Ichnologic Note

Shell-filled burrows in the Upper Oligocene Antigua Formation, Antigua, Lesser Antilles

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Limestones of the Upper Oligocene Antigua Formation of Antigua unusual burrows filled with the densely packed debris of shelly benthos. Unlined burrows (*Planolites*?) in deep-water biofacies at Half Moon Bay, parish of Saint Philip, are packed with a monospecific assemblage of large benthic foraminiferans (*Lepidocyclina canelli* Lemoine & Douvillé) and a single brachiopod valve, *Tichosina* sp. A similar burrow in shallower-water biofacies at Hughes Point, parish of Saint Philip, is packed with echinoderm debris and, particularly, test fragments of the spatangoid echinoid *Lovenia* n. sp. Fragments of the same echinoid fill a conical burrow, *Bergaueria* isp. The latter is probably a physical accumulation, the common fragments of echinoid being washed into an empty burrow. In contrast, the infill of *Planolites*? isp. is more likely to be an accumulation mediated by the burrower.

Keywords paleoecology, taphonomy, *Planolites*, *Bergaueria*

INTRODUCTION

Antigua, like most of the islands of the Lesser Antilles, has a poorly documented ichnological record. Only from one unit of a Lesser Antillean island, namely the Middle Miocene Grand Bay Formation of Carriacou, the Grenadines, has a diversity of trace fossils been recorded and described in detail (Pickerill et al., 2001, 2002a, b, 2003; Donovan et al., 2003; Donovan, in press). The only previous systematic study of traces from Antigua was neoichnological and described Recent borings in reworked Upper Oligocene oysters derived from the Antigua Formation (Donovan et al., 2014a). Yet the Antigua Formation *sensu stricto* is rich in trace fossils, most commonly *Thalassinoides* isp. or ispp., which we have noted at many localities. Herein, we describe rare, but notable, burrows that are closely packed with remains of shelly invertebrates. The obvious question posed by such occurrences is was the process of filling passive or biologically controlled?

The terminology of burrow morphology and the philosophy of systematic ichnology mainly follows Häntzschel (1975) and Pickerill (1994). Bengtson's (1988) recommendations on open nomenclature are followed below. Specimens were not collected because of the probability that they would have been irreparably damaged. We request that anyone following in our footsteps shows a similar respect for these rare trace fossils.

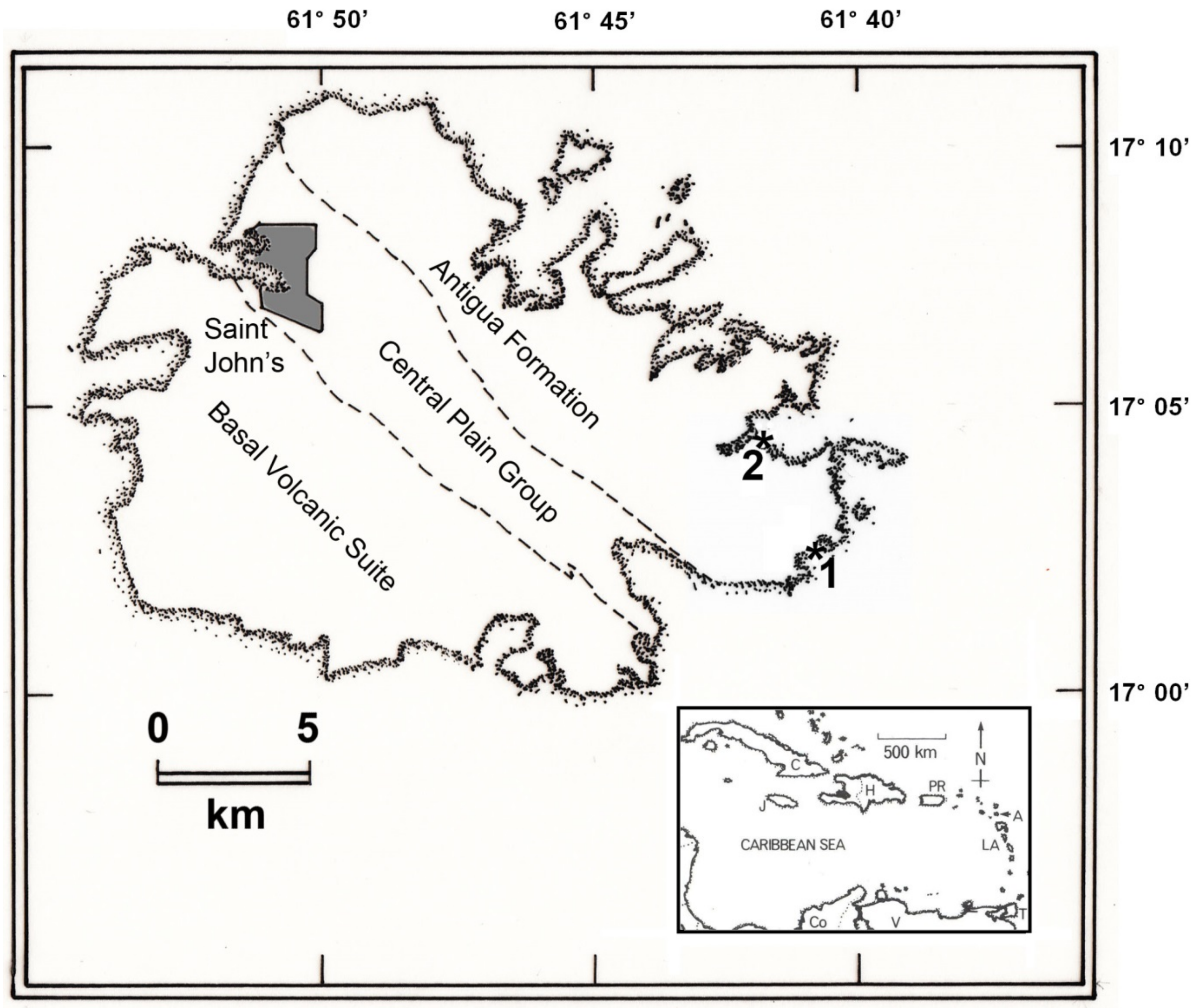

FIG. 1. Outline map of Antigua (redrawn and modified after Weiss, 1994, fig. 3), showing the principal geological subdivisions and the city of Saint John's. The regional dip is towards the northeast. Localities 1 (Half Moon Bay) and 2 (Hughes Point) are marked. Inset map (modified after Donovan, 2010, fig. 2) shows the position of Antigua in the Caribbean. Key (clockwise from Jamaica): J=Jamaica; C=Cuba; H=Hispaniola (Haiti+Dominican Republic); PR=Puerto Rico; A = Antigua (arrowed); LA=Lesser Antilles; T=Trinidad; V=Venezuela; Co=Colombia.

LOCALITIES AND HORIZONS

Specimens described herein are from the Upper Oligocene limestones of the Antigua Formation, exposed in the north and east of Antigua, West Indies, and were found in two contrasting lithologies at Half Moon Bay (Locality 1) and Hughes Point (Locality 2), both in the parish of Saint Philip (Fig. 1).

Locality 1: The limestones exposed on the north-east side of Half Moon Bay are among the stratigraphically highest in the Antigua Formation and represent deeper-water deposition than, for example, Hughes Point. The section exposes 8+ m of the Antigua Formation (Fig. 2; Donovan et al., in press); specimens illustrated in Figure 3 come from the top of bed 2 therein. Three fossil groups provide evidence for this deeper-water environment, namely brachiopods, crinoids and large, thin-walled fossil sponges (Donovan et al., in press). Other faunal elements include calcareous algae, echinoids, rare oysters and other benthic molluscs. Foraminiferans from these beds include flat *Lepidocyclina canellei* Lemoine & Douvillé and inflated *Eulepidina* sp. cf. *E. undosa* (Cushman).

Locality 2: The upper part of the section at Hughes Point represents a distinct biofacies (Collins and Donovan, 1995; Donovan et al., 2014b); many large fallen blocks from these beds litter the base of the cliff, derived from about 15-20 m above the shore. They are composed of straw-coloured, well-indurated calcarenites with rust-brown banding and small, spherical, calcareous concretions. Some beds within the boulders contain abundant *Thalassinoides* burrows. Tube-like accumulations of shelly debris are burrow fills. These boulders are richly fossiliferous, yielding common pectinid bivalves, spatangoid echinoid tests and asteroid marginal ossicles (Blake et al., in press), with rarer bryozoans, decapod crustaceans and branching corals.

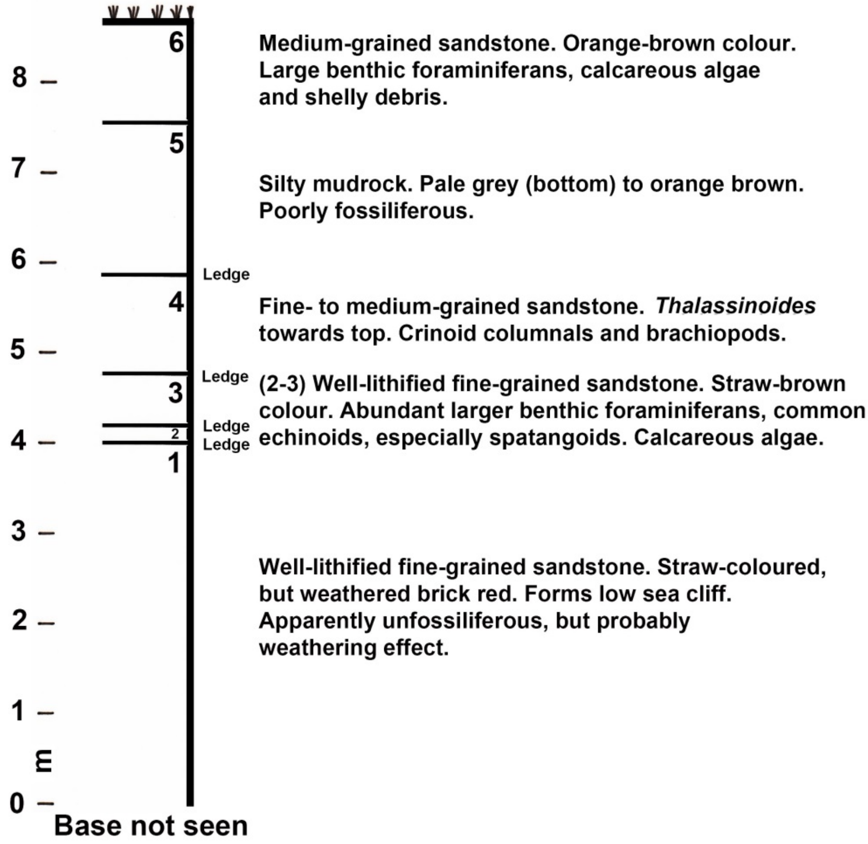

FIG. 2. A measured section of the north-east point of Half Moon Bay (Locality 1), parish of Saint Philip, south-east Antigua; Antigua Formation (Upper Oligocene) (after Donovan et al., in press, fig. 3). Note the section is entirely in limestones; terms such as sandstone and mudrock refer to grain size.

DESCRIPTIONS

Locality 1 (Fig. 3): The shorter burrow (Fig. 3A, B) is 200 mm long and 18 mm wide. It is apparently circular in section, parallel to bedding, unlined and unbranched. The burrow is packed by a monospecific assemblage of flat, larger benthic foraminiferans, *Lepidocyclina canellei* Lemoine & Douvillé. These vary from being oriented perpendicular to the long axis of the burrow (meniscus-like) to lying 'flat', parallel to the long axis. The ends of the burrow are not seen.

A morphologically similar burrow is 240 mm long and up to 40 mm wide (Fig. 3A, D). The fill is identical to that of the shorter burrow fragment apart from the presence of a valve of the brachiopod *Tichosina* sp. (Fig. 3C).

The 'background' ichnology of this succession is *Thalassinoides* isp. It is not ubiquitous, only occurring at certain horizons and not, apparently, at the same level as the filled burrows (Fig. 3A).

Locality 2 (Fig. 4): A similar burrow to those described from Locality 1 is oriented parallel to bedding, 90-100 mm long (but incomplete) and 20 mm in diameter (Fig. 4A). It is filled with echinoid fragments, mainly of the test of the spatangoid *Lovenia* n. sp. (*sensu* Poddubiuk and Rose, 1985, table 1), which is abundant in fallen blocks from the top of these cliffs, but also one spine of a regular echinoid. Fragments of *Lovenia* in the burrow are irregularly shaped and are not arranged in any systematic way. Nearby, on the same bedding plane, is an irregular accumulation of fragments of *Lovenia* n. sp. (Fig. 4C).

A concial trace preserved in section and perpendicular to bedding occurs in another boulder at this site (Fig. 4B). This pit-like trace is 25 mm deep and 28 mm wide. This is filled by platy fragments of the test of *Lovenia* n. sp.

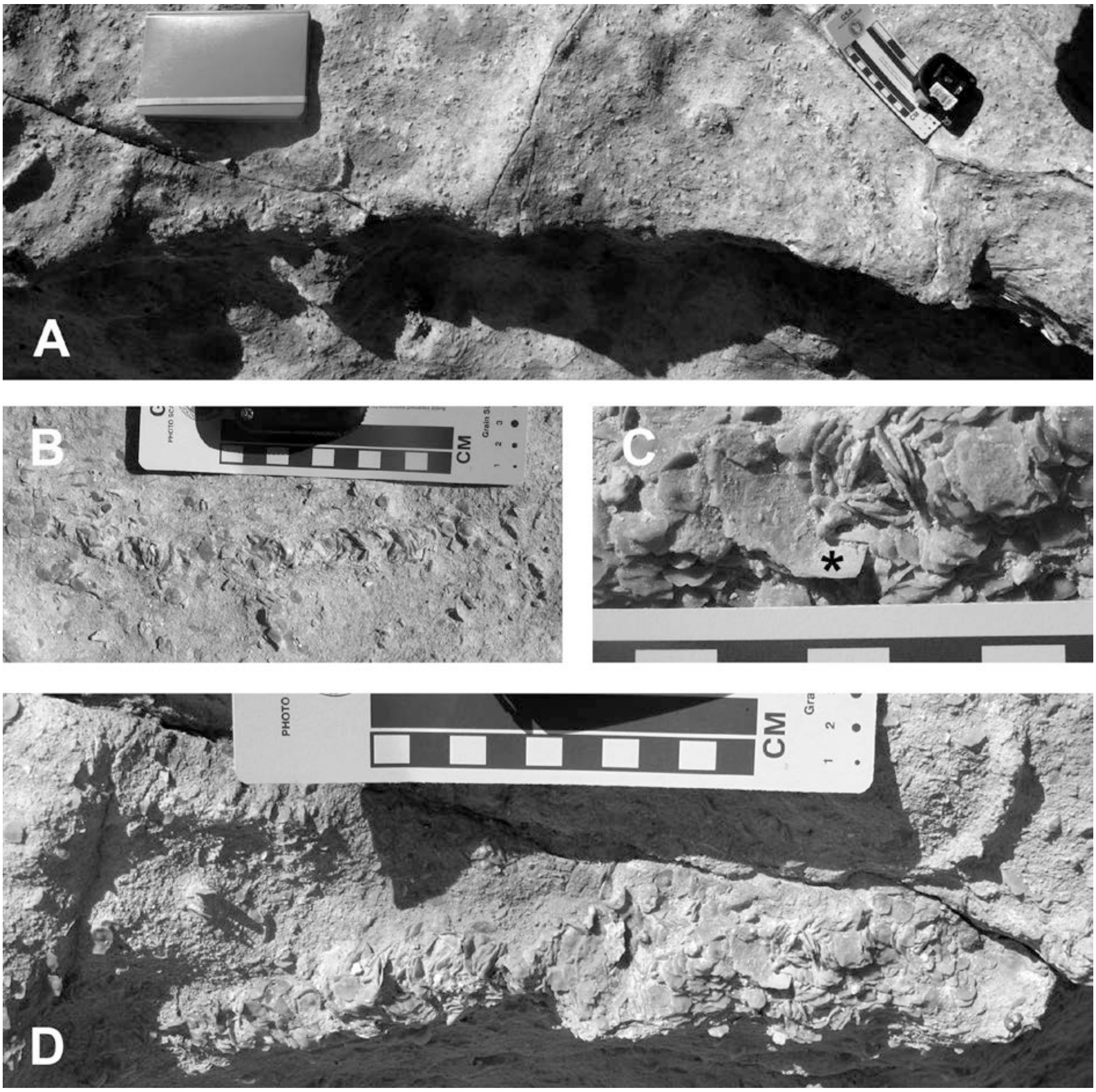

FIG. 3. Burrows packed with shelly debris, *Planolites*? isp. aff. *P. beverleyensis* (Billings, 1862), Half Moon Bay, Antigua (Locality 1). **(A)** General view of bedding surface; filled burrows are on the edge below the notebook (6 o'clock) and at 8 o'clock (left and below) to the scale. **(B)** Shorter burrow (right in (**A**)) packed with larger benthic foraminiferans. **(C, D)** Longer burrow (left in (**A**)). **(C)** Detail of *Tichosina* sp. valve (*) and close-packed foraminiferans. **(D)** Longer burrow packed with larger benthic foraminiferans and a single valve of the brachiopod *Tichosina* sp. (right of center). Scale bars in cm.

DISCUSSION

The burrows described above are all identifiable to ichnogenus. The three elongate, packed, but unlined burrows (Figs 3A, B, D, 4A) are close to *Planolites* Nicholson, 1873 (Häntzschel, 1975, pp.

W95-W97; Pemberton and Frey, 1982, p. 865; Fillion and Pickerill, 1990, p. 48; Uchman, 1995, p. 12; Keighley and Pickerill, 1995), apart from the probability that the shelly backfill was actively mediated by the burrower (see below), although it is not meniscate. The burrow wall is very poorly seen, so it may have been lined, although apparently not. The gross morphology of these burrows, infill apart, is close to *Planolites beverleyensis* (Billings, 1862) (see, for example, Fillion and Pickerill, 1990, pp. 49-50, pl. 12, figs 6, 15) and specimens are referred to *Planolites*? isp. aff. *P. beverleyensis*, the use of open nomenclature indicating our doubts. The producing organisms were probably vagile polychaete worms which could have been feeding on shelly benthos; the burrow fills may be debris produced by feeding. *Planolites* ispp. *sensu stricto* is well known from the Antilles, particularly from Jamaica, such as the Paleogene Richmond Formation, mid-Tertiary White Limestone Group and Miocene-Pliocene Lower Coastal Group (Donovan et al., 2015, and references therein), and the Middle Miocene Grand Bay Formation of Carriacou (Donovan et al., 2003).

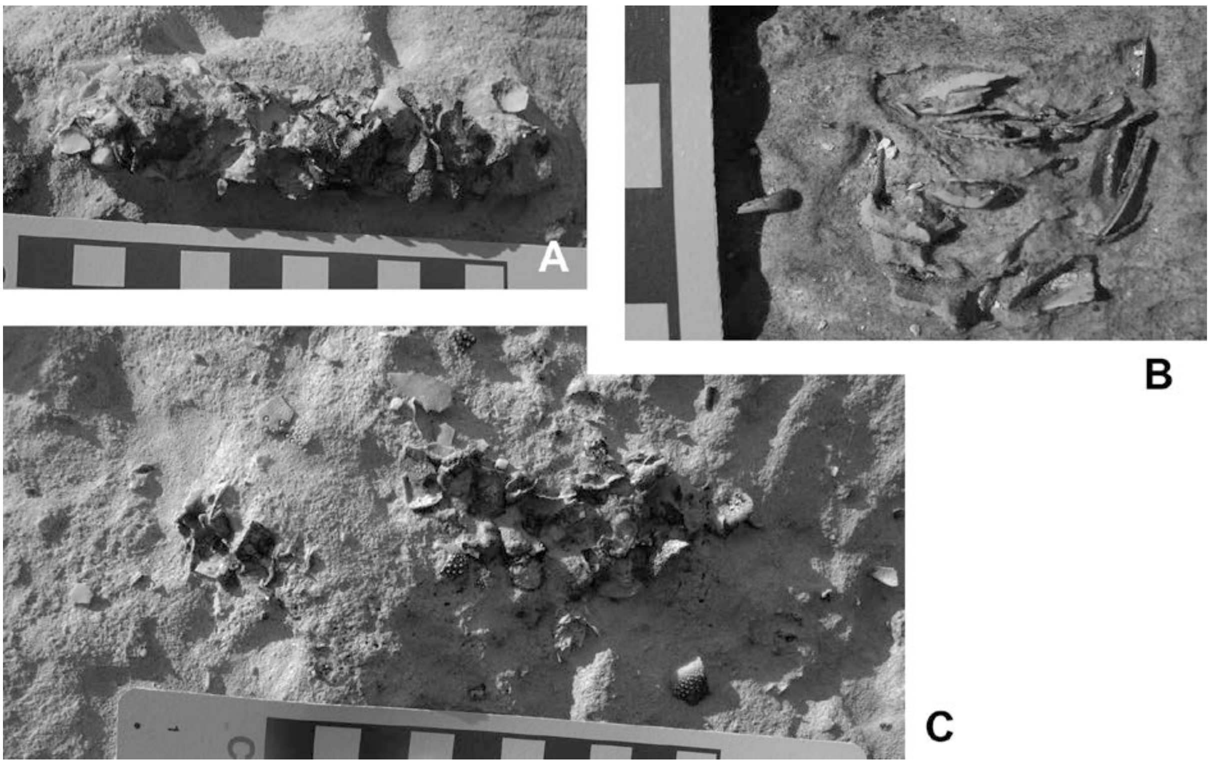

FIG. 4. Burrows packed with shelly debris, Hughes Point, Antigua (Locality 2). **(A)** *Planolites*? isp. aff. *P. beverleyensis* (Billings, 1862), short burrow packed with echinoid debris, mainly fragments of *Lovenia* n. sp. **(B)** Conical burrow or pit,

Bergaueria isp., naturally sectioned perpendicular to bedding and packed with echinoid debris. Although not easily discernable, bedding in this view is parallel to the top of the pit, that is, from left to right. **(C)** Local accumulation of debris of *Lovenia* n. sp. on bedding plane close to specimen in (**A**). Scale bars in cm.

The second morphology of shell-filled burrow is distinct from *Planolites*? isp. and is referred to *Bergaueria* Prantl, 1945 (Alpert, 1973; Häntzschel, 1975, pp. W45-W46, fig. 28.2a-c; Pickerill, 1989; Fillion and Pickerill, 1990, pp. 21-22, pl. 1, figs 3, 4, 6, 7, 9, 10, 11, 13). Although commonly described from convex hyporelief, it seems most probable that this specimen is conichnogeneric even though it is only seen in section, its morphology emphasized by the infill of echinoid test fragments. However, the limited morphological data available favors classification in open nomenclature as *Bergaueria* isp. The producing organism of this domichnian was most probably a sea anemone (Alpert, 1973). This may be the first report of *Bergaueria* from the Oligocene (Fillion and Pickerill, 1990, p. 21). The only previous report of *Bergaueria* from the Antilles of which we are aware was by Blissett and Pickerill (2004, p. 346, pl. 1, fig. A) from the Lower Miocene Montpelier Formation, White Limestone Group, of northern Jamaica.

We propose two contrasting modes of infilling for the two different gross morphologies of burrow described above. It is inconceivable that *Planolites*? isp. (Figs 3, 4A) could become filled with larger benthic foraminiferans or fragments of echinoid by physical processes unless the surrounding sediment was lithified, preventing it from being eroded away by the same water currents. In the absence of evidence for such early lithification, we must conclude that the fill results from active packing by the burrowing organism, whether fecal or otherwise. The dominance of *Lovenia* n. sp. in this fill at Locality 2 may be significant, as it is an infaunal spatangoid and thus readily available as a prey organism for a burrowing predator.

In contrast, we suggest that after the producing organism had vacated *Bergaueria* isp. (Fig. 4B), due to either death or local migration, the pit in the sediment surface was probably filled passively by physical processes on the seafloor. Certainly, bedding plane views of this part of the succession show that complete tests and fragments of *Lovenia* n. sp. are common (Fig. 4C); for example, S.K.D. and R.W.P. have collected 50 + complete specimens of this taxon from this site during rare visits since 1993. This explanation of passive physical infill is considered more plausible than that the producer was an echinoid-eating sea anemone, which died after a good meal. It should be emphasized that this burrow would likely have been missed in the field if it had not been made prominent by the infill of echinoid fragments.

In conclusion, two morphologically contrasting burrows, *Planolites*? isp. aff. *P. beverleyensis* (Billings) and *Bergaueria* isp., which occur in the Upper Oligocene Antigua Formation of Antigua, are rarely filled by shelly debris, either larger benthic foraminiferans (*Planolites*? isp. only) or fragments of echinoids. The contrasting morphologies of these burrows suggest different modes of concentration. *Planolites*? isp. was filled with shelly debris by the producing (polychaete?) organism; physical packing would have destroyed the burrow unless the limestones were already lithified at this time. In contrast, it seems that the open pit of *Bergaueria* isp., vacated by the producer (sea anemone?), would have formed a natural depression and a natural sink for shelly debris being washed around on the sea floor.

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