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Revised lithostratigraphy of the Coastal Group of south-eastern St. Thomas, Jamaica

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ABSTRACT. The lithostratigraphy of the Coastal Group (Neogene) in the south-eastern part of the parish of St. Thomas, Jamaica, is formally described based on detailed geological mapping. Four formations and two members are recognised: August Town Formation (including the Leith Hall Member [new member]); Layton Formation (reintroduced name) (including the Bowden Member); Old Pera Formation (changed rank) and Port Morant Formation (formerly introduced). Type sections for each new and upgraded formation are described. The paper presents the revised lithostratigraphy of the formations, clarifies some previous misconceptions, and places the formations into a formal nomenclature as set out by the International Stratigraphic Commission.

Key words: Coastal Group, Jamaica, lithostratigraphy, Neogene, Quaternary.

The sedimentary succession in the Coastal Group of Jamaica, was important in the establishment of the biostratigraphic zones of the Neogene based on planktic foraminifers and calcareous nannofossils (see summary in Bolli et al., 2007). While this work has revised the biostratigraphy, there has been less work on the lithostratigraphic succession.

Given the rigour required for lithostratigraphy as indicated in the International Stratigraphic Guide (Salvador, 1994; Murphy and Salvador, 1999), we have undertaken a revision of the lithostratigraphy of the Coastal Group in eastern Jamaica based on geological mapping in the parish of St. Thomas. In this paper we examine the history of usage of lithostratigraphic names, present a new geological map, and provide a revision of the lithostratigraphy of the Coastal Group of eastern Jamaica.

2. HISTORY OF RESEARCH

Lucas Barrett and James Gay Sawkins began their geological survey of Jamaica by jointly mapping the eastern part of the current parish of St. Thomas (then called St. Thomas-in-the-East) in 1859 (Sawkins, 1869). The Cenozoic succession, from base to top was: 1. Gravels, Clay and Yellow Marls (here were included a variety of conglomerate beds now included in various different units from the area of Whitehall and the Pteropod Marl); 2, White Limestone (1000-2000 feet thick); 3, Marls and White Limestone; 4, Coast Limestone (now the reef facies of the Port Morant and Falmouth formations); and 5, Alluvium (the conglomerate facies of the Port Morant Formation herein).

The description given by Sawkins in 1860 (Sawkins, 1869) from mapping conducted by both Barrett and Sawkins of St. Thomas-in-the-East, along with Barrett's description of the Portland successions, indicates that both geologists felt that the succession commenced with Eocene shales, was succeeded by the Pteropod Marl (with the Miocene Bowden Shell Bed fauna); this was overlain unconformably by the White Limestone (Pliocene), which in turn was overlain unconformably by the Coast Limestone (with its recent coral fauna). During his visit to England for the Great Exhibition of 1862, Barrett clearly changed his opinion of the Jamaican succession (the personal communications and sections published by Woodward, 1862, and Jones, 1863); possibly based on identifications of fossil foraminifers from the Pteropod Marl (Jones and Parker, 1864). Now, Barrett was indicating a different succession, starting with: 1. Eocene Shales, succeeded by; 2. the orbitoidal limestone; 3. the White Limestone; and finally, 4. the Pteropod Marl (one assumes the Coast Limestone and alluvium were above, but neither is shown on the sections). Sawkins continued to believe that the Pteropod Marl (and associated units) lay below the White Limestone (as shown in geological cross-sections for St. Thomas and Round Hill in Vere by Duncan and Wall, 1865), and that these were equivalent to the Yellow Limestone of Clarendon with its giant *Cerithium* (Duncan and Wall, 1865). Intriguingly, Sawkins description of the Yellow Limestone contrasts markedly with the deep water fauna of the Pteropod Marl, but this contradiction was left unsolved.

Spencer (1898) introduced the name Layton Series and Layton Formation for all deposits which overlie the White Limestone. He designated the

area of Low Layton (3 miles west of the Low Layton volcano) to be the type locality for the Layton Formation. Spencer described the Layton Formation as the series of marls, yellowish to white which overlie the volcanic deposits of the Low Layton volcano. The boundary between the White Limestone (attributed to the Miocene) and the marls was characterized by the presence of pebbles of limestone, gravels and siliceous rocks.

Hill (1899, pp. 9-14) recognised the problems with the Sawkins and Barrett survey, and that the rocks at Bowden, which he now called the Coastal Series, were above the White Limestone, whereas the Yellow Limestone was below. On his map (Hill, 1899), the rocks of the Coastal Series along the Portland coastline are shown as the Manchioneal beds, whereas those along the St. Thomas coastline are shown as the Bowden beds. In the Bowden beds, Hill included both the classic shell bed from which Dall (Spencer, 1898) had listed some 400 species of molluscs, as well as the conglomerates on the shore of Morant Bay (which are now included in the Port Morant Formation). The name Buff Bay beds was only used for the road-side exposures east of Buff Bay (although these were coloured as Manchioneal beds on Hill's map). The younger portion of the Coastal Series consisted of *'loose yellow marl and lumpy white limestone'* and was included within the Manchioneal beds. The Bowden beds were to acquire much greater significance with the publications of Woodring (1925, 1928), who described 600 species of gastropods, bivalves and scaphopods.

Trechmann (1930, p. 201) stated that the typical Manchioneal beds extend from *'Buff Bay to the mouth of the Plantain Garden River.'* Trechmann (1930) could not recognise the *'Pteropod Marls'* of Sawkins (1869) but suggested that they might equate with either some part of the Manchioneal beds of Hill (1899) or with the *'chalky marls of the White Limestone series'* of Sawkins (1869). Trechmann (1930, p. 202) also considered that the Kingston Formation of Hill (1899), that is the Liguanea Formation of Spencer (1898), was *'much more recent than Pliocene,'* the age which Hill (1899) had assigned to the Manchioneal beds. Trechmann (1930, p. 205) placed the succession above the 'chalky marls of the White Limestone formation' exposed to the east of Buff Bay in the Manchioneal beds, but made note that Hill (1899) had referred to this as the Bowden Formation. Elsewhere in the eastern part of the island, Trechmann (1930) described sections of the Manchioneal beds at Innes Bay, Manchioneal Harbour, Port Antonio, Navy Island and Low Layton. In each case where the relationship was exposed, the Manchioneal beds rested on the White Limestone and were overlain by the Coral Rock. Around Port Morant Harbour, Trechmann (1930, p. 202) recorded the Manchioneal beds in a road cut on the western side of the harbour, which exposed 30 ft. of intercalated grey-buff coloured marls and harder calcareous beds, and similar beds on the east side of the harbour that seem to overlie the Bowden shelly gravels. Thus Trechmann (1930) included all the beds now referred to the Coastal Group of eastern Jamaica in the Manchioneal Formation with the exception of the Bowden Beds (the shell bed and probably fossiliferous Port Morant Formation on the coast at Old Pera), which were beneath, and the Coral Rock (now the Falmouth Formation), which was above.

Matley's (1951) study of the Kingston district resulted in the recognition that between the White Limestone and the alluvium of the Liguanea Plain, there was a unit of conglomerates and impure limestones to which he gave the name August Town Formation.

Chubb (1959) described the gravels seen around Port Morant and pointed out that the clasts were volcanic and that they form a part of the Bowden Series and that they were *'probably the same age as or a little younger than, the August Town Formation'* Chubb (1959, p. 270).

Robinson (1967, 1969a) revised the lithostratigraphic nomenclature of the Coastal Group of eastern Jamaica as given by Hill (1899), recognizing a Lower Coastal Group and an Upper Coastal group. The Lower Coastal Group (Robinson, 1967) consisted of three formations, the Buff Bay and Bowden formations in the east that were a lateral equivalent of the August Town Formation in the west. The Upper Coastal Group (Robinson, 1967), which was separated from the Lower Coastal Group by a stratigraphic gap and angular unconformity, consisted of the Manchioneal Formation with the Navy Island Member at the base.

In this paper we revise the lithostratigraphy of the formations belonging to the Coastal Group in southern St Thomas. We follow the guidelines set out in the International Stratigraphic Guide (Salvador, 1994; Murphy and Salvador, 1999).

Table 1. Lithostratigraphic units in the Coastal Group in southern St. Thomas.

Formation	Age	Description	Thickness (m)
Port Morant Formation	Late Pleistocene	Reef facies which pass laterally into a heterogeneous association of shallow marine to terrestrial carbonates and clastics.	7
Old Pera Fm (Upgraded)	Early Pleistocene	Shelf calcareous sandstones and fine-grained conglomerates with solitary corals and mollusc casts.	30
Layton Formation	Miocene to Pliocene	Buff marlstones, includes the Bowden Member, the San San Clay Member and the Buff Bay Member.	-
Bowden Member	Pliocene	Impure stratified brown and buff marlstones with three distinct lithofaces - conglomerate/sandstone, marlstone, and micritic limestone.	140
August Town Formation	Mid Miocene to Pliocene	Limestones, sandy limestones and calcareous sandstones with sporadic clays or conglomerates.	342
Leith Hall Member (New Member)	Middle Miocene to Pliocene	A conglomerate succession with: pebble conglomerates, poorly sorted muddy sandstones, coarse grained sandstones with conglomerate lenses, imbricate boulder conglomerates, bioturbated sandstones with *Thalassinoides* burrows, and oyster conglomerates.	25
White Limestone Gp	Eocene to Miocene	Pure shallow- and deep-water pale limestones.	-

3. LITHOSTRATIGRAPHY

We retain the name Coastal Group in this paper, but do not divide it into lower and upper parts. The formations we recognize are mappable units that are distinguished on lithostratigraphic criteria and we employ the oldest suitable terms for each unit. We recognize the Bowden, San San and Buff Bay as members because they have biostratigraphic and not lithostratigraphic integrity.

The formations studied in south-eastern St. Thomas from the oldest to the youngest are: August Town Formation, Layton Formation (reintroduced name from Spencer, 1898), Old Pera Formation (changed rank) and Port Morant Formation and these are summarized in **Table 1**.

The White Limestone Group has been mapped only where it forms boundaries with the formations of the Coastal Group. The formations observed in the White Limestone Group were the Montpelier (Versey in Zans et al., 1963) and Wilmington (Wadge and Eva, 1978) formations. These formations were not mapped separately.

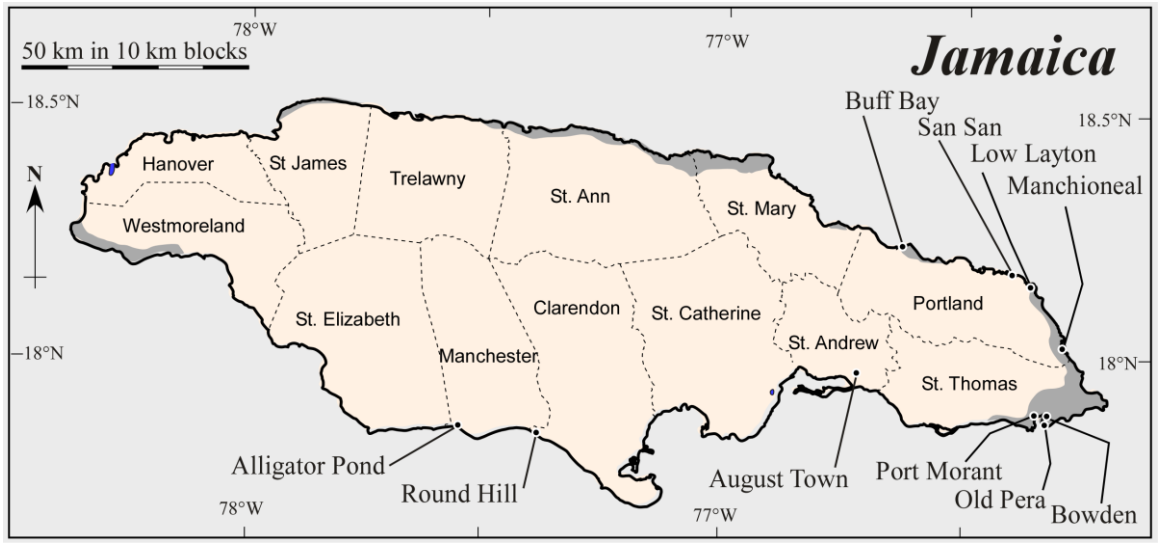

Figure 1. Geographic location of places related to the Coastal Group (grey) mentioned in the text.

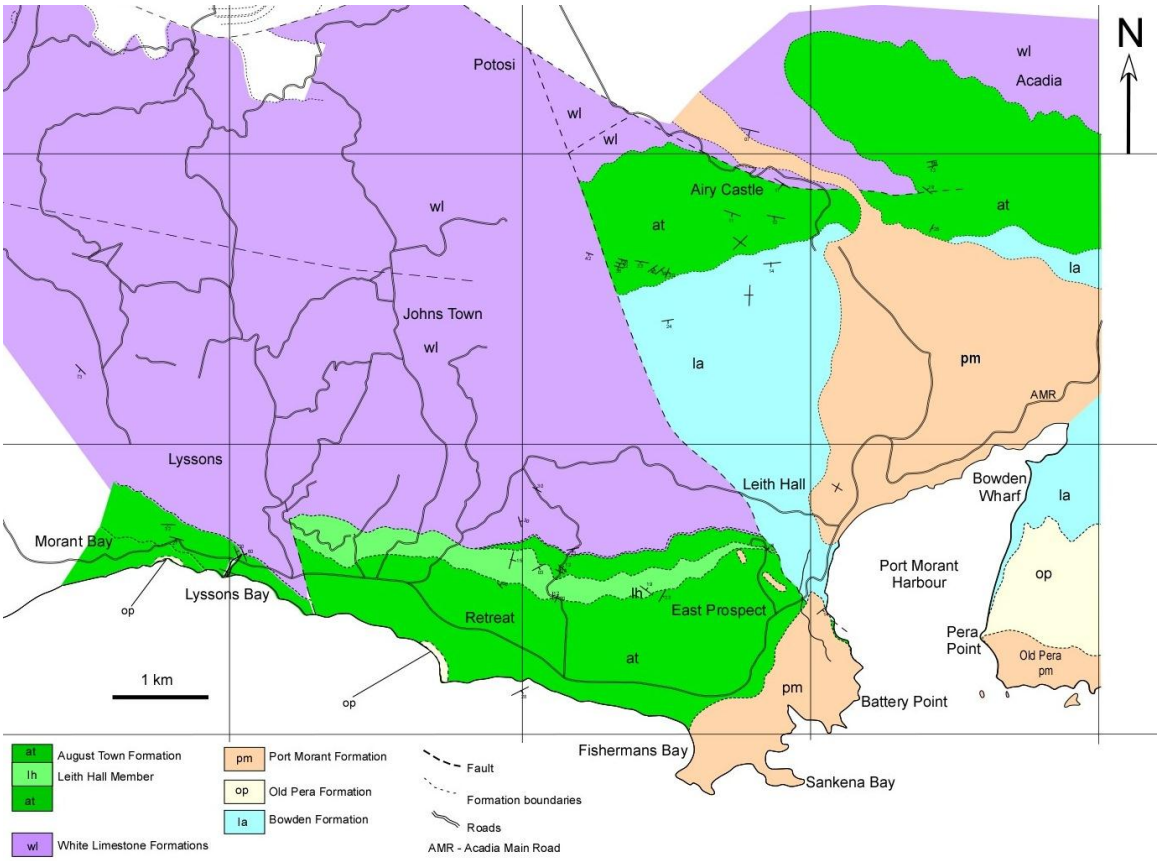

Figure 2 Geological Map of the area from Lyssons to Old Pera, parish of St. Thomas, Jamaica.

3.1. August Town Formation

Introduction. The term August Town Formation is used here for the shallow-water mixed clastic-carbonate deposits of Miocene to Pliocene age, found stratigraphically above the rocks of the White Limestone Group but below those of the Bowden Formation (**Figure 2**). The August Town Formation was first described by Matley (1951) as fossiliferous sands, gravels and calcareous marls. The formation crops out along the south coast at Alligator Pond in Manchester and Round Hill in Clarendon (Donovan et al., 1989; Pickerill et al., 1993, Donovan et al., 1995; Donovan and Miller, 1998), August Town to Bull Bay in Kingston (Matley, 1951) and Morant Bay to Airy Castle in St. Thomas (James-Williamson, 2008). This project has identified a lithostratigraphic member in the August Town Formation, which is called the Leith Hall Member here.

Type Locality. The type section of the August Town Formation is located in the gorge of the Hope River, extending from the village of August Town southward for 6 km to the St. Thomas main road (Matley, 1951; Chubb, 1959; Coates, 1970; Zans et al. ,1963). Faulting of the August Town Formation near the village of August Town means that only the upper and lower portions of the formation are seen (Zans et al., 1963). The type locality shows a yellow, sandy or marly limestone with calcareous breccias and conglomerates. The August Town Series previously described by Matley (1951) and Zans et al. (1963) can be traced as far west as D'Aguilars Run and as far east as the ninth mile post along the St. Thomas main road (Zans et al., 1963).

Description. The August Town Formation has a diverse range of lithologies, ranging from limestones, sandy limestones to calcareous sandstone with occasional clays or conglomerates. The limestones are dominated by benthic molluscs and benthic foraminifers whereas the sandy limestones are dominated by corals and molluscs in the type section in August Town (Matley, 1951; Zans et al., 1963). In south-eastern St. Thomas, the August Town Formation is exposed along the coast at Fisherman's Bay and inland at Airy Castle (James-Williamson, 2008). At Fisherman's Bay,

yellowish to brown mixed clastic-carbonate rocks contains abundant corals and molluscs; whereas at Airy Castle, thinly bedded micritic impure limestones contain corals and molluscs (James-Williamson, 2008).

Boundaries. At its type locality, the August Town Formation rests unconformably on the White Limestone (Matley, 1951). The same relationship is seen along the St. Thomas main road (Matley, 1951; Donovan et al., 1995; Donovan and Miller, 1998) and other areas in St. Thomas (Wadge and Eva, 1978) and probably also at Round Hill, although here the boundary is not exposed (Robinson, 1969a; Mitchell, 2004).

Biostratigraphy and Age. The fossils found in the yellow limestones and marls of the August Town Formation at the type locality are: *Gypsina*, *Amphisorus*, *Placocyathus*, various molluscs and echinoids. There is also a 66-ft. (20 m) thick bed of coral with corals preserved in their growth position (Zans et al., 1963). The August Town Formation spans the Late Miocene to ?Late Pliocene or even younger based on the coral assemblages.

3.2. Leith Hall Member (New Member; August Town Formation)

Introduction. This member has not been previously described.

Type Locality. The type locality for the Leith Hall Member is located on the coast of Port Morant Harbour near the village of Leith Hall, St. Thomas, Jamaica (17°52'09.11 N, 76°19'57.66 W). The locality can be accessed using a minor road off the Port Morant main road approximately 3 km west of the town of Port Morant and 10 km east from the town of Morant Bay (**Figure 2**). This minor road is taken to the coast where a traverse eastwards on foot along the coast to the marker at Battery Point (part of an old fort; **Figure 2**). The locality is approximately 200 m east of Battery Point. The surf at this locality can be rather rough.

Description. The section at Leith Hall shows steep (30°) southeastly dipping strata. Six lithofacies were observed at this locality: (i) pebble conglomerate, (ii) poorly sorted muddy sandstone, (iii) coarse grained sandstone with conglomerate lenses, (iv) imbricate boulder conglomerates, (v) bioturbated sandstone with *Thalassinoides* burrows, and (vi) oyster conglomerates.

Geographic Extent. The Leith Hall Member extends along the coast at the type section for about 150-200 m (**Figure 2**). The minimum thickness of the Leith Hall member is estimated at 25 m.

Boundaries. The base of the formation can be mapped north of the coast between Lyssons and Port Morant, where the limestones and sandy limestones of the lower August Town Formation are overlain by the conglomerates of the Leith Hall Member. The upper boundary is marked by an angular unconformity at the base of the Port Morant Formation.

Age. The Leith Hall Member is in the upper part of the August Town Formation and is overlain unconformably by the Port Morant Formation. It is tentatively assigned a late Miocene to Early Pliocene age.

3.3. Layton Formation

Introduction. The name Layton Series was first introduced by Spencer (1898) to describe the marls which overlie the white limestones (Miocene formations) across the island. He categorized the base of these marls in northeast Jamaica as overlying the deposits of the Low Layton volcano and the Miocene White Limestones. He described the marls as yellowish with the base characterized by a conglomerate including boulder and pebbles of limestone, silicate and volcaniclastics (Spencer 1898).

The name is reintroduced here for the formation which includes the Bowden Member, the San San Clay Member and the Buff Bay Member. The three members show similar lithologies and cannot be separated by geological mapping. The members, can only be distinguished by micropalaeontological analyses, which indicates that the members are separated by short stratigraphic gaps (e.g., Aubry, 1993). Only the Bowden Member is seen in the parish of St. Thomas.

3.3.1. Bowden Member

The rocks in the Bowden Member were called the Bowden Series by Sawkins (1869) and the Bowden Beds by Hill (1899); later the name Bowden Formation was used by Woodring (1925). The formation was also reviewed by Robinson (1969b) and the name formalised by Robinson (1969b) and referred to as the Bowden Marls by Donovan (1998).

Chubb (1959, p. 270) described gravels seen at Port Morant and pointed out that the clasts were volcanic and that they form a part of the Bowden Series being *'probably the same age as or little younger than, the August Town Formation.'* These conglomerates could belong to either the Leith Hall Member of the August Town Formation or the Port Morant Formation.

Type Locality. Robinson (1969c) described the Bowden Formation as consisting of near horizontal (2-10°) slightly seaward dipping beds of conglomeratic layers and foraminiferal marls overlain by silty sandy marls interbedded with thinly bedded sandstones and micritic sandy limestones. The type section is exposed in cliffs located on the eastern side of the Port Morant Harbour between Pera Point (about 200 m North) and Bowden Wharf (**Figure 2**). The type section does not include the aforementioned Bowden Shell Bed, which while being an important part of the member is not a mappable or laterally traceable unit (Pickerill et al., 1998).

Description. The Bowden Beds were described by Hill (1899, p. 82-83) as *'an extensive occurrence of gravel beds less than 50 feet in thickness, containing rolled specimens of nearly every species of volcanic rock found on the island, which grades upwards into an impure stratified brown and buff coloured marl, the latter having a thickness of 200 ft…'*

The Bowden Member is a succession of buff- to brown-marlstones which crop out in the district of Bowden as well as along the road to Acadia, north of Port Morant in St. Thomas. The formation is dominated by marlstones at Bowden and micritic limestones along the Acadia main road (**Figure 2**).

Boundaries. North of Bowden, the Bowden Member rests unconformably on the August Town Formation and is overlain disconformably by the Old Pera Formation (previously the Old Pera Beds of the Manchioneal Formation). The Bowden Member is not seen west of East Prospect where the Leith Hall Member of the August Town Formation is overlain directly by the Old Pera Formation.

Biostratigraphy and Age. Woodring 1928, p. 27 speculated *'…that the bulk of the Bowden species represent autochthonous Oligocene and Miocene phyla … few are due to increments from the Mediterranean and from the eastern Pacific.'* However, elsewhere he estimated the age of the Bowden fauna as Middle Miocene. Woodring (1928) gave several comparisons of the fauna found in Bowden with similar species and genera found in the Americas and the eastern Caribbean.

Kohl and Robinson (1998) identified and charted a total of 182 species and 105 genera of benthic foraminfers from the locality on the eastern side of the Port Morant Harbour. They placed the section in the Late Pliocene equivalent to Zone N21 of Blow (1969). All samples are below the Last Appearance Datum (LAD) of *Globorotalia miocenica* and *Gl. exilis* and above the LAD of *Dentoglobigerina altispira* and *Globorotalia multicamerata*. Thus, the Bowden Member is assigned to the Early Pliocene (from the late Zanclean to the Gelasian) (Aubry, 1993; Berggren et al., 1995; Hardenbol et al., 1998).

3.4. The Old Pera Formation (changed rank)

Introduction. The Old Pera Beds were considered to be part of the Manchioneal Formation (Trechmann, 1930; Budd and McNeill, 1998; Donovan et al., 1994). The two units differ in lithology; the Old Pera Beds are siliciclastic sandstones; whereas the Manchioneal Formation consists of deeper-water nodular limestones. Although they contain similar fossil assemblages, according to the International Stratigraphic Guide (Salvador, 1994; Murphy and Salvador, 1999) they should be separated on the basis of lithology. The Old Pera Beds are therefore upgraded to formation status here.

Type Locality. The type locality for the Old Pera Formation is near the village of Old Pera in St. Thomas. Outcrops extend from Pera Point to Canoe Bay with a thickness of approximately 18.2 m (Robinson, 1969a). Outcrops of the Old Pera Formation have also been identified along the coast at Lyssons Bay (17º52´49.98N, 76º23´48.50W).

Description. The Old Pera Formation consists of a series of calcareous sandstones and fine-grained conglomerates with interbedded coral debris beds (with *Porites* and ?*Stylophora*) and sandy siltstones and claystones. The upper part of the formation consists predominantly of sandstones with pectiniids, solitary corals, and molluscs preserved as casts.

Boundaries. The Old Pera Formation unconformably overlies the Bowden Formation and is unconformably overlain by the Port Morant Formation.

Biostratigraphy and Age. The Old Pera Formation has been assigned to the Pleistocene because of the presence of *Globorotalia truncatulinoides* (Banner and Blow, 1965; Robinson, 1969b) together with common *Pulleniatina obliquiloculata* (Robinson, 1969a). The gastropod *Turritella exeolata jamaicensis* Trechmann is also common (Robinson, 1969a).

3.5. Port Morant Formation

Introduction. Robinson introduced the name Port Morant Formation in his Ph.D. thesis (1969b) and field guide (1969c) for Neogene sections around

Port Morant. Though named as a formation, the Port Morant Formation was never formally described. It was theorised that the Port Morant Formation rested unconformably on the Old Pera Formation, proposed to be of Late Pliocene to Early Pleistocene age (Robinson, 1969b; Donovan, et al,. 1994; Budd and McNeill, 1998). The conglomerates, which we include in the Port Morant Formation, had been described by Sawkins (1869) as a gravel conglomerate deposited from a possible river that was subsequently captured.

Type Locality. The type locality of the Port Morant Formation is located at Pera Point in the village of Old Pera (**Figure 2**). This locality was chosen because the base of the formation is exposed and the unconformable relationship with the underlying Old Pera Formation can be seen (James-Williamson, 2008). The locality can be accessed by driving to the village of Port Morant, continue on the main road to a fork in the main road where there is an obscure roundabout, approximately 1 km from the square. The minor road on the right is taken to the town of Old Pera. At Old Pera Square a right turn leads directly to the coast through a set of wooden fisherman houses. The type locality is exposed for approximately 1.5 km along the coast from Pera Point to Canoe Bay (James-Williamson, 2008).

Description. The Port Morant Formation is exposed in sea cliffs from Port Morant to Old Pera, south of Pera Point (Mitchell et al., 2001) and coral reef deposits on the coast at East Prospect (Fishermans Bay, Prospect Point and Sankena Bay) (James-Williamson, 2008). The Port Morant Formation consists of a reef facies containing *Diplora strigosa*, *Acropora palmata*, *Acropora cervicornis*, *Montastrea annularis*, and *Porites furcata* as the dominant coral species. These deposits have been extensively karstified (James-Williamson, 2008). The reef deposits pass laterally into a heterogeneous association of shallow marine to terrestrial carbonates and clastics (Mitchell et al., 2006; James-Williamson, 2008).

Boundaries. The Port Morant Formation has a basal erosion surface, either truncating the gently southerly dipping beds of the Old Pera Formation (Mitchell et al., 2001) or the steeply southeasterly dipping beds of the Leith Hall Member of the August Town Formation (James-Williamson, 2008). Alluvial deposits belonging to the Port Morant Formation can be seen along inland river valleys and in swamps at the mouth of streams (James-Williamson, 2008).

Biostratigraphy and Age. Mitchell et al. (2001) conducted Electron Spin Resonance (ESR) on a species of coral, *Solenastrea bournoni*, from the Port Morant Formation, Old Pera section. This was found to be Sangamonian (125 ± 9 kyr to 132 ± 7 kyr). No planktic foraminifers have been documented from the Port Morant Formation.

4. CONCLUSION

The geology of south-eastern St. Thomas has proven to be more complex than initially thought by previous workers. The area includes conglomerates in the Early Eocene, Late Miocene, Pliocene and Late Pleistocene, and only careful detailed mapping can work out the succession; and even then, confusion can still occur. The marlstones of the Bowden Member are not distinguishable without micopalaeontological analyses, but belong to a widespread unit of marlstones which is mappable and for which the name Layton Formation is used. The Old Pera Formation is mappable and can easily be distinguished from the Manchioneal Formation and as such is upgraded to formation status.

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