

Early Cretaceous (Albian) Nannofossils from the Bisbee Group, Little Hatchet Mountains, New Mexico

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Abstract

Fieldwork in the Little Hatchet Mountains of New Mexico was undertaken to investigate the potential of recovering nannofossils from the early Albian Old Hachita Member of the U-Bar Formation. These samples contain the first record of Early Cretaceous nannofossils from the Bisbee Group, which consists of sediments deposited along a marine embayment that extended east-west across southern New Mexico and Arizona in the United States, northern Chihuahua and northern and central Sonora in Mexico, and possibly into the Gulf of California. Samples from the Old Hachita Member were analyzed, and 20 of the 35 samples yielded nannofossils. The nannofossils are generally poorly preserved and of low diversity, but key biostratigraphic markers such as *Braarudosphaera batilliformis*, *Prediscosphaera columnata*, and *Crucibiscutum bosunensis* indicate the Old Hachita Member is of early Albian age; this is supported by the presence of ammonites of the early part of the *Douvilleiceras* Zone. Maximum sea level attained in the Old Hachita Member is interpreted in a sample 25 m above the base of the unit based on maximum nannofossil diversity. Another potential sea-level increase is identified between 54 and 56 m above the base of the section. This study highlights the potential of using nannofossils in interpreting the precise ages and paleobathymetry of the Early Cretaceous Bisbee Group seaway in other parts of New Mexico, Arizona, and northern Mexico.

Introduction

Identification of calcareous nannofossils from New Mexico is rare, with the only previous description by Schueth and Lees (2019), who documented calcareous nannofossil assemblages from the Turonian of the Niobrara seaway in the San Juan Basin of northwestern New Mexico. Nannofossils from the Late Cretaceous Western Interior Seaway have been extensively studied (e.g., Watkins, 1989; Bralower and Bergen, 1998; Corbett et al., 2014; Kita et al., 2017). Early Albian to late Aptian marine sediments are recorded from onshore Texas on outcrop and in studied boreholes dominated by shallow marine carbonate deposits of the Glen Rose Formation (Phelps et al., 2014, 2015; Godet et al., 2023), which to date has only resulted in the recovery of nannofossils from the basal part of the Glen Rose Formation (Phelps et al., 2015).

Here we document the first known Early Cretaceous calcareous nannofossil assemblage from New Mexico and correlate it to an early Albian ammonite assemblage (Lucas and Estep, 1998; Lucas, 2000a, 2000b). Early Cretaceous calcareous nannofossils were extracted from the Bisbee Group strata that were deposited along an east-west corridor that potentially connected the Gulf of Mexico to the Gulf of California (Fig. 1; Mack et al., 1986; Lucas and Estep, 1998; Lawton et al., 2004; Madhavaraju et al., 2015; Robert et al., 2018; Aisner-Williams and Kerans, 2020), prior to deposition of the north-south late Albian Skull Creek Formation and establishment of the Cenomanian Niobrara Western Interior Seaway (Kauffman and Caldwell, 1993; Slattery et al., 2013).

Location and Geologic Setting

Early Cretaceous sediments crop out in the mountain ranges of southwestern New Mexico and southeastern Arizona. These sediments are deposits of the most northerly extension of an Early Cretaceous seaway that extended northwestward from northern Mexico through the Sabinas and Chihuahua troughs into southwestern New Mexico and southeastern Arizona (Mack et al., 1986; Lucas and Estep, 1998; Lawton et al., 2004; Madhavaraju et al., 2015; Robert et al., 2018; Aisner-Williams and Kerans, 2020). The seaway was bordered to the north by the Mogollon Highlands of central Arizona and New Mexico (Corbett and Watkins, 2013).

In southwestern New Mexico, ammonite-bearing sediments of Aptian/Albian age belong to the U-Bar Formation of the Bisbee Group (Zeller, 1965); the U-Bar Formation in southwestern New Mexico is as much as 1067 m thick. The Bisbee Group (Lucas and Estep, 1998) of the Little Hatchet Mountains was sampled for calcareous nannofossils during a field campaign in November 2014. The outcrop of U-Bar sediments analyzed for this study is located in the Little Hatchet Mountains, Hidalgo County (lat. 31° 52' 5.88" N, long. 108° 25' 46.13" W). Sediments crop out along the base of Howells Ridge, off New Mexico State Route 9 and about 4 miles southwest of the town of Hachita (Figs. 2 and 3).

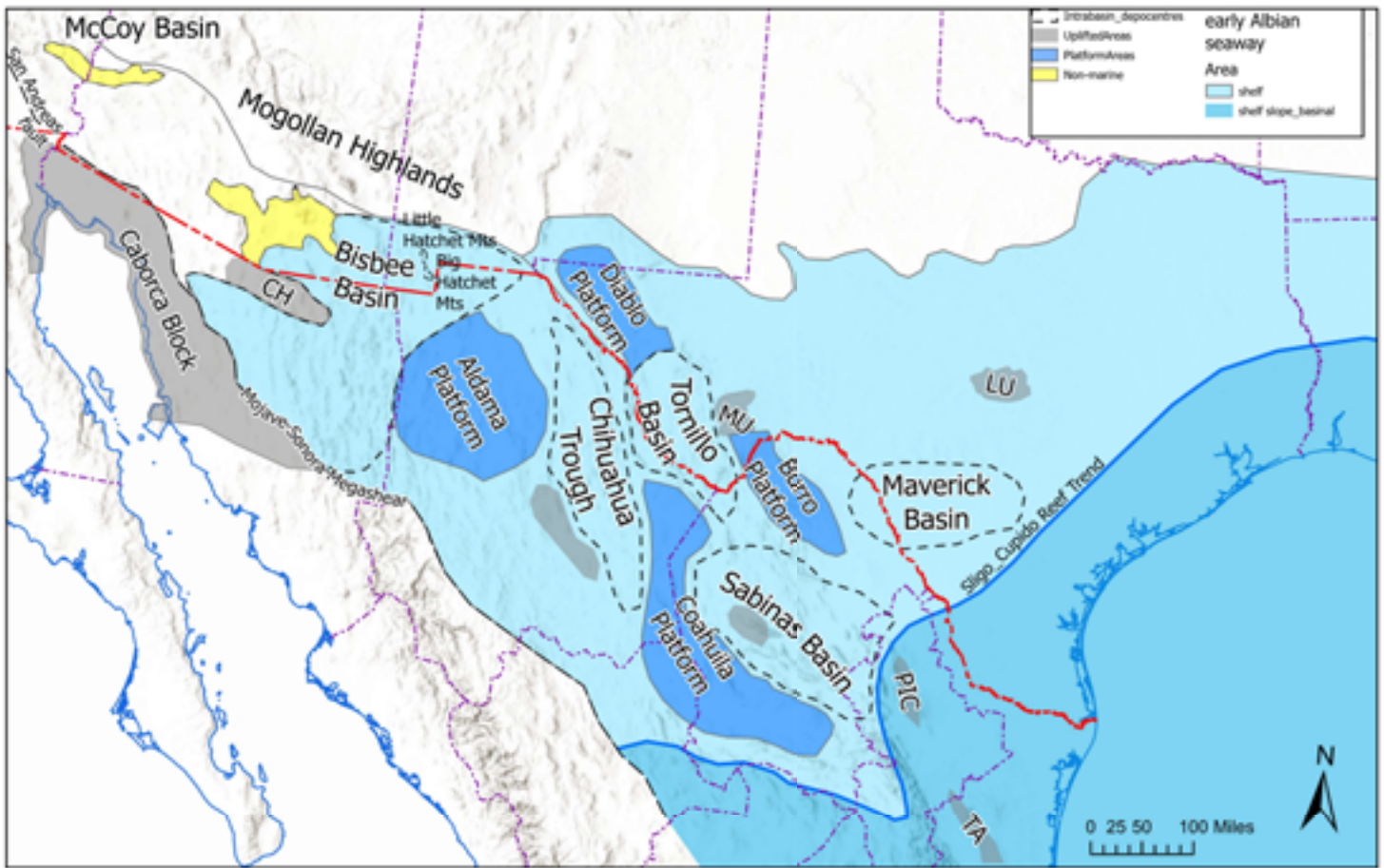


Figure 1. Map showing the location of the Little Hatchet Mountains outcrop and generalized paleogeography of the early Albian seaway. CH—Cananea high, MU—Marathon uplift, LU—Llano uplift, PIC—Picachos block, TA—Tamaulipas block.

The U-Bar Formation is divided into five members; from oldest to youngest they are the Big Tank (Lucas and Estep, 1998), Carbonate Hill (Gillerman, 1958), Old Hachita (Lucas and Estep, 1998), Still Ridge (Gillerman, 1958), and Howells Ridge Members (Lucas and Estep, 1998). Only two members were analyzed for this study: the Carbonate Hill and the overlying Old Hachita Members. The Carbonate Hill Member consists of shallow marine to lagoonal, gastropod-bearing shales overlain by mostly gray to black, bioclastic, *Exogyra*-bearing limestones. A late Aptian age for this member is confirmed by sporadic ammonites, including *Immunitoceras* sp., *Kazanskyella spathi*, *K. arizonica*, and *Acanthoplites berkeyi* (Lucas and Estep, 1998; Lucas, 2000a), which were recovered from outcrops in both the Little and Big Hatchet Mountains.

Above the Carbonate Hill Member, approximately 130 m of tan marls intercalated with mollusk-bearing limestones of the Old Hachita Member crop out in the Little Hatchet Mountains (Lucas and Estep, 1998; Lucas, 2000b). These sediments contain the ammonite *Douvilleiceras* aff. *D. mammillatum* throughout the section and are considered to be early Albian; they are found together with “*Beudanticeras newtoni*” and fragments of *Hypacanthoplites* (*H. mayfieldensis*; Lucas, 2000a, 2000b). Lucas (2000a, 2000b) considered the Carbonate Hill/Old Hachita

contact to be disconformable due to the absence of the lowermost Albian *Hypacanthoplites cragini* ammonite assemblages described from central Texas (Young, 1974).

Methods

Four samples were taken from the Carbonate Hill Member, all of which lacked nanofossils, and a total of 35 samples were analyzed from the Old Hachita Member, of which 15 lacked nanofossils. Calcareous nanofossils were analyzed using simple smear slides, with the sediment distributed on the slides utilizing the picking brush method of Jeremiah (1996) and utilizing standard light microscope techniques (Bown and Young, 1998). Samples were analyzed semi-quantitatively by counting the first 30 fields of view (FOV) with a Leitz Orthoplan microscope and then scanning the remaining portion of the slide for rare specimens outside of the count. Calcareous nanofossil species abundances and events are detailed in the stratigraphic range chart (Fig. 4)¹, which employs the bed numbers of Lucas and Estep (1998) cited against the thickness. The NC nanofossil zonation of Roth (1977) and Bralower et al. (1993) is utilized. Taxonomic references can be found in Bown et al. (1998) or the Nannotax website (Young et al., 2022; <http://www.mikrotax.org/Nannotax3/>).

¹ The full-size version of Figure 4 is available for download at <https://geoinfo.nmt.edu/repository/index.cfm?rid=20250002>



Figure 2. Map showing the location of the Little Hatchet Mountains outcrop (circle with dot).



Figure 3. Study area in the Little Hatchet Mountains, New Mexico (view is approximately to the south). The Cretaceous beds are gently dipping to the north, with the Old Hachita Member reappearing in the scrub in the foreground. The Old Hachita Member here is about 130 m thick.

Results and Discussion

Thirty-five outcrop samples from the Old Hachita Member were analyzed for nannofossils, 15 of which lacked nannoflora; the remaining samples yielded very poor to moderate abundances and diversity. All nannofossil-bearing samples had poorly preserved nannofloras, a result of the thermally mature, tectonized, and altered nature of the sediments, which have intrusive dolerites in the section at various stratigraphic levels. Increases in nannofossil abundance and diversity are recorded at 25 m and 54–56 m above the base of the Old Hachita Member (Fig. 4), and these levels are considered to record sea-level rise.

The entire section is considered to be earliest Albian, Subzones NC8a/NC8b (Bralower et al., 1993), based on the occurrences of *Braarudosphaera batilliformis*, *Prediscosphaera columnata*, *Crucibiscutum bosunensis*, and *Hayesites albiensis/irregularis*. Key nannofossil species are illustrated in Figure 5.

Braarudosphaera batilliformis (Figs. 5.2 and 5.3) was recovered from Sample 6B (+25 m). Jeremiah (2001) noted that *B. batilliformis* has an extremely restricted stratigraphic range within the boreal (LK9B Subzone of Jeremiah, 2001) latest Aptian *Hypacanthoplites jacobi* Ammonite Zone (AZ) of the North Sea basin, where it is recorded below the LO (last occurrence) of *Crucibiscutum bosunensis*. Alves et al. (2017) described *B. batilliformis* and *B. pseudobatilliformis* from the Brazilian continental margin and considered this form as restricted to the late Aptian based on the *Chelonicerias-Eodouvilleicerias* ammonite lineage recorded from the Sergipe-Alagoas basin (Bengtson et al., 2018). Fauth et al. (2022) also recorded both *B. batilliformis* and *B. pseudobatilliformis* from a cored section at the Aptian/Albian boundary in the onshore Sergipe-Alagoas basin.

Kennedy et al. (2000) documented *B. batilliformis* from basal Albian beds at the Col de Pré-Guittard candidate base Albian Global Boundary Stratotype Section and Point (GSSP). More recently, Bruno et al. (2020) recorded *B. batilliformis* from the early Albian in the lower cored sequence (1029.5–1032.37 m) at Deep Sea Drilling Project (DSDP) Site 364, Kwanza Basin, Angola. *Braarudosphaera batilliformis* is here associated with the FO (first occurrence) of the early Albian ammonite *Leymeriella tardefurcata*. It appears, therefore, that *B. batilliformis* has an extremely restricted stratigraphic range that straddles the Aptian/Albian boundary. Its occurrence at the Little Hatchet outcrop is within the earliest Albian and thus in the upper part of its stratigraphic range.

Prediscosphaera columnata (Fig. 5.14) is rare and has a sporadic occurrence in the Old Hachita Member (25–54 m, samples 6B and 12; Fig. 3), possibly due to the poor preservation of the studied material combined with the stratigraphic level of the Old Hachita Member in the lower part of its range. The FO of *P. columnata* marks the base of the Albian (Subzone NC8a; Bralower

et al., 1993). In warmwater Mediterranean and Atlantic North Africa studies (Bralower, 1987; Bralower et al., 1993; Kennedy et al., 2000, 2014; Lubert et al., 2019), the FO of circular *P. columnata* is recorded close to the Aptian/Albian boundary. In the current study, the usage of *P. columnata* is strictly allocated to circular forms of the genus *Prediscosphaera*.

Crucibiscutum bosunensis (Figs. 5.5–5.7) is recorded through most of the Old Hachita Member section from sample 6B (+24 m) through to sample 20A (+83 m; see Fig. 4). *Crucibiscutum bosunensis* has previously been recorded from upper Aptian sediments at the Pearsall/Glen Rose Formation boundary along the San Marcos Arch, Texas (Phelps et al., 2015, their supplementary nannofossil chart). *Crucibiscutum bosunensis* is a characteristic species of the late Aptian through earliest Albian. An abundance acme has been recorded from the late Aptian of the Atlantic Morocco margin (Lubert et al., 2019) in beds of the local *Elsaisabellia tiskatinensis* AZ (equivalent to the Tethyan *Nolanicerias nolani* AZ) and in the late Aptian *Parahoplites nutfieldiensis* AZ of the Boreal realm (Jeremiah, 2000, 2001; Jeremiah et al., 2010). Bown et al. (1998) also recorded frequent *C. bosunensis* (identified as *Crucibiscutum* cf. *C. salebrosum*) from the late Aptian within the upper part of the Boreal nannofossil Zone BC21. Rare *C. bosunensis* are recorded consistently from the latest Aptian *Hypacanthoplites jacobi* AZ of the North Sea basin, where it is associated with *Braarudosphaera batilliformis*, common *Assipetra terebrodentarius*, and *A. terebrodentarius youngii* (Jeremiah, 2000, 2001). At DSDP 370, offshore Morocco (Lubert et al., 2019), *C. bosunensis* has a recorded LO in the basal part of the early Albian NC8a Subzone (Bralower et al., 1993), co-occurring with *Prediscosphaera columnata*, *Rhagodiscus achlyostaurion*, and *Assipetra terebrodentarius youngii*.

Hayesites albiensis/H. irregularis forms (Fig. 5.10) are recorded sporadically throughout the Old Hachita Member (samples 6B–30B; Fig. 4). The FO of *H. albiensis* was used as the datum for the base of Subzone NC8b by Bralower et al. (1993), who placed the FO in the latest Aptian, just above the FO of *Prediscosphaera columnata* (base Subzone NC8a). Kennedy et al. (2000) discussed the difficulty of differentiating *H. albiensis* from the ancestral form, *H. irregularis*, which detracts from the reliability of *H. albiensis* as a marker species in the Tethyan realm. In the current study, the two species are merged because it is impossible to differentiate the forms at this stratigraphic level; no differentiation of Subzones NC8a/NC8b is made here, so the two subzones are merged.

Rhagodiscus achlyostaurion is widely published as having a FO close to the Aptian/Albian boundary (Jeremiah, 1996, 2001; Kennedy et al., 2000; Mutterlose et al., 2003; Jeremiah et al., 2010; Lubert et al., 2019). It can be rare toward the base of its range, and this, together with the poor preservation of the material from the Little Hatchet Mountains, is the most likely explanation of its absence.

Latest Aptian through earliest Albian assemblages are often characterized by *Assipetra terebrodentarius* associated with the larger form *A. t. youngii*, which has its LO in the earliest Albian (Tremolada and Erba, 2002; Luber et al., 2019). Unfortunately, this event is not recorded in the Little Hatchet Mountains, and only a single isolated *A. terebrodentarius* is recorded from level 6B (25 m; Fig. 4).

The nannofossil assemblage recovered is Tethyan and did not yield any early Albian cold-water indicators such as *Seribiscutum primitivum* or *Repagulum parvidentatum*.

Ammonite Biostratigraphy

Prior to this report of calcareous nannoplankton, correlation of the Old Hachita Member has been based primarily on ammonites (see reviews by Lucas, 2000a, 2000b; Lucas and Lawton, 2000). These ammonites were taken to indicate the *Douvilleiceras mammillatum* Zone (or Superzone of some authors; see Kennedy and Klinger, 2015), which is early Albian in age.

Douvilleiceras is a very polymorphic Early Cretaceous ammonite genus, and there have been diverse approaches to its species-level taxonomy. For example, Casey (1962) recognized eight species

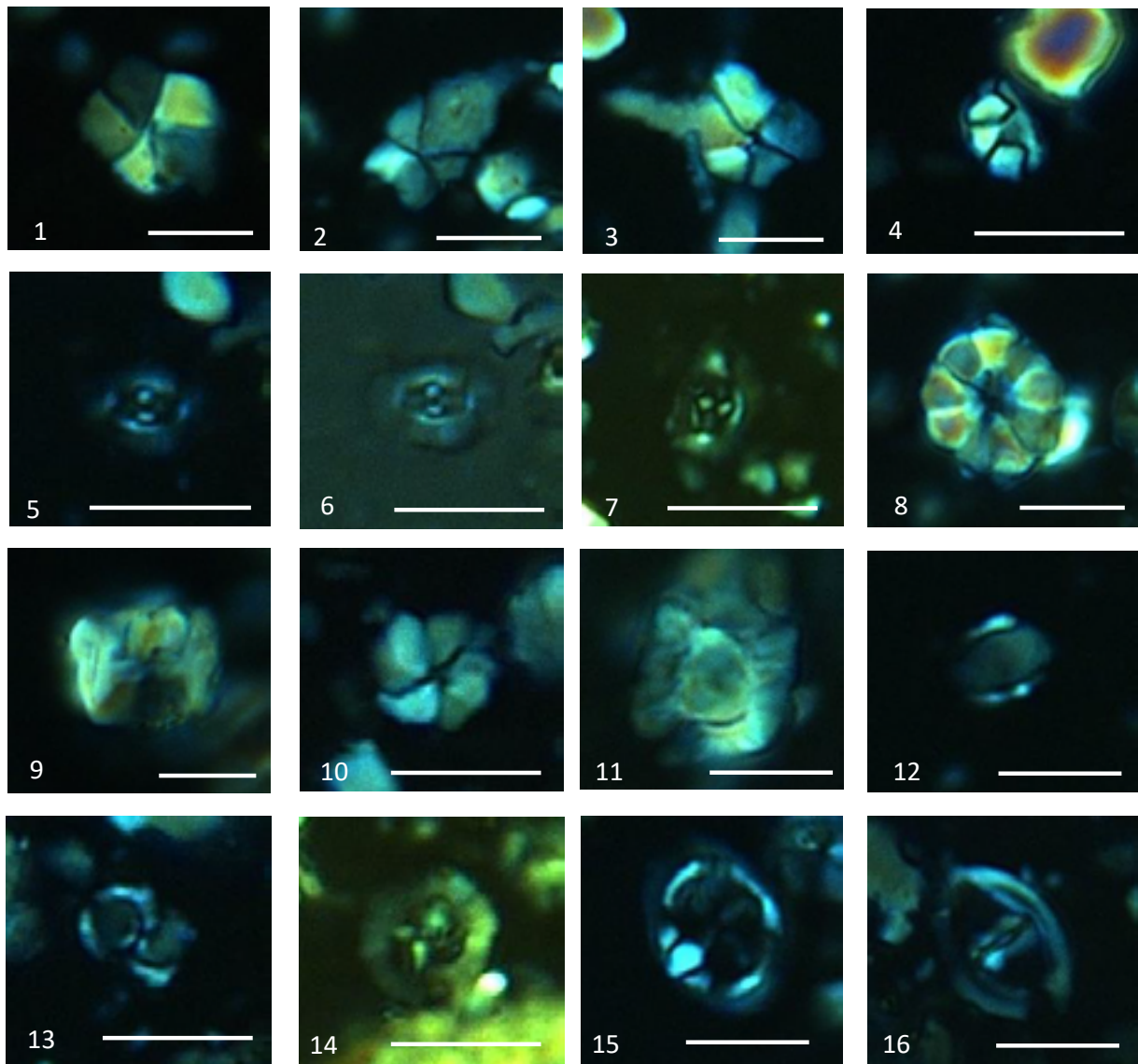


Figure 5. Selected calcareous nannofossils, Old Hachita Member, Little Hatchet Mountains, New Mexico. Scale bar is 5 μ m in all photos. 1: *Braarudosphaera africana*, Bed 30A, 115 m. 2: *Braarudosphaera batilliformis*, Bed 6B, 25 m. 3: *Braarudosphaera batilliformis*, Bed 6B, 25 m. 4: *Calculites dispar*, Bed 12, 54 m. 5: *Crucibiscutum bosunensis*, Bed 12, 54 m. 6: *Crucibiscutum bosunensis*, Bed 12, 54 m. 7: *Crucibiscutum bosunensis*, Bed 12, 54 m. 8: *Eprolithus floralis*, Bed 12, 54 m. 9: *Eprolithus floralis* (side view), Bed 12, 54 m. 10: *Hayesites albiensis/irregularis*, Bed 14, 56 m. 11: *Nannoconus quadriangulus*, Bed 30B, 116 m. 12: *Orastrum perspicuum*, DSDP367, 1083.40 m. 13: *Owenia partitum*, Bed 6B, 25 m. 14: *Prediscosphaera columnata*, Bed 6B, 25 m. 15: *Stoverius achylosus*, Bed 12, 54 m. 16: *Zeugrhabdotus diplogrammus*, Bed 30B, 116 m.

of the genus, some with two or more “varieties,” whereas Kennedy and Klinger (2015) only recognized two valid species, the very polymorphic *D. mammillatum* and the less variable *D. inaequinodum*. In contrast, Futakami and Haggart (2018) recognized five valid species of *Douvilleiceras*.

Lasky (1938, 1947) first reported specimens of *Douvilleiceras* from New Mexico from the Little Hatchet Mountains, and Scott (1940) described them as a new genus and species, *Trinitoceras reesidei* Scott and *Douvilleiceras* sp. indet. Zeller (1965) reported *D. mammillatum* from the U-Bar Formation in the Big Hatchet Mountains. Lucas (2000a, 2000b) assigned all of these earlier reported specimens to *D. aff. D. mammillatum*, based in large part on Young’s (1974) concept of that taxon. *Douvilleiceras* specimens (Fig. 6) from the Little Hatchet and Big Hatchet Mountains are from the Old Hachita Member of the U-Bar Formation.

The specimens of *Douvilleiceras* from the Little Hatchet Mountains in the collection of the New Mexico Museum of Natural History & Science (NMMNH) are encompassed by the polymorphic concept of *D. mammillatum* of Kennedy and Klinger (2015) and belong to that species as defined by Futakami and Haggart (2018). Particularly significant is the lack of a ventral sulcus. However, the NMMNH specimens (Fig. 6) are too incomplete or too poorly preserved to confidently be referred to that species. Thus, *Douvilleiceras* specimens from the Old Hachita Member are only half or quarter whorls, mostly steinkerns that lack suture, and many of them are laterally crushed and do not preserve taxonomically critical morphology (cf. Kennedy and Klinger, 2015; Futakami and Haggart, 2018). In light of these considerations, we continue to follow Lucas (2000a, 2000b), who identified them as *D. aff. D. mammillatum*. We also note that the relatively narrow cross sections and closely spaced ribbing

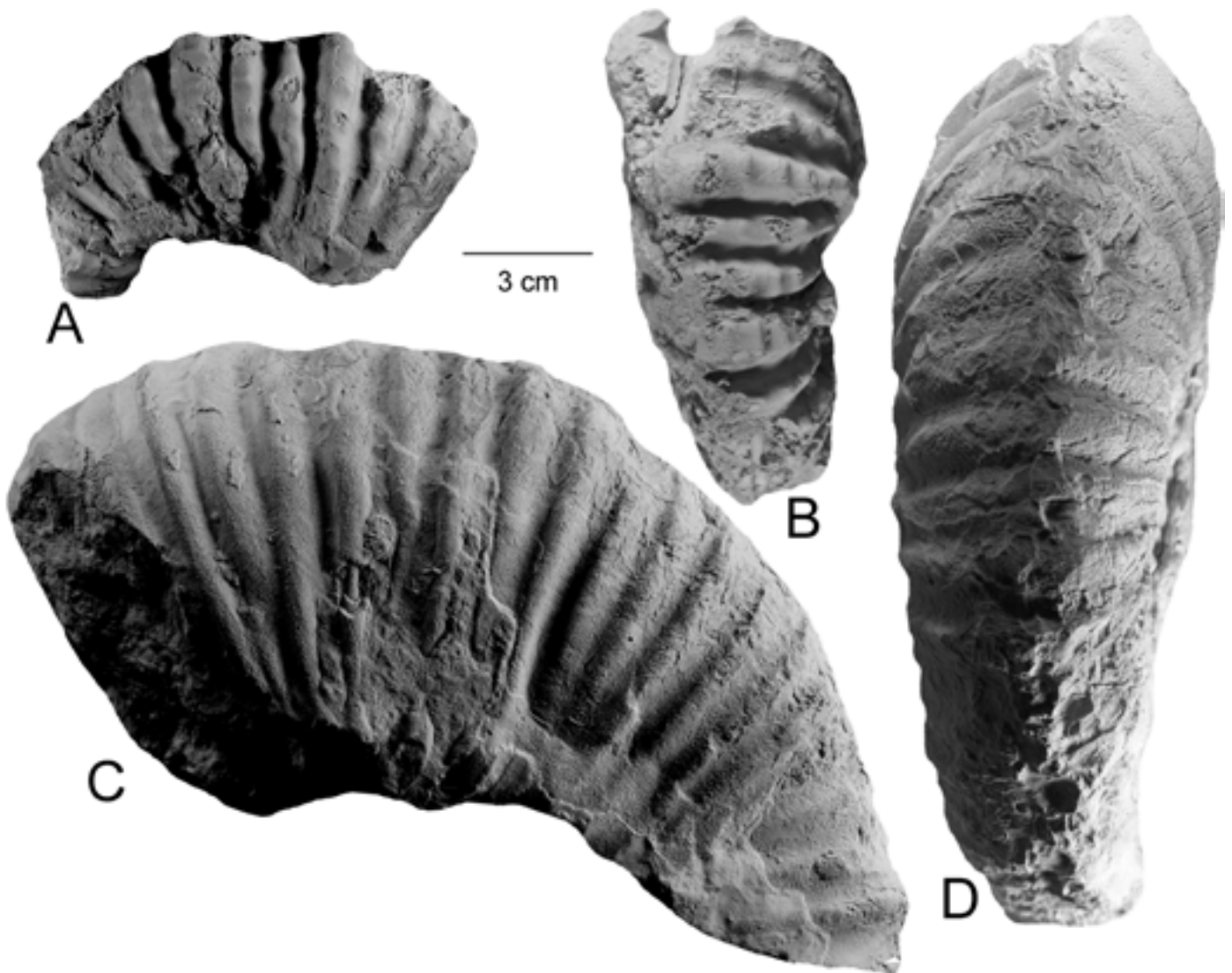


Figure 6. *Douvilleiceras* sp. aff. *D. mammillatum* from the Old Hachita Member of the U-Bar Formation in the Little Hatchet Mountains, NMMNH (New Mexico Museum of Natural History & Science) locality 1365. A and B: NMMNH P-31422, tuberculate part of inner whorl in lateral (A) and ventral (B) views. C and D: NMMNH P-38997, part of outer whorl in lateral (C) and ventral (D) views.

of the Old Hachita Member *Douvilleiceras* also more resemble early *Douvilleiceras* species such as *D. solitae* (d'Orbigny) (cf. Kennedy and Klinger, 2015, their fig. 19) than *D. mammillatum*. However, without more complete and better-preserved specimens, the species-level attribution of *Douvilleiceras* specimens from the U-Bar Formation will remain uncertain.

Hypacanthoplites, normally a late Aptian/earliest Albian ammonite and known from the underlying Carbonate Hill Member, is also present in the Old Hachita Member (Lucas, 2000a). Influenced primarily by the work of Young (1974), Lucas (2000a, 2000b) concluded that the Old Hachita Member can be correlated to early in the *Douvilleiceras mammillatum* Zone of early Albian age. The apparent absence of the oldest Albian ammonite zone of Young's (1974) biostratigraphy, the *Hypacanthoplites cragini* Zone of earliest Albian age, above the latest Aptian *Kazanskyella spathi* Zone in the Carbonate Hill Member suggested to Lucas (2000a, 2000b) the presence of an unconformity at the contact of the Carbonate Hill and the Old Hachita Members (i.e., across the Aptian/

Albian boundary). Such an unconformity may exist, but the nannoplankton biostratigraphy suggests that, if present, it is much shorter than Lucas (2000a, 2000b) envisioned. The ammonite record from the Old Hachita Member is consistent with that conclusion because it is not demonstrative of the *D. mammillatum* Zone and may represent an older interval of the Albian.

Conclusions

The Early Cretaceous Bisbee Group of New Mexico has, for the first time, yielded nannofossils, assemblages that include *Braarudosphaera batilliformis*, *Prediscosphaera columnata*, and *Crucibiscutum bosunensis*, which are characteristic of lowermost Albian sediments. The associated *Douvilleiceras* ammonite assemblages support an early Albian age assignment. This recovery of nannofossils from the Bisbee Group indicates the potential for improved stratigraphic calibration of equivalent-age sediments preserved in Arizona and northwestern Mexico.

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The Early Cretaceous (Albian) rudist reef on Howells Ridge in the Little Hatchet Mountains shows the massive, cliff-forming reef core, which is coral/rudist boundstones, packstones, and bafflestones, above slope-forming offshore shales and nodular limestones and below bedded packstones, wackestones, and grainstones that are the back-reef facies that ultimately prograded over the reef.

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