First planktonic foraminifera from the Early Cretaceous (Albian) of the Upper Magdalena Valley, Colombia

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Abstract—Albian planktonic foraminifera have been found in the Caballos and “Villeta” formations at two localities in the Upper Magdalena Valley. This is the first documented record of Early Cretaceous planktonic foraminifera in Colombia. Hedbergellids and heterohelicids dominate; keeled forms are absent. The sedimentologic features and the associated microfauna indicate the onset of restricted environments from the middle Albian on.

Resumen—Se describen foraminíferos planctónicos de edad Albiano de las formaciones Caballos y “Villeta” en dos localidades del Valle Superior del Magdalena. El presente trabajo constituye la primera documentación de foraminíferos planctónicos del Cretácico temprano en Colombia. La fauna está compuesta por hedbergellidos y heterohelicidos. Las formas quilladas están ausentes. Esto indica, junto con las características sedimentológicas, condiciones paleoceanográficas restringidas a partir del Albian medio.

INTRODUCTION

IN THE GEOLOGIC RECORD, the Early Cretaceous was an epoch in which the simple globigeriniform foraminiferal species that first appeared in the Jurassic, or possibly even in the Triassic, began to diversify (Lipps, 1973). Before the Aptian, planktonic foraminifers had particular characteristics such as low diversity or small size. They are considered primitive, opportunistic forms that (re)colonized the oceanic realm after periods of environmental stress (Caron and Homewood, 1983). Their degree of speciation and morphologic evolution is likewise low, in comparison with the morphologically highly specialized and diverse taxa of the Late Cretaceous (see, e.g., Robaszynski et al., 1984; Caron, 1985).

In Colombia, only Late Cretaceous planktonic foraminifera have been studied in any detail (e.g., Gandolfi, 1955; Cushman and Hedberg, 1941; Martínez, 1989). The only references to Early Cretaceous forms are limited to a few citations summarized below.

Early Cretaceous beds bearing foraminifera were reported in the Eastern Cordillera by Colom (1962), who identified foraminifera in thin sections as Globigerina. He described a sample replete with specimens of this genus, which he believed belonged to the middle Albian, but gave neither species identification nor arguments for the dating of the samples.

A record of the planktonic species Globigerinella escheri (Kaufmann) in middle Albian beds of the Western Cordillera of Colombia, identified by H. Duque-Caro (Ingeominas, Bogotá), was given by Etayo et al. (1980). This taxon is a synonym of Globigerinelloides escheri (Kaufmann) (among many others) according to Masters (1977, p. 411), who gave an “Upper Albian, Turonian-Maastrichtian” range for this species. Considering Etayo’s ammonite-supported age determination, the range of the species could be extended to the middle Albian. In fact, this is the only record of a planktonic Early Cretaceous species in Colombia.

Martínez (1990) reported Praeglobotruncana stephani and Rotalipora micheli from beds of the Hilo Formation of the Eastern Cordillera, which also contain Albian ammonites, in particular Oxytropidoceras. These are also associated with Rotalipora reicheli, whose biochron lies between late early Cenomanian and late Cenomanian (Stock, 1993). Therefore, the Hilo Formation and the range of Oxytropidoceras may not be limited to the Albian.

Benthonic Early Cretaceous foraminifera were documented by Petters (1954), in particular the assemblage Choffatella, Epistomina mosquensis, Orbitolina concavata texana, and Haplostiche texana, which he assigned to ages between earliest Barremian (?) and late Albian. Although some of these assemblages would appear to be
time markers, no further biostratigraphic work has proved this. Large orbitolinids occur in the Payandé area of the Upper Magdalena Valley (F. Colmenares, pers. comm., 1991) and deserve further study.

The present work is the first documented record of Early Cretaceous planktonic foraminifera in Colombia, as no real data have been previously reported or illustrated. It is intended to show their applicability and biostratigraphic usefulness within the study area, especially in the monotonous black shale series of the Colombian Cretaceous.

**GENERAL GEOLOGY**

The foraminifers presented here were recovered from the Upper Magdalena Valley (UMV), a long, folded sedimentary basin along the Rio Magdalena, bounded by the Central and Eastern Cordilleras. The basin is divided into the northern (Girardot) subbasin and the southern (Neiva) subbasin, separated by the Natagaima uplift. Samples from the Neiva subbasin were taken from the ravines known as Quebradas Bambucá and Ocal (Fig. 1).

The basin fill consists of Mesozoic and Cenozoic strata. The Lower Cretaceous units recognized in the UMV are the Yavi, Caballos, and Villeta Formations. The Yavi Formation is a predominantly continental facies, but some marine microfossils have recently been reported (Prössl and Vergara, 1993).

The sandstones of the Caballos Formation are the reservoir for most of the oil produced in the basin, presently about 50,000 bpd. In turn, the organic-rich shales of the "Villeta" Formation are the source rock for this petroleum. The planktonic fauna reported in this paper are from the Caballos and "Villeta" Formations.

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**Fig. 1.** Geographic setting of the investigated profiles.
First Early Cretaceous planktonic foraminifera, Upper Magdalena Valley, Colombia

Caballos and "Villeta" Formations

Fig. 2. Lithologic column of the Caballos and "Villeta" Formations in Quebradas Palmorosa and Bambucá.

Caballos Formation

This formation was named by Olsson (1956, p. 307) in the region of Prado Dolores, Tolima. Its age ranges from Aptian to Albian, according to Corrigan (1967) and Beltrán and Gallo (1969), who correlated the Caballos Formation with the Une Formation in the Eastern Cordillera and with the Hollín Formation in Ecuador. The Caballos Formation consists mainly of sandstones, with carbonate intercalations, and it records the arrival of the Cretaceous sea in the UMV during the Early Cretaceous. It either unconformably overlaps pre-Cretaceous rocks (Corrigan, 1967) or lies conformably on top of the Yaví Formation where this formation is present. The Caballos Formation has been mapped as such in the UMV by Núñez et al. (1984) and Fúquen et al. (1989), and as horizon K-9 by Raasveldt and Carvajal (1957a,b).

"Villeta" Formation

Hettner (1892) defined the "Villetaschichten" as stratigraphically intermediate between the Girón and Guadalupe beds of the Eastern Cordillera and originally assigned it an age of "Neocomian to Gault."

The name Villeta Formation has been applied in different areas of Colombia (and even Venezuela) where Cretaceous strata of similar lithology crop out (e.g., Grosse, 1930; Stutzer, 1926). In this paper we follow Corrigan (1967, p. 232), who recommended using this name for what he described as a "well defined lithologic unit sandwiched between the older Caballos sands and the overlying Guadalupe sands." Prevalent lithologies are black shales with carbonate concretions or intercalated carbonate beds.

In the UMV, however, physical and temporal limits of the Villeta Formation (sensu Corrigan, 1967) are different
from those in the Eastern Cordillera. Following the Code of Stratigraphic Nomenclature (American Commission on Stratigraphic Nomenclature, 1983), the use of the name Villeta Formation in the UMV should be abandoned. Julivert (1968) pointed out that in order to avoid confusion, the name Villeta Formation should be used only on the western flank of the Eastern Cordillera, as in Cáceres and Etayo (1969). A revision of the stratigraphic nomenclature for the UMV is presently in progress (Ingeominas, Universidad Nacional Bogotá). In this paper, the "Villeta" Formation is used with quotation marks.

LITHOSTRATIGRAPHY

The Quebrada Bambucá section is located in the Quebradas Palmorosa and Bambucá (Fig. 1), where a continuous profile of the Caballos and "Villeta" Formations crops out between coordinates X 859 870 N, Y 860 490 E and X 860 090 N, Y 860 200 E. The lithologic column recorded at this location is shown in Fig. 2.

The Quebrada Ocal section is situated to the west of the road between Neiva and Yaguará, between coordinates X 795525 N, Y 847 100 E and X 795850 N, Y 848250 E (Fig. 1). The sampled section starts in sandstone and limestone beds of the lower "Villeta" Formation approximately 50 m above the Caballos Formation. A siderite bed (believed to be a marker bed; Corrigan, 1967; Vergara, 1992) occurs above the contact between these two formations. The presence of this bed is used to separate the Lower "Villeta" from the Caballos sandstones. Figure 3 shows a preliminary stratigraphic column of the Quebrada Ocal section. Detailed field work was carried out, and further analysis is currently in progress.
Caballlos Formation

In the Quebrada Bambucá section, the Caballlos Formation can be divided into five lithologic segments (from oldest to youngest):

1. Lithic, feldspathic, or quartz arenites, where sideritic concretions appear in light-colored mudstones.

2. Black shales and intercalated carbonates containing the first appearance of metazoans — in particular, lamellibranchs. The carbonates are biosparites and biomicrites and contain unoriented bivalve shells. The shale intercalations of this segment have yielded the earliest Cretaceous planktonic foraminifers.

3. Predominantly quartz arenites with minor intercalations of siltstones, mudstones, and stratified or concretionary siderite.

4. Another succession of black shales and stratified carbonates, especially biomicrites and biosparites and some thin sideritic layers. Fossils found include planktonic as well as bentonic foraminifer, ostracods, and abundant ichnofossils.

5. Littoral deposits of sandstones and interlayered black mudstones with flaser and other typical intertidal sedimentary structures.

"Villeta" Formation

In the Quebrada Bambucá section, the lower boundary of the "Villeta" Formation is an even, normal surface between fine-grained sandstones of the Caballlos Formation and black laminated mudstones. The "Villeta" Formation represents a monotonous series of black shales and limestones. Sideritic beds containing volcanic rock fragments and glauconite occur in the lowest part of the formation. The remainder of the formation is composed of a thick series of black shales commonly intercalated with oil-bearing layers of biomicrite. Many of these have a wavy, lenticular or concretionary morphology. Thin, locally discontinuous micrite laminae commonly alternate with the black shales. Large carbonate concretions (formerly called "Wagon Wheels") are found in this unit.

In the part of the "Villeta" Formation studied at Quebrada Ocal, the unit begins with a series of sandstones, intercalated with sandy shales and fossiliferous limestones. Ammonites and oysters are abundant. This series is overlain by black shales intercalated with limestone layers tens of a meter thick. The shales contain calcareous concretions. About 140 m upward in the section, 15 m of black shales were sampled. These are intercalated with thin limestone layers containing inoceramids and dinosaur bones. Some 45 m higher, the section continues with irregular bedded bluish-grey limestones with large nodular structures. These limestones are overlain by a 2-m-thick black shale intercalation, overlain in turn by massive grey fossiliferous limestones in beds a meter or more thick.

BIOSTRATIGRAPHY

Preparation Methods

Microfossils of the Bambucá section were prepared at Ingeominas using the traditional Quaternary-O method (see Lipps, 1973). Material collected from the Ocal section was treated with H₂O₂ at Gießen University. Other than these two kinds of preparation, there were no major differences in preservation of the specimens. Additionally, the foraminifers were examined in thin sections. Table 1 shows the distribution of microfossils.

Quebrada Bambucá Section

The oldest planktonic foraminifers in the Cretaceous succession are from Segment 2 (sample 250096) of the Caballlos Formation. Most of the taxa can only be classified as hedbergellids, but we could identify Hedbergella sigali (Moullade) (see Fig. 6.1).

According to Caron’s biozonation (1985), this species has a stratigraphic range from Barremian to “middle” Aptian; however, in Sliter’s zonation (1989), H. sigali becomes extinct in the middle Albian. Palynologic data (Prössl and Vergara, 1993) from the same sample reveal an early Albian age. This supports a range of H. sigali at least into the early Albian.

The next planktonic foraminifera are from Segment 4 (sample 250098), where Ticinella cf. primula Luterbacher and T. roberti (Gandolfi) (see Fig. 6) appear in association with other indeterminable hedbergellids. Bentonic foraminifera are also present, in particular Lenticulina gaultina (Berthelin). The identification of the associated ostracod Neocythere sp. is worth mentioning, as it has potential stratigraphic value in Lower Cretaceous strata in Colombia (Martinez, written comm., 1991). Other associated fossils include bivalves and fish scales.

Numerous small hedbergellids are found in the lower "Villeta" Formation (sample 250102). Higher in the column, sample 250107 contains an abundance of Ticinella cf. roberti (Gandolfi), T. primula Luterbacher, Hedbergella planispira Tappan, and H. simplex (Morrow). This association allows no better stratigraphic resolution than Albian. However, in a sample (250144) higher in the column, the appearance of T. madecassiana Sigal together with Heterohelix sp. indicates a late Albian age (R. ticeensis–R. appenninica zones). This age is valid for the uppermost part of the Bambucá section displayed in Fig. 2. The Heterohelix individuals are a primitive, dwarfed fauna, probably indicating restricted conditions. The dating of the early and late Albian permits us to infer the position of the middle Albian. We believe this to be the age of the Caballlos-"Villeta" boundary at this locality.

Quebrada Ocal Section

The first recorded planktonic foraminifera occur above the lowest sandstones and limestones of the "Villeta" For-
Table 1. Distribution of microfossils from the Quebrada Bambucá and Quebrada Ocal samples.

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<tr>
<th>Sample-Nº</th>
<th>Species</th>
<th>Hedbergella sigali</th>
<th>Hedbergella planispira</th>
<th>Hedbergella delrioensis</th>
<th>H. gorbachikae</th>
<th>Ticinella roberti</th>
<th>Ticinella primula</th>
<th>Hedbergella simplex</th>
<th>Ticinella raynaudi</th>
<th>Ticinella madecassiana</th>
<th>Hedbergellids</th>
<th>Heterohelicids</th>
<th>Lenticulina sp.</th>
<th>Lenticulina gautina</th>
<th>Nodosariids</th>
<th>Ammobaculites sp.</th>
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In the middle part of the "Villeta" Formation (11-10-05-90, 11-10-06-90, 11-10-07-90), the forams are poorly preserved and could not be classified at a specific level. Only Hedbergella delrioensis (Carsey), Globigerinelloides cf. escheri (Kaufmann), and Heterohelix sp. were identified. This part of the "Villeta" Formation is very likely of late Albian/late Cenomanian age, based on its lithostratigraphic position. In the upper part of the profile (11-10-08-90) a Turonian/Coniacian age is provided by palynologic data (Prössl, 1992).

Microfacies Interpretation of the Quebrada Ocal Section

In the middle part of the "Villeta" Formation (11-10-05-90, 11-10-06-90, 11-10-07-90), the forams are poorly preserved and could not be classified at a specific level. Only Hedbergella delrioensis (Carsey), Globigerinelloides cf. escheri (Kaufmann), and Heterohelix sp. were identified. This part of the "Villeta" Formation is very likely of late Albian/late Cenomanian age, based on its lithostratigraphic position. In the upper part of the profile (11-10-08-90) a Turonian/Coniacian age is provided by palynologic data (Prössl, 1992).

Microfacies Interpretation of the Quebrada Ocal Section

Thick sections (samples 11-10-02-90, 11-10-03-90) of the basal part of the "Villeta" Formation show very fine, non-bioturbated lamination with occasional quartz grains. These grains range from 20 to 50 microns in size, which supports an aerial transport interpretation (Füchtbauer, 1989). The only biogenic remains are tests of planktonic forams (heterohelicids, hedbergellids), which comprise up...
to 10% of the sediment. Nevertheless, washed samples also yielded some rare benthonic forams (see Fig. 4.12).

The planktonic forams are very small, ranging from 60 to 120 microns (see, e.g., Figs. 7.7 and 7.8). Many of the tests are filled with clay minerals or frambooidal pyrite (cf. Figs. 7.4 and 7.6), which is also scattered throughout the sediment.

The small size of the planktonic forams might be due to shallow marine conditions (Berger, 1971) and/or to a stressed ecologic environment in the water column (Caron and Homewood, 1983). However, the presence of benthonic forams suggests periods of better paleoxygenation.

Thin sections from the middle part of the profile (11-10-04-90 through 11-10-07-90) also show a very fine lamination without bioturbation. Quartz is absent, whereas planktonic forams (hedbergellids, heterohelicids) are occasionally rock-forming. These forams are approximately twice as large as those from the basal part of the profile (see Figs. 7.1, 7.2, 7.3). The chambers are filled with sparry calcite. One thin section (see Fig. 7.9) shows a cyclic alternation of layers consisting exclusively of forams and organic-rich laminated layers with scattered forams. Layers rich in forams range from 350 to 700 microns in thickness. The intercalated layers are approximately 1500 microns thick and contain approximately 30-40% forams. Probably the pure foraminal layers reflect blooms in the water column in a poorly supplied terrigenous basin. These might be induced by periodic changes in local hydrodynamics affecting paleoecologic factors such as nutrient supply (Lipps, 1979). An additional indicator for those effects are phosphate laminae in the lower “Villeta” Formation of Quebrada Bambucú.

**DISCUSSION**

The planktonic foraminifera presented here constitute a reference for future biostratigraphic and exploratory work. Although biostratigraphic zones could not be established for the sections studied, an age determination was possible where no macropaleontologic data were available. Our foram-supported stratigraphy is in agreement with the palynologic results of Prössl (1992) in the Quebrada Ocal section. The proposed age for the strata of the Caballos and “Villeta” Formations dealt with herein seems to be applicable for the Upper Magdalena Valley.

The foram-bearing segments (nos. 2 and 4) from the Caballos Formation obviously represent episodes of deeper water conditions than during deposition of the sandstone segments (nos. 1, 3, 5). For an interpretation of these facies in terms of sea-level changes, see Vergara (1992).

During the middle Albian, a deepening of the basin, deduced from lithologic changes, made it possible for planktonic forams to proliferate. However, these deposits do not represent deep-water environments (cf., e.g., Hart, 1980; Hart and Bailey, 1979). The relatively low variety and high number of species in our samples may reflect stressed paleoceanographic conditions at the water column. This is also supported by the presence of dwarfed microfauna, as mentioned above.

Blooms of planktonic foraminifera and metazoans, as well as the presence of terrigenous quartz, indicate both marine and terrigenous influx for the basin. The forams can provide additional clues to the origin of the Cretaceous black shales in the study area. They reveal quiet sedimentation over a long period of time. This fact can hardly be compared to the sharply bounded events of the Cretaceous (e.g., Jenkyns, 1980, 1991; Stöhr, 1993). Thus, we suggest that black shale was deposited here during the Early Cretaceous because the basin had a restricted circulation and was poorly oxygenated. Tribovillard *et al.* (1991) presented similar factors giving rise to a regional “anoxic event” for the Upper Cretaceous La Luna Formation (Venezuela). Further work on this question is in progress.

Future research utilizing better preserved foraminifers can lead to evolutionary conclusions, in particular to the early appearance of the genus *Heterohelix*. According to Caron (1985) and Nederbragt (1991), this taxon is thought to appear in the late Albian with *H. moremani* (Cushman). Our specimens could represent unknown ancestors.

**SYSTEMATIC DESCRIPTIONS**

Order FORAMINIFERA Eichwald 1830

Suborder GLOBIGERININA Delage & Herouard 1896

Superfamily ROTALIPORACEA Sigal 1958

Family ROTALIPORIDAE Sigal 1958

Subfamily TICINELLINAE Longoria 1974

**Genus Ticinella Reichel 1950**

*Ticinella madecassiana* Sigal 1966

Fig. 6.6a-c

* 1966 *Ticinella madecassiana* n.sp. — Sigal: p. 197; pl. 3, figs. 7a-b (Holotype).

1985 *Ticinella madecassiana* Sigal — Caron: p. 76; figs. 36/4-5.

**Description**

*Spiral side:* frequently 6, sometimes 5 or 7 chambers in the last whorl; chambers globular, increasing gradually in size as they are added; sutures radial and depressed; outline lobulate.

*Umbilical side:* chambers ovoid, the first chambers sometimes subtrapezoidal; sutures radial and depressed; umbilicus very narrow; primary aperture extra-umbilical, nearly peripheral; supplementary apertures not visible.

*Lateral view:* low trochospiral.
First Early Cretaceous planktonic foraminifera, Upper Magdalena Valley, Colombia

Ticinella primula Luterbacher 1963
Figs. 5.3a-c, 5.11a-c (cf.), 6.8a-c

* 1963 Ticinella primula n.sp. — Renz, Luterbacher & Schneider: p. 1085; text-fig. 4 (Holotype).

1974 Ticinella primula Luterbacher — Longoria: pp. 96-98; pl. 25, figs. 1-6; pl. 26, figs. 12-14.

1985 Ticinella primula Luterbacher — Caron: p. 79; figs. 36/6-7.

Description

Spiral side: 7-8 chambers in the last whorl; chambers ovoid to subtrapezoidal in shape, increasing gradually in size as they are added; sutures radial and depressed; outline slightly lobulate.

Umbilical side: chambers ovoid to subtrapezoidal in shape; sutures radial and depressed; umbilicus moderately wide; primary aperture extra-umbilical, nearly peripheral; supplementary apertures umbilical.

Lateral view: very low trochospiral, pseudo-planispiral.

Remarks

The specimen shown in Fig. 5.11a-c is described here as Ticinella cf. primula. It shows the typical characteristics of T. primula but exhibits only 6 chambers in the last whorl.

Ticinella raynaudi Sigal 1966
Figs. 4.2a-c, 4.4a-c, 5.12a-c

* 1966 Ticinella raynaudi n.sp. — Sigal: p. 200; pl. 6, figs. 1(a-b) – 3(a-b).

1985 Ticinella raynaudi Sigal — Caron: p. 79; figs. 36/10-12.

Description

Spiral side: 6-8 chambers in the last whorl; chambers globular, the later chambers are either radially elongated or digitiform; chambers increasing gradually in size as they are added; sutures radial and depressed; outline lobulate.

Umbilical side: chambers globular, the last ones becoming radially elongated or digitiform; the last chamber sometimes extends into the umbilicus; sutures radial and depressed; umbilicus narrow; primary aperture extra-umbilical, nearly peripheral; supplementary apertures umbilical (Fig. 4.2a).

Lateral view: low trochospiral.

Ticinella cf. roberti (Gandolfi 1942)
Figs. 6.5a-c

Remarks

The specimen illustrated shows close relationships to Ticinella roberti, but the trochospire is too low and possesses fewer chambers than Gandolfi’s (1942) holotype.

Family HEDBERGELLIDAE Loeblich & Tappan 1961
Subfamily HEDBERGELLINAE Loeblich & Tappan 1961

Genus Hedbergella Brönnimann & Brown 1958

Hedbergella delrioensis (Carsey 1926)
Figs. 4.3a-c and 5.2a-c

* 1926 Globigerina cretacea D’Orbigny var. delrioensis n.var. — Carsey: p. 43 (without figs.).

1936 Globigerina cretacea D’Orb. — Brotzen: 169; pl. 13, figs. 1a-c.

1974 Hedbergella delrioensis (Carsey) — Longoria: p. 54; pl. 10, figs. 1-3 (Neotype); pl. 10, figs. 1-12.

1979 Hedbergella delrioensis (Carsey) — Robaszyński & Caron: p. 123; pl. 22, figs. 1, 2; pl. 23, figs. 1-2.

1980 Hedbergella delrioensis (Carsey) — Weiss: p. 110; pl. 1, figs. 1-3.

1980 Hedbergella delrioensis (Carsey) — Peryt: p. 54; pl. 10, figs. 1a-c.

1980 Hedbergella portsdounensis (Williams & Mitchell 1948) — Peryt: p. 55; pl. 9, figs. 1a-c.
**1984 Hedbergella delrioensis** (Carsey 1926) — Weidich: p. 81; pl. 3, figs. 1-4.

**1985 Hedbergella delrioensis** (Carsey) — Caron: p. 57; figs. 25/6-7.

**1993 Hedbergella delrioensis** (Carsey 1926) — Stock: pp. 54-56; pl. 4, fig. 1a-c.

**Description**

**Spiral side:** 5-6 chambers in the last whorl; chambers globular, increasing gradually in size as they are added; sutures radial and depressed; outline slightly lobulate.

**Umbilical side:** chambers globular; sutures radial and depressed; umbilicus very narrow; aperture extra-umbilical, nearly peripheral.

**Lateral view:** low to slightly high trochospiral; the last chambers are displaced towards the umbilical side.

**Remarks**

The great intraspecific variability of **Hedbergella delrioensis** is already well known. According to Weidich (1984) and Stock (1993), all variations from low trochospiral forms to higher trochospiral "portsdownensis" forms can be found in mid-Cretaceous sediments.

**Hedbergella gorbachikae** Longoria 1974

* 1974 Hedbergella gorbachikae Longoria, n.sp. — Longoria: p. 56; pl. 15, figs. 11-13 (Holotype), 1-10, 14-16 (Paratypes).

**1985 Hedbergella gorbachikae** Longoria — Caron: p. 59; figs. 25/8-9.

**Description**

**Spiral side:** 5 chambers in the last whorl; chambers globular, increasing gradually in size as they are added; sutures radial and depressed; outline more or less lobulate.

**Umbilical side:** chambers globular; sutures radial and depressed; umbilicus very narrow; aperture extra-umbilical, nearly peripheral.

**Lateral view:** low trochospiral; plano-convex, spiral side flattened, umbilical side convex.

**Remarks**

The specimen was ruined during SEM preparation and is thus not illustrated here.

**Hedbergella planispira** (Tappan 1940)

Figs. 4.5a-c, 4.6a-c, 5.1a-c, 6.2a-c

* 1940 Globigerina planispira n.sp. — Tappan: p. 122; pl. 19, figs. 12a-c (Holotype).

**1972 Hedbergella planispira** (Tappan 1940) — Hanzlikova: p. 101; pl. 26, figs. 1-2; non pl. 25, fig. 15.

**1979 Hedbergella planispira** (Tappan 1940) — Robaszynski & Caron: p. 139; pl. 27, figs. 1-3; pl. 28, figs. 1-4.

**1980 Hedbergella planispira** (Tappan, 1940) — Peryt: p. 54; pl. 10, figs. 5-6.

**1984 Hedbergella planispira** (Tappan 1940) — Weidich: p. 81; pl. 3, figs. 5-8.


**Description**

**Spiral side:** 6-8 chambers in the last whorl; chambers globular with a smooth surface, increasing gradually in size as they are added; sutures radial and depressed; outline slightly lobulate.

**Umbilical side:** chambers globular with a smooth surface; sutures radial and depressed; umbilicus wide; aperture extra-umbilical, nearly peripheral.

**Lateral view:** very low trochospiral; pseudo-planispiral.

**Hedbergella sigali Moullade 1966**

Fig. 6.1

* 1966 Hedbergella (Hedbergella) sigali n.sp. — Moullade: p. 87; pl. 7, figs. 20-23, 24-25 (Holotype).
Fig. 6. Planktonic foraminifera from the Quebradas Bambucá and Palmorosa sections (sample numbers in brackets; 8 mm = 50 microns):
1: Hedbergella sigali Moullade [250096]
2: Hedbergella planispira (Tappan) [250107]
3: Hedbergella cf. simplex (Morrow) [250144]
4: Hedbergella simplex (Morrow) [250107]
5: Ticinella cf. roberti (Gandolfi) [250107]
6: Ticinella madecassiana Sigal [250144]
7: (?) Hedbergella sp. [250144]
8: Ticinella primula Luterbache [250107]

Fig. 7. Thin-section micrographs of planktonic foraminifera from the Quebrada Ocal section (sample numbers in brackets; for 7.1 through 7.8, 8 mm = 50 microns):
1: Hedbergella delrioensis (Carsey) [11-10-04-90]
2: Hedbergella sp. [11-10-04-90]
3: Heterohelix sp. [11-10-04-90]
4: Heterohelix sp. — note the small size of the specimen; the chambers are filled with framboidal pyrite [11-10-03-90]
5: Heterohelix sp. [11-10-03-90]
6: Heterohelix sp. [11-10-03-90]
7: Heterohelix sp. [11-10-03-90]
8: ? Globigerinelloides sp. [11-10-03-90]
9: Cyclic alternation of layers consisting exclusively of foraminifera (dark layers) and laminated layers with scattered foraminifera (bright layers). The foram-rich layers reach 350-700 microns in thickness. The intercalated layers are approximately 1500 microns thick. [Negative-print, 11-10-04-90]
Hedbergella sigali Moullade 1966 — Longoria: p. 68; figs. 6-8; pl. 22, figs. 1-13.

Hedbergella sigali Moullade — Caron: p.59; figs. 25/21-22.

Description

Spiral side: 4-5 chambers in the last whorl; chambers globular, increasing gradually in size as they are added; sutures radial and depressed; outline lobulate.

Umbilical side: chambers globular; sutures radial and depressed; umbilicus narrow; aperture extra-umbilical, nearly peripheral.

Lateral view: moderately high trochospiral.

Remarks

The high degree of variability of Hedbergella simplex has led to the creation of a number of new species and one genus (Clavihedbergella), most of which were placed in the synonymy of H. simplex in the micropaleontological literature in recent years.

Superfamily PLANOMALINACEA

Bolli, Loeblich & Tappan 1957

Family GLOBIGERINELLOIDIDAE Longoria 1974

Subfamily GLOBIGERINELLOIDINAE Longoria 1974

Genus Globigerinelloides Cushman & Ten Dam 1948

Globigerinelloides cf. escheri (Kaufmann) — Fig. 4.7a-c

Description

Planispiral; 5 chambers in the last whorl; chambers globular, increasing rapidly in size as they are added; surface of the first chambers covered by pustules; sutures radial and depressed; outline strongly lobulate; aperture peripheral.

Remarks

A single specimen recovered from presumed late Albian strata in the Quebrada Ocal. It closely resembles Globigerinelloides escheri (Kaufmann), previously reported from the Western Cordillera by Etayo et al. (1980; see Introduction), and in northwestern Colombia by Gandolfi (1955) as Globotruncana beldingi beldingi. (For a taxonomic discussion, see Masters, 1977.)

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