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# Valanginian and Hauterivian bochianitid ammonoids from the Rosa Blanca Formation of Colombia: Palaeobiogeographic implications

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ABSTRACT

The Lower Cretaceous record of heteromorph ammonoids in northern South America is still poorly known, occurrences are often mentioned only without detailed analysis of their morphology and palaeobiogeographic implications. Here, we describe the first occurrence of *Bochianites neocomiensis* from the Valanginian of northern South America. This finding is from the upper Valanginian section of the Carrizal Member of the Rosa Blanca Formation. It underlines the meaning of high amplitude late Valanginian sea level rise, and related opening of migration routes, as part of the Weissert Event. Additionally, we identify *Janenschites oosteri* from the lower Hauterivian El Sapo Member, also within the Rosa Blanca Formation in the Zapatoca region of Colombia. The presence of *B. neocomiensis* and *J. oosteri* in Colombia broadens the palaeobiogeographical record for these species to northern South America, both trace the improving migration routes for ammonoids along the margins of the South American continent during the course of the Early Cretaceous.


## 1. Introduction

The typical ammonoid bauplan comprises closely spirally coiled shells with the whorls attached to each other. Most heteromorphs ammonoids are distinct by their coiling with at least partly detached whorls, however, they are clearly polyphyletic in origin (Hoffmann et al., 2021; Landman et al., 2021, references therein). As a group, heteromorphs have no systematic significance, however heteromorph conch shapes tend to be less abundant in many ammonoids fossil assemblages in contrast to planispiral forms (Arkadiev et al., 2011, 2012). Among the Jurassic and Cretaceous heteromorph ammonoids, the family Bochianitidae display a moderate disparity and their representatives are abundant, represented by at least five genera according to Klein et al. (2007). This family comprises the genera: *Bochianites* Lory, 1898, which is the most diverse with at least 25 species; *Baculina* d'Orbigny, 1850, a monospecific genus only including *Baculina rouyana* d'Orbigny, 1850; *Euptychoceras* Breistroffer, 1952, with at least eight species; *Janenschites* Durand-Delga, 1954, including the three species *J. janenschi* Zwierzycki, 1914, *J. oosteri* Sarasin and Schöndelmayer (1902), and *J. incises* Arkadiev (2008), following Arkadiev (2008); *Kabylites* Durand-Delga, 1954 with two species; and *Glaucoceras*, a monospecific genus based on the type species *G. revenieri* Matamales-Andreu et al. (2019).

The Lower Cretaceous fossil record of bochianitid ammonoids in Northern South America is poorly documented, especially in Colombia, from where only few taxa have been reported. The first of these reports was made by Karsten (1858, 1886), in which he mentioned two taxa originally attributed to the genus *Baculites* Lamarck (1799), namely *Baculites granatensis* Karsten (1858, 1886; pl. II, 1a, b) and *Ba. maldonadi* Karsten (1858, 1886; pl. II, 2a, b). Later these were assigned to *Bochianites* (Covacevich, 1976; Klein et al., 2007). According to Marin et al. (2023), these two taxa exhibit a ribbing style that fit perfectly within the variability of *B. neocomiensis* d'Orbigny, 1842. Possibly a forthcoming revision of the material of Karsten (1858, 1886; pl. II, 1–2) might reveal that *Ba. granatensis* and *Ba. maldonadi* might be conspecific with *B. neocomiensis*, based on the morphology figured in these works, but since the original material has not been re-examined, we

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provisionally keep them here as separate species. A third record of bochianitid ammonoids from Colombia is *Bochianites zigzag* Etayo-Serna (1985) from the Valanginian Lutitas de Macanal Formation of La Sierra Nevada del Cocuy. Recently, Etayo-Serna and Guzmán-Ospitia (2019) reported the occurrence of *Bochianites kiliani* Turner (1962) from the lower Hauterivian El Sapo Member of the Rosa Blanca Formation. This material is revised here based on new fossils and comparison of the specimen figured by Etayo-Serna and Guzmán-Ospitia (2019, Lámina 11.5) with the original description included in Turner (1962), and the later emendation made by Busnardo et al. (2003), who considered *B. kiliani* as synonym of *Janenschites oosteri* (also referred to as *Bochianites oosteri* by authors; compare e.g. Arkadiev, 2008; Vašíček, 2020). Furthermore, we report and describe herein the first occurrence of *B. neocomiensis* for the northern part of South America, from the upper Valanginian part of the Carrizal Member of the Rosa Blanca Formation. We also discuss the palaeobiogeographical implications of bochianitid ammonoids from this formation.

## 2. Geological setting, materials and methods

Five different bochianitid specimens are described herein. The first two, UR-CP-0232 and UR-CP-0366, were collected at La Virgen West and La Virgen localities, layer Q-Q0 (Fig. 1A, B) of the Carrizal Member of the Rosa Blanca Formation following the stratigraphic framework of Etayo-Serna and Guzmán-Ospitia (2019). The other three specimens (UR-CP-168, UR-CP-0363, and UR-CP-0364) were found at the El Sapo West locality, top of the El Sapo Member of the Rosa Blanca Formation, in a wackestone identified as "IV layer" (Fig. 1C), following Etayo-Serna and Guzmán-Ospitia (2019). The Rosa Blanca Formation is a sabkha-subtidal to shallow marine sequence composed of black to greenish-gray limestones with intercalations of laminated calcareous shales and thick mudstones and wackestones (Morales et al., 1958; Moreno, 1990; Etayo-Serna and Guzmán-Ospitia, 2019). The Rosa Blanca Formation is divided into five members, which are from the base to the top: Lagunetas, Carrizal, Zo, El Sapo, and Zapatoca (Etayo-Serna and Guzmán-Ospitia, 2019). Most fossiliferous in vertebrates, invertebrates, and microfossils are the Carrizal and El Sapo members.

Specimens UR-CP-0168 and UR-CP-0363 were prepared using a 5 % hydrochloride acid (HCl) solution to remove some carbonate crusts and enhance the visibility of sutures. This preparation was performed at the Core Lab of the Faculty of Natural Sciences at the Universidad del Rosario, Bogotá, Colombia. Subsequently, the specimens were catalogued and are now stored in the palaeontological collection at the Universidad del Rosario, Quinta Mutis campus in Bogotá, Colombia. They were examined and photographed using a Nikon SMZ-1270 stereomicroscope coupled with a camera. Specimens were also coated using ammonium chloride ($NH_4Cl$) for better definition of ribs and sutures, and photographed using a Canon EOS Rebel T6 digital camera.

The Valanginian palaeobiogeographical occurrences of *Bochianites* and *Janenschites* were obtained from a survey of the literature by one of us (JL), then plotted in a palaeotectonic reconstruction. For a full list of references see Klein et al. (2007), for recent additions Marin et al. (2023).

Description and anatomical measurements included length of the specimen, and dorso-ventral and lateral diameters of the cross section (Table 1) were obtained with a caliper following Arkadiev (2008). Systematic palaeontology follows Klein et al. (2007) and Arkadiev (2008), and Vermeulen et al. (2020), for higher levels Hoffmann et al. (2022) for the classification on the superfamily level.

***Institutional Abbreviations*: UR-CP,** Palaeontological Collection, Facultad de Ciencias Naturales, Universidad del Rosario, Bogotá, Colombia.

## 3. Systematic palaeontology

Order Ammonitida Haeckel, 1866.
Superfamily Bochianitoidea Spath, 1922
Family Bochianitidae Spath, 1922
Genus *Bochianites* Lory, 1898
*Bochianites neocomiensis* d'Orbigny, 1842
Figure 2A-K

*1842 *Baculites neocomiensis*, d'Orbigny; d'Orbigny, p. 560; pl. 138, figs. 1-5
*2008 *Bochianites neocomiensis* (d'Orbigny, 1840[sic]); Arkadiev, p. 471; pl. 3, figs. 1–5 (and synonymy)
*2012 *Bochianites neocomiensis* (d'Orbigny, 1840[sic]); Arkadiev et al. p. 218; pl. 38, figs. 1-5
*cf. 2019 *Bochianites kiliani* (Turner, 1962); Etayo-Serna & Guzman-Ospita, pl. 11, fig. 5
*2020 *Bochianites neocomiensis* (d'Orbigny, 1842); Petrova, p. 33; fig. 9b–w
*2022 *Bochianites neocomiensis* (d'Orbigny, 1842); Főzy et al. pl. 60, fig. 7, 9
*2023 *Bochianites neocomiensis* (d'Orbigny, 1842); Marin et al. p. 4; fig. 3a-e, fig. 4a-h (and synonymy)

***Material***. Two partially preserved internal molds. UR-CP-0232 from La Virgen West locality, 6°52′24.61″ N, 73°14′18.35″ W; and UR-CP-0366 from La Virgen Locality, 6°52′13.33″ N, 73°13′59.22″ W. Both localities are from Zapatoca, Santander Department, Colombia (Figs. 1 A,B,D).

***Description***. UR-CP-0232 is an incomplete internal mold of a heteromorph ammonoid phragmocone with an almost perfectly preserved baculiticone shape, measuring a length of 22.1 mm (Fig. 2A-D). The dorso-ventral diameter gradually increases along the phragmocone from 2.9 mm to 4.2 mm. In cross-section, the internal mold exhibits an almost perfectly circular shape, same dorso-ventral, and lateral diameters (Fig. 2E). It is preserved as iron oxide internal mold. The ribs are very faint, simple, almost homogenously spaced, being convex on venter (Fig. 2A), slanted on flanks, and concave on dorsum (Fig. 2B). The sutures and septa are delicately preserved and show a simple ammonitic pattern with three main lobes (ventral, lateral, and dorsal), of which only the ventral lobe is bipartite, while the others are unipartite (Fig. 2F). The saddles are bipartite, forming U-shaped or almost straight lines (Fig. 2F).
UR-CP-0366 is also an incomplete internal mold including most of the body chamber and the last portion of the phragmocone, measuring a length of 12.2 mm, and a dorso-ventral diameter that varies from 2.8 mm on the phragmocone to 5.1 mm at the body chamber margin (Fig. 2G-J). The sutural pattern and shape of the mold in cross-section are identical to those exhibited by UR-CP-0232 (Fig. 2K), also exhibiting an ornamentation pattern of single ribs convex on venter, slanted on flanks, and concave on dorsum.

***Stratigraphy***. Between horizons Q-Q0 of the Carrizal Member, Rosa Blanca Formation following the stratigraphic framework of Etayo-Serna and Guzmán-Ospitia (2019). An upper Valanginian age is suggested by the occurrence of the index of the *Saynoceras verrucosum* (d'Orbigny, 1841) ammonoid biozone following Etayo-Serna and Guzmán-Ospitia (2019).

Genus *Janenschites* Durand-Delga, 1954
Among the most recent authors we follow Arkadiev (2008), but not Vašíček (2020) here in keeping separate *Bochianites* and

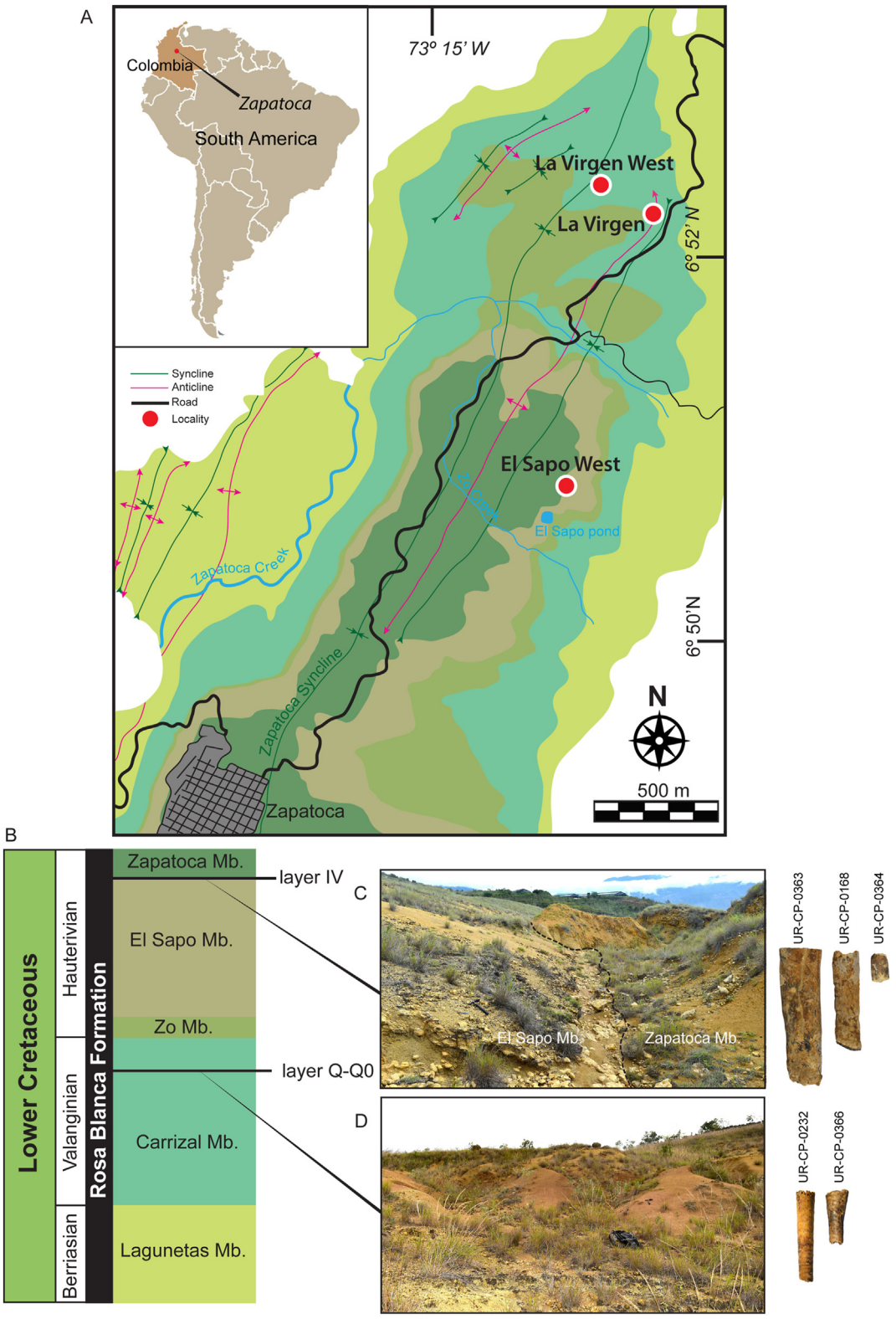
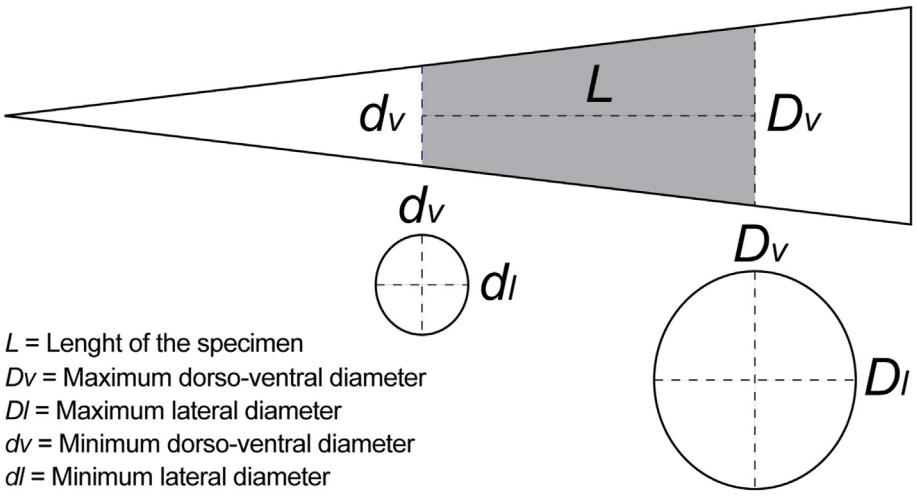



**Fig. 1.** Geographical location of Zapatoca, Colombia, and geology of the region where the ammonoids described were found. **A,** geologic map of the Zapatoca region taken and modified from Etayo-Serna and Guzmán-Ospitia (2019), indicating the three localities (La Virgen West: 6°52′24.61″ N, 73°14′18.35″ W; La Virgen: 6°52′13.33″ N, 73°13′59.22″ W; and El Sapo West: 6°50′34″ N, 73°14′ 34.2″ W) where bochianitids were found. **B,** general stratigraphic divisions of the Rosa Blanca Formation following Etayo-Serna and Guzmán-Ospitia (2019) with stratigraphic levels of bochianitid ammonoids. **C**, outcrop of El Sapo West locality, showing the specimens of *Janenschites oosteri* described herein. **D**, outcrop of La Virgen West locality, showing one the specimens of *Bochianites neocomiensis* described herein.

**Table 1**
Anatomical measurements of the bochianitd specimens described in this manuscript as preserved. All of them given in millimeters along with their graphical representation.




| Specimen/species | L | Dv | Di | dv | di |
|---|---|---|---|---|---|
| *Bochianites neocomiensis* | | | | | |
| UR-CP-0232 | 23.0 | 4.2 | 4.0 | 3.0 | 2.9 |
| UR-CP-0366 | 12.2 | 5.1 | 4.6 | 3.2 | 3.0 |
| *Janenschites oosteri* | | | | | |
| UR-CP-0168 | 65.1 | 17.6 | 16.5 | 16.6 | 15.4 |
| UR-CP-0363 | 82.5 | 25.6 | 20 | 19.4 | 19 |
| UR-CP-0364 | 19.3 | 13 | 11.2 | 11.6 | 10.8 |

*Janenschites* as different genera. Nevertheless, this concept remains difficult (cf. also with the Treatise, Wright et al., 1996), being aware that the knowledge about ontogenetical morphological change of these genera is incomplete, including their sutural ontogeny (Arkadiev, 2008: 470). In fact, we also recognize that the variability of the suture is not investigated in detail yet. Furthermore, although septal frilling seems to be constrained by shell morphology and cross section in heteromorph ammonoids (Peterman and Barton, 2018), we see that the complexity is strikingly different among the species of the Bochianitidae that all show a very similar cross section though except for differences in shell ornamentation. Since the suture is the critical feature regarding generic separation (Arkadiev 2008: 474), there might be the need to re-evaluate the systematic approach on the genus level in the future. Therefore, we regard the genus separation as provisional.

*Janenschites oosteri* (Sarasin and Schöndelmayer, 1902).
Figure 3A-N

*1902 *Bochianites Oosteri*, nov. sp.; Sarasin & Schöndelmayer, p. 179, pl. 24, figs. 3-4
*2008 *Janenschites oosteri* (Sarasin et Schöndelmayer, 1902); Arkadiev, p. 475; pl. 3, fig. 12
*2020 *Bochianites oosteri* Sarasin & Schöndelmayer (1902); Vašíček, p. 77; fig. 2a (and synonymy)

***Material***. UR-CP-0168, partially preserved internal mold of the phragmonoce; UR-CP-0363, partially preserved internal mold of the body chamber and the last portion of the phragmocone; UR-CP-0364, a small portion of a preserved internal mold of the phragmocone. All from El Sapo West locality, Zapatoca, Santander Department, Colombia, 6°50′34″ N, 73°14′ 34.2″ W (Figs. 1A-C).
***Description***. UR-CP-0168 is an incomplete internal carbonate mold. It is slightly curved when seen in ventral and dorsal views, measuring a length of 65.1 mm (Fig. 3A-E). In cross-section, the fragment exhibits a nearly perfectly circular shape (Fig. 3G), and the dorso-ventral diameter varies from 15.4 mm to 17.6 mm. The surface of the mold is almost smooth, lacking ribs but with a strong constriction convex on venter and dorsum, and concave on flanks. The sutures are well-preserved and exhibit an ammonitic pattern with moderately strongly frilled lobes and saddles (Figs. 3F, H). The suture involves three well-defined tripartite lobes, and the saddles are subdivided in two independent tripartite elements. The siphuncle can be seen almost along the entire length of the shell (Fig. 3E, F).
Specimen UR-CP-0363 is an internal mold of a relatively large specimen, measuring 82.5 mm in length (Fig. 3I-J). In cross section, UR-CP-0363 exhibits a more oval outline than UR-CP-0168, with a lateral diameter of 19 mm and a dorso-ventral diameter of 25.6 mm (Fig. 3L). Similarly to specimen UR-CP-0168 it lacks ribs and has one constriction but in this case across the body chamber. Regarding the suture line, the number and morphology of lobes and saddles is identical to those described for UR-CP-0168 (Fig. 3K).
UR-CP-0364 is a very short part of a carbonate internal mold, measuring 19.3 mm in length (Fig. 3M–N), and resembling in all aspects the sutural pattern, lobes, saddles and circular outlines of UR-CP-0168. Its almost circular cross section has a dorso-ventral diameter of 13 mm and 10.8 mm of lateral diameter. Constrictions are absent in this specimen probably because of its fragmentated preservation.

***Stratigraphy***. Top layer of the El Sapo Member of the Rosa Blanca Formation, in a wackestone rock layer identified as “IV layer” (Fig. 1C), following Etayo-Serna & Guzmán-Ospitia (2019). It is considered as lower Hauterivian based on the occurrence of *Oosterella colombiana* Haas (1960) and *Olcostephanus boussingaultii* d’Orbigny, 1842.

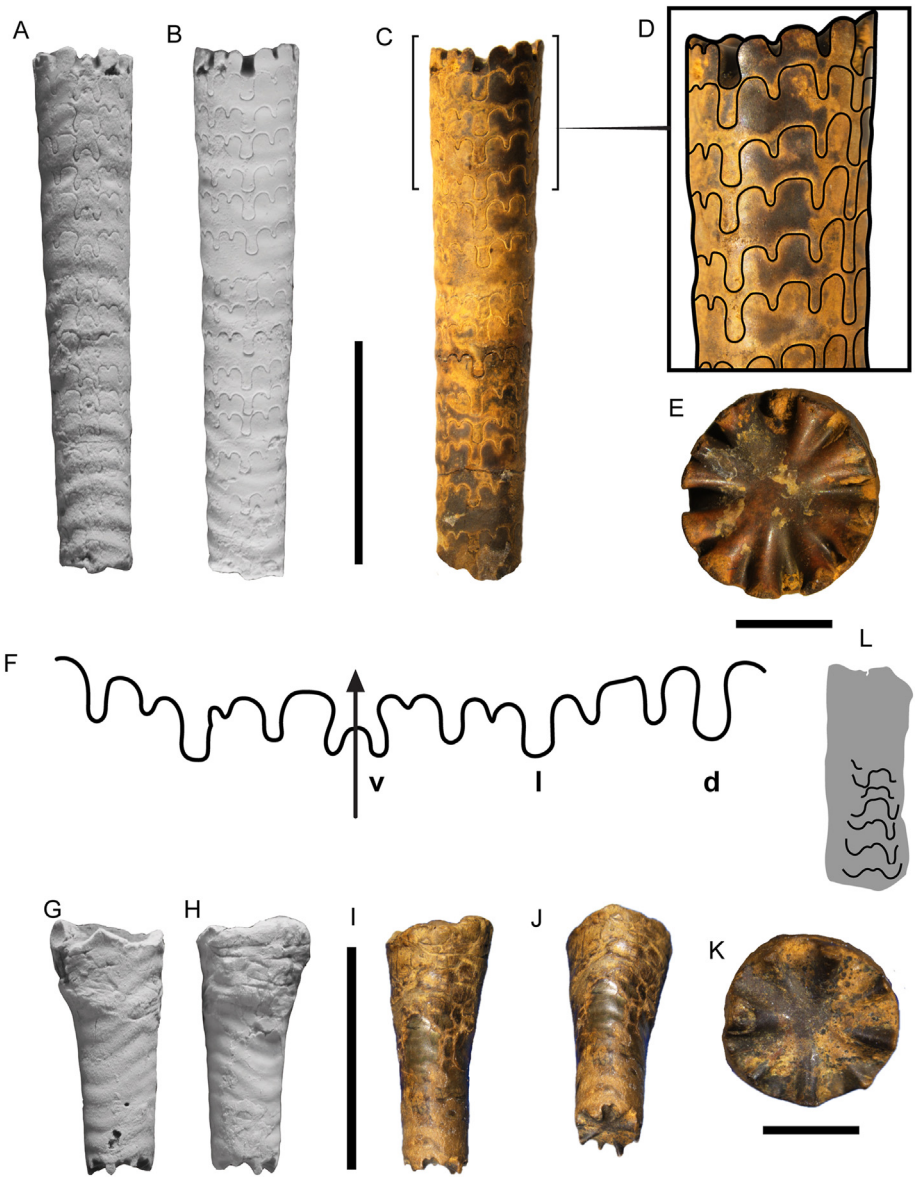



**Fig. 2.** *Bochianites neocomiensis* specimens from the Rosa Blanca Formation. **A-E**, UR-CP-0232 specimen in: **A,** ventral view coated specimen; **B,** lateral view coated specimen; **C,** lateral view in color; **D,** close-up of a region of the lateral view exhibiting the well-preserved sutural pattern; **E,** cross-section view; **F,** sutural pattern. **G-K,** UR-CP-0366 specimen in: **G,** dorsal view coated specimen; **H,** ventral view coated specimen; **I,** ventral view in color; **J,** dorsoventral view in color showing the beginning of the phragmocone; **K,** cross-section view of the phragmocone; **L,** *B. neocomiensis* uncatalogued specimen redrawn from Etayo-Serna and Guzmán-Ospitia (2019, Lámina 11.5). Abbreviations: **d,** dorsal lobe; **l,** lateral lobe; **v,** ventral lobe. Vertical scale bars = 10 mm, horizontal scale = 2 mm applies for E and K.

## 4. Discussion

### 4.1. Taxonomical identity

The discovery of fairly well-preserved heteromorph ammonoid specimens from the region of Zapatoca, Colombia, motivated a study of the Valanginian and Hauterivian bochianitid ammonoids of the Rosa Blanca Formation. This results in the following taxonomical considerations: *1)* The Colombian specimen reported and figured by Etayo-Serna and Guzmán-Ospitia (2019, lámina 11.5) and redrawn herein (Fig. 2L) was initially identified as *Bochianites kiliani*. Here, we re-assign it to *Bochianites neocomiensis*. It agrees in shape, size and sutural pattern with specimens UR-CP-0232 and -0366 identified as *Bochianites neocomiensis* described herein (Fig. 2). *2)* The presence of three of lobes and the shape of the sutures exhibited by UR-CP-0168, 0363 and 0364 described here (Fig. 3) from the top layer of the El Sapo Member are almost identical with the sutural pattern described for *J. oosteri* figured in Sarasin and Schöndelmayer (1902, fig. 6), and Arkadiev, (2008, fig. 3e), and redrawn here for comparisons (Fig. 3L). Following Arkadiev (2008) lobes and saddles are more serrated compared to that of *Bochianites neocomiensis*, thus lacking the distinct ribbing. This supports the attribution of these three specimens to *J. oosteri*.

The bochianitids UR-CP-0232 and -0366 share the same rib pattern with other specimens of *Bochianites neocomiensis* (e.g. Marin et al., 2023), a species that is the most common and widely distributed species of the genus (Klein et al., 2007). The simpler and smoother sutural pattern exhibited by *B. neocomiensis* specimens might be explained by their preservation as somewhat worn molds; however, also variability in sutural complexity seems to play a more significant role in this group of ammonoids (see Arkadiev, 2008: Fig. 4).

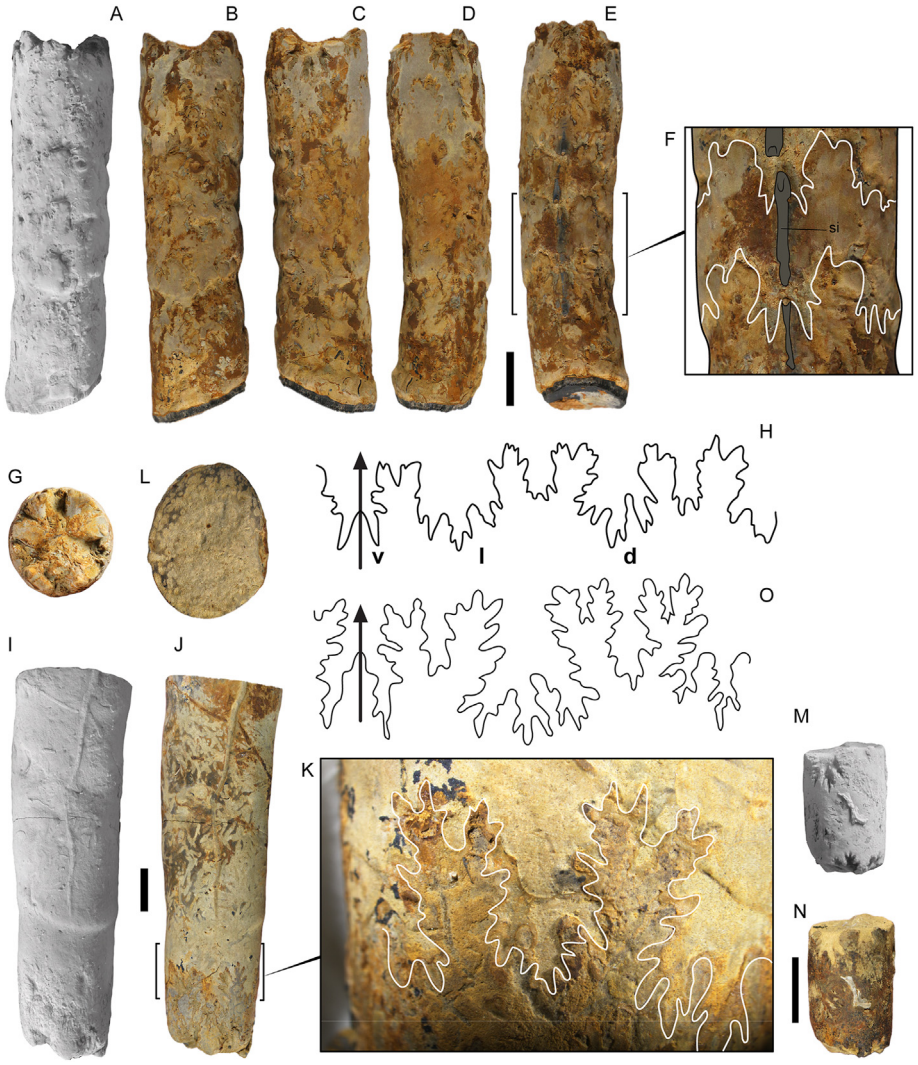



**Fig. 3.** *Janenschites oosteri* specimens from the Rosa Blanca Formation. **A-H,** UR-CP-0168 specimen: **A,** right lateral view coated specimen; **B,** right lateral view in color; **C,** left lateral; **D,** dorsal view; **E,** ventral view; **F,** close-up of a region of the ventral view exhibiting the well-preserved sutural pattern and the siphuncle; **G,** cross-section view; **H,** sutures of *Janenschites oosteri* UR-CP-0168 specimen. **I**–**K,** UR-CP-0363 specimen; **I,** dorsal view coated specimen; **J,** dorsal view in color; **K,** close-up of a region of the dorsal view exhibiting the well-preserved sutural pattern; **L,** cross-section view; **M-N,** UR-CP-0363 specimen in dorsal view; **O,** sutures of *Janenschites oosteri* redrawn from Arkadiev (2008, fig. 3e). Abbreviations: **d,** dorsal lobe; **l,** lateral lobe; **si,** siphuncle; **v,** ventral lobe. Scale bars = 1 cm.

### 4.2. Palaeobiogeography and biochronostratigraphy

In South and Central America ammonoid is characterized by a high degree of endemism for the late Jurassic and earliest Cretaceous (Gerth 1921; Leanza 1980; Leanza & Wiedmann 1980; Lehmann et al., 2015 and references therein). This is believed to be changed by megaplate tectonics connected to the opening of the South Atlantic (Wiedmann 1988). Early rifting in the South Atlantic tilted the South American plate not only towards the west, but also towards the north, allowing the establishment of new migration pathways. During Valanginian-Hauterivian times Colombian ammonoid faunas were belonging to the northwestern limit of the Indo-Pacific Subrealm of the Tethyan Realm (Fig. 4; Lehmann et al., 2015). Particularly since the Valanginian immigrations of species from the Mediterranean-Caucasian Subrealm (M–C Sr) of the Tethyan Realm and cosmopolitan species are recorded in South and Central America (Wiedmann 1988; González-Arreola 2007; Rawson 2007). *Bochianites* and *Janenschites* are both ammonoids of M–C Sr origin (Vašíček & Faupl 1998; Lukeneder 2005; Mutterlose et al., 2022). In the case of *Bochianites neocomiensis* we hypothesise that its appearance in Colombia is related to the establishment of new pathways by megatectonic rearrangement and the interfingering with sea level change. Particularly its co-occurrence in the same layer of the Carrizal Member of the Rosa Blanca Formation with the well-known lower upper Valanginian index ammonoid *Saynoceras verrucosum* (see Szives et al., 2024) is an important argument. The co-occurrence is stratigraphically consistent with its report from other Valanginian sections of Europe and South America (Klein et al., 2007; Marin et al., 2023, references therein). This stratigraphical interval marks the onset of one the most significant palaeoceanographic events of the Early Cretaceous, the Weissert Event, that ranges from the upper lower Valanginian to the middle upper Valanginian (Mattioli et al., 2014; Cavalheiro et al., 2021). It represents a main perturbation of the carbon cycle evidenced by a positive carbon isotope shift, a crisis of neritic as well as pelagic carbonate producers, and climatic fluctuations. Nevertheless, a primary relationship of ammonite occurrence with sea level is regarded as most relevant from our point of view since the stratigraphic interval in focus falls into a high global sea level respectively a fast sea level rise (Lini et al., 1992, Gréselle & Piczzezt,

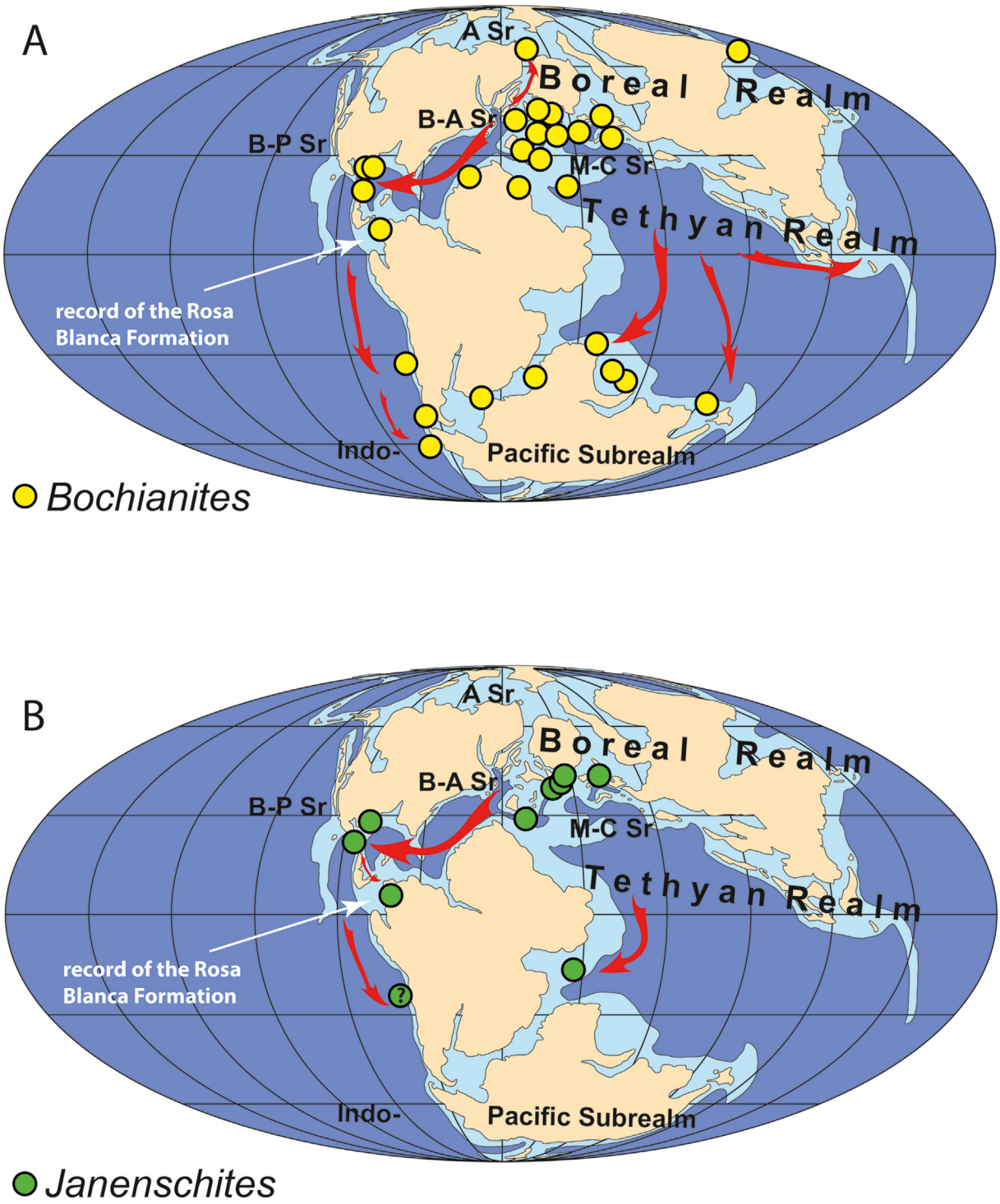



**Fig. 4.** Palaeogeographic reconstruction of the globe for the Valanginian-Hauterivian, palaeobiogeographic distribution of the studied bochianitids and assumed migration routes. Map based on a 135 Ma reconstruction (Blakey 2014), for details and subdivision into provinces see Lehmann et al. (2015). **A,** Valanginian records of *Bochianites* spp. Note that there is a further record of the genus from Colombia besides the one presented here (*B. zigzag* Etayo-Serna 1985). **B**, Hauterivian records of *Janenschites* spp., the questionable record from Chile is based on Mourgues (2007), see also Marin et al. (2023). M–C Sr = Mediterran-Caucasian Subrealm of the Tethyan Realm. B-A Sr = Boreal-Atlantic Subrealm, B–P Sr = Boreal-Pacific Subrealm, A Sr = Arctic Subrealm, all of these are subrealms of the Boreal Realm.

2010). In fact, significant magnitudes of sea level changes, globally characterizing the Valanginian, are believed to be linked to climatically driven glacial-eustasy (Ray et al., 2019). In the Boreal Realm a 'boreal nannoplankton excursion' occurs in the *Saynoceras verrucosum* Zone, interpreted as controlled by sea-level rather than by climate (Melinte & Mutterlose 2001). Since this nannoplankton event is associated with a migration of ammonoids from the M–C Sr into the Boreal Realm it appears likely that these eustatic changes also triggered ammonoid migration from the M–C Sr into the northwestern Indo-Pacific Subrealm of the Tethyan Realm.

Therefore, the occurrence of *Bochianites neocomiensis* not only corroborates the widespread occurrence of this species across Europe, North Africa. Moreover, this first undisputable record of this species in northern South America (Fig. 4A) it also underlines the global faunal change related to the Weissert Event. We are currently beginning to explore this event in detail at the chemostratigraphical and faunistic levels in the lower latitudes of Gondwana, using the Rosa Blanca Formation as an example.

The record of *Janenschites oosteri* from the top of the El Sapo Member expands the occurrence of this genus that is known from Europe, North America and Africa (Fig. 4B). Palaeobiogeographically, the record of this species that also originated in the M–C Sr is less surprising compared to that of *Bochianites neocomiensis*. Our record of *Janenschites oosteri* is early Hauterivian, by this time the migration from the M–C Sr were already well-established. The faunal exchange around the formerly isolated shelf seas around the South American continent were successively allowing a mixing of faunas during the course of the later Early Cretaceous (Wiedmann 1988; Rawson 2007). However, it is important to notice that this depends on the interpretation if the distinction of the three genera of the family Bochianitidae (*Bochianites*, *Kabylites* and *Janenschites*) is meaningful as discussed above (Durand-Delga, 1954; Klein et al., 2007; Arkadiev, 2008; Arkadiev et al., 2011). *Kabylites* and *Janenschites* could be considered as synonyms of *Bochianites* (e.g. Wiedmann, 1962), a genus with a worldwide distribution including South America (see Marin et al., 2023, fig. 9). *J. oosteri* has been reported from rocks of the lower Barremian of Crimea, Austria and Switzerland (Arkadiev, 2008; a late Valanginian record from Austria, Lukeneder, 2004, is not considered in Fig. 4). Nevertheless, Vašíček (1999) reports *J. oosteri* frequently also from the lower part of the early Hauterivian, this corresponds to the age proposed for the top part of the El Sapo Member of the Rosa Blanca Formation (Etayo-Serna and Guzmán-Ospitia, 2019).

## 5. Conclusions

This study sheds light on the taxonomy, palaeobiogeography, and biochronostratigraphy of the heteromorph ammonoid family Bochianitidae, in the Valanginian and Hauterivian Rosa Blanca Formation in Northern South America. The re-evaluation of a specimen, previously included as *Bochianites kiliani* in Etayo-Serna and Guzmán-Ospitia (2019), now classified as *Bochianites neocomiensis*, based on the resemblance of its shape and sutural pattern with this taxon. The discovery of *Bochianites neocomiensis* in the Carrizal Member marks its first assured record in northern South America, contributing to a its almost global palaeobiogeographical distribution during the Berriasian to lower Hauterivian. It is related to a major sea level rise on the late Valanginian and falls within the sequence of the Weissert Event. We also record *Janenschites oosteri* from the El Sapo Member that is dated early Hauterivian. This constitutes the first evidence from South America and its occurrences is part of the increasing migration routes during the later Early Cretaceous.

## CRediT authorship contribution statement

**Edwin-Alberto Cadena:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Jonatan Bustos:** Writing – review & editing, Visualization, Investigation, Data curation. **Jens Lehmann:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis.

## Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Edwin-Alberto Cadena reports financial support was provided by University of the Rosary Faculty of Natural Sciences and Mathematics. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Data availability

Data will be made available on request.

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