Barremian planktonic foraminiferal events correlated with the ammonite zones from the San Lucas Formation, Michoacán (SW Mexico)

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ABSTRACT

We studied the Tiringueo section from the San Lucas Formation, located in the state of Michoacán, SW Mexico. The section is a flysch sequence consisting of a rhythmic deposit of shale, siltstone, and fine to medium graded sandstone interbedded with limestone. The sequence contains ammonites, foraminifera and radiolarians.

The biostratigraphic analysis, based on the planktonic foraminifera and ammonites, permitted the recognition of the biostratigraphic units established on both fossil groups, for first time in SW Mexico. Although the planktonic foraminifera are scarce and poorly preserved, some important events such as the first occurrence of Hedbergella similis, Globigerinelloides blowi and Globigerinelloides aptiensis were correlated with the ammonite zones. By means of these foraminiferal events, the Zones of Hedbergella similis and Globigerinelloides blowi partim (early and late Barremian) were identified. The faunal assemblage and distinctive lithological characteristics suggest that the San Lucas Barremian sequence was deposited in pelagic conditions.

Key words: planktonic foraminifera, Barremian, San Lucas Formation, Michoacán, Mexico.

RESUMEN

La sección Tiringueo de la Formación San Lucas, localizada en el Estado de Michoacán, es una secuencia de tipo flysch que consiste en un depósito rítmico de lutita, limolita, y arenisca gradada de media a fina, interestratificada con caliza. Esta secuencia contiene amonites, foraminíferos y radiolarios.

El análisis bioestratigráfico basado en el estudio de los foraminíferos planctónicos y amonites permitió reconocer las unidades bioestratigráficas de ambos grupos fósiles por primera vez en el Sureste de México. Aunque los foraminíferos planctónicos son escasos y pobremente conservados algunos importantes eventos como la primera aparición de Hedbergella similis, Globigerinelloides blowi y Globigerinelloides aptiensis fueron correlacionados con las zonas de amonites. Por medio de estos eventos las Zonas de Hedbergella similis y Globigerinelloides blowi partim (Barremiano temprano y tardío) fueron identificadas. La asociación faunística y las características litológicas sugieren que la Formación San Lucas (Barremiano) fue depositada en un ambiente pelágico.

Palabras clave: foraminíferos planctónicos, Barremiano, Formación San Lucas, Michoacán, México.
INTRODUCTION

Most of southwest Mexico belongs to the Guerrero Terrain, characterised by magmatic, volcanic, and sedimentary sequences typical of island arcs. The San Lucas Formation is a complex volcano-sedimentary succession of Early Cretaceous age constituted in its lower part mostly of shale, sandstone, conglomerate, and limestone, while its upper part contains volcaniclastic material (Pantoja-Alor, 1990). This formation crops out around the San Lucas town, in Michoacán State, SW Mexico (Figure 1), where the Tiringueo section (100° 55’, 100° 45’W and 18° 40’, 18° 30’N) was sampled principally to study ammonites. The same samples were used for the foraminiferal analysis reported in this work.

Early Cretaceous planktonic foraminifera are rarely reported, mainly due to the fact that samples of that age consist mainly of hard limestone which can be studied only in thin sections. The few softer samples found interbedded with hard limestone are generally rich in organic matter and pyrite, in which planktonic foraminifera are poorly preserved. Few Early Cretaceous (Barremian) planktonic foraminifera have been observed in Mexico, although Longoria (1977) in his zonal scheme for Mexico recorded the first appearance of Globigerinelloides duboisii, G. blowi, Hedbergella excelsa, H. semielongata and H. sigali - the upper part of the C1-5 Zone (Nannoconus wasalli/Nannoconus coloni) in the Barremian. Besides, Omaña et al. (2003) reported on the Barremian planktonic foraminifera from the San Lucas Formation in Michoacán.

Studies of pre-Aptian planktonic foraminifera species have been reported by Moullade (1966) from the Lower Cretaceous in the Vocontian Basin. These microfossils appeared in the upper Hauterivian (P. angulicostata Zone) and continue until the base of the Aptian. Clavihedbergella eocretacea occurs with H. sigali in the upper part of the lower Barremian. Fuchs (1971) recorded the first appearance of H. similis at the top of the Barremian

Sigal (1977), in his zonal scheme for the Tethyan Cretaceous, dated the first occurrence of the planktonic foraminifer Favusella hauterivica as Hauterivian, followed by undetermined species of Hedbergella in the upper Hauterivian (P. angulicostata Zone), then by H. sigali at the base of the Barremian, and C. eocretacea, which identifies a total range zone in the late early Barremian and the schackoinids in the latest part of the early Barremian.

A good record of Early Cretaceous sediments was obtained from an offshore DSDP hole drilled in Morocco (Pflaumann and Krasheninnikov, 1978). At this site, 370 individuals of Hedbergella sigali, H. planispira, H. aff. gorbachikae, H. aff. infracretacea, Globigerinelloides aptiensis, G. ultramicrus, G. gottisi, Gubkinella graysonensis and Loeblichella moulldaei were recorded. The benthic component of the foraminifera fauna included calcareous forms such as Gyroidina, Cibicides, lagenids and spirillinids.

Grigelis and Gorbatchik (1980) review the taxonomy of Jurassic and Early Cretaceous globigerine-like foraminifera and give a modified and amended description of the Family Favusellidae and of the genera incorporated. The range of the family is defined more precisely from the Middle Jurassic up to early Cenomanian. Salaj (1980, 1984) in Tunisia recorded Favusella hauterivica as the only species in the Hauterivian, but a more diversified assemblage from the Barremian was observed. Aguado et al. (1992) recorded a few planktonic foraminifera from the Barremian in the Betic Cordillera. Banner et al. (1993) described and illustrated several planktonic foraminifera of early Barremian and late Aptian ages from bore holes drilled in the central North Sea. Cecca et al. (1993) reported a correlation between ammonites, calcareous nanofossils, planktonic foraminifera and magnetic chrons in the upper Hauterivian-Barremian interval from the Umbria–Marche area (Central Italy). A study on the Early Cretaceous from the Río Argos in Spain (Coccioni and Premoli-Silva, 1994) demonstrated that the abundance and diversity of the planktonic foraminifera began much earlier than previously considered.

The objective of this paper is to record the foraminiferal assemblage in the lower part of the San Lucas Formation (Figure 2), in order to obtain an accurate dating of this interval. The significance of this study lies in the calibration of the Barremian planktonic foraminiferal events with the ammonite zones.

![Figure 1. Geographic setting of the studied Tiringueo section, near the town San Lucas.](Image)
Geological setting and local stratigraphy

The area studied comprises a Lower Cretaceous sequence which crops out near the town of San Lucas in the south-eastern part of the state of Michoacán (Figure 1). This area belongs to the tectonostratigraphic Guerrero Terrain (Campa and Coney, 1983). The Lower Cretaceous deposit was developed within a magmatic island arc in an active margin as result of a complex process of uplift and drop of tectonic blocks affected by volcanic construction (endogenous processes), and the aerial erosion (Pantoja-Alor, 1990).

Pantoja-Alor (1959) proposed the name the San Lucas Formation for a flysch sequence composed of shale, sandstone and conglomerate, deposited over the Upper Jurassic sediments (the Zirándaro Formation), which crops out in the San Lucas Anticlinorium. The San Lucas Formation was subdivided into two parts (Pantoja-Alor, 1990). The

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Figure 2. Stratigraphic column of the San Lucas Formation in the Tiringueo section.
lower member, Terrero Prieto, consists of shale, calcareous, fine to medium graded sandstone and conglomerate (turbidites) with biostrom rudist banks at the top. In some outcrops, a few layers of explosive volcanics and lava flows are observed, and in other beds there is evidence of soft sediment deformation, such as syndepositional slumping, convolute bedding, and flame-like structures. In the lower part of this member, ammonite and aptychi of Valanginian age have been studied. Ammonites of Barremian age have been reported from the middle part of the member (Gómez-Luna et al., 1993).

The upper member, Las Fraguas, is composed of thick to massive bedded volcanic, feldspathic, and lithic sandstone with interbedded siltstone and finely grained conglomerate, which represent distal deltaic fan deposits with some turbiditic facies (Pantoja-Alor, 1990).

MATERIALS AND METHODS

The material collected from the lower part of the San Lucas Formation consists of 15 samples of calcarenites, calcareous siltstone, marly limestone and limestone (Figure 2). The samples contain ammonites and a microfaunal assemblage that consists mostly of planktonic foraminifera and radiolarians, but benthic foraminifera were also observed.

The analyses were carried out on thin sections from the limestone samples. These show a discontinuous presence of foraminifera, which are scarce and poorly preserved. Identification was difficult, but the marker species were identified, and some planktonic foraminiferal events were recorded. The textural features of the limestone were evaluated.

SYSTEMATIC PALEONTOLOGY

The identification of the species is based on morphological characteristics observed in two-dimensional axial or transverse sections. In general, the studied planktonic foraminiferal assemblage contains trochospiral hedbergellids forms which are the most important components of the association. Depending on the species, they have four to six chambers in the last whorl. Some important Globigerinelloides species and benthonic foraminifera are present. The described species are housed in the Paleontology Collection of the Institute of Geology (UNAM).

Planktonic Foraminifera

Favusella hoterivica (Subbotina)  
Figure 3.11

Globigerina hoterivica Subbotina, 1953, p. 50, pl. 1, figs. 1-4.
gradually and slowly increasing in size as added, sutures radial straight and depressed.

Remarks. *Hedbergella mitra* differs from *H. similis* for possessing a more depressed inner spire and less lobate periphery.

**Hedbergella gr. sigali** Moullade

Figure 3.3


Description. Test small with 4 to 4.5 globular chambers in the last whorl gradually increasing in size as added, periphery broadly rounded, umbilicus narrow; sutures radial and straight on spiral and umbilical sides; primary aperture a low arch, extrumbilical bordered by a lip.

Remarks. The transversal section of this species is comparable with the illustration of Premoli-Silva and Verga (2004).

**Hedbergella similis** Longoria

Figures 3.1a, 3.1b

*Hedbergella similis* Longoria, 1974, p. 68, pl. 16, figs. 10–21, pl. 18, figs. 12, 13, pl. 23, figs. 14–16. Sliter, 1999 p. 335, pl. 3, figs. 6, 13.

Description. Test small to medium low trochospiral, with five to six chambers in the last whorl initially globular then elongate gradually increasing in size as added, peripheral margin lobate, ovoid in peripheral view; sutures radial, slightly curved, depressed on both umbilical and spiral sides.

Remarks. *Hedbergella similis* is differentiated from *Hedbergella semielongata* by having a depressed inner spire and more chambers in the last whorl. The specimens identified as *Hedbergella similis* from the Tiringueo locality could be comparable to the transversal section illustrated by Sliter (1999).

**Globigerinelloides aptiensis** Longoria

Figure 3.7

*Globigerinelloides aptiensis* Longoria, 1974, p. 79, pl. 4, figs. 9–10, pl. 8, figs. 4–6, 17, 18. Sliter, 1999, p. 334, pl. 2, figs. 8, 9.

Description. Test evolute, small, peripheral outline subcircular lobate, with six globular chambers in the last whorl, sutures radial and depressed, relict apertures and flaps could be observed.

Remarks. *Globigerinelloides aptiensis* differs from *Globigerinelloides blowi* by having more numerous chambers in the last whorl and slow growth rate resulting in a lobate test. The spiral view of the specimen observed is comparable to the illustration of Premoli-Silva and Verga (2004).

**Globigerinelloides blowi** (Bolli)

Figure 3.6


Description. Test small, planispiral biumbilicate involute. Globular chambers four to five in the last whorl increasing rapidly in size. Peripheral outline circular. Sutures radial deeply depressed.

Remarks. *Globigerinelloides blowi* differs from *G. paragottisi* by having globular chambers and more circular peripheral outline as well as a small but deeper umbilicus. The axial section of *Globigerinelloides blowi* is comparable to the photography presented by Sliter (1989).

**Globigerinelloides paragottisi** Verga and Premoli-Silva

Figure 3.8


Description. Test small planispiral with 5–5.5 (usually 5) chambers in last whorl increasing rapidly in size; chambers globular to subglobular, inflated in lateral view; equatorial periphery ovoid moderately lobate; sutures straight, slightly depressed and radial; umbilical area rather shallow and wide.

Remarks. This species was proposed by Verga and Premoli-Silva (2003) for some specimens previously identified in the literature as *G. gottisi*, the holotype of which is considered for them attributable to *Globigerinelloides blowi* (Bolli).

**Globigerinelloides sp.**

Figure 3.9

Description. Test small, distinctly compressed, with 5 subglobular chambers in the last whorl increasing fast in size as added, umbilicus shallow. Peripheral outline ovoid subcircular. Sutures straight, radial and depressed.
Gorbatchikella sp.
Figure 3.10

Description. Test trochospiral, aperture semi-circular in shape with a thin rim, with four chambers in last whorl. The observed specimens are similar those illustrated by Premoli-Silva and Verga (2004).

Benthonic Foraminifera

Gavellinella barremiana Bettenstaedt
Figure 3.12


Description. Test trochospiral with 7.5–9 chambers in the last whorl with curved sutures, resulting in narrow chambers.

CORRELATION BETWEEN THE AMMONITE ZONES AND THE PLANKTIC FORAMINIFERAL EVENTS.

The Tiringueo section contains abundant and well preserved ammonites which allow the recognition of most of the zones proposed by Hoedemaker et al. (2003). According to Ramirez–Garza (2003), the lower beds of the Tiringueo section can be assigned to the ammonite Kotetishvilia nicklesi Zone (lower Barremian) (SL-0-SL-1F). In this interval, the planktonic foraminifera are more abundant and larger in size than the specimens observed in the subsequent levels, and we recorded Hedbergella similis together with other foraminifera such as Hedbergella mitra, H. gr. sigali, Globigerinelloides paragottisi, Globigerinelloides sp. and Gorbatchikella sp. Some benthic foraminifera and radiolarians were observed (Figures 3.13 and 3.14).

Immediately above of this section, the Kotetishvilia compressissima Zone (level SL-1F-SL 2) was recognized. This interval is characterised by no identifiable pyritized ammonites. The following level corresponds to the Ancyloceras vandenheckii Zone (level SL-2C’-SL-2D; upper Barremian), where Globigerinelloides duboisii was first recorded (SL-2C”). Finally, the Gerhardtia sartousiana Zone (level SL-2D to SL-11; upper Barremian) was recognised. In the level SL-11, the foraminiferal assemblage contains scarce specimens of planispiral forms with six chambers identified as Globigerinelloides aptiensis; Hedbergella excelsa also appears.

These planktonic foraminiferal events could be correlated with the record of planktonic foraminifera found in Mexico (Longoria, 1977) and Rio Argos (Coccioni and Premoli-Silva, 1994). The events observed in the Tiringueo section are difficult to correlate with the CI-5 Zone (Nannoconus wasallii/Nannoconus coloni), proposed by Longoria (1977) for the Barremian. This author reported the first appearance of Globigerinelloides duboisii, G. blowi, Hedbergella excelsa, H. semielongata, and H. sigali, but only in the upper part of this zone. However, some events can be correlated with the foraminiferal occurrences in Rio Argos (Coccioni and Premoli-Silva, 1994). Thus, in the Tiringueo section the first occurrence of Hedbergella similis is in the Kotetishvilia nicklesi Zone (early Barremian), this event is consistent with the finding from the Rio Argos site (Coccioni and Premoli-Silva, 1994). Globigerinelloides blowi first appears in the lower part of the ammonite Ancyloceras vandenheckii Zone (late Barremian), while at the Rio Argos it was recorded later, at the top of the same ammonite zone. The first appearance of Globigerinelloides aptiensis was recorded in the Gerhardtia sartousiana Zone, which is earlier than in the Rio Argos section, where this foraminifer species was registered in the H. feraudianus Zone.

Planktonic foraminifera and ammonites were studied using the same samples, allowing a direct correlation between both groups. Although planktonic foraminifera from the Tiringueo section were generally scarce, poorly preserved and unevenly distributed, it was possible to record several foraminiferal events which have been correlated with the ammonite zones. The first one is the FO (First Occurrence) of Hedbergella similis. This event indicates the Hedbergella similis Zone, where the first appearance of forms with clavate chambers occurs (Premoli-Silva and Sliter, 1999). Another important event is the FO of Globigerinelloides blowi, which has been used as a boundary marker to distinguish the later zone. On the basis of these foraminiferal data, two zones were identified, Hedbergella similis Zone (early Barremian) and Globigerinelloides blowi Zone (partim) (late Barremian), according to the zonal schemes of Sliter (1989, 1999), Coccioni and Premoli-Silva (1994), Robaszynski and Caron (1995), and Premoli-Silva and Verga (2004). Moreover, the FO of Globigerinelloides aptiensis and Hedbergella excelsa were recorded.

Depositional and environmental interpretation

The main lithology of the Tiringueo section consists of calcarenite in the lower part, followed above by calcareous silstone with pellets and pyrite. The overlying beds are composed of calcarenite and limestone. The limestone is predominantly wackestone with foraminifera and radiolarian. The lithology and faunal association suggest a pelagic deposit in an open marine environment.
CONCLUSIONS

The Tiringueo sequence of the San Lucas Formation represents an important record of Early Cretaceous deposits in SW Michoacan State, characterized by pelagic facies. The integrated study of planktonic foraminifera and ammonites dated this succession as early and late Barremian and made possible a correlation between the foraminiferal planktonic events and the ammonite zonal scheme.

Despite of the poor state of preservation of the planktonic foraminifera, different species of *Hedbergella, Globoigerinelloides* and other foraminifera have been identified and described in thin section.

The planktonic foraminiferal assemblage is similar in content and stratigraphic distribution to the fauna of some European localities such as Rio Argos (Coccioni and Premoli-Silva, 1994), where studies on the Lower Cretaceous planktonic foraminifera have provided an important contribution to knowledge of the evolution of the group.

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