas that at La Bédoule is dominated by limestones. Further studies (Toucas, 1888; Kilian, 1888) revealed that the assemblage contained in the limestone beds was older than the one found in the marly beds. Thus, the original Aptian Stage of d'Orbigny was divided into two substages: the Bedoulian, which included the lower calcareous beds (Toucas, 1888), and the Gargasian, which enclosed the upper marly beds. The Gargasian was also characterized by an uppermost horizon particularly rich in fossils, which was named the "Clansayes Horizon" (Kilian, 1888). Subsequently, Breistoffer (1947) identified a third substage for the Aptian based on his studies of the ammonite assemblage contained in the "Clansayes Horizon", which he raised to the level of a substage. These three substages have been widely accepted, and are known as Bedoulian, Gargasian, and Clansayesian for the lower, middle, and upper Aptian, respectively. La Bedoule, Gargas, and Clansayes are the historical type sections for these subdivisions, but they are apparently problematic for correlation purposes (Rawson, 1983; Busnardo, 1984). This issue was brought to discussion at the Lower Cretaceous Colloquium held in Lyon, France in 1963, concluding with its corresponding recommendations to revise the stratotypes (BRGM, 1963). The previous work towards the construction of a standard ammonite zonation for the Aptian was on set. A preliminary ammonite zonation for the Lower Cretaceous of the Mediterranean Region was presented by Hoedemaeker and Bulot (1990). As part of the concluding remarks of this work, a scheme developed in Georgia and Turkmenistan by Bogdanova (1971, 1983) was accepted as the standard biozonation for the Aptian. Thus, the current Aptian standard ammonite zonations for England (Casey, 1961), and for the Mediterranean faunal province (Hoedemaeker *et al.*, 1993; Bogdanova and Tovbina, 1994; Erba, 1996; Szives, 1999; Hoedemaeker and Rawson, 2000) have been developed throughout the last decades; for the Mediterranean, the last amendment stems from the first international workshop of the IUGS Lower Cretaceous Working Group, the "Kilian Group" held in Lyon, France on July 2002 (Hoedemaeker *et al.*, 2003). As stated by Bogdanova and Tovbina (1994) and Delanoy (1995), because of their local use, and the fact that the stratotype sections of the Aptian in France have not yet been revised, despite the corresponding recommendations of the Lyon Colloquium in 1963, the Aptian is still best subdivided into the biozones developed in Georgia and Turkmenistan by Bogdanova (1971, 1983).

Regarding studies of the Aptian ammonites of northern Mexico, pioneering works provided important information for lithologic and general biostratigraphic correlation in the area (Burckhardt, 1925; Imlay, 1936; Humphrey, 1949). However, most of the published fauna lacked precise stratigraphic control impeding precise long distance correlations. To alleviate this limitation, several ammonite biozonations for the Aptian Stage of northern Mexico have been established during the last decades (Cantú-Chapa, 1963; Young, 1969; Contreras-Montero, 1977). In spite of these advances, remained the uncertainty concerning the exact correlation between these Mexican Aptian biozonations and those established for different areas of the Boreal and Tethyan realms. One of the main problems for broad regional correlations stemmed from apparent taxonomic provinciality during this age (Barragán, 2000). Furthermore, these biozonal schemes have been helpful for general stratigraphic use, and served worthy purposes, but difficulties arise because their biozones did not include well-defined biostratigraphic horizons (FAD´s and LAD´s) of the nominal taxa.

The aim of this work is to present the progress of an ongoing project towards the construction of a standard ammonite zonation for the Aptian of northern Mexico. This goal was envisaged through new precisely controlled stratigraphic data and the refinement of those biozonations presented by previous authors. The new biozonation is intended for regional use in northern Mexico until further studies allow its calibration with the standard for the Tethyan Realm.

GEOGRAPHICAL AND GEOLOGICAL SETTING

The area of study is located in northeastern Mexico, which includes the states of Nuevo León and Coahuila, and parts of the surrounding states of Tamaulipas, San Luis Potosí, Zacatecas, Durango, and Chihuahua (Figure 1). Mesozoic sedimentary rocks dominate the area with a physiography marked by distinctive structural fabrics of the orogenic belt of the Sierra Madre Oriental, formed during the Laramide event (Morán-Zenteno, 1994). The present study focuses on the rhythmic alternations of marls, limestones, sandstones, and marly limestones of three outcrops of the La Peña Formation (Imlay, 1936; Humphrey, 1949) (Figure 2).

METHODS

Three Aptian stratigraphic sections were chosen on the basis of their adequacy for the collection of stratigraphic data, as well as for ammonite collection. Ammonites were collected on a bed-by-bed scale during six field seasons between 1995 and 2002. Field recognition of physical formational characteristics was based on formal lithostratigraphic units previously established by earlier workers (Imlay, 1936; Muir, 1936; Humphrey, 1949).

Ammonites were prepared, studied, and deposited in the National Paleontological Collection of the Museum of Paleontology "María del Carmen Perrilliat Montoya" at the Universidad Nacional Autónoma de México. Special emphasis was given to the vertical succession of ammonites for biochronological purposes. These data were used for the recognition of standard Aptian biozones previously established for this area of Mexico (Cantú-Chapa, 1963, 1976; Contreras-Montero, 1977). The resulting biochronological scheme was based on these previous zonations, updated in accordance with the observations of this study. Finally, the ammonite zonation presented herein was based on the stratigraphic ranges of all identified Aptian species found at the three stratigraphic sections, and conforms to the recommendations of the International Subcommission on Stratigraphic Classification (Amos, 1994), and to the rules of the North American Commission on Stratigraphic Nomenclature (1983) for the establishment of biostratigraphic units.

THE STRATIGRAPHIC SECTIONS

Francisco Zarco Dam Section

This section is located at Lat 25º16´N, Long 103º 46´W, within the state of Durango in the "Sierra El Rosario", southwest of Torreón City (Figure 1). The studied stratigraphic section of the La Peña Formation crops out by a dam, along part of the west limb of a NNW-trending breached anticline, eroded by the superposed Nazas River. Excellent exposure along the access road to the dam on the south side of the canyon offers a unique opportunity to study the succession of strata and ammonite content of the La Peña Formation. Locally, this formation consists of 55 meters of an alternation of dark gray to black limestones, and light olive gray to dusky yellow sandstones, marls, and marly limestones containing abundant ammonites (Figure 2).

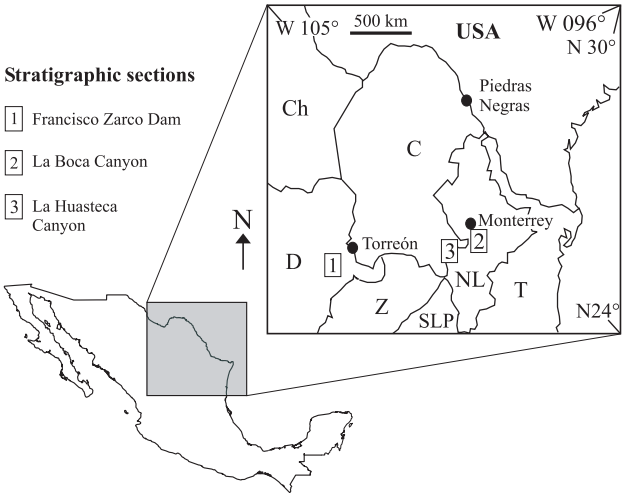

Figure 1. Map of northeastern Mexico displaying the location of the three Aptian stratigraphic sections of this study. States: Ch=Chihuahua, C=Coahuila, D=Durango, Z=Zacatecas, NL=Nuevo León, SLP=San Luis Potosí, T=Tamaulipas.

La Boca Canyon Section

This section is located at Lat 25º26´N, Long 100º 07´W within the state of Nuevo León, in the southern region of the Sierra Cerro de la Silla, southeast of Monterrey City (Figure 1). The studied stratigraphic section of the La Peña Formation crops out along the road across the dam built at the canyon formed by the superposed Rio San Juan. Structurally, the section is part of the west limb of a NNW-trending anticline of the anticlinorium series of the Sierra Madre Oriental (Morán-Zenteno, 1994). Locally, the La Peña Formation consists of 111.5 meters of dark gray to black limestones, alternating with light olive gray, dusky yellow, or yellowish gray sandstones, marls, and marly limestones containing abundant ammonites (Figure 2).

La Huasteca Canyon Section

This section is located within the National Park "Cumbres de Monterrey" in the state of Nuevo León, southwest of Monterrey City (Figure 1). The studied stratigraphic section of the La Peña Formation crops out along part of the west limb of an open anticline of the "Los Muertos" Anticlinorium. Locally, only a condensed section of the lowermost part of the La Peña Formation crops out, and it consists of 5.78 meters of a rhythmic alternation of limestones, marly limestones, and marls, with extremely abundant, somehow deformed but well-preserved ammonites (Méndez-Franco, 2003) (Figure 2).

THE PROPOSED BIOZONATION

The formerly established ammonite biozonal scheme for the Aptian of northeastern Mexico (Cantú-Chapa, 1963; Contreras-Montero, 1977), was based on the presence of index taxa from the La Peña Formation, and include three zones or informal units from oldest to youngest as follows: 1) "Unidad con *Dufrenoyia justinae*", 2) "Unidad con *Caseyella reesidei* (=*Pseudohaploceras reesidei*) and *Rhytidohoplites robertsi*", and 3) "Unidad con *Hypacanthohoplites* gr. *jacobi* and *Acanthohoplites* s.s." (Contreras-Montero, 1977) (Figure 3) .

In the present work, two types of biozones were used in the construction of the biozonal scheme, Taxon-Range-Zone and Interval-Zone. Due to the differential thickness of the La Peña Formation exposed at the three studied sections, the results are presented as a composite biochronological scheme that represents a comprehensive interpretation of

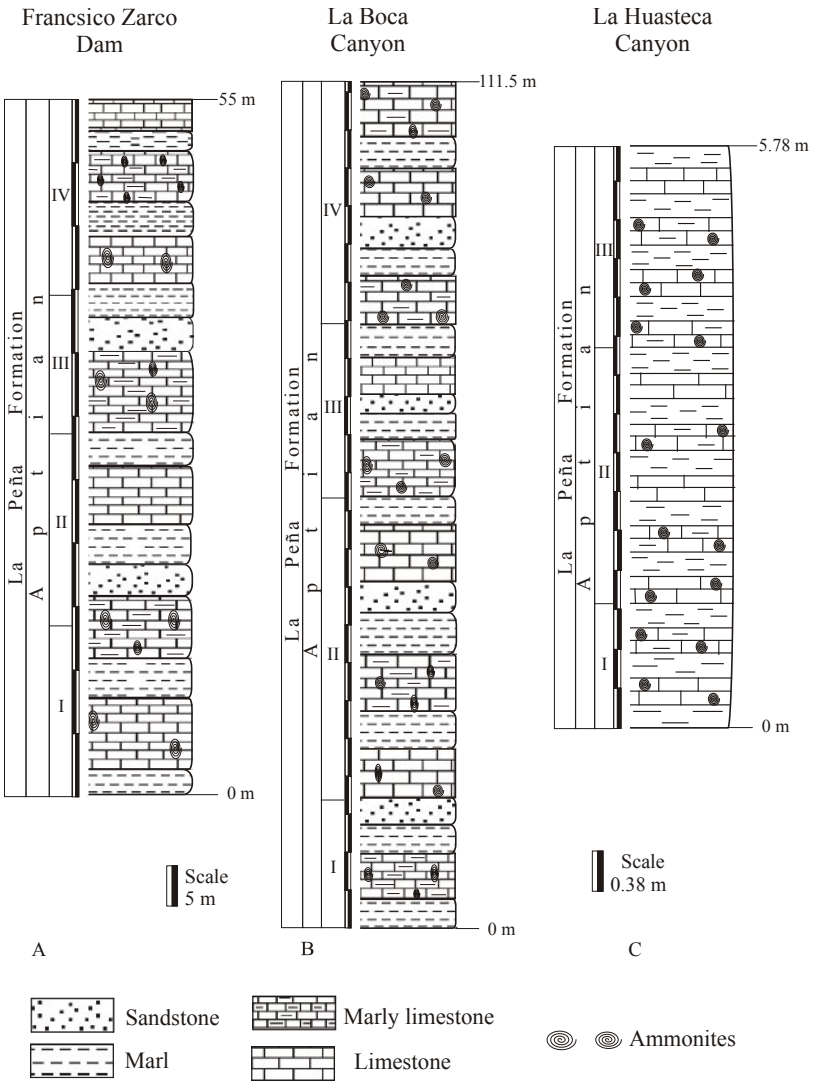

Figure 2. Stratigraphic columns of the three studied sections displaying lithology and relation to the proposed biozonation. Biozones: I) *Dufrenoyia justinae* Taxon-Range-Zone, II) *Epicheloniceras* cf. *subnodosocostatum*/*Acanthohoplites acutecosta* Interval-Zone, III) *Acanthohoplites aschiltaensis* Taxon-Range-Zone, and IV) *Hypacanthoplites* cf. *leanzae* Taxon-Range-Zone.

the ammonite data in a regional sense. Thus, four formal ammonite biozones for the Aptian of northern Mexico are proposed herein. Their description and boundaries are described from oldest to youngest as follows:

Dufrenoyia justinae Taxon-Range-Zone

Definition

The full range of occurrence of *Dufrenoyia justinae* (Hill, 1893) essentially characterizes this zone. Therefore, the first (FAD) and last (LAD) appearance of the nominate taxon, mark its base and its top respectively (Figure 4). This zone also includes the full range of *D. boesei* Humphrey, 1949, and *D. durangensis* Humphrey, 1949, and the partial concurrent occurrence of *D. dufrenoyi* (d'Orbigny, 1840) and *D. scotti* Humphrey, 1949, which extend into the lower part of the superjacent zone. The upper part of the *Dufrenoyia justinae* Zone can also be distinguished by the acme of *Colombiceras spathi* Humphrey, 1949, and by punctual records of the nautiloid *Paracymatoceras milleri* Humphrey, 1949.

Correlation

The *Dufrenoyia justinae* Zone described in the present work can be correlated with the *Dufrenoyia justinae* Zone described by Cantú-Chapa (1963) and Contreras-Montero (1977), however, these authors placed the Aptian of northern Mexico into the two-fold division, with the *Dufrenoyia justinae* Zone being placed at the base of the upper Aptian (Figure 3). The present assignment of the *Dufrenoyia justinae* Zone to the uppermost ammonite zone of the lower

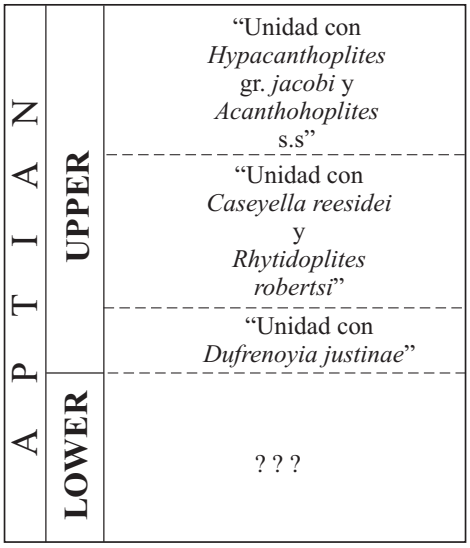

Figure 3. Aptian ammonite biozonation proposed by Contreras-Montero (1977).

Aptian of northern Mexico (Figure 5) is based on correlation with the *Dufrenoyia furcata* Zone of the Mediterranean region (Hoedemaeker *et al.*, 2003). This new stratigraphic consensus also adopted a subdivision of the Aptian into lower, middle, and upper, which is used in the present work.

Epicheloniceras cf. *subnodosocostatum*/ *Acanthohoplites acutecosta* Interval-Zone

Definition

The base of the zone is delimited by the first appearance (FAD) of *Epicheloniceras* cf. *subnodosocostatum*, whereas its top is marked by the first appearance (FAD) of *Acanthohoplites acutecosta* Riedel, 1938 (Figure 4). The upper part of this biozone is distinguished by the full range of *Rhytidoplites robertsi* Scott, 1940. The *Epicheloniceras* cf. *subnodosocostatum*/*Acanthohoplites acutecosta* Zone is also characterized by a rich assemblage of ammonite species, showing the highest diversity in the Francisco Zarco Dam section. The basal part of the zone includes the last stratigraphic occurrences (LAD's) of *Dufrenoyia dufrenoyi* and *Dufrenoyia scotti* and the total stratigraphic range of the only species of *Burckhardtites* identified in this work, namely *B. nazasensis* (Burckhardt, 1925). In addition, the middle part of the zone is marked by punctual occurrences of *Peltocrioceras* (?) sp., *Acrioceras* (*Epacrioceras*) (?) sp., and cf. *Kazanskyella arizonica* Stoyanow, 1949, and by a distinctive horizon bearing species of the genus *Mathoceras*. The upper part of the zone comprises the first appearance and partial range of *Parahoplites mexicanus* Humphrey, 1949, which extend into the lower part of the superjacent zone. The complete stratigraphic range of *Penaceras rursiradiatus* (Humphrey, 1949) is also contained at the top of this zone.

The upper boundary of the *Epicheloniceras* cf. *subnodosocostatum*/*Acanthohoplites acutecosta* Zone is also coincident with the first stratigraphic occurrences (FAD's) of *Cheloniceras inconstans* Humphrey, 1949, *Cheloniceras fossae* Humphrey, 1949, and *Acanthohoplites aschiltaensis* (Anthula, 1900).

Correlation

The *Epicheloniceras* cf. *subnodosocostatum*/ *Acanthohoplites acutecosta* Zone correlates with the informal zone named "Unidad con *Rhytidoplites*" by Contreras-Montero (1977), which was recognized in the La Peña Formation of northeastern Mexico. Contreras-Montero (1977) placed the *Rhytidoplites* unit, together with another unit containing *Pseudohaploceras reesidei*, in the middle of the upper Aptian (Figure 3). However, that author also correlated the *Rhytidoplites* unit with the *Parahoplies nutfieldiensis* zone described by Spath (1923) for the Aptian of England, which in turn is coeval with the *Cheloniceras* (*Epicheloniceras*) *subnodosocostatum* zone characteristic of the basal part of the middle Aptian as argued by Hoedemaeker *et al.* (2003). Moreover, this unit can also be correlated with the *Epicheloniceras martinoides* zone of the basal part of the upper Aptian under the two-fold division of the stage (Casey, 1961) (Figure 5). Since the characteristic ammonites of the subjacent *Dufrenoyia justinae* Zone are certainly lower Aptian, and the taxa of the subsequent zone are by all indications upper Aptian, it is therefore suggested here that the *Epicheloniceras* cf. *subnodosocostatum*/*Acanthohoplites acutecosta* Zone may represent or approximate the entire span of the middle Aptian in northern Mexico (Figures 4 and 5).

Acanthohoplites aschiltaensis Taxon-Range-Zone

Definition

This biozone is characterized by the full range of the nominate taxon, which is closely approximate with that of Cheloniceras fossae. Thus, the lower and upper boundaries of the Acanthohoplites aschiltaensis Zone are defined by the first (FAD) and last (LAD) appearances of the nominate taxon (Figure 4). The lowermost part of this zone encloses the complete records of *Acanthohoplites acutecosta* Riedel, 1938, and *Acanthohoplites potreritensis* Humphrey, 1949. This biozone is further characterized by the presence of three species of the genus *Pseudohaploceras* identified in this work, namely *P. aguilerae* (Burckhardt, 1925), *P. jacobi* (Burckhardt, 1925), and *P. reesidei* (Humphrey, 1949). The first occur only in the middle of the zone, whereas *P. reesidei* and *P. jacobi* continue into the lower part of the overlying zone. The base of the biozone is also characterized by having the upper part of the stratigraphic range of *Parahoplites mexicanus*. The uppermost part of

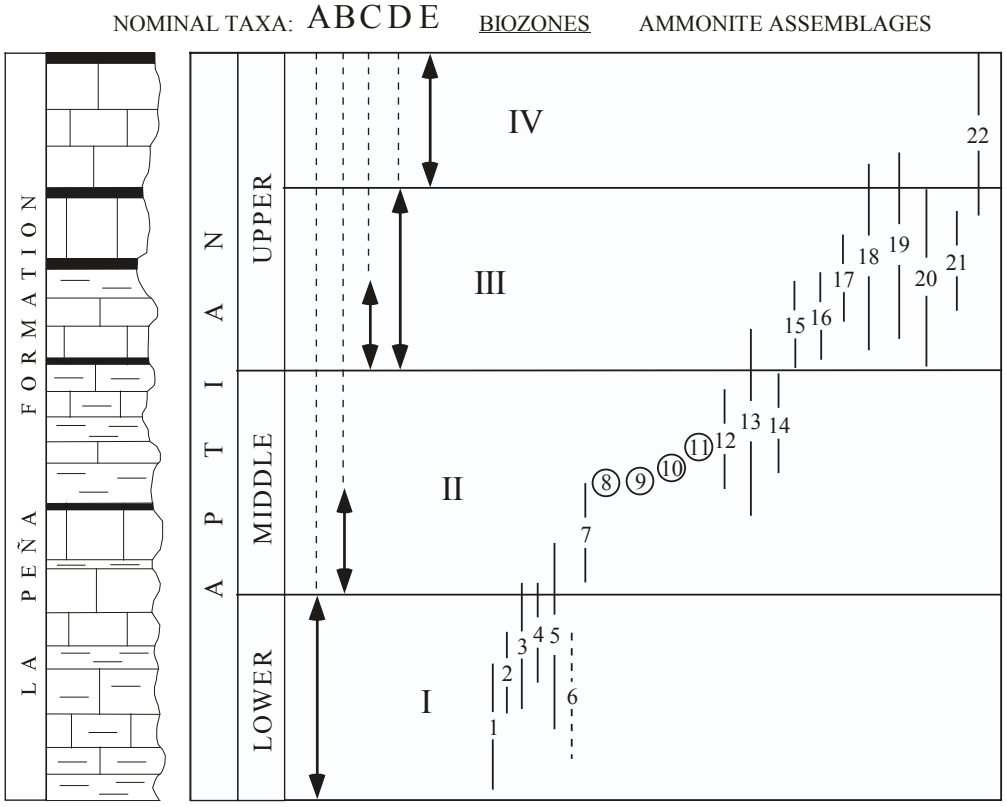

Figure 4. The proposed biozonation in relation to the three-fold division of the Aptian. Nominal taxa: A) *Dufrenoyia justinae*, B) *Epicheloniceras* cf. *subnodosocostatum*, C) *Acanthohoplites acutecosta*, D) *Acanthohoplites aschiltaensis*, E) *Hypacanthoplites* cf. *leanzae*. Biozones: I) *Dufrenoyia justinae* Taxon-Range-Zone, II) *Epicheloniceras* cf. *subnodosocostatum*/*Acanthohoplites acutecosta* Interval Zone, III) *Acanthohoplites aschiltaensis* Taxon-Range-Zone, IV) *Hypacanthoplites* cf. *leanzae* Taxon-Range-Zone. Biozonal assemblage components: 1) *Dufrenoyia boesei*, 2) *D. durangensis*, 3) *D. dufrenoyi*, 4) *D. scotti*, 5) *Colombiceras spathi*, 6) *Paracymatocears milleri*, 7) *Burckhardtites nazasensis*, 8) *Peltocrioceras* (?) sp., 9) *Acrioceras* (*Epacrioceras*) (?) sp., 10) *Kazanskyella arizonica*, 11) *Mathocera*s spp., 12) *Rhytidoplites robertsi*, 13) *Parahoplites mexicanum*, 14) *Penaceras rursiradiatus*, 15) *Acanthohoplites acutecosta*, 16) *A. potreritensis*, 17) *Pseudohaploceras aguilerae*, 18) *P. jacobi*, 19) *P. reesidei*, 20) *Cheloniceras fossae*, 21) *Ch. inconstans*, 22) *Hypacanthoplites* spp.

the biozone records the first stratigraphic appearances of the genus *Hypacanthoplites*, of which that of *H.* cf. *leanzae* Humphrey, 1949, is up to now coincident with its upper boundary (Figure 4).

Correlation

Species of the genus *Acanthohoplites* are normally assigned to biozones characteristic of the basal part of the upper Aptian (Hoedemaeker *et al.*, 2003) (Figure 5). This is adopted in the present work where the stratigraphic position of species of this genus relative to the temporal distribution of the other taxa is compatible with them being placed in the lowermost part of the upper Aptian (Figures 4 and 5).

Hypacanthoplites cf. *leanzae* Taxon-Range-Zone

Definition

The boundaries of the *Hypacanthoplites* cf. *leanzae* Zone are distinguished by the first (FAD) and last (LAD) appearances of the nominate species (Figure 4). The basal part of this biozone is also characterized by having the last stratigraphic ocurrence of *Pseudohaploceras reesidei* and *P. jacobi*. This zone is rather poor in ammonites, as it contains mostly one species throughout.

Correlation

Species of the genus *Hypacanthoplites* are characteristic of the uppermost part of the upper Aptian (Hoedemaeker *et al.*, 2003). This biozone is correlative with the *Hypacanthoplites jacobi* zone characteristic of the uppermost part of the upper Aptian of England (Casey, 1961) and the Mediterranean region (Hoedemaeker *et al.*, 2003) (Figure 5). Moreover, the *Hypacanthoplites* cf. *leanzae* Zone is equivalent to the informal unit "Unidad con *Hypacanthoplites* gr. *jacobi* and *Acanthohoplites* s.s." defined by Contreras-Montero (1977) for the La Peña Formation of northeastern Mexico (Figure 3). *Hypacanthoplites jacobi* was not found in the study areas, and therefore has not been considered in the construction of the biozonation of this work. However, correlation of *Hypacanthoplites* cf. *leanzae* Zone of this work, with the unit previously defined

		MEDITERRANEAN AND SUBMEDITERRANEAN (HOEDEMAEKER ET AL., 2003)		NORTHEAST MEXICO (THIS WORK)		NORTHEAST EUROPE (CASEY, 1961)
LA PEÑA FORMATION	APTIAN	UPPER	*Hypacanthoplites jacobi*	*Hypacanthoplites* cf. *leanzae* Taxon-Range Zone	UPPER	*Hypacanthoplites jacobi*
			Acanthohoplites nolani	*Acanthohoplites aschiltaensis* Taxon-Range Zone		
		MIDDLE	*Parahoplites melchioris*	*Epicheloniceras* cf. *subnodosocostatum*/ *Acanthohoplites acutecosta* Interval Zone		*Parahoplites nutfieldiensis*
			Epicheloniceras subnodosocostatum			*Epicheloniceras martinoides*
		LOWER	*Dufrenoyia furcata*	*Dufrenoyia justinae* Taxon-Range Zone	LOWER	*Tropaeum bowerbanki*
			Deshayesites deshayesi			*Deshayesites deshayesi*
			Deshayesites weissi			*Deshayesites forbesi*
			Deshayesites oglanlenis			*Prodeshayesites fissicostatus*

Figure 5. Correlation of proposed biozonation with the standards of the Mediterranean and sub-Mediterranean regions, and Northeast Europe.

by Contreras-Montero (1977) for the Aptian of northeastern Mexico was based in the apparent coeval ranges of both species of the genus *Hypacanthoplites* that define both biozones in the area.

DISCUSSION

The new biozonation presented herein is intended for regional use in northern Mexico because of recognized endemism of the characteristic taxa of the western Tethyan realm. In addition, because of the intermittent character of the stratigraphic occurrence of some ammonite species in the sections studied, the first occurrences (FAD's) and the last occurrences (LAD's) of the taxa are here considered strictly as stratigraphic events rather than evolutionary phenomena. Thus, the absolute boundaries of the proposed biozones may be closely approximate, but they may differ from one area to another. Figure 5 shows the proposed biozonation and its approximated correlations to formerly established biozones for European regimes (Casey, 1961; Hoedemaeker *et al.*, 2003). It is important to stand out the lack of the lowermost biozones for the Bedoulian in northern Mexico. The absence of records of the *Deshayesites oglanlensis* through the *Deshayesites deshayesi* zones in northern Mexico, is explained by the dominance of shallow carbonate platforms in the area through most of the Bedoulian as in other parts of the world. A transgressive event which drowned those carbonate platforms at the end of this substage, and recorded by the onset of deposition of the La Peña Formation, allowed for the development of conditions that favored the incursion of the ammonoid faunas into these areas of Mexico (Barragán, 2001). Thus, the first stratigraphic record of Aptian ammonites in this part of Mexico represents a rich assemblage of species belonging to the genus *Dufrenoyia*. This assemblage is proposed here as the *Dufrenoyia justinae* Taxon-Range-Zone, and can be correlated to the *D. furcata* zone of the Mediterranean regime, though, its lower boundary is dependant of the timing of the onset of the sedimentary conditions, and therefore it can be diachronous in a regional sense. The *Epicheloniceras* cf. s*ubnodosocostatum*/*Acanthohoplites acutecosta* Interval-Zone assigned for the whole middle Aptian needs further revision. The basal part of this biozone can be definitively correlated to the *E. subnodosocostatum* zone of the Mediterranean regime. However, uncertainty remains regarding the nature of its upper part until future work allows the recognition of indexes of the *Parahoplites melchioris* zone in Mexico and its subsequent splitting into a formal biostratigraphic unit. The biozones regarded as indication of the Upper Aptian in the area of study, are doubtless coeval with the *Acanthohoplites nolani* and Hypacanthoplites jacobi of the Mediterranean region.

CONCLUSIONS

This work improves the current Aptian ammonite biochronological scheme for northern Mexico. The four ammonite biozones proposed herein are derived from

studies of the stratigraphic records of indexes species of three continuous Aptian sections from the area. This new biozonation is intended for regional use, however, it can be correlated approximately with the uppermost part of the Bedoulian, the Gargasian, and the Clansayesian substages of the traditional Aptian stage in southern France. Further studies are needed for a complete refinement or standardization of the ammonite zonation for the Aptian of northern Mexico.

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