

## Yuruma Formation (Barremian - lower Aptian?) In the Yuruma hill and Punta Espada, Alta Guajira, Uribia, Colombia

### Formación Yuruma (Barremiano – Aptiano inferior?) en el cerro Yuruma y Punta Espada, Alta Guajira, Uribia, Colombia

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**Abstract:** The Yuruma Formation in the Yuruma hill area its type locality can be differentiated into two stratigraphic intervals. The lower and upper intervals of the Yuruma Formation can also be subdivided into two segments. The lithological, sedimentological and fossiliferous characteristics support this differentiation, which allows to interpret the accumulation energy influences over the sea floor. The lower interval is characterized by intercalations of very fossiliferous marlstones and biomicrites with benthonic and nektonic fossils from the lower Barremian. The upper interval is represented by marlstones and biomicrites with poor benthonic and nektonic fossils from the upper Barremian and probably from the lower Aptian. In the Punta Espada area, whit scarce lithological controls over the lower and upper parts of the Yuruma Formation, were found biomicrites with benthonic and nektonic fossils of the lower Barremian to the lower part, and to the top were recognized biomicrites that underlie beds with lower Aptian ammonites.

**Keywords:** Yuruma Formation, lower cretaceous, type locality, La Guajira, Colombia.

**Resumen:** La sucesión de los depósitos de la Formación Yuruma, con base en la sección del cerro Yuruma, su localidad tipo, se puede diferenciar en dos intervalos estratigráficos, el inferior y el superior, que a su vez pueden subdividirse en dos segmentos cada uno. Las características litológicas, sedimentológicas y fosilíferas sustentan esta diferenciación, permitiendo interpretaciones de la energía de acumulación sobre el fondo del depósito. El intervalo inferior está caracterizado por presentar intercalaciones de lodolitas calcáreas muy fosilíferas y biomicritas con fósiles bentónicos y nectónicos del Barremiano inferior. El intervalo superior se caracteriza por presentar lodolitas calcáreas y biomicritas con poca fauna bentónica y nectónica del Barremiano superior y posiblemente de parte del Aptiano inferior. Para el sector de Punta Espada, a partir de reconocimientos puntuales de la parte inferior y superior de la Formación Yuruma, se identificaron respectivamente biomicritas con fósiles bentónicos y nectónicos del Barremiano inferior y biomicritas del techo de la unidad a pocos metros del registro de amonitas del Aptiano inferior.

**Palabras clave:** Formación Yuruma, Cretáceo inferior, localidad tipo, La Guajira, Colombia.

## 1. INTRODUCTION

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Knowledge of the Cretaceous lithostratigraphic units of the Alta Guajira, Colombia (Figure 1) continues to be scarce, and the few publications related to the Cretaceous stratigraphy and paleontology of the La Guajira Peninsula are not very detailed. Renz (1956, 1960), Bürgl (1960) and Rollins (1960, 1965) introduced valuable stratigraphic data but did not illustrate the fossils reported. Zuluaga et al. (2009) synthesized the existing Cretaceous stratigraphy into geological maps. Salazar (2010) investigated the Palanz Formation, which involves continental and transitional deposits. Patarroyo (2020) and Patarroyo and Götz (2020) described the Barremian and Aptian deposits and fossils. Based on ammonites, other mollusks and echinoderms, Renz (1956, 1960), Bürgl (1960), Rollins (1960, 1965), Patarroyo (2020) and Patarroyo and Götz (2020) recognized the existence of calcareous deposits of the Lower Cretaceous in the Alta Guajira.

The sedimentary succession and fossil association of the Yuruma Formation (Alta Guajira) allow a separation in intervals and stratigraphic ranges, which clearly involve the Barremian and probably the lower part of the lower Aptian, providing evidence of the sedimentological and environmental differences related to the contemporary deposits of the Cretaceous basin in central Colombia.

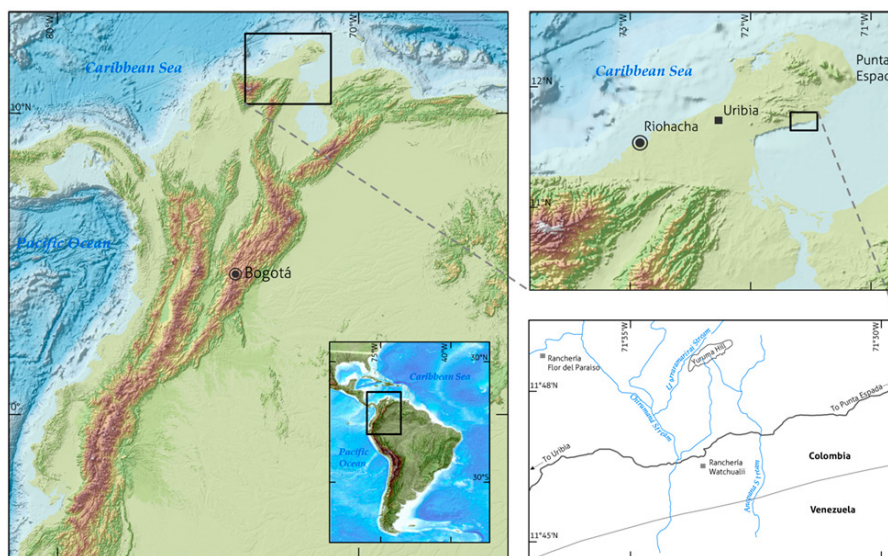


FIGURE 1.

Location of the study area

a) location of La Guajira in northern Colombia; b) department of La Guajira, with the locations of Riohacha, Uribia and Punta Espada; c) Yuruma hill sector, near to ranchería Watchuali (IGAC, Instituto Geográfico Agustín Codazzi), 10Bis-I-A topographic map.

Thus, the present contribution seeks to provide data on the lithostratigraphy, nomenclature and biostratigraphy of the Yuruma Formation in its type locality, as well as nearby outcrops located to the north in Punta Espada (Uribia, La Guajira-Colombia).

## 1.1. LOCATION

Yuruma hill is located at 8.5 km N of ranchería Wuatchuali (in the Wayuunaiki language) or Wuatchuari (Spanish), approximately 90 km from the urban center of Uribia, in the La Guajira Peninsula (Figure 1) and very close to the border with Venezuela; to the NE of this sector, Punta Espada is located approximately 70 km away.

## 2. METHOD

The initial input focused on a bibliographic analysis, which allowed the locations of the areas of interest to be recognized, including the Cretaceous sedimentary succession and the Yuruma Formation deposits in the Alta Guajira.

Since mid-2009, based on personal research carried out in the Punta Espada area, the Cretaceous deposits and marine fossils of the Alta Guajira (Patarroyo, 2011, 2020; Patarroyo and Götz, 2013, 2014, 2020) have been recognized from field trips by the Department of Geosciences at the Universidad Nacional de Colombia in Bogotá. Later, between the end of February and the beginning of March 2018, under the auspices of the Servicio Geológico Colombiano, the Yuruma hill (Figure 2) was surveyed to advance the work related to the book of The Geology of Colombia (Patarroyo, 2020). During this last visit, since the base (northwestern side) until the upper part of the Yuruma hill (side southeast), the sedimentary succession was measured using a Jacob's staff; additionally, rock samples and macrofossils were collected, and the thickness and geometry of the beds were determined following Campbell (1967), moreover comparatively was obtained the color of the rocks with a reference table. To achieve continuous recognition of the succession, bed levels were followed laterally, therefore controls were performed at different sites of the hill, from which four partial columns were obtained.

The rock samples allowed a conventional macroscopic description of the different types of lithologies. The macrofossils were collected directly in the field, prepared or cleaned with conventional techniques using hammers, chisels, needles and pneumatic hammers. These fossils were coated with ammonium chloride, photographed and then digitally processed. The fossil taxonomy is mainly based on Jaworski (1938), Etayo-Serna (1985), Guzmán (1985) and Patarroyo (2020).



FIGURE 2.

Panoramas of the Yuruma hill north of ranchería Wuatchuali from two locations to the SW and NE

In Punta Espada area, with the help of the collected fauna, were identified lower Barremian deposits of the Yuruma Formation (Patarroyo, 2011, 2020) and higher stratigraphically probably lowest Aptian deposits

of the Yuruma Formation because they underlay beds with lower Aptian ammonites (Patarroyo and Götz, 2020).

### 3. GEOLOGICAL FRAMEWORK

The geology in the continental northern area of Colombia is very particular because the Caribbean plate has exerted a great tectonic influence on the geological blocks in this area, so regionally, the Oca, Cuisa (or Cuiza) and Huimatirra faults are recognized (cf. Álvarez, 1967; Colmenares et al., 2019; Gómez, 2001; Irving, 1971; MacDonald, 1964, 1965; Patarroyo and Götz, 2020; Renz, 1960; Rollins 1960, 1965), which constitute the main lineaments of the allochthon blocks of the Media and Alta Guajira. The Oca and Cuisa faults (Figure 3) are considered dextral strike-slip faults, so they have continuity toward Venezuela. To the south and north of the Cuisa Fault, it is possible to find Cretaceous deposits, whose rock bodies are recognized under the same names. The Cretaceous deposits of the Alta Guajira are included in the Palanz, Moina, Yuruma, “Cogollo”, “Maraca”, “La Luna”, Guaralamai and Parauinkrein (Parabanclen) formations, following Renz (1960), Bürgl (1960), Rollins (1960, 1965), Zuluaga et al. (2008 a and b, 2009), Salazar (2010), Patarroyo (2011, 2020) and Patarroyo and Götz (2013, 2014, 2020).

#### 3.1. NOMENCLATURE OF THE YURUMA FORMATION

The Yuruma Formation is one of the lithostratigraphic units that includes marine deposits of the Lower Cretaceous of the Alta Guajira. Rollins (1960, 1965) and Julivert et al. (1968) indicate that the denomination Yuruma was first used by geologists at the Richmond Exploration Company in approximately 1947.

Related with Yuluma (in the Wayuunaiki language) or Yuruma (Spanish) hill, the lithostratigraphic denomination arises under the term Yuruma Formation, formalized by Renz (1956) to refer to a Hauterivian - Barremian succession, which differentiated into “lower Yuruma” and “upper Yuruma”. Later, Renz (1960) restricted the term Yuruma Formation to the

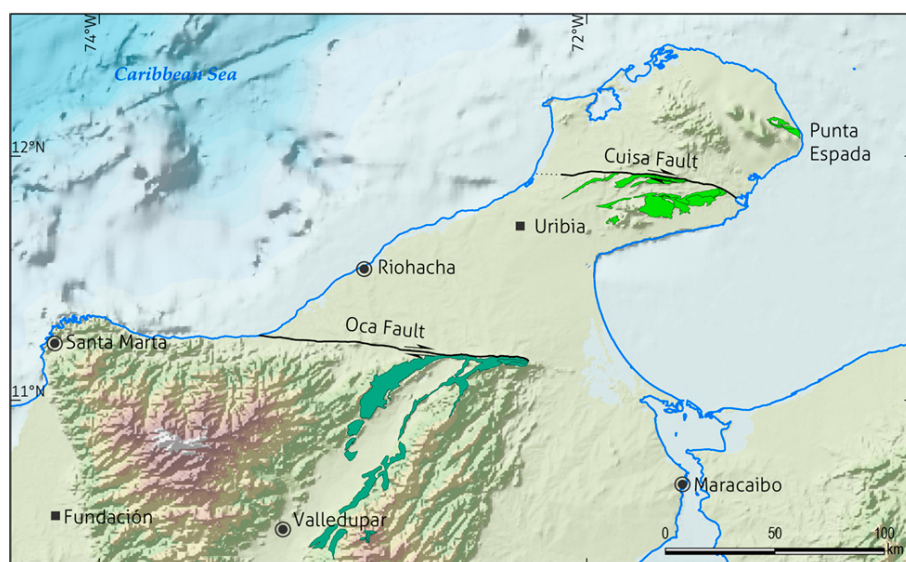


FIGURE 3

Location of the La Guajira province, showing the outcrop distribution of the Cretaceous deposits to the south and north of the Oca and Cuisa faults  
General location in Figure 1b.



Valanginian – Barremian (?) Aptian – Cenomanian	Renz (1956)	Renz (1960)	Rollins (1960, 1965)		Patarroyo and Götz (2020) and this work
	"Cogollo" F.	"Cogollo" G.	"Cogollo" Group	"Maraca" F.	?
				lower "Cogollo" F.	?
	upper Yuruma F.	Yuruma F.	Yuruma Group	upper Yuruma F.	Yuruma F.
	lower Yuruma F.	Moina F.		Moina F.	Moina F.
	Río Negro F.	Palanz F.	Palanz F.		Palanz F.

TABLE 1.

Comparative diagram of the lithostratigraphic units of the Lower Cretaceous and their stratigraphic range and limits  
Source: Based on Renz (1956, 1960), Rollins (1960, 1965), and Patarroyo and Götz (2020).

"upper Yuruma" succession with Barremian fossils, so he designated the "lower Yuruma" as the Moina Formation.

According to the proposal of Renz (1960), the Yuruma Formation underlies the Moina Formation of the Valanginian - Hauterivian (in the sense of Rollins, 1960, 1965) or the "lower Yuruma" of Renz (1956), which underlies the "Cogollo" Formation. Notably, Rollins (1960, 1965) modified the top boudary of the Yuruma Formation, placing it higher stratigraphically (Table 1), therefore the succession becomes thicker than that considered by Renz (1960). It means that according to Renz (1956, 1960), part of the lower interval of the Cogollo Formation became the highest segment of the Yuruma Formation (Rollins 1960, section BB' and plate 4 of the geological map of the La Guajira Peninsula; 1965) proposal followed in this study.

Related with the type locality, Rollins (1960, 1965) indicated a thickness of 269 m for the upper Yuruma, which should be understood as the succession of the Yuruma Formation. Although there are other known outcrops of the Yuruma Formation in the Alta Guajira, which, according to the literature, show some thickness and lithological variations, in the Yuruma hill (Figure 2), there is a very good exposure. Some outcrops near Punta Espada, NE of the type locality, are recognized by Barremian fossil fauna; thus, they are associated with this lithostratigraphic unit, as also was recognized by Renz (1960), Bürgl (1960), Rollins (1960, 1965), Patarroyo (2011, 2020) and Patarroyo and Götz (2013, 2014, 2020).

## 4. RESULTS

The literature analysis, moreover the fieldwork in the Yuruma hill and in the Punta Espada area, were the fundamental inputs to obtaining the results of this contribution.

### 4.1 Lithostratigraphy

At the base of the Yuruma hill, along the Uarramarirai or Uarramaralijai Stream (Figures 1c and 4), the sharp contact between the bioclastic levels with ostreids to the top of the Moina Formation and the marlstones at the base of the Yuruma Formation is observed. There structural orientation of the beds toward the lithostratigraphic boundary is N70° E/11° SE.

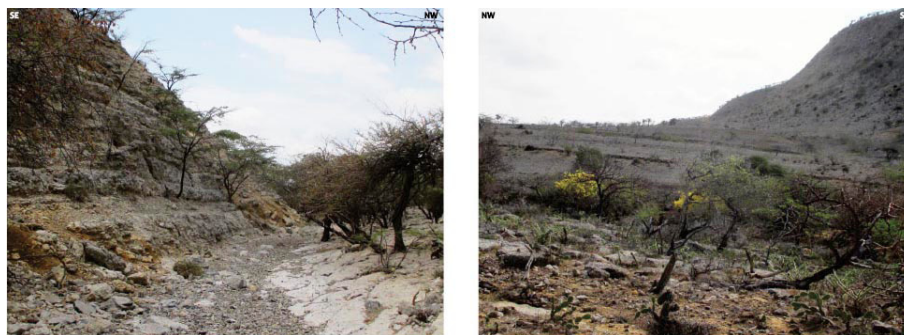


FIGURE 4.

Surface of the sharp contact between the top bed of the Moina Formation  
and the base of the Yuruma Formation, Uarraramarirai Stream  
Lower Yuruma hill section

A large part of the succession described here, since the base (Uarraramarirai or Uarramaralijai stream) until the upper part of Yuruma hill, has a thickness of approximately 190 m (Figures 2 and 5), measured directly with a Jacobs staff and with global positioning system (GPS) control. Based on fieldwork and lithological characteristics, the succession can be divided into two stratigraphic intervals (Figure 5), coinciding with observations proposed by Rollins (1960, 1965). The lower interval,

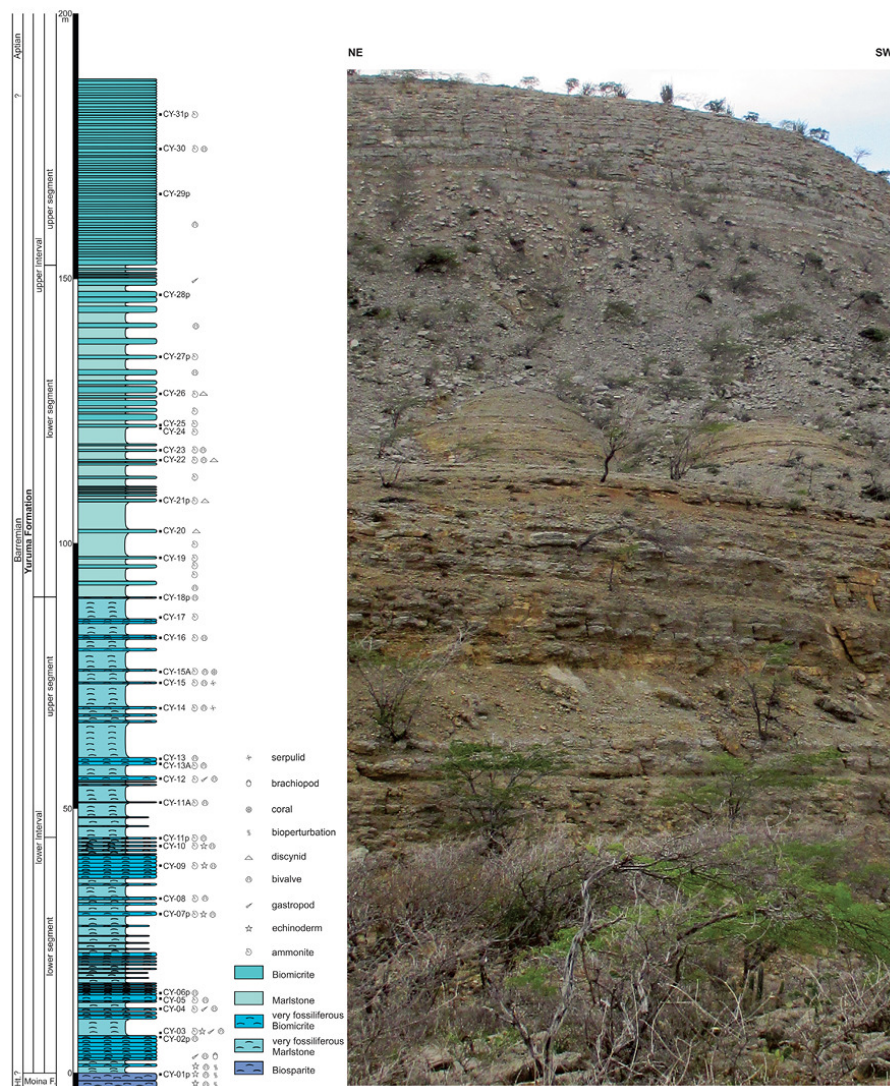


FIGURE 5.

Stratigraphic section of the sedimentary succession of the Yuruma Formation in the Yuruma hill area and panoramic view of the succession since the Uarraramarirai Stream until the upper part of the hill (Uribia, La Guajira) Includes the top of the Moina Formation and a large part of the Yuruma Formation.

90 m, shows intercalations of very fossiliferous to fossiliferous biomicrites and very fossiliferous marlstones with mollusks, echinoids, articulated brachiopods, serpulids and colonial corals, with thin to very thick beds and irregular to regular geometries. To the upper interval was possible to described only 100 m (Figure 5), without reaching the top of the unit, represented by intercalations of poor fossiliferous biomicrites and marlstones. The fossil content of this interval varies markedly compared with its underlying beds because the fossil amount decreases. In addition, benthic organisms are scarce and the few that exist have thin shells (bivalves and disarticulated brachiopods). Likewise, the change in the sedimentological characteristics is perceived; there is a tabular geometry in the beds with flat to parallel wavy lamination, scarce macrofauna (microfauna is predominant) and without fragmentation of the fossils.

The upper boundary with the “Cogollo” Formation was not recognized in the Yuruma hill area in this study. Based on Rollins (1960, Figure 6, BB’ section and plate 4 of the geological map of the La Guajira Peninsula; 1965, Figure 6), for this sector, the boundary of the Yuruma Formation is found at the limestones with ostreids in the SE margin of the Yuruma hill. In the sector of the Punta Espada, following Patarroyo



and Götz (2020), the upper boundary of the Yuruma Formation is located in the highest structural plane of biomicrites of the upper interval, coinciding with a very prominent morphological change (Figure 6).

Similarly, each of the aforementioned intervals can be subdivided into two segments. For the lower interval, the lower segment (Figures 5, 7 and 8) has 44.5 m of intercalations, in which there is a greater predominance of biomicrites (N1-N5) with irregular geometries of thin, medium and thick beds on very fossiliferous marlstones (N1) (Figure 8).

Whole fossils are in the marlstones, while in the biomicrites, thick-shelled benthic fossils are more frequent, which present principally aleatory distributions and, in many cases, fragmentation. There may also be bioperturbations in some of the strata.

The upper segment of the lower interval (Figures 5 and 7), with thickness of 45.5 m, has a higher proportion of marlstones (N1) than biomicrites (N1-N5). The marlstone beds are very thick, and the biomicrite layers are medium to thin. The fossils in the marlstones show parallel orientations according to the stratification plane, while in the biomicrites, the thick shell benthic fossils mainly present aleatory distributions and, in some cases, fragmentation. Bioperturbation may occur in some strata. In the succession of the lower interval, trigonids (*Pterotrigonia* sp.), ostreids (*Ceratostreon* sp.), gastropods of variable sizes (*Nododelphinula* sp.), ammonoids, irregular echinoderms, serpulids, articulated brachiopods, and others are either fragmented or complete (whole).

For the upper interval, the lower segment (Figures 5 and 9) is 65 m thick with intercalations between weathered marlstones (N1, 5YR 4/1) and biomicrites (N1, N2, N3, N4, 5YR 2/1, 5YR



FIGURE 6.

Biomicrite strata at the top of the Yuruma Formation in the Punta Espada area

The morphological change in the structural plane with strong tectonic and karstic effects dips to the N, coinciding with the lithostratigraphic boundary (photographic capture from the N, Piedra del Destino valley, cf. Patarroyo and Götz, 2020, Figure 2).

4/1, 5YR 6/1). The tabular beds of marlstones are very thick, and the biomicrites are medium thick (Figure 10), mainly with flat parallel lamination. In both the marlstones and biomicrites, the fossils have the same orientations as the bedding plane, and the few benthic fossils (bivalves and discynid brachiopods) have thin shells (Figure 10). In the upper segment of the upper interval (Figures 5, 9 and 10), only 35 m of strata are described, represented by tabular, medium to thick beds, mainly containing biomicrites with dominantly parallel flat lamination; the benthic and nektonic fauna are scarce, while the microfossils (foraminifera?) are more abundant.

In other controls of the Punta Espada area, thin beds of biomicrite (Figure 11) were recognized, in which abundant benthic fossils with thick shells appear, mainly disjointed and fragmented, and nektonic fossils are less frequent. These lithostratigraphic characteristics are similar to those observed in the lower segment of the lower interval of the Yuruma hill sector.



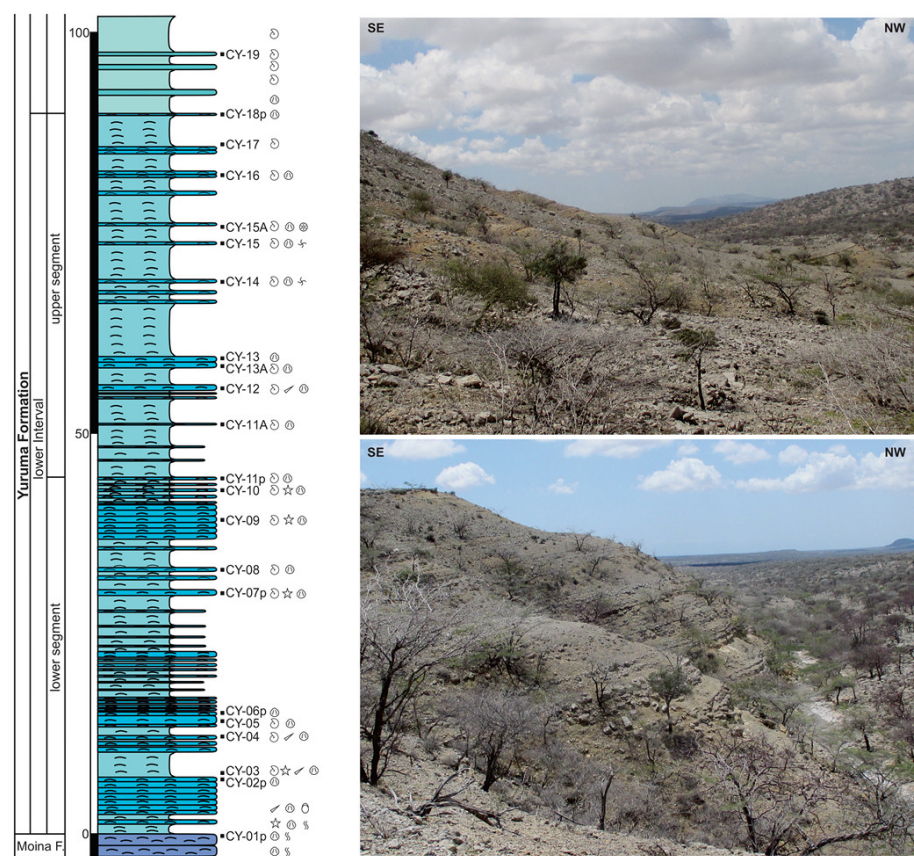


FIGURE 7.

Stratigraphic succession and outcrops of the lower interval of the Yuruma Formation, Yuruma hill section

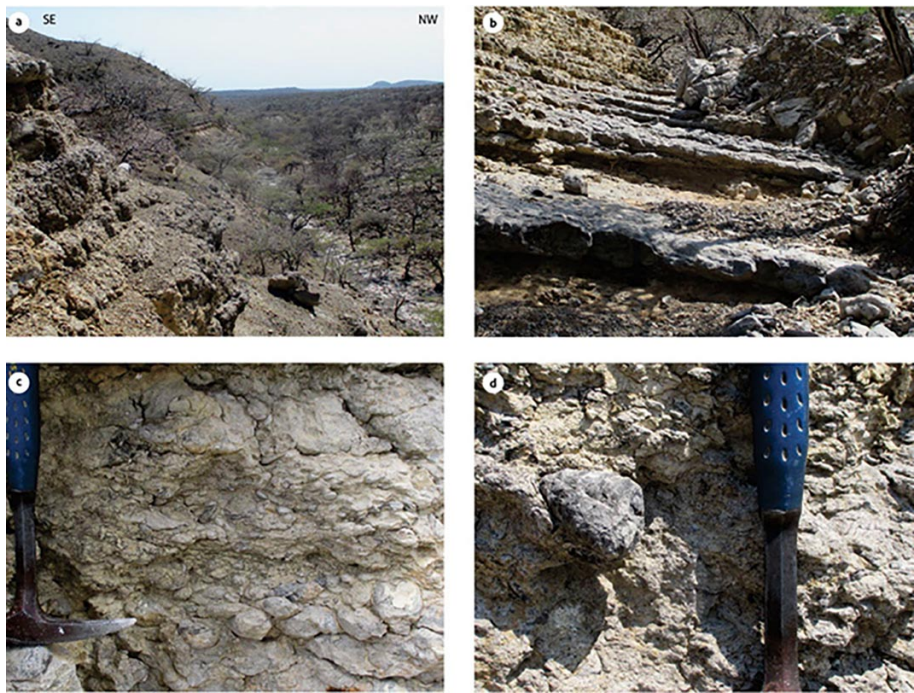
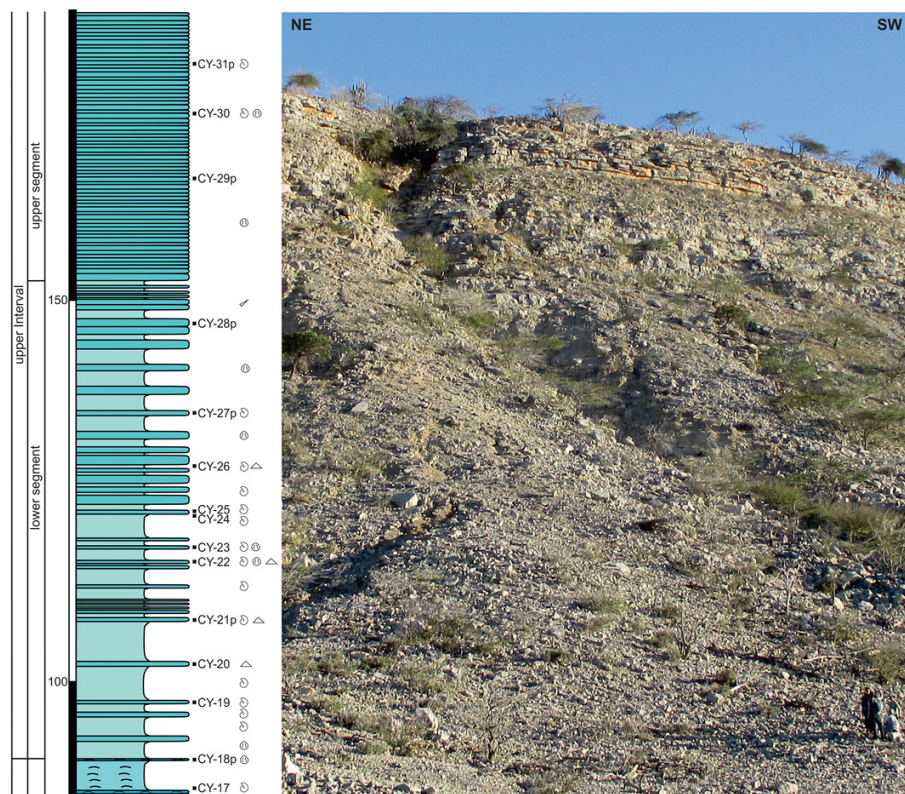


FIGURE 8.

a) Sedimentary outcrops of the entire lower segment of the lower interval of the Yuruma Formation; b) close up picture, where the irregular geometries of the thin beds are notorious (meters 37 to 39); c and d) fossils and their bed distribution; and d) Pterotrionia sp.



**FIGURE 9.**  
Stratigraphic succession and outcrops of the upper interval of the Yuruma Formation  
Medium to upper Yuruma hill section.





**FIGURE 10.**

Details of the outcrops of the tabular beds of marlstones and biomicrites of the upper interval and some of their macrofossils  
a and c) biomicrites and weathered marlstones of the lower segment; b, d and e) biomicrites of the upper segment; f) biomicrite with an ammonoid fragment; and g) biomicrite with a bivalve, in which soft thickening of the growth lines is observed. Fossils remain in the field.





FIGURE 11.

Succession of the lower part of the Yuruma Formation at Punta Espada  
In the background, the coastline and the Punta Espada lighthouse can be seen.

#### 4.2 Biostratigraphy and stratigraphic range

Based on the fossil vertical distribution, especially the ammonoids, it is possible to identify the stratigraphic range of the Yuruma hill succession following postulates for the equivalent Cretaceous successions of central Colombia.

In the upper section of the Moina Formation (Figure 12), the predominance of the ostreid *Ceratostreon* sp. may be present in both the Hauterivian and Barremian deposits, a case that is similar to what occurs in the stratigraphic section at the top of the Rosablanca Formation in the middle of Magdalena Valley.

Within the lower segment of the lower interval of the Yuruma Formation (Figure 12), the following fossils are recognized: sample CY-03, *Nicklesia pulchella* (d'Orbigny, 1840) (Figure 13a), *Nicklesia karsteni* (Uhlig, 1882) (Figure 13b), *Karsteniceras beyrichi* (Karsten, 1858) (Figure 13c), *Karsteniceras* cf. *beyrichi* (Figure 13 d and e), and *Neitheia* sp. (Figure 13f); sample CY-04, *Karsteniceras* cf. *beyrichi* (Figure 13g, e, i), *Karsteniceras* sp. (Figure 13 h), and *Nododelphinula* sp. (Figure 13j) in the sense of Jaworski (1938, pl. 23, 5); sample CY-05, *Nicklesia* cf. *karsteni* (Figure 13k, l); samples CY-07 and CY-08, *Pulchellia galeata* (von Buch, 1838) (Figure 13 m and n); sample CY-08, *Pulchellia* sp. (Figure 13o); sample CY-09, *Karsteniceras* sp. (Figure 14a); sample CY-10, *Pulchellia* sp. (Figure 14b), *Moutoniceras?* sp. (Figure 14c), and *Pulchellia* cf. *galeata* (Figure 14 d and e); and sample CY-11A; *Nicklesia pulchella* (Figure 14f).

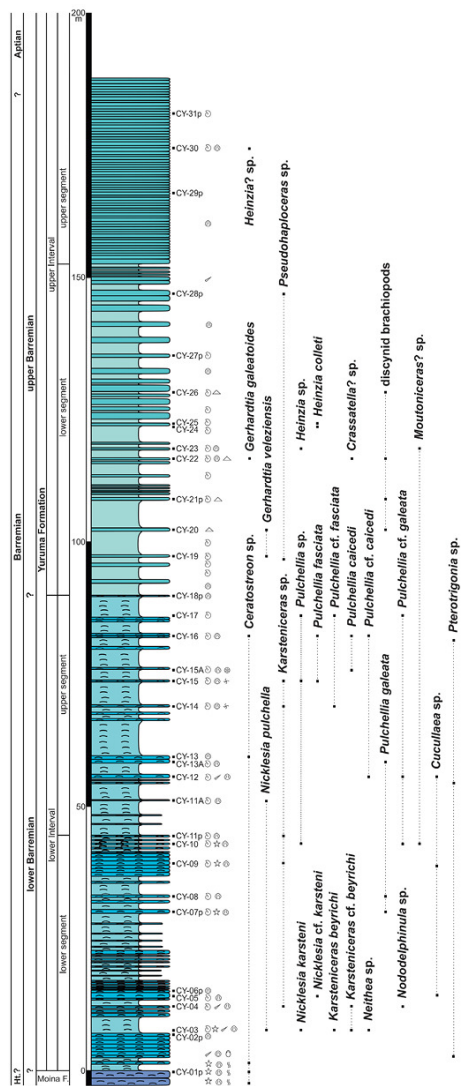


FIGURE 12.  
Sedimentary succession of the Yuruma hill section with the vertical fossil distribution



**FIGURE 13**

a) *Nicklesia pulchella* (CY-03); b) *Nicklesia karsteni* (CY-03); c) *Karsteniceras beyrichi* (CY-03); d and e) *Karsteniceras cf. beyrichi* (CY-03); f) *Neitheia* sp. (CY-03); g, e, i) *Karsteniceras cf. beyrichi* (CY-04); h) *Karsteniceras* sp. (CY-04); j) *Nododelphinula* sp. (CY-04); k, l) *Nicklesia cf. karsteni* (CY-05); m, n) *Pulchellia galeata* (CY-07 and CY-08); and o) *Pulchellia* sp. (CY-08) [Graphic scale: 10 mm]





**FIGURE 14**

a) *Karsteniceras* sp. (CY-09); b) *Pulchellia* sp. (CY-10); c) *Moutoniceras?* sp. (CY-10); d and e) *Pulchellia* cf. *galeata* (CY-10); f) *Nicklesia pulchella* (CY-11A); g) *Pulchellia* cf. *galeata* (CY-12); and h) *Pulchellia* cf. *caicedi* (CY-12) [Graphic scale: 10 mm]



FIGURE 15

a) *Pulchellia galeata* (CY-13A); b, c, d, e and f) *Pulchellia cf. fasciata* (CY-14); g) *Pulchellia fasciata* (CY-15); h) *Pulchellia* sp. (CY-15); i) *Karsteniceras* sp. (CY-15); j) *Pulchellia caicedi* (CY-15A); k) *Pulchellia fasciata* (CY-16); l) *Pulchellia cf. caicedi* (CY-16); m) *Pulchellia cf. galeata* (CY-16); and n) *Pulchellia caicedi* (CY-16) [Graphic scale: 10 mm]

For the upper segment of the lower interval, the following fossils are recognized: sample CY-12, *Pulchellia cf. galeata* (Figure 14g) and *Pulchellia cf. caicedi* (Karsten, 1858) (Figure 14h); sample CY-13A, *Pulchellia galeata* (Figure 15a); sample CY-14, *Pulchellia cf. fasciata* (Gerhardt, 1897) (Figures 15 b, c, d, e and f); sample CY-15, *Pulchellia fasciata* (Figure 15 g), *Pulchellia* sp. (Figure 15 h) and *Karsteniceras* sp. (Figure 15i); sample CY-15A, *Pulchellia caicedi* (Figure 15j); sample CY-16, *Pulchellia fasciata* (Figure 15k); sample CY-16, *Pulchellia cf. caicedi* (Figure 15l), *Pulchellia cf. galeata* (Figure 15m) and *Pulchellia caicedi* (Figure 15n); and sample CY-17, *Pulchellia cf. fasciata* (Figure 16a), *Pulchellia* sp. (Figure 16b) and *Pulchellia cf. galeata* (Figure 16c). In addition, *Pterotrionia* sp. (Figure 8d), *Ceratostreon* sp., *Pholadomya* sp., *Pinna* sp., gastropods of small size (*Nododelphinula* sp.) large (internal molds with low spire), irregular echinoderms (cf. Figure 18), and articulated brachiopods and colonial corals are found.

Thus, based on the ammonoids finding in the lower interval, this stratigraphic section involves deposits of the Lower Barremian taking into account the index species of the unnamed interval biozones of *Nicklesia pulchella* and *Pulchellia galeata* (cf. Patarroyo, 1999, 2000 a and b, 2004, 2020).

To the other hand, within the succession of the Lower Barremian of the Yuruma Formation (Figure 12), a stratigraphic level is recognized, in which individuals of *Nicklesia* and *Pulchellia* coincide, similar to that is found in the center of Colombia (Patarroyo, 1999, 2000 a and b, 2004, 2020). Given this finding and its constancy through Colombia, from the biostratigraphic point of view, it would be more appropriate to propose a concurrent range subzone for this interval than a new biozone for the lower Barremian. Thus, the subzone in which *Nicklesia* and *Pulchellia* coexist is restricted to the lower part of the interval biozone (based on lowest occurrences) of *Pulchellia galeata* (Patarroyo, 1999, 2000 a and b, 2004, 2020).

In the lower segment of the upper interval, the following fossils are present in the samples: CY-19 and CY-20, *Gerhardtia veleziensis* (Hyatt, 1903) (Figure 16d and e); CY-20 and CY-22, discynid brachiopods (Figures 16f and 17a), *Gerhardtia galeatoides* (Karsten, 1858) (Figure 17b), and *Crassatella?* sp. (Figures 17c and 18h); CY-23, *Heinzia* sp. (Figure 17d) and *Moutoniceras?* sp. (Figure 17e); CY-24 and CY-25, *Heinzia colleti* (Bürgl, 1956) (Figures 17 f and g) and *Pseudohaploceras* sp. (Figure 18i); and for the upper segment of the upper interval, in CY-30, *Heinzia?* sp. (Figure 17 h).

Based on the collected ammonoids in the upper interval, this stratigraphic succession involves deposits of the Upper Barremian, as indicated by the presence of the index species of the biozone of *Gerhardtia veleziensis* (cf. Patarroyo, 1999, 2000 a and b, 2004, 2020). It is not possible to indicate a clear stratigraphic range for the highest deposits of the Yuruma Formation in Yuruma hill because the recovery of ammonoids in these strata unfortunately was not successful. Furthermore, it was not possible to describe there the succession until the boundary with the overlying “Cogollo” Formation. However, in the sector of Punta Espada, a few meters from the upper boundary of the Yuruma Formation and toward the base of the “Cogollo” Formation, *Dufrenoyia* cf. *hansbuerghii* Etayo-Serna of the Lower Aptian (Patarroyo and Götz, 2020) was found; thus, the possibility remains that part of the deposits in the upper segment of the upper interval in the Yuruma Formation may be represented the lowest part of the Lower Aptian.

Similarly, at Punta Espada, the sample PEY-1 contains *Nicklesia* sp. (Figure 17i) and *Epistomina caracola*, which were identified in the thin section of the same sample. This material is from the lower Barremian and is related to the lower stratigraphic level of the Yuruma Formation (Figure 11) in this sector of the Alta Guajira.

The citation of *Pedioceras*, *P. caquesense* or *P. caquensense* (sic) to the upper Barremian in the upper part of the Yuruma Formation (Rollins, 1960, p. 29, Figure 6, Figure 10; 1965, p. 53, Figure 6, Figure 10) is highly controversial because in the central Cretaceous marine deposits of Colombia, *Pedioceras* is restricted to the lower part of the lower Barremian (cf. Etayo-Serna, 1964; Patarroyo, 1995, 2000 a and b, 2004, 2020).

### 4.3 Environmental considerations

Considering the lithological, sedimentological and fossil variations, preliminary environmental interpretations of the sedimentary succession of the Yuruma hill can be proposed.

The environmental conditions of the upper part of the Moina Formation indicate currents with high energy levels over the bottom of the deposit, as demonstrated by the mechanical accumulation of mollusks (Figure 18a) and the fragmentation of shells and carapaces.

The sharp contact between the top bed of the Moina Formation and the lower bed of the Yuruma Formation (Figure 4) indicates a change in the sedimentary conditions of the medium since there is an increase in the content of calcareous mud without decreases benthic macrofauna. Thus, a transgressive



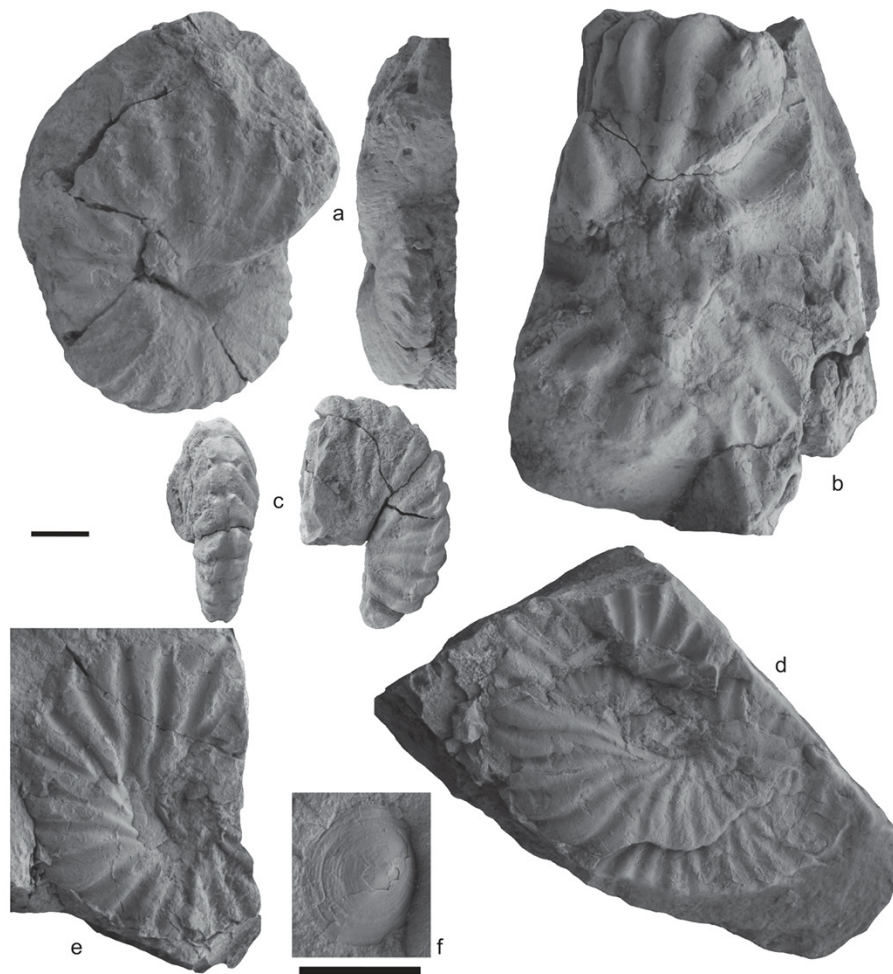


FIGURE 16.

a) *Pulchellia* cf. *fasciata* (CY-17); b) *Pulchellia* sp. (CY-17); c) *Pulchellia* cf. *galeata* (CY-17); d and e) *Gerhardtia veleziensis* (CY-19 and CY-20); and f) discynid brachiopod (CY-20) [Graphic scales (a, e) 10 mm and (f) 5 mm]

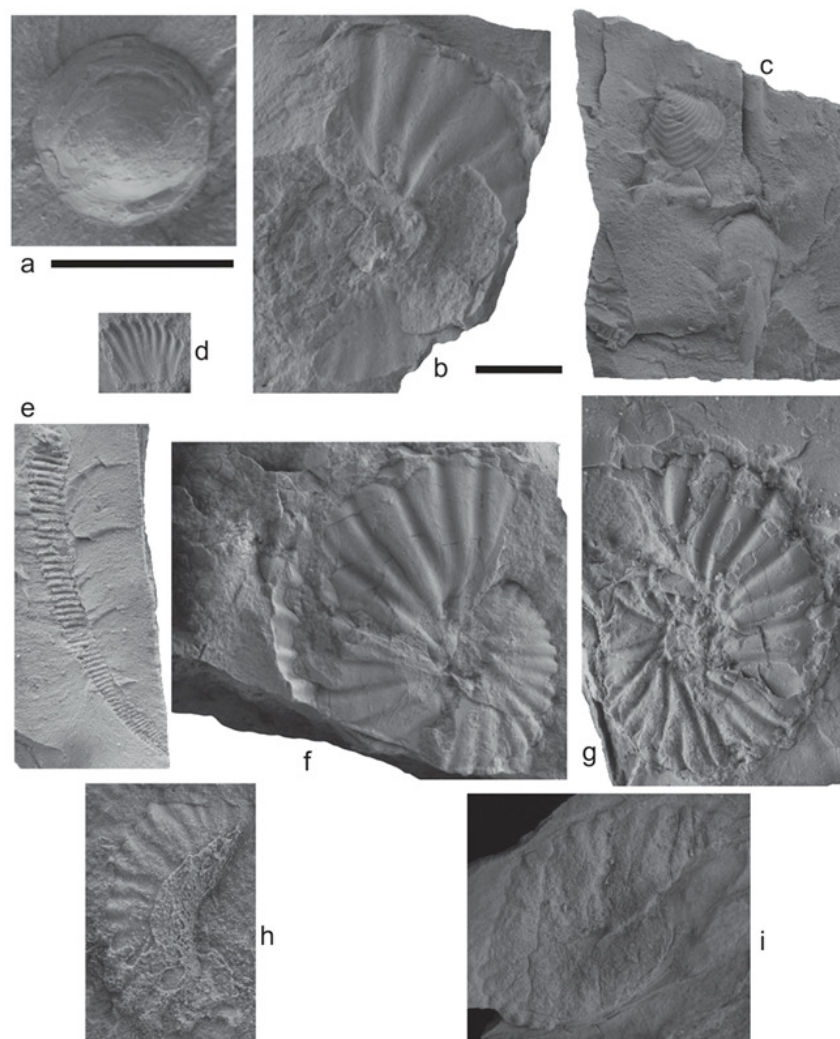


FIGURE 17

a) Brachiopod discynid (CY-22); b) *Gerhardtia galeatoides* (CY-22); c) *Crassatella?* sp. (CY-22); d) *Heinzia* sp. (CY-23); e) *Moutoniceras?* sp. (CY-23); f and g) *Heinzia colleti* (CY-24 and CY-25); h) *Heinzia?* sp. (CY-30); and i) *Nicklesia* sp. (PEY-1. Punta Espada) [Graphic scales (a) 5 mm and (b, i) 10 mm]

surface is identified as a consequence of deepening of the bottom of the deposit and a decrease in energy levels. The alternation between very fossiliferous marlstones and biomicrites with irregular layers allows to interpret variations in the depth of the deposit bottom and consequently in the energy flow over it. These variations in the lower interval deposits were more constant in the lower segment than in the upper segment because the biomicrites are subordinate to the marlstones.

In the upper interval, calmer environmental conditions are identified as a result of a greater deepening of the bottom of the deposit. The tabular beds geometries and the continuous or discontinuous plane-parallel internal lamination, plus the scarce presence of benthic fauna, corroborate this postulate.

#### 4.4 Geology of Cerro Yuruma

Considering the stratigraphic findings at the Yuruma hill and in its surroundings, it was possible to recognize and differentiate the deposits of the upper part of the Moina Formation in the Uarramarirai or Uarramaralijai Stream (Figures 1c and 4); consequently, the sharp boundary of the base of the Yuruma

Formation and from there, stratigraphically ascending, the following succession of the Yuruma Formation until the upper part of the Yuruma hill (overview, Figures 2 and 19).

Based on the data obtained in this contribution, related with the 10Bis-I-A topographic map of the IGAC (scale 1:25,000), the lateral boundaries continuity between the formations was projected based on public satellite images, panoramic



FIGURE 18.

a) mechanical accumulation of mollusks in the upper part of the Moina Formation with *Ceratostreon* sp.; b) small gastropod (g) and *Ceratostreon* sp. (c) with articulated shells and parallel orientation to the bedding plane at the base of the Yuruma Formation; c) *Cucullaea* sp.; d) irregular echinoid; e) internal mold of a large gastropod; f) *Pholadomya* sp.; g) *Pinna* sp.; h) *Crassatella*? sp.; and i) biomicrite bed with the whorl section of *Pseudohaploceras* sp. and parallel orientation to the bedding plane.

observations, field controls (compass and GPS data) and the morphology of the lithostratigraphic units. Although the upper boundary of the Yuruma Formation with the base of the “Cogollo” Formation was not recognized in the adjacent area of the Yuruma hill, the morphological change between these units was considered (Figures 2 and 19), which is coincident with the proposition and mapping of Rollins (1960, 1965). Therefore, a geological map of this sector was obtained (Figure 19), which shows the relationship of the rocks of the Yuruma Formation, following Rollins (1960, 1965), with the underlying Moina Formation and with the overlying “Cogollo” Formation. This last contact is sharp, according to Patarroyo and Götz (2020, Figure 2), as is recognized in the Punta Espada area.

The geological map, Plate 10Bis Rancho Grande (Yuruma hill) and Plate 6 Castilletes (Punta Espada) of Zuluaga et al. (2008 a and b) show different geological interpretations because they do not consider the same lithostratigraphic boundary between the Yuruma Formation and the “Cogollo” Formation. As it was discussed this boundary is taken following Rollins (1960 and 1965) to the Yuruma hill (panoramic Figure 19) and to Punta Espada area (cf. Patarroyo and Götz, 2020).



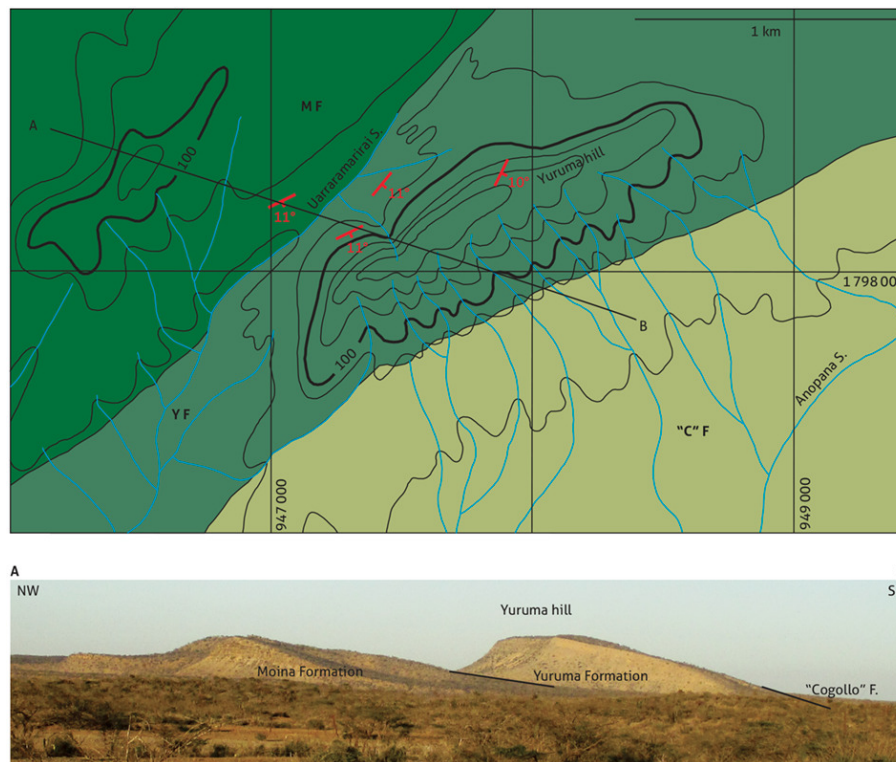


FIGURE 19.

Geological map of the Yuruma hill area based on the 10Bis-I-A topographic map of the IGAC and obtained from field data, morphological expression, panoramic photographs and satellite images

The two stratigraphic intervals of the Yuruma Formation in the Yuruma hill present variable morphological characteristics; thus, initially in the relief, the succession is principally competent although incompetent beds appear as intercalations (Figures 4, 5, 7 and 8); in the intermediate part, a morphological depression is manifested by the predominance of incompetent beds (Figures 5, 7 and 9). Finally, for the upper part, there is a pronounced escarpment (Figures 5, 9 and 10). In the Yuruma hill and Punta Espada area, to the upper interval, karst phenomena are evident, so much so that in the upper sector of the Yuruma hill, travertine associated with speleothems is recognized.

The sharp contact between the highest bioclastic bed of the Moina Formation and the lower marlstone beds of the Yuruma Formation is associated with a morphological change representing a transgressive surface that was developed very close to the Hauterivian-Barremian boundary. At the top of the Yuruma Formation, the boundary with the marlstones of the "Cogollo" Formation is sharp, based on geological controls recognized in Punta Espada (Patarroyo and Götz, 2000) following the postulates of Rollins (1960 and 1965, Figure 6).

## 5. DISCUSSION

The Yuruma Formation of the Barremian - lower Aptian? is a lithostratigraphic unit with marine deposits that are geologically associated with the Alta Guajira block. Its lower boundary is sharp with the Moina Formation at the type locality, as was recognized by Renz (1960) and Rollins (1960, 1965), and its upper boundary is sharp with the Cogollo Formation, following Rollins (1960, 1965). Based on the lithostratigraphic limits used here and the geomorphology of the Yuruma Formation, it is clearly better to follow the proposals of Rollins (1960, 1965) than those of Renz (1960) to obtain a geological mapping.

The Yuruma Formation and the Moina Formation do not crop out to the south in the Perijá Mountain range, where the type locality of the “Cogollo” Group or Formation is found (cf. Patarroyo and Götz, 2020). Care must be taken to extend regionally the lateral continuity of the lithostratigraphic units of the Perijá Mountain range because the tectonic and paleotectonic of the Oca and Cuisa faults indicate that the northern blocks of the Alta Guajira were originally located to the west of their current position. This type of misstatement generates unnecessary stratigraphic confusion.

The paleotectonic, paleoecological and sedimentological deposits conditions of the Yuruma Formation are not directly related to the equivalent deposits of the central Cretaceous basin in Colombia, although they show similar biostratigraphic elements in the nektonic fauna, which enables the establishment of their stratigraphic range (cf. Patarroyo, 2020).

## 6. CONCLUSIONS

In the studied section of the Yuruma hill, the succession of the Yuruma Formation can be differentiated into two stratigraphic intervals, lower and upper intervals, which in turn can be subdivided into two segments each.

The lower interval is characterized by intercalations of very fossiliferous marlstones and biomicrites with benthic and nektonic fossils of the lower Barremian. *Nicklesia pulchella*, *N. karsteni*, *N. cf. karsteni*, *Karsteniceras* sp., *K. beyrichi*, *K. cf. beyrichi*, *Neitheia* sp., *Nododelphinula* sp., *Pulchellia* sp., *P. galeata*, *P. cf. galeata*, *P. caicedi*, *P. cf. caicedi*, *P. fasciata*, *P. cf. fasciata*, *Moutoniceras?* sp., *Pterotrigonia* sp., *Ceratostreon* sp., *Pinna* sp., small and large gastropods, echinoderms, brachiopods and corals were found.

The upper interval is characterized by marlstones and biomicrites with scarce benthic and nektonic fauna of the upper Barremian and possibly part of the lower Aptian. *Gerhardtia veleziensis*, *G. galeatoides*, *Heinzia* sp., *H. colleti*, *H.?* sp., *Moutoniceras?* sp., *Pseudohaploceras* sp., *Crassatella?* sp. and discynid brachiopods are found. In the Punta Espada area, a few meters from the top of the Yuruma Formation, *Dufrenoyia cf. hansbuerghii* Etayo-Serna from the lower Aptian was found toward the base of the “Cogollo” Formation (Patarroyo and Götz, 2020).

Considering the lithological and sedimentological variations in the succession of the Yuruma hill, variable environmental conditions can be interpreted. At the top of the Moina Formation, the sea bottom experienced high energy influxes with the accumulation of shell and carapace fragments. In the lower deposits of the Yuruma Formation, there is a change in the environmental conditions of the deposit due to the presence of marls, an indicator of deepening for the lower interval succession where very fossiliferous marlstones and biomicrites with dominant benthic macrofossils are present. Then, there is a greater deepening related with the upper interval succession, where poor fossiliferous marlstones and biomicrites appear with scarce benthic and nektonic macrofossils.

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