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Field guide to the geology of the Eocene Chapelton Formation (Yellow Limestone Group), western Central Inlier

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ABSTRACT. This field guide provides details of an excursion that demonstrates the faunas and sedimentary facies of the Yellow Limestone Group in the western part of the Central Inlier, between Dump (near Christiana), parish of Manchester, and Stettin, parish of Trelawny. Units examined include the Freemans Hall beds, Stettin Member, Guys Hill Member and Dump Limestone, representing a range of shallow water, near shore palaeoenvironments.

INTRODUCTION

THIS FIELD guide is based on excursions that I led on several occasions for the final year 'Advanced Palaeontology' option while I was a member of teaching staff at the Department of Geology, University of the West Indies, Mona. However, I failed to write an accompanying guide until The Natural History Museum, London, field study tour of May-June 2001. The present communication is adapted from this earlier, but unpublished, guide. The itinerary is designed to demonstrate the range of faunas and sedimentary facies of the Chapelton Formation, associated with the transgression of the Yellow Limestone sea in western Jamaica in the earlier part of the Eocene. Of the localities discussed, only Wait-a-Bit Cave does not have at least some easy roadside access (Fig. 1).

For background reading, general introductions to Jamaican geology include Porter *et al.* (1982), Porter (1990), Robinson (1994), Donovan *et al.* (1995) and Draper (1998). Useful maps for this excursion include the 1:50,000 geological sheets #8 "Falmouth" (Green, 1974), #9 "Balaclava" (Bateson, 1974a), #11 "Discovery Bay" (Bateson, 1974b) and #12 "Spaldings" (Bateson, 1974c), and 1:50,000 topographic sheet (metric edition) #7 "Albert Town-Alexandria". The itinerary has been written on the assumption that the starting point is Discovery Bay Marine Laboratory, University of the West Indies, parish of St. Ann, although it can be easily adapted for any other base in central Jamaica.

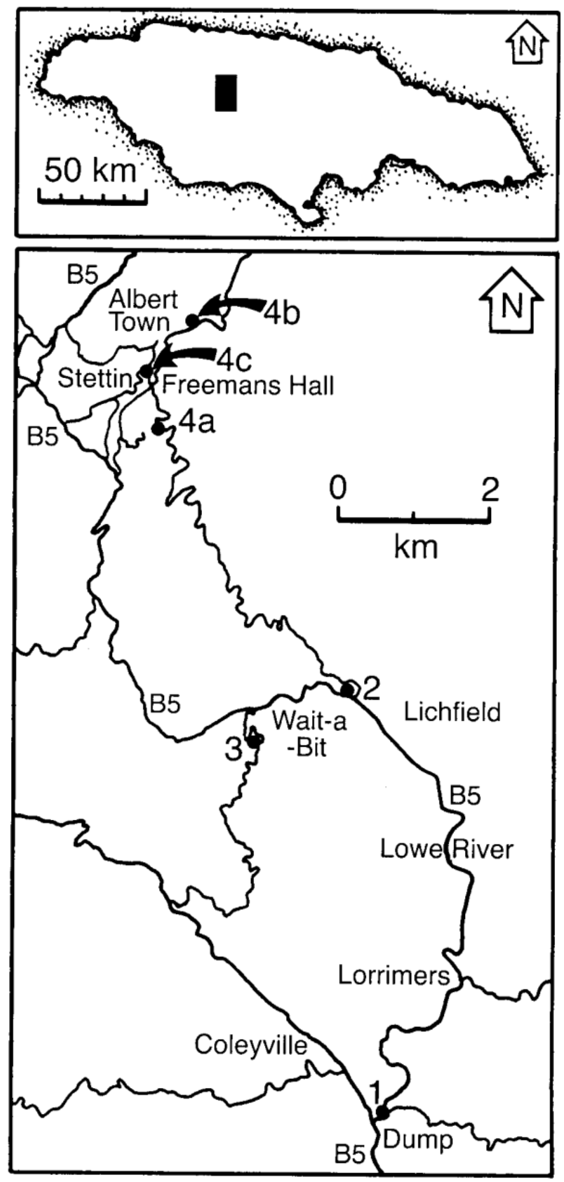

Figure 1. Locality map showing principal roads and settlements of the area between Dump, parish of Manchester, and Stettin, parish of Trelawny, central Jamaica, based on 1:50,000 topographic sheet (metric edition) #7 "Albert Town-Alexandria". Localities 1-3 and 4a-4c are indicated by numbers and solid black circles. The inset map shows the approximate position of this area within Jamaica (shaded).

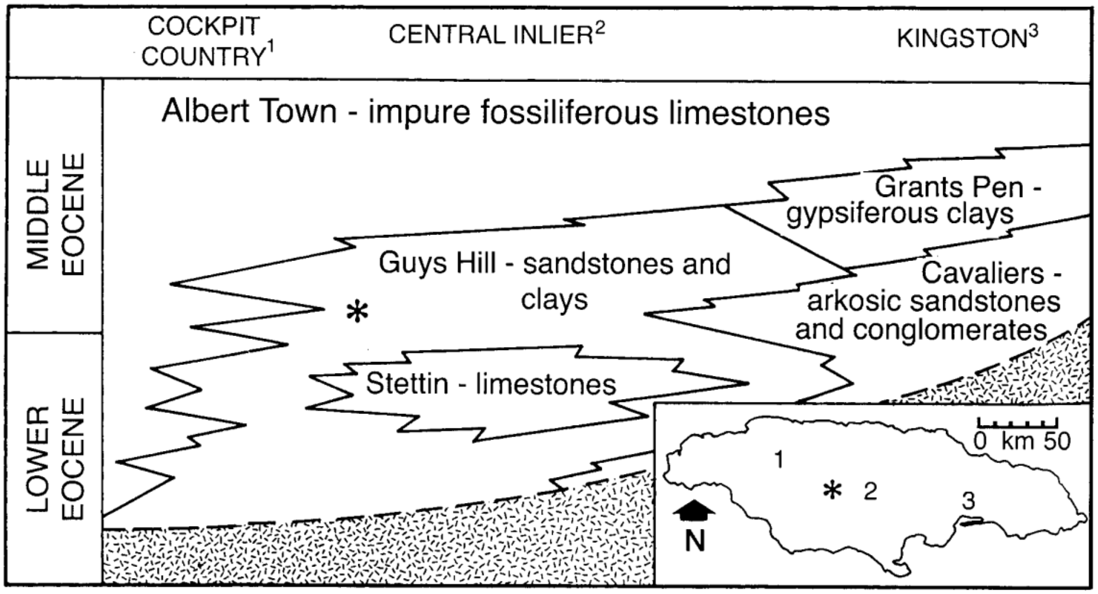

Figure 2. Major subdivisions (members) of the Chapelton Formation (Yellow Limestone Group) in the region of the Central Inlier (after Donovan et al., 1990, fig. 1, redrawn after Robinson, 1988, fig. 3). The inset map of Jamaica shows the positions of Cockpit Country (1), the Central Inlier (2) and Kingston (3). Key: * = Dump Limestone.

STOP 1: THE DUMP LIMESTONE

Take the main A1 road west from Discovery Bay. The river bridge just before Rio Bueno marks the boundary between the parishes of St. Ann and Trelawny. At Rio Bueno, turn south on the meandering B5 road, which climbs onto the limestone plateau. Continue south on the same road after Jackson Town, passing the impressive fault scarp of the Alps to the west, and on to Ulster Spring and Albert Town. Continue south through the Stettin district, Wait-a-Bit, Lowe River and Lorrimers. Dump, in the parish of Manchester, is a few km north of Christiana (Fig. 1). The following account is adapted, with revision, from Donovan *et al.* (1990).

The outcrop of the Dump Limestone is within the Guys Hill Member, Chapelton Formation (Fig. 2), at the village of Dump, near Christiana, parish of Manchester (NGR 969 721; Robinson, 1969, fig. 1). This is the type locality of the crocodilian *Charactosuchus kugleri* Berg, 1969 (see also Domning and Clark, 1993). The holotype of this species came from bed 3 (E. Robinson, pers. comm.; Fig. 3); additional bones and teeth of fishes, crocodilians, turtles and sirenians have been found, rarely, at this and other horizons at this locality. Although otherwise indeterminate, fragments of turtle carapace are only known from one other Eocene locality in Jamaica. More significantly, the Dump Limestone yielded the first bones of a prorastomid sirenian (sea cow) to be found in Jamaica since the mid 19th century, although more plentiful, approximately coeval bones and teeth are now known from the Seven Rivers vertebrate site to the west, in the parish of St. James (Portell *et al*., 2001). The Dump Limestone sirenian is close to *Prorastomus sirenoides* Owen, 1855, originally described from a loose boulder in the Quashie's River near Stettin, parish of Trelawny (see Stop 4; Savage *et al.*, 1994).

The Guys Hill Member is predominantly composed of quartzo-feldspathic sandstones, siltstones and mudstones, channelled and locally rich in carbonized plant remains, such as palms and mahogany, which commonly occur in lignitic shales (Hose and Versey, 1957, p. 31; Robinson, 1988, p. 60; Graham, 1993, pp. 448, 450). Shelly fossils are rare, apart from biostromes of oysters or the anomid bivalve *Carolia cantraine* (Trechmann, 1923), although fragmentary decapod crustaceans, asteroid marginal ossicles and echinoid test plates occur locally. These associations suggest deposition in a nearshore marine system. The low diversity of euryhaline bivalves forming biostromes is analogous to those produced by some modern oysters (Kaplan, 1988, pp. 69-71). The Dump Limestone is a succession lacking lignitic shales, suggesting 'cleaner' water conditions lacking plant debris and favouring deposition of impure limestones. The impoverished shelly fauna at the type locality is suggestive of a restricted marine

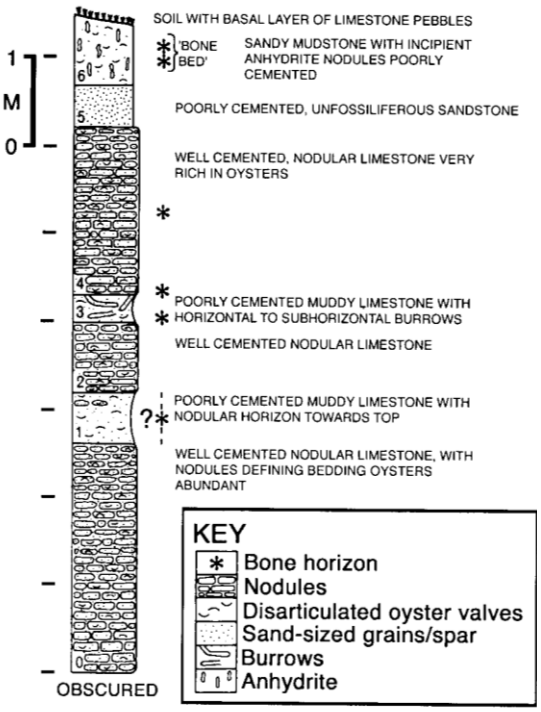

Figure 3. Weathering profile of part of the Dump Limestone, parish of Manchester, showing horizons that have yielded rare vertebrate remains (after Donovan *et al.*, 1990, fig. 2).

environment, although more open marine assemblages are known from elsewhere in this unit (S.F. Mitchell, written comm.). Although all bones in unit 6 are disarticulated, they are not abraded (indicating minimal transport), most breakage appears to have occurred post-burial and oysters do not encrust the bones, suggesting little aquatic exposure following decay of soft tissues.

STOP 2: GUYS HILL MEMBER BETWEEN LICHFIELD AND WAIT-A-BIT

From Stop 1, return northwards on the B5 road towards Albert Town. Between Lichfield and Wait-a-Bit, the road is largely situated on the Guys Hill Member, Chapelton Formation (Fig. 2). This unit is particularly well-exposed as a cliff on the right (east) of the road (approximately NGR 964 775) (Fig. 4A, B).This locality is approximately 9.3 km from Stop 1 and 1.6 km before the turning from the main road to Wait-a-Bit Cave. See also stop 2 of Wright and Robinson (1974). Robinson (1996, fig. 2) published a revised geological map of this area.

The principal features of the Guys Hill Member are summarised under Stop 1. Three principal lithologies are apparent at this stop; lignitic shales (best exposed towards the top of the exposure; Fig. 4A), grey mudstones and brown- to straw-coloured sandstones, which are cross-bedded at some horizons and may include vertical and horizontal burrows. Some mudstones are gypsiferous due to weathering of pyrite (S.F. Mitchell, written comm.), whereas others are rich in fossil leaves. The sandstones may also contain rip-up clasts. Invertebrate body fossils are rare, but oysters are locally common in nodular horizons, associated with rare gastropods. The exposure is disrupted by parallel to sub-parallel normal faults (Fig. 4B).

Based on available palynological and lithological evidence, Graham (1993, p. 448, 450) considered that the lignitic shales of the Guys Hill Member were "*deposited under coastal, brackish-water conditions in ... tropical climates. The sediments [accumulated] in lagoons, bays, estuaries, and other low energy environments where coastal currents [did] not disperse the organic material*." Wright and Robinson (1974, p. 56) considered this section to represent a tidal flat palaeoenvironment. Robinson (1996, p. 30) noted that "*Because it forms the main slope feature of the Chapelton Formation landscape, the Guys Hill Member is susceptible to extensive landslipping*...", an obvious feature of this locality.

STOP 3: WAIT-A-BIT CAVE

Keep travelling towards Albert Town. Take the last turning on the left before Wait-a-Bit police station (the police station is not in view at this point, so it is wise to identify the turning on the way to Stop 1). Once in the valley, drive past the concrete structure associated with water distribution on the right. Park about 100 m before the bar on the right. The side entrance to Wait-a-Bit Cave (Fig. 4D) can be reached across the fields. The following account is adapted from Miller and Donovan (1996).

Cavernous limestones are well developed in Jamaica (Fincham, 1997), mainly in the upper beds of the Chapelton Formation, and in the Troy and Claremont formations, low in the overlying White Limestone Group. Caves in these units are typically rectangular, indicating a strong control by bedding and joint planes (Wadge and Draper, 1977). Many of the caves are associated with rivers which flow off the Cretaceous inliers and sink on reaching the surrounding Eocene limestones. Caves of the Chapelton Formation tend to be higher than wide and may show stepped profiles, indicative of

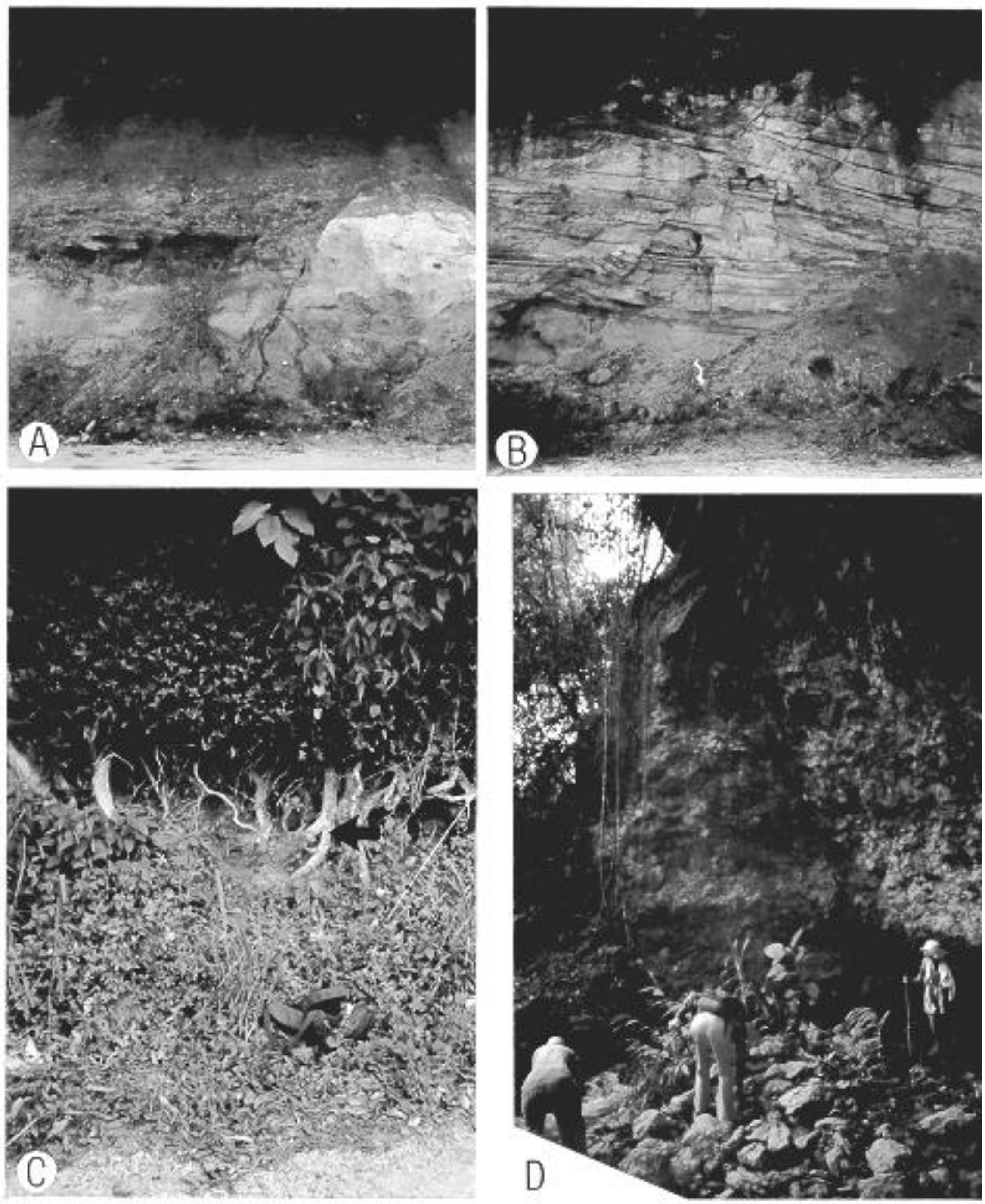

Figure 4. Chapelton Formation of the western Central Inlier, Jamaica. A, B. Stop 2, Guys Hill Member in roadside section between Lichfield and Wait-a-Bit. A. Prominent normal fault in sandstone-mudstone succession: lignitic form a dark band towards the top, just beneath modern foliage. B. Same exposure, slightly closer to Lichfield, dominantly sandstones, commonly cross-bedded, with minor mudstones, the section being disrupted by normal faults. Note the hammer for scale. C. Stop 4b, somewhat overgrown Freeman's Hall beds. The arrow (right of centre) indicates the approximate level that yields septarian nodules containing undeformed plant macrofossils. D. Stop 3, cliff in the Stettin Member overhanging the exit of Wait-a-Bit Cave. Locally derived fossils may be collected from the bed of the stream.

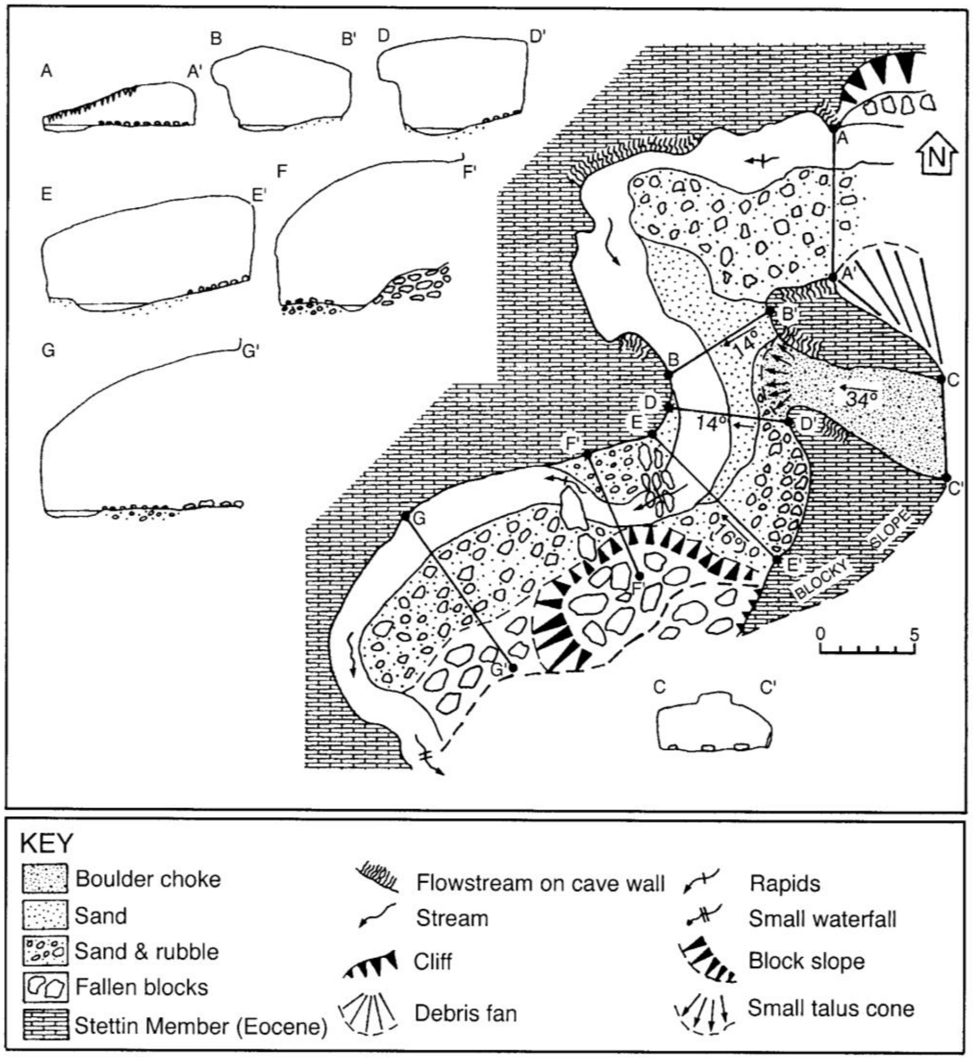

Figure 5. Cave survey and selected passage cross-sections (A-A' to G-G') of Wait-a-Bit Cave, parish of Trelawny (after Miller and Donovan, 1996, text-fig. 2). The thick dashed line to the west of E', and south of F' and G', marks the edge of the limestone overhang from the northwest.

variable solubility from one bed to another. Wait-a-Bit Cave is, in many respects, a typical cave of the Chapelton Formation.

Wait-a-Bit Cave (or Lichfield Cave; Fincham, 1997, p. 227) (NGR 951 769), south of Green Town, parish of Trelawny (Fig. 5), is an archetypal cave meander which shows a range of geomorphological features. The cave and surrounding area include a well-exposed succession within the Stettin Member (Chapelton Formation; Porter and Robinson, 1974), which has yielded a diverse Eocene fauna at Stop 3 and elsewhere. Wait-a-Bit Cave is a small through-cave with a short, single-conduit, sinuous passage about 20-25 m long, up to 5 m high and 5-10 m wide (Fig. 5). The entrance consists of a small, sub-horizontal rift at the base of a 15 m high cliff. The cave exit (near to section E-E') is a much larger rectangular passage, downstream of which is a 15 m high cliff with a prominent overhang more than 10 m deep and 8-8.5 m high (Fig. 4D). The cave is also comprised of a secondary upper side entrance (C-C') about 6-7 m above the level of the stream, forming a short, steeply-sloping passage down to the `main' stream conduit.

The cave passage shape is controlled by approximately horizontal limestone beds. The passage is marked by vertical walls in nodular, rubbly, impure limestone, while the ceiling consists of a sub-horizontal bedding plane within more massive limestone (=units 1 and 2, respectively; see below). The cave entrance (A-A') is a relatively small, horizontal rift about 8 m wide which is supported by near-vertical walls. The remainder of the cave passage (B-B' to E-E') is predominantly rectangular with a sub-horizontal roof supported by near-vertical walls. The rectangular cave exit, near section E-E', is much wider. Downstream of section E-E', the cave passage gives way to a vertical wall about 4.7-5.0 m high, above which is a pronounced overhang (sections F-F' and G-G'; Fig. 5) rising to about 8.5 m and over 10 m wide. The roof is relatively unstable with many `fresh' exposures due to collapse. The upper side entrance forms a similar, but steeper, sloping, rectangular-shaped passage which connects with the main conduit between sections B-B' and D-D'. The main process causing collapse at Wait-a-Bit Cave is probably mechanical erosion and undercutting by the free swinging, meandering stream. Roof and wall breakdown probably also explains why the exit passage is larger than the entrance, an unusual situation for a river cave, and suggests mechanical erosion and entrenchment is the main process of cave formation.

Speleothems festoon some of the cave walls in the form of straw and slightly larger stalactites, and flowstone and dripstone pendants, curtains and buttresses. These occur especially in the entrance section of the cave along the limestone wall, on the north bank of the cave stream and on the roof supporting pillar at A' and B'. Elsewhere speleothems on the cave walls are rare due to the unstable nature of much of the impure, rubbly, nodular limestone. Speleothems are, for the most part, relict phenomena, with cave roof breakdown continually removing them. They probably developed under wetter conditions than those prevailing at the present.

The lithological succession at Wait-a-Bit Cave is illustrated in Figure 6. Unit 1 consists of large limestone nodules up to 400+ by 180 mm in maximum dimension. These nodules are elongated parallel to bedding and discontinuous, separated by partings of grey, slightly silty clay that has been compacted between and around them. The unit shows differential cementation, probably as a result of pressure solution. Nodules are loose and numerous rock falls have occurred. Prominent macrofossils include spatangoid echinoids, bivalves (*Cardium (Trachycardium)* sp. of Trechmann, 1923, p. 363), gastropods (including *Campanile* sp. A of Jung, 1987), rare nautiloids and sirenian ribs.

The roof of the main cave is formed by the base of unit 2, cut by major joints, but essentially continuous. This unit is a well-indurated, straw to brown coloured biosparite rich in macrofossil fragments and microfossils. Units 2, 4 and 6 are lithologically similar, unit 4 constituting the main roof of the side cave. Unit 3 is similar in lithology to unit 2, but is less well indurated and weakly nodular. Unit 5 is an unusual echinoid coquina,

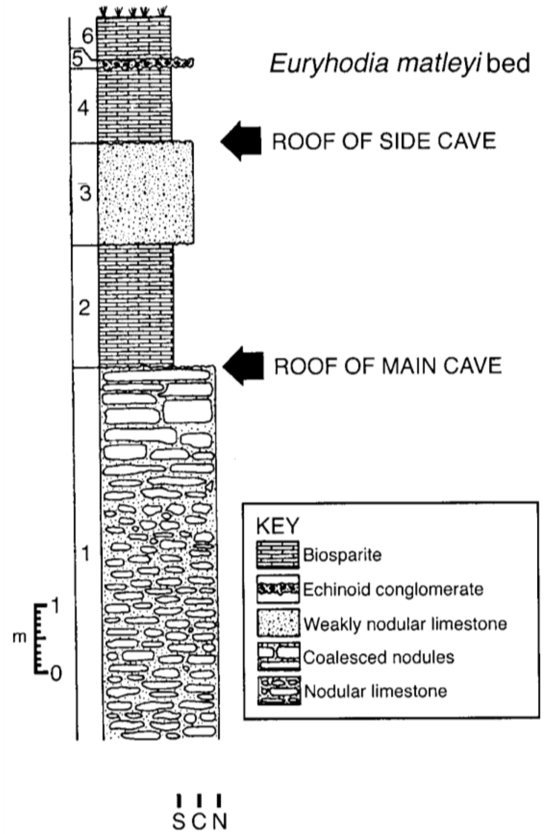

Figure 6. Measured section through the Stettin Member, Chapelton Formation, Yellow Limestone Group at Wait-a-Bit Cave, showing the principal limestone horizons present (after Miller and Donovan, 1996, text-fig. 3). Unit 2 forms the roof of the main cave; unit 4 forms the roof of the side cave. Key: S = sparite; C = pebble conglomerate or weakly developed nodular limestone; N = well-developed nodular limestone.

with numerous complete tests of the cassiduloid *Eurhodia matleyi* (Hawkins, 1927). This bed has particularly undulose contacts with the adjacent units, varying in thickness from 50-120 mm. *E. matleyi* also occurs in units 2 and 4.

The Stettin Member represents a transgressive, carbonate platform deposit typically containing a fauna of Middle Eocene larger benthic foraminiferans (Robinson and Wright, 1993, p. 285; Robinson and Mitchell, 1999). The nodular carbonates of unit 1 are inferred to have been deposited as lime-rich muds and silts, carbonate nodules having formed during diagenesis. The included fauna, such as burrowing bivalves and the heart urchin *Schizaster hexagonalis* Arnold and Clark, 1927, support this interpretation. *Campanile* sp. A was probably a shallow-water algal feeder (Jung, 1987, p. 895) and sirenians feed on sea grass (Domning, 1981). The inference that sea grass was present suggests that this unit was deposited in relatively shallow water, less than 50 m and probably no more than 25-30 m.

Units 2-6, comprised mainly of calcarenites, have a different echinoid fauna, dominantly *E. matleyi* and neolaganid sand dollars. *Eurhodia matleyi* is thought to have burrowed in or, more probably, lived epifaunally upon relatively coarse-grained sands, a habit similar to that of other cassiduloids (Smith, 1984, p. 47). Carter *et al*. (1989) considered that neolaganids broadly similar to the Wait-a-Bit species varied from epifaunal to infaunal in grainstone substrates. Unit 5, the *E. matleyi* coquina, suggests that these beds were deposited at least above storm wave base, with what were presumably live tests of this species having been concentrated by an energetic event. If these echinoids were indeed buried alive, as seems probable, their occurrence in this thin unit would support the inference that they were only, at best, weak burrowers. Alternately, this unit may represent a hiatal concentration, although the complete preservation of tests and the absence of an encrusting epibiota is perhaps more suggestive of a rapid deposition event.

STOP 4: STETTIN, FREEMANS HALL AND THE QUASHIES RIVER

Return to the B5 road and turn north (=left) towards Albert Town. At Stettin take the right turning, downhill, towards Freemans Hall. The isolated limestone exposures at the roadside between the B5 and Freemans Hall represent the type section of the Stettin Member, Chapelton Formation (Robinson, 1988, p. 60). At Freemans Hall take the hairpin bend at the 'crossroads' and deep down into the valley of the Quashies River. Stop at the bridge over the Quashies River (NGR 938 810).

The first part of this stop (Stop 4a; Fig. 1) is of some historical interest (NGR 938 810). The Quashies River is the type locality of *Prorastomus sirenoides* Owen, a member of the most primitive family of sea cows known (Savage *et al*., 1994; Domning *et al*., 2001). However, the type specimen, consisting of a skull, jaw and atlas vertebra, came from a loose boulder in the riverbed and derived from the Yellow Limestone Group. The rocks flanking the river belong to the Upper Cretaceous(?) to Paleogene Summerfield Formation (Robinson, 1994, pp. 118-119), which underlies the Chapelton Formation. The Summerfield Formation is an unfossiliferous, 'red bed', volcaniclastic unit that, in turn, rests on the Campanian-Maastrichtian Guinea Corn Formation (Donovan *et al*., 1995). Limestone boulders include a rich fauna of macroinvertebrates, including *Campanile* sp. A and irregular echinoids, but no further bones of *P. sirenoides*, have subsequently been collected from the site.

Turn around and follow the minor road along the river valley north, passing the junction with the road that was taken down into the valley, until a low exposure of nodular brown siltstones and sandstones is reached, situated on the left of the road just before a church (Stop 4b; NGR 941 822) (Fig. 4C). These are the Freemans Hall beds (Robinson, 1988, p. 60, fig. 11; 1996, pp. 27-28, fig. 3). Unlike the Summerfield Formation, these beds are poorly fossiliferous. Robinson (1996) recorded the occurrence of ostreid oysters in this unit. At this locality, carbonized plant remains are preserved in three dimensions within septarian nodules. It is convenient to walk down to the bed of the Quashies River at this point and prospect for reworked fossils of the Chapelton Formation in the river sediments.

Return towards Freemans Hall. The section exposed below the hairpin bend (Stop 4c; NGR 937 817) shows the fossiliferous Stettin Member to good effect and demonstrates that, unlike lower in the valley, these beds were deposited in fully marine conditions. For example, one horizon includes the irregular echinoid *Eurhodia matleyi* (Hawkins), an old friend from Stop 3, in abundance.

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