The Journal of the Geological Society of Jamaica
Vol. 33, pp. 31 to 41, 1999

Report of a field meeting to south-central Jamaica, 23rd May, 1998

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INTRODUCTION

"*Time and again we studied the same stratification ... and yet each time advanced one step further, because of what we had learned on the last visit, because the previous interpretation had time to settle, or because this time our eyes were a little keener and now observed what hitherto had escaped them. I write this for the student who, many years back and decades later, replied to my question as to why he had not come with us on a field-trip by saying he "had already been there once." I said nothing to him at the time. For he who is not born a geologist, cannot be made into one.*" (Cloos, 1953, pp. 28-29, *loc. cit*. Pettijohn, 1956, p. 1461).

THE SEQUENCE of well-exposed, Miocene-Quaternary rocks at Round Hill, parish of Clarendon, has formed the subject of at least three previous field excursions by the Society (Prescott and Versey, 1958; Edward Robinson, 1967b; Donovan *et al*., 1989). In recent years it has also been visited by the Geologists' Association (Donovan *et al*., 1995; Eric Robinson, 1996) and the Department of the Geophysical Sciences, University of Chicago, as well as forming the subject of regular field excursions by first year classes from the University of the West Indies. Amongst the many attractions of this section is the excellence of the exposure, what Eric Robinson (1996, p. 147) referred to as a "... *splendid sequence, almost continuous*..." Splendid is the right word, for the rocks at Round Hill display beautifully a number of important geological features - unconformity, disconformity, beds in horizontal, dipping and vertical attitudes, small and larger faults, as well as the most impressive fossiliferous deposit in Jamaica - that make it unparalleled as a teaching section in Jamaica and, perhaps, the Antillean region. The purpose of the excursion on 23rd May, 1998, was to walk the coastal section and demonstrate important points of the local geology and geomorphology, in order to show how these have been used to investigate the geological history of this part of Jamaica. The party then made good use of the recently resurfaced road to Alligator Pond in order to examine a possibly coeval, and highly fossiliferous, deposit that is exposed in eastern Manchester.The locations of the three stops are shown in Figure 1. All of the stops that were visited can be found on the 1:50,000 topographic sheet (metric edition) #16, "Alligator Pond". Relevant 1:50,000 geological sheets are #10 "Alligator Pond" and #13 "Mandeville". The accounts of God's Well, the beach sands and the Round Hill beds are adapted, with revision, from Donovan *et al*. (1995, pp. 7-12). Table 1 summarises the geological history of the Round Hill area.

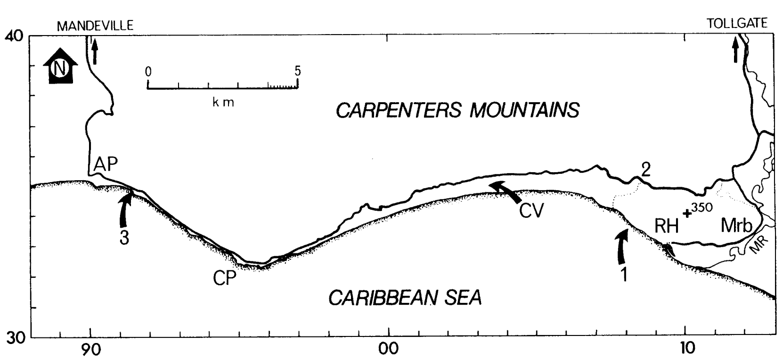

Figure 1. Locality map showing principal features of the area between Milk River Bath, parish of Clarendon, and Alligator Pond, parish of Manchester, south central Jamaica. Key: AP=Alligator Pond; CP=Cuckold Point; CV=Canoe Valley; MR=Milk River; Mrb=Milk River Bath; RH=Round Hill; +=spot height (in m); 1, 2, 3=Stops 1, 2, 3. Grid derived from 1:50,000 topographic sheet (metric edition) #16, "Alligator Pond"

Table 1. Geological history of the Round Hill area. Key: R.H.B. = Round Hill beds

UNIT	GEOLOGICAL EVENTS	AGE
	Further uplift and continuing coastal erosion	Holocene
distal fans/talus cones	Deposition of (predominantly) terrestrial deposits as a series of fans and talus cones	Late Quaternary (Holocene?)
'Raised beach'	Deposition of allochthonous(?) shell debris on the shore platform (=unconformity)	Late Quaternary (Holocene?)
	Uplift and faulting; planation of tilted Round Hill beds (=rocky shore platform)	Pleistocene?
R.H.B. unit D - unit C R.H.B. unit B R.H.B. unit A	Progradational deposition of the Round Hill beds in nearshore marine to terrestrial environments	Mio-Pliocene? or Plio-Pleistocene?
	Initial unroofing of Cretaceous rocks in central Jamaica, resulting in a change from pure carbonate to mixed siliciclastic - carbonate sedimentation	late Miocene
Newport Formation	Deposition of pure limestones in a Bahamas Bank-like environment	Miocene

STOP 1: ROUND HILL, PARISH OF CLARENDON

"*Round Hill, the greatest elevation in this parish [of Vere], rises about 620 feet [=191 m] from the sea [but compare with Fig. 1 herein]. It is very difficult of access, being covered with dense forests and precipitous escarpments ... Passing round this hill by the shore some fine sections occur by which the lower beds of the white limestone and the upper beds of the yellow limestone are exposed*" (Sawkins, 1869, pp. 160, 162).

Twenty three members and friends of the Society took the main A2 road west from Kingston. At Toll Gate, the turning to Farquhar's Beach is on the left just past the electricity substation on the right. The route to the south on the B12 was taken, past the Milk River Bath Hotel and on towards the coast. This last stretch of road is poor, but attractive views were to be had of Milk River on the left and Round Hill on the right. Fallen boulders of the Newport Formation were seen at the side of the road. Vehicles were parked at, but not on, Farquhar's Beach.

Round Hill is a prominent topographic feature on the central south coast of Jamaica in the parish of Clarendon (Donovan *et al*., 1989). The purpose of this extended stop was to examine the Plio-Pleistocene Round Hill beds of the August Town Formation, a sequence of marine sedimentary rocks unconformably overlain by a late Quaternary conglomeratic sequence of terrestrial origin.

The party walked down to the beach and continued northwest along the coast for about 2 km. There were four planned localities on this walk, which were examined in returning from the furthest point. However, there was much else of interest on the way.

Geology

Newport Formation, White Limestone Group. The oldest rocks exposed in this area are the white limestones of the Miocene Newport Formation, which form the impressive bulk of Round Hill and the southern Carpenters Mountains (Fig. 1). These are poorly- to well-bedded, poorly fossiliferous limestones that were deposited in a shallow water setting based on available faunal evidence. Typical fossils include the foraminifer *Amphisorus*, and ostreid and pectinid bivalves (Hose and Versey, 1957; Versey, 1963); scleractinian corals and benthic molluscs are moderately diverse (Frost, 1972; Jung, 1972). This formation is conformably overlain by the Round Hill beds (Edward Robinson, 1967b); similarly, the August Town Formation rests on the Newport Formation with "near conformity" in the type area (Hose and Versey, 1957, p. 38). Rare boulders on Farquhar's Beach are composed of karstified white limestone and were derived from the Newport Formation of Round Hill.

Round Hill beds, August Town Formation, Coastal Group. The highly fossiliferous succession of the Round Hill beds at Farquhar's Beach is a sequence of more or less sandy limestones and siliciclastics, with a fossil biota dominated by benthic molluscs and benthic foraminifers, with less common corals, echinoids, balanid barnacles, bryozoans, wood and trace fossils (both burrows and borings). Beds dip steeply towards the sea or are vertical, and the outcrop is incised by few faults. This coastal exposure was first documented by Duncan and Wall (1865, p. 6, fig. 4), who considered the succession to consist of Miocene sedimentary rocks overlain by a white limestone (see also Sawkins, 1869, pp. 160-163). Edward Robinson (1967b) correctly reinterpreted the structure as a possibly conformable contact between the underlying white limestones of the Newport Formation and the younger Round Hill beds. In turn, the Round Hill beds are unconformably overlain by the distinctive conglomerates of Farquhar’s Beach. Major faults in the Round Hill beds are truncated by the angular unconformity with the conglomerates.

The age of the Round Hill beds is uncertain, but they are at the oldest late Miocene. Sawkins (1869, p. 163) considered that the fauna of these beds was similar to that of Bowden (presumably the Bowden shell bed), parish of St. Thomas, implying a Pliocene age; however, this preliminary determination awaits conclusive confirmation almost 140 years later. However, it may be that this determination of faunal equivalence was coloured by Sawkins’s desire to correlate all rocks which he perceived to be “yellow limestone” (including much that is now recognised to belong to the Coastal Group) (Chubb, 1962, p. 29). Edward Robinson has suggested that these rocks are Miocene-Pliocene in age (1967a, p. 33) or possibly Pliocene, perhaps extending into the Pleistocene (written comm. *in* Littlewood and Donovan, 1988, p. 1015). A detailed account of the sedimentary sequence of the Round Hill beds has yet to be published (but see Edward Robinson, 1969; Bowen, 1989; Britton, 1989), but it is comprised of four units, informally called A to D by Donovan *et al*. (1995, pp. 10-11).

Unit A lies at the base of the sequence. It is comprised mainly of bedded limestones, which are often nodular. Nodules are cemented by iron-rich carbonates and in at least some examples follow the burrow systems most probably produced by crustaceans (=the trace fossil *Thalassinoides* isp.). Barnacles and oysters are sometimes found at bedding planes, suggesting that the nodular carbonates formed hardground surfaces. The palaeoenvironment was originally interpreted by S.K.D. as open marine, possibly analogous to that of the carbonate slopes in the northern Bahamas (Mullins *et al*., 1980). However, this preliminary interpretation must be revised to include a micritic limestone containing freshwater(?) ostracodes underlain by a lignite-rich bed, both of which were discovered by a visiting party from the Geologists’ Association in January 1993. These horizons indicate a near shore origin for at least part of this unit.

Unit B is a sequence of siliciclastic rocks, in particular planar to cross-bedded sandstones and polymict pebble conglomerates, with soft sediment slumps(?), minor limestones and moderately common oyster beds in channel fills. Tepee structures, first recognised by Professor Susan Kidwell of the University of Chicago, and indicative of early cementation and dewatering (Scoffin, 1987, p. 98), are developed near the top. Unlike unit D (see below), the pebble conglomerates, which also include robust fossils as clasts, are laterally continuous on the scale of exposure. Fossils include calcified wood, various benthic molluscs, the pea-like benthic foraminifer *Sphaerogypsina globulus* (Reuss) (Edward Robinson, 1967b, p. 46), bryozoans, rare echinoids (*Clypeaster rosaceus* (Linné)) and trace fossils, notably *Dactyloidites ottoi* (Geinitz) (Pickerill *et al*., 1993), and pebble clasts with borings such as *Entobia* isp. and *Gastrochaenolites* isp. This unit includes fossils of both marine and brackish-water organisms. The brackish-water association occurs in the oyster bed(s); these have an erosive contact with the underlying beds with a more open marine fauna.

Edward Robinson (1967b, p. 46) noted "*Several remarkable beds of oysters occur near the base of the sequence [that is, within unit B], with the oysters in an original position of growth, and with many individual shells reaching 15 inches [=380 mm] or more in length*." Prescott and Versey (1958, p. 39) considered that these oysters resembled *Ostrea haitiensis* Sowerby, but they are, in fact, *Crassostrea virginica* (Gmelin). The main bed of oysters is 3.3 m thick, including many individuals in life position, and appears to have been a bank in a channel similar to those being formed by the same species in the American Gulf Coast region at the present day (Littlewood and Donovan, 1988). *Crassostrea virginica* is preserved variously as broken shell fragments, dissociated valves, recumbent articulated valves and upright articulated valves. Barnacles and juvenile oysters encrust the valves, on both the inner and the outer surfaces. Young oysters are particularly prominent on some of the largest, upright, mature specimens of *C. virginica* near the top of the bed. Some shells of *C. virginica* have been bored, most probably post-mortem, by various invertebrates including clionid sponges (*Entobia* isp.), amongst others. Shells in life position occur throughout this unit, but are concentrated at particular horizons, especially towards the top, where shells reach 400 mm in height. Such shells are amongst the largest *C. virginica* known.

Various lines of evidence show this bed to be a life assemblage. The unusually large oyster shells are often still articulated and even preserved in life position. Encrusting organisms are still in life position, growing on oyster shells. These would have been abraded and scraped off if excessive transport had occurred. Disarticulated oyster shells are probably the result of death by natural causes and subsequent rotting of soft tissues with minimal local reworking. An unusual feature of this assemblage is the dominance of one species, *C. virginica*. This is indicative that environmental conditions were particularly favourable for this taxon, almost to the complete exclusion of all other shelly organisms, although a diversity of soft-bodied, weakly mineralised and delicate mineralised taxa could have been lost post-mortem (compare with Lawrence, 1968).

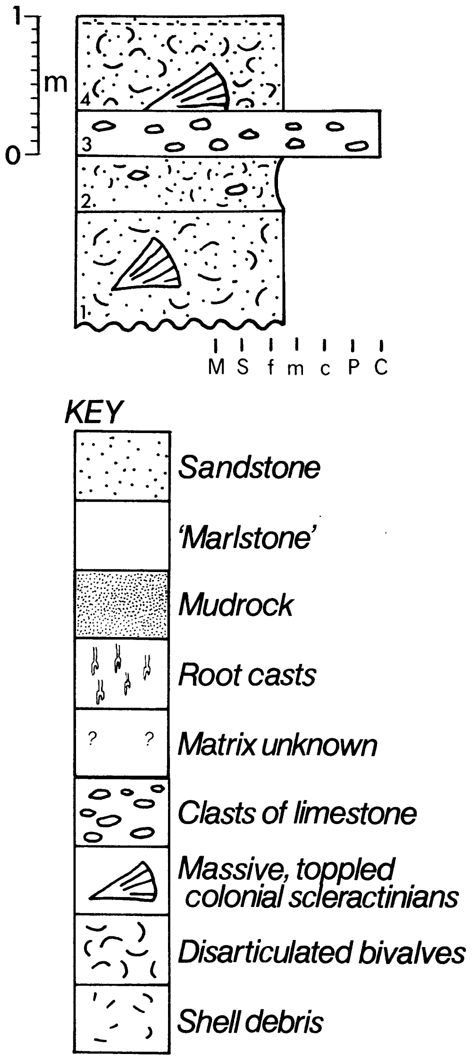

Figure 2. Measured section of the 'raised beach' exposed in the gully above the more southeasterly fault at Stop 1C, adjacent to the section in Figure 3. Key: M=mudstone; S=siltstone; f, m, c=fine-, medium-, coarse-grained sandstone; P=pebble conglomerate; C=cobble conglomerate; 1-4=beds 1-4. Note that conglomerates in Figures 2 and 3 are matrix-supported.

Unit C is a sequence of poorly bedded, monotonous, white limestones which abruptly overlie the well-bedded succession of unit B. Fossils in unit C are mainly small, disarticulated oysters and pectinids, with *Spondylus* and *C. virginica* valves near the base. Rare fragments of a burrowing spatangoid echinoid have been found higher in the section. While marine in origin, unit C is tentatively interpreted as a possible lagoonal environment, with a restricted shelly benthos, but with the sedimentary sequence highly bioturbated, presumably by a mainly soft-bodied infauna.

Unit D has a markedly different lithology to the other units. It is comprised of a series of dull, brown-coloured, siliciclastic sedimentary rocks which lack a shelly benthos. Medium- to coarse-grained sandstones are common and some beds show cross-bedding. These include vertical to sub-vertical, green (=reduced) structures which may be due to water percolating through cracks or plant roots. Polymict pebble conglomerates include a typical 'south coast' assemblage of pebbles (maximum dimension about 40 mm), presumably derived from Cretaceous inliers inland and transported westwards by longshore drift. This unit is about 50 m thick and is apparently fluvial in origin (Edward Robinson, 1963, p. 48). It appears to be overlain by unit C, at least in part, which in turn overlies unit B to the southeast. However, units C and D also outcrop in close lateral association without any obvious structural discontinuity such as a fault. Thus, units C and D may be coeval. It is provisionally postulated that units D and C represent more near shore/fluvial and more offshore/marine components, respectively, of what may be a fluvial/lagoonal association. Unit D is exposed at the far northwest end of the section.

'Raised beach'. Edward Robinson (1967b, p. 46) described this unit as "... *a thin deposit of raised beach sand, containing marine molluscs of modern aspect*", that he considered to lie unconformably on the Round Hill beds. We use 'raised beach' in the broad sense herein, that is, a beach feature elevated above present sea level, whether this position results from either uplift of the land or a drop in sea level (Lowe and Walker, 1997, p. 84). At the time of deposition of the 'raised beach', the eroded surface which now forms the unconformity on the Round Hill beds presumably formed a wave-cut, rocky shore platform. This was subsequently buried by the 'raised beach' and overlying distal fans/talus cones.

Four beds (1-4) are recognised in this deposit in the V-shaped gully at Stop 1C (Fig. 2; beware that access involves some simple rock climbing). Bed 1 is a fine- to medium-grained sandstone that rests unconformably on the Round Hill beds. The fauna consists of disarticulated bivalves and obviously allochthonous, colonial scleractinians. Bed 2 is lithologically similar, but includes mainly broken shells in association with some pebbles and cobbles of limestone. This is overlain by bed 3, an unfossiliferous limestone conglomerate (clasts up to 62 mm maximum dimension, mean 35-40 mm) with a fine-grained, siltstone matrix. Bed 4 is similar in lithology to bed 1, with a well-lithified cap. This sequence is overlain by a conglomeratic deposit, although we are uncertain if this is *in situ* or scree. At some other localities where the unconformity can be examined, the 'raised beach' is less well-developed or absent.

Distal fans and talus cones of Farquhar's Beach. These beds are noticeably conglomeratic, particularly in

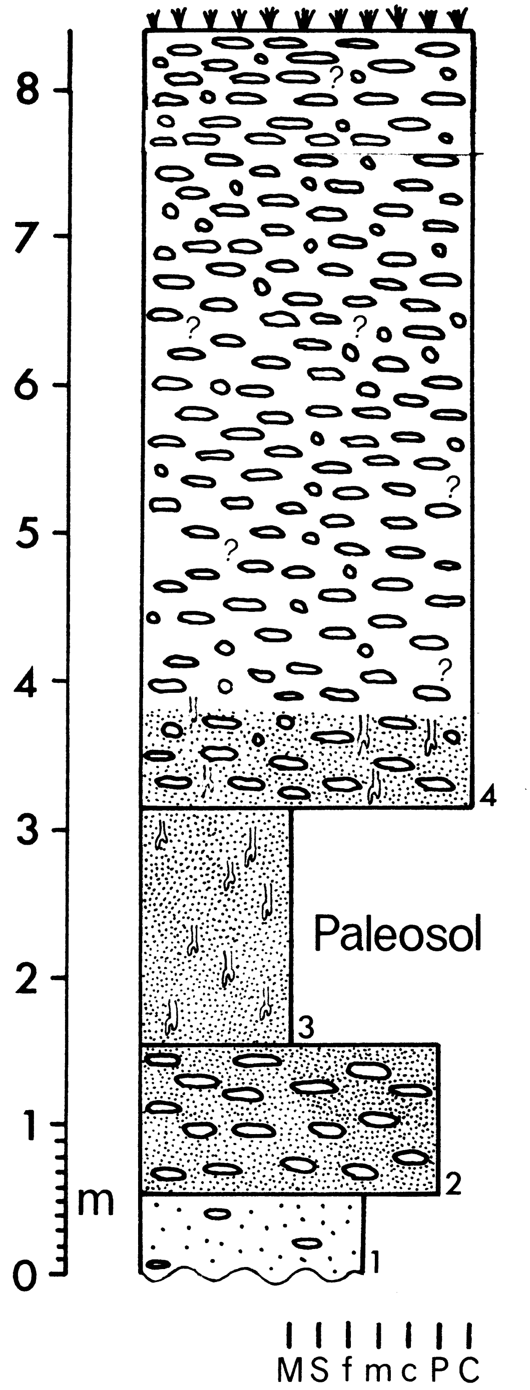

Figure 3. Semi-schematic measured section of the distal fans/talus cones exposed on the southeast side of the gully above the more southeasterly fault at Stop 1C (see also Fig. 4). The top half of this section was determined from photographs due to difficulty of access and, in consequence, lacks detail. Key as in Figure 2.

their upper part, and contain rounded pebble- to cobble-sized, or rarely larger, clasts composed of white limestone (derived from the Newport Formation and including fossils of marine origin) in a red, calcareous mudstone to sandstone matrix which includes calcareous crusts, terrestrial gastropods and root casts (those in paleosols, or fossil soil horizons, are apparent in the cliff; calcified roots are rare in toppled, conglomeratic boulders). This unit thickens towards the southeast, where the unconformity reaches beach level. Figure 3 illustrates a measured section in this unit at one locality, although there are lateral variations (see also Figure 4).

Figure 4. The section measured in the distal fans/talus cones (=Figure 3), exposed on the southeast side of the gully above the more southeasterly fault at Stop 1C. The prominent bench is formed by the paleosol.

For example, and to discuss well-exposed examples on either side of the measured section, to the northwest of the more northwesterly fault at Stop 1C (see below), the lower half of the section is not particularly conglomeratic. This lower part is mainly red, but is white towards the bottom and grey at the unconformity. A discontinuous, brown paleosol also occurs in this lower part of the succession, with white root casts at the top of the soil. Near Stop 1D and towards the Milk River end of the cliff section, where the cliff itself is about 8-10 m high, the basal unconformity is only about 2-3 m above beach level. Here, the lower 4 m of the distal fans/talus cones are very white and unconglomeratic, with discontinuous bedding-parallel ‘stringers’ of better cemented rock, probably limestone. This is below a bench in the cliff, above which is a brown paleosol, overlain by conglomerates. From about 1 m below the paleosol, at an irregular surface, to the top of the cliff, the beds are deep red in colour.

The commonest boulders on the beach are derived from the upper half of this unit. These are easily identifiable by their red matrix and white limestone clasts. Although the clasts contain various marine fossils, such as colonial scleractinian corals, tubes of the bivalve *Kuphus* sp. and rare sand dollars, the matrix includes a moderately diverse fauna of land snails all assignable to extant Jamaican taxa. These snails and the intense red colour of the matrix testify to the terrestrial origin of this unit. Supporting evidence is provided by those boulders which include calcified root remains.

Beach sands. Farquhar's Beach is one of several `black sand' beaches that occur along the south coast of Jamaica. The sand is composed primarily of titano-magnetite and titano-haematite crystals with lesser amounts of feldspar, quartz and calcite; the geochemistry and provenance of these deposits is now being studied by Ms Betsy Bandy (Bandy *et al*., 1998). Because the black sands are concentrated at the mouth of the Rio Minho and westwards along the south coast from Farquhar's Beach in Clarendon to Long Acre Point in St. Elizabeth, Chubb (1960) surmised that the sources of the sands were from the Cretaceous inliers in the interior of central Jamaica. Erosion and transport by rivers flowing southward, accompanied by westerly longshore currents, account for the dispersion of sand along the coast.

A notable inhabitant of these sands is the burrowing bivalve *Donax denticulata* Linné, living in the breaker zone, and migrating up and down the beach with the tides. A neotaphonomic study on Farquhar’s Beach by S.K.D. has demonstrated considerable post-mortem, hydrodynamic sorting of these shells. In a collection of 65 dead specimens, there were 62 right valves, two left valves and only one articulated shell. Thus, although these shells are presumably parautochthonous, if fossilized they would appear to be a death assemblage. In an analysis of the commoner right valves, there was also sorting towards larger (adult) shells, with a mode of 20.0-21.9 mm shell length (14 specimens, using a 2 mm class interval), and minimum and maximum lengths of 9.0 and 30.0 mm, respectively. Fifty five of the right valves were preserved in the hydrodynamically stable, concave down position. Valve orientation, measured from the posterior to the anterior, showed a preferred alignment between 270-029º (47 specimens) on a beach trending about 116º and with a gentle slope of about 7º SW.

Geomorphology

Round Hill is an imposing, roughly oval-shaped limestone massif orientated in an approximately east-west direction. It is bounded to the east and south by the floodplain and mangrove swamps of the Milk River, and to the west by similar wetlands within the lower reaches of the Alligator Hole River. To the north, Round Hill is bordered by conical hills and enclosed depressions forming poorly developed kegelkarst, which gives way in the northwest to collapse dolines around God’s Well and to small limestone gorges associated with uplands containing some enclosed depressions in the Alligator Hole River area. Much of the southwest margin of Round Hill is skirted by a gently sloping, apron-like footslope covered with scrubland vegetation and comprising limestone conglomeratic debris with many fallen limestone blocks on its surface, which terminates at the coast as an 8-10 m high seacliff, below which is a discontinuous beach containing black sand.

Although Round Hill is composed of limestones of the Newport Formation, there is a general lack of typical, large-scale karst landforms on its surface. For the most part, the slopes of Round Hill are broadly convex to rectilinear, but are occasionally broken by benches and steps, particularly on the north- and south-facing slopes, which can be interpreted as ‘structural benches’, probably marking bedding planes or structural trends within the limestones. There are also numerous gullies and possible old landslide scars cut into the flanks of Round Hill, especially on its southwest-facing slopes, whilst many former drainage lines can be traced on its surface on all aspects of the massif. These gullies and drainage lines are predominantly relic phenomena and were presumably cut during periods of more significant rainfall than at present, or, alternatively, secondary permeability of the limestones has now advanced to a stage where all rainfall simply infiltrates below the surface. Many of the gullies which drained to the lower slopes, especially on the colluviated footslopes on the southwest flanks of Round Hill, are associated with fans and talus cones, comprising conglomeratic limestone debris and larger fallen blocks. The distal ends of some of these fans are exposed in the seacliff to the west of Farquhar’s Beach as Holocene conglomeratic beds containing predominantly limestone boulders and pebbles in a reddish, rendzina-like matrix. The conglomeratic beds contain moderately rare calcified root remains and calcrete horizons, and also are associated with semi-continuous paleosol horizons. This suggests that the mass movement and fluvial processes which formed the fans and talus cones were episodic, and punctuated by periods where the fans were at least temporarily stabilised by a vegetation and soil cover. The gastropods within the conglomerates confirms their terrestrial origin as mass movement and fluvial deposits laid down in a debris fan and talus cone environment. Generally on all aspects, the base of Round Hill is marked by an abrupt break of slope, below which are much gentler slopes mantled with fallen limestone blocks and boulders.

Large-scale karst solution features and landforms are extremely poorly developed on Round Hill, though a few 'enclosed depressions' occur towards the summit area, and on one of the structural benches on the northeast flanks, whilst some isolated 'conical hills' near the summit also mark incipient karst development. The poor karstification seen on the surface of Round Hill may be related to the length of time the massif has been a subaerial feature; it could be fairly recent and there simply has not been enough time for full karst development. Alternatively, the character of the limestone, which seems on weathering to break up into conglomeratic debris, may preclude karst development. It is interesting to note that similar limestone massifs along the south coast of Jamaica, such as Dallas Mountain, Long Mountain, the Hellshire Hills and Portland Ridge are also poorly karstified, and are also mainly in limestones of the Newport Formation.

The most significant karst development on Round Hill occurs as small-scale solution sculpturing features. Round Hill displays a range of karren weathering forms on its exposed limestone surfaces. The main solution sculpturing phenomena is honeycomb weathering, whilst hydrodynamically controlled linear sculpturing, chiefly in the form of rillenkarren, is also common. Rillenkarren are small dissolution channels elongated down the slope of bare limestone surfaces, with channel widths in the region of 10-25 mm. Rillenkarren are the product of direct rainfall onto the surface of the limestone, and are generally best developed in fine-grained, homogenous limestones, dolomites and marbles (Jennings, 1985, p. 75; Ford and Williams 1989, p. 385), such as the Newport Formation. Other bare limestone surfaces are fluted and may take the form of rinnenkarren, being small dissolution channels which display sharp rims and flat or rounded bottoms. Limestone sculpturing phenomena are not restricted to the limestones on Round Hill itself, but are also common on the many fallen blocks at the foot of its slopes.

Karst solution features are limited to small-scale phenomena and karstification of Round Hill is generally extremely poorly developed or absent. Therefore, it would appear that a strong initial geological control, together with surface water flow in gullies and other drainage lines, and mass movement processes, were of greater significance in the early evolution of the geomorphology of Round Hill than were limestone dissolution processes. At present, the major geomorphic process appears to be small-scale dissolution, with occasional rock- and blockfall.

The coastline from the mouth of the Milk River to Farquhar's Beach is a sandy beach backed by mangrove swamps. It is one of several black sand beaches that occur along the south coast of Jamaica (see above). West of Farquhar's Beach, the coastline is marked by a low seacliff, which is about 8-10 m high, and exposes the Round Hill beds and overlying distal fans/talus cones. The cliff is generally poorly stabilised, and many fallen blocks of both these units litter the beach below. The more stable sections of the cliff are buttressed by the more resistant components of the Round Hill beds. Uncommonly, the cliff is broken by gullies, whilst slumped sections occur to the extreme west of the cliffline. The slumps could be the product of wave action undermining the base of the cliff, though they may also be related to groundwater movements to the southwest of Round Hill. For the most part, the mass movements within the slumped cliff zones can be classified as small-scale slab and toppling failure, with some rotational components.

Four stops were made on this section of coast, as follows:-

Stop 1A (Fig. 5a). Unit D and the contact with unit C are exposed towards the northwest end of the beach. Mr. James Halliwell excavated a specimen that seems to suggest that at least some of the vertical, reduced structures in unit D are indeed root casts rather than joints.

Stop 1B (Fig. 5a, b). The contact between units B and C, and the unconformity between the Round Hill and overlying distal fans/talus cones, are beautifully exposed in cliff section. The lithology of the conglomerates of the distal fans/talus cones were examined in the numerous fallen boulders. A disconformity/channel fill within unit B is infilled by *in situ C. virginica* and probably forms part of the same channel seen at Stop 1D (see below).

Stop 1C (Fig. 5c). Major, conjugate normal faults in the dipping unit A are separated by vertically dipping unit B(?) at this stop. These faults are truncated by the unconformity. The more southeasterly of the two faults shows obvious drag on the strata adjacent to the structure, as indicated by their increased dip, approaching vertical. The measured section in the distal fans/talus cones (Figs 3, 4) was determined above the prominent V-shaped gully (Fig. 5c). The 'raised beach' deposits (Fig. 2) are exposed in this gully, but none of the party was sufficiently adventurous to climb up and see them!

The party was entertained by D.J.M. moving backwards down the slope under the influence of gravity. In a horizon in the vertical Round Hill beds, Ms Gail Simpson and others found well-preserved, but disarticulated, valves of the spiny oyster *Spondylus* sp.

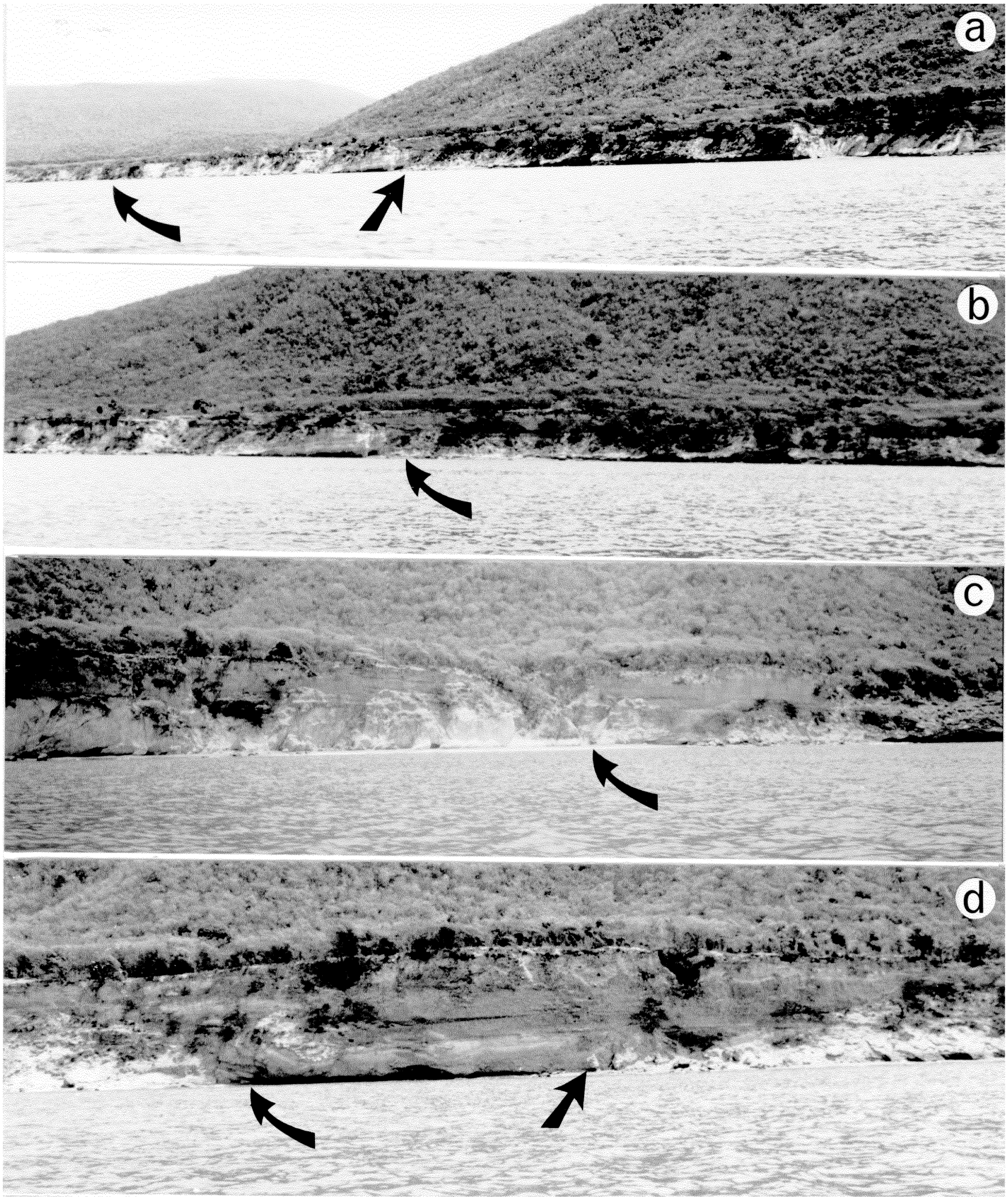

Figure 5. General views of Stop 1. (a) Northwest end of Round Hill (to right), showing Stops 1A (recurved arrow to left) and 1B (straight arrow to right). (b) Stop 1B (recurved arrow) viewed from closer to the shore. (c) The southeastern end of Stop 1C (recurved arrow) showing the prominent V-shaped gully at this locality. To the left of the gully the Round Hill beds (beneath the unconformity) are vertical; to the right, they are dipping towards the sea. (d) The oyster beds at Stop 1D (recurved arrow). The straight arrow indicates the position of a fallen boulder containing part of the main oyster bed.

The paleosol in the distal fans/talus cones is weathering back as a notch above the southeast fault.

Stop 1D (Fig. 5d). Two most unusual fossiliferous horizons were examined at this stop: a single horizon within unit B with very abundant examples of the trace fossil *Dactyloidites ottoi* (Pickerill *et al*., 1993), and the 3.3 m-thick oyster bank of *Crassostrea virginica* (Littlewood and Donovan, 1988).

STOP 2: GOD'S WELL, PARISH OF CLARENDON

"*After passing over this level area and a broken limestone country and arriving at a low ridge, and then turning west through a dense forest with huge blocks of limestone on the surface and open cracks and fissures traversing the ground, an immense circular cavity occurs called God's Well, the dimensions of which are supposed to be 160 feet in diameter and 70 feet from the rim to the surface of the water [a stone of two pounds weight was 3½ seconds in reaching the water], which is of a beautiful light blue colour. The depth of the water was not ascertained on account of the impossibility of approaching it, the walls of the well being perpendicular, and covered with stalactitic tufa or carbonate of lime so completely as to conceal the lines of stratification of the beds.*" (Sawkins, 1869, p. 163).

The party returned back towards and past the Milk River Bath Hotel, and then took the left turn (5.1 km = 3.2 miles) towards Alligator Pond, which initially follows the valley between Round Hill to the south and the Carpenters Mountains to the north. After 9.0 km (5.6 miles) the party halted by the track on the right. God's Well is about 10 minutes walk along this track.

God's Well is a spectacular sink hole within the Newport Formation of the Carpenter Mountains, north of Round Hill. It was described by Sawkins (1869) and Zans (1960). A major east-west fault which extends along the northern side of Round Hill, plus the northwest-southeast joint systems, have greatly facilitated the karst development of the area (Zans, 1960). God's Well itself was most probably produced by the collapse of a limestone roof over a major underground cavern.

The orifice of the sink hole is oval and measures between 25 to 40 m in diameter. The sink hole has near vertical walls and the distance from the top of the depression to the water level below is approximately 25 m. The water level fluctuates about 0.7 m between wet and dry seasons. God's Well is drained underground to the west, where it issues as a spring at the head of the Alligator Hole River (Zans, 1960).

STOP 2 TO STOP 3: FEATURES OF THE CANOE VALLEY ROAD

Continuing west, the Alligator Hole River Project is 9.6 km (6.0 miles) from Farquhar's Beach. A little to the west of this is a locality that yields a species of the echinoid *Clypeaster* with a low test (Donovan, 1991). The Canoe Valley road, formerly somewhat derelict, was recently resurfaced. Recent blast holes are apparent in the limestone of the Newport Formation, suggesting that the road was also widened. Small caves in the limestone are moderately common on the northern side of the road, but pipes infilled with laterite are relatively rare. Surface karst features include honeycomb weathering and rillenkarren. There is no distinct, late Pleistocene, sea level notch apparent here, unlike the Discovery Bay area due north (Donovan and Miller, 1995).

Milepost 48 was passed after 16.2 km (10.1 miles). There was a prominent shelter cave at 19.8 km (12.4 miles). A limestone quarry on the right side of the road was a distinctive landmark at 20.1 km (12.6 miles). After 25.6 km (16.0 miles), Cuckold Point was rounded, and there was a view towards Port Kaiser, Lovers Leap and Great Pedro Bluff. 'Sunset Lounge' is after 29.1 km (18.2 miles), just after milepost 56. The exposures to be examined were on the beach, a little to the northwest of this spot.

STOP 3: *ENCOPE* BED AT SUNSET LOUNGE, PARISH OF MANCHESTER

Our knowledge of many fossil and extant groups from Jamaica suffers from poor stratigraphic or locality data, or both. The only locality data given in the original description of the clypeasteroid echinoid *Encope homala* Arnold and Clark was "*...from the parish of Manchester*" and only the aboral surface was figured (Arnold and Clark, 1934, p. 142, pl. 2, fig. 1). The oral surface was not figured because it is concealed by a pebbly, matrix-supported conglomerate comprising moderately well-rounded lithic clasts (up to about 15 mm maximum dimension). These clasts are of predominantly volcanic origin and are embedded in a straw-brown, medium- to coarse-grained sandstone matrix. This lithology is highly suggestive of certain horizons within the Coastal Group on the south coast of Jamaica. Because the coastline of Manchester is short and much of it is the site of active mangrove growth, there is little exposure of the Coastal Group from which this specimen could have been derived.

The fossiliferous horizon, informally named the Sunset Lounge *Encope* bed herein, was defined and described by Donovan *et al*., (1994). It was brought to the attention of S.K.D. by Dr. Ashlyn Armour-Brown. It is well-exposed on the south coast of Jamaica, near the 'Sunset Lounge', 1.6 km east of Alligator Pond and south of the road to Milk River (approximate GR 915 347). The unit which yields common fossil *E. homala* is a massive, matrix-supported, pebble conglomerate with rounded limestone and igneous clasts up to 150 mm in length which occur in a brown matrix of medium-grained sandstone (Donovan *et al*., 1994). Fossils in this unit include articulated shells and disarticulated valves of bivalves, especially cardiids and valves of *C. virginica*, *E. homala* (up to 100+ mm in diameter), colonial scleractinian corals, gastropods, balanid barnacles, encrusting bryozoans and crab chelae. This fauna is similar to that of the Round Hill beds. Shells and pebbles display a variety of borings (R.K. Pickerill and S.K.D., research in progress). The matrix is generally well-cemented. The upper surface of the bed is very uneven. This unit is probably a lateral equivalent to part of the Round Hill beds.

E. homala is almost invariably preserved with the oral surface downwards. Although tests are largely preserved complete and in life orientation, it is probable that they are allochthonous, as indicated by the coarse-grained nature of the enclosing sedimentary rock and the close association with other, obviously disarticulated bioclasts such as the large shells of *C. virginica*. Unlike most other echinoids, the sturdy tests of clypeasteroids are quite likely to survive energetic transport and deposition intact. Preservation in a life orientation may merely indicate the most stable hydrodynamic orientation.

Following this last stop, rest and relaxation was taken at the 'Sunset Lounge'. On behalf of the Society, Mr. Donovan Blissett gave a vote of thanks to the leaders. Returning towards Kingston, there were spectacular views to be had looking towards Round Hill.

ACKNOWLEDGEMENTS — We thank the numerous individuals who have been involved in our Round Hill field research since 1987, including Hal Dixon, Trevor Jackson (both UWI), Eamon Doyle (ex-UWI), Tim Littlewood (now The Natural History Museum, London), Ron Pickerill (University of New Brunswick), Carla Gordon (now NRCA) and Rex Dixon (Kingston). We thank Trevor Jackson and Simon Mitchell (both UWI) for their constructive review comments.

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