Stratigraphy and Distribution of the Coastal Group, St. Elizabeth Parish, Jamaica

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Abstract

This contribution examines the characteristics and ages of sedimentary units in the Coastal Group located along the southwestern Jamaica coast between Great Pedro Bluff and Fort Charles Bay in southwestern St. Elizabeth Parish. The coastline is characterized by laterally discontinuous low cliff exposures, separated by modern beach deposits and tectonically raised shore platforms composed of the White Limestone Group (mid-Eocene to mid-Miocene) and coral rudstone to floatstone and calcareous sandstone of the Coastal Group (late Pleistocene). Electron-Spin Resonance spectroscopy conducted on corals collected from a coral rudstone to floatstone facies yielded an estimated age of 120 ka. The coral facies may be assigned to the Falmouth Formation, and it has been confirmed to have been deposited within the MIS 5e (132 ka – 115 ka). However, the other units within the Coastal Group likely are diachronous. Significant amounts of sand and silt components are present throughout the Coastal Group exposures. These vertical exposures cannot be a standard for determining relative mean sea level (RMSL) as they have been tectonically disturbed and the upper surface of the coral facies may have been eroded below cross-bedded sandstones. Due to the widespread variability of sedimentary units both locally and longshore, assignment of existing stratigraphic nomenclature of the Coastal Group to these formations is difficult. While these exposures in southwestern Jamaica cannot serve as a proxy for correlation of MIS 5e strata due to tectonism and siliciclastic influxes, they provide an example of the potential for accelerated sea-level rise with current trends in climate changes.

Introduction

Global climate oscillations between warm and cold periods have occurred naturally throughout geologic history due to various factors. However, studies of the observed warming trend over the past century cannot be explained by natural causes alone, indicating the significance of human activities on the climate system. Current predictive climate models (e.g. Alexander et al., 2018) suggest that this trend is likely to continue at the current alarming rate or possibly accelerate by the end of this century having continued profound effects on global climate, especially marine ecosystems and coastal communities. The Marine Isotope Stage (MIS) 5e, a period characterized by warmer global mean surface temperatures and rapid, multi-meter sea-level fluctuations, occurred roughly between 132,000 and 115,000 years ago and provides a reasonable comparison for predictive climate models. This study aims to examine the characteristics and ages of sedimentary units in the Coastal Group in southwestern St. Elizabeth parish, southwestern Jamaica in an attempt to contribute to the comprehensive global framework of data available from the last interglacial maximum.

Methodology

A collection of 1,837 outcrop photographs between Pedro Bay and Fort Charles Bay were compiled from two separate field excursions using an Olympus TG-4 GPS camera. On January 9, 2018, aerial drone imagery, collected by Dr. Toby Dogwiler, was collected covering an area of 3.51 km^2 using a DJI Phantom 4 UAV to create ultra-high resolution orthomosaic images and DEMs. In addition to photograph documentation, eleven vertical sections were measured and described along a 2.7 km long northwest-southeast-trending transect between Fort Charles Bay and Billy Bay where the Coastal Group is nearly continuously exposed. Gamma-ray profiles were created for five of the eleven measured sections. Three fossil coral samples were collected and sent to Williams College for Electron-Spin Resonance (ESR) spectroscopy and McCaster University for Neutron Activation Analysis (NAA). The combination of outcrop photographs, drone imagery, stratigraphic descriptions, and geochronology analysis were utilized to further define the regional distribution and sedimentological characteristics of the Coastal Group in St. Elizabeth parish, southwestern Jamaica.

Location of Field Photographs

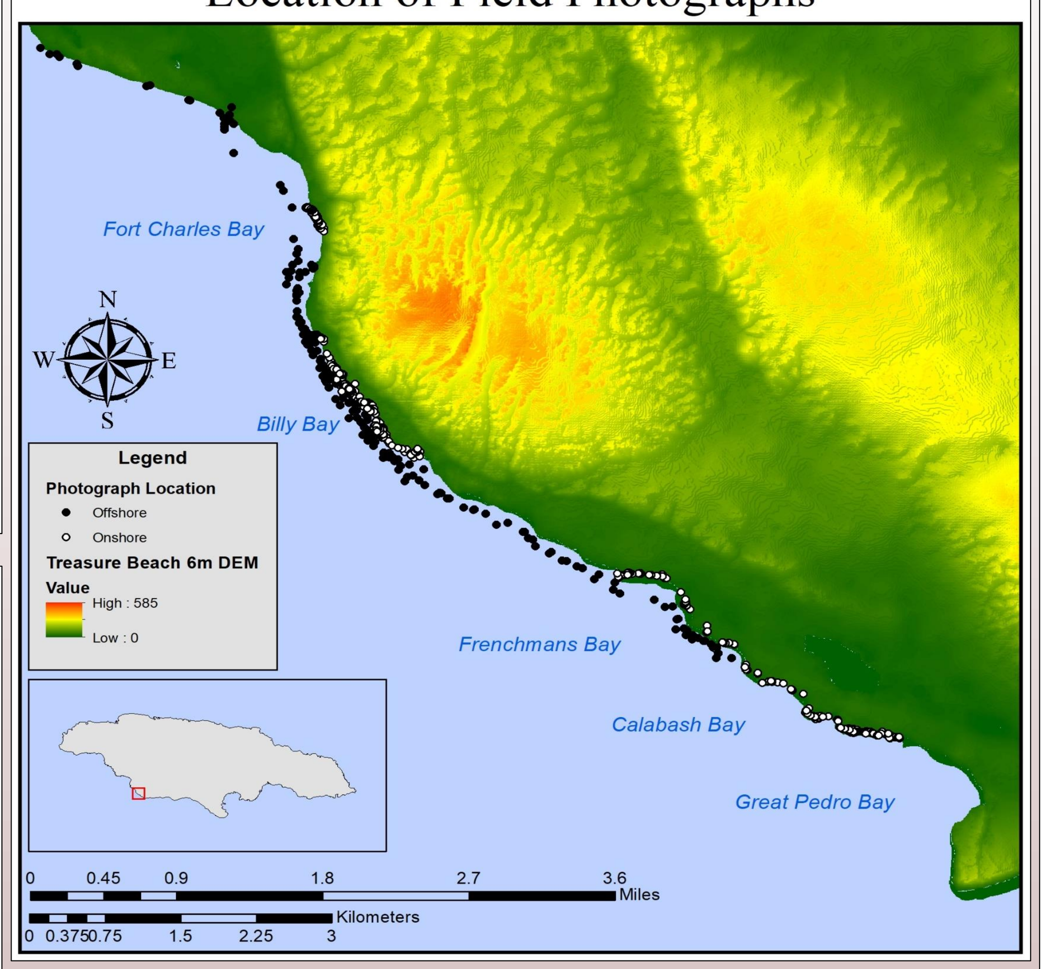

Figure 3. Location map of 1,837 photographs taken in the field. Black dots indicate photographs taken from a boat. White dots represent photographs taken while walking along the shoreline. DEM has a resolution of 6 meters from Mona Geoinformatics.

Location of Stratigraphic Sections

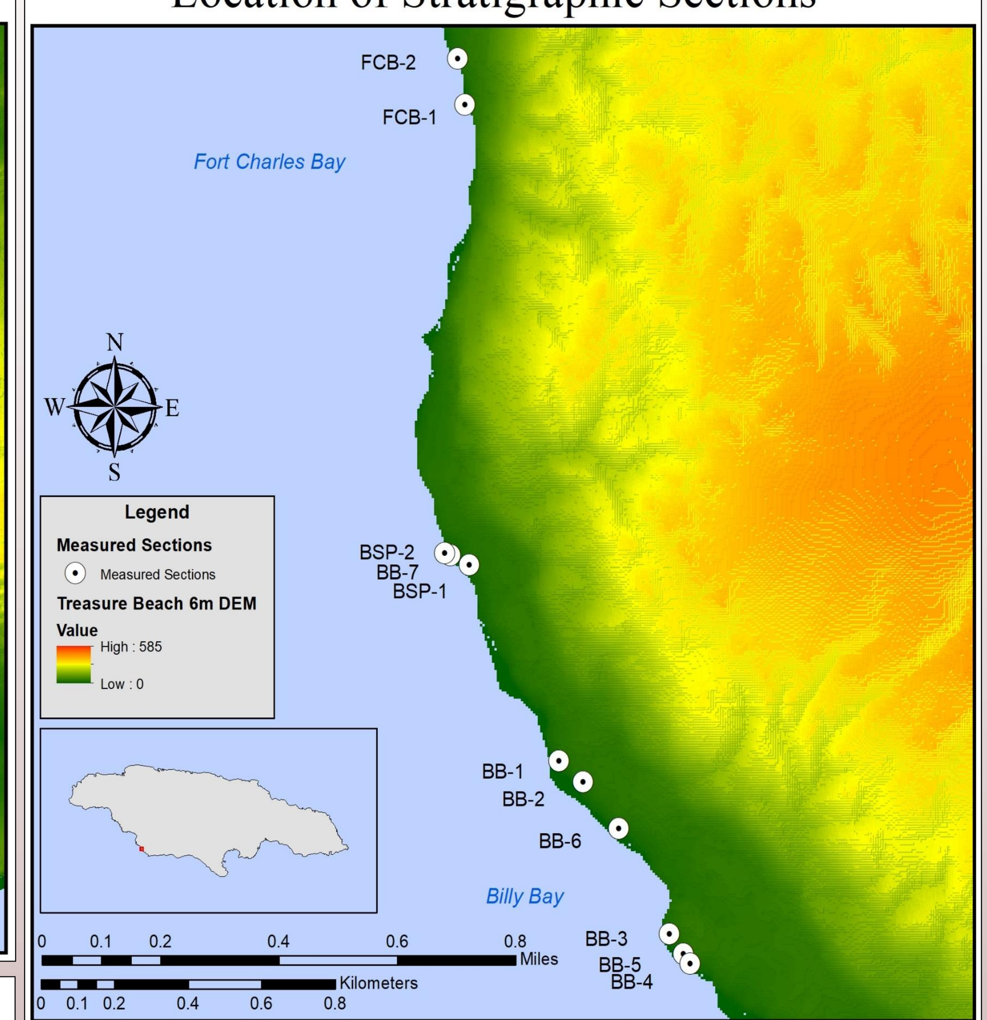

Figure 4. Location map of the eleven stratigraphic sections. DEM has a resolution of 6 meters from Mona Geoinformatics.

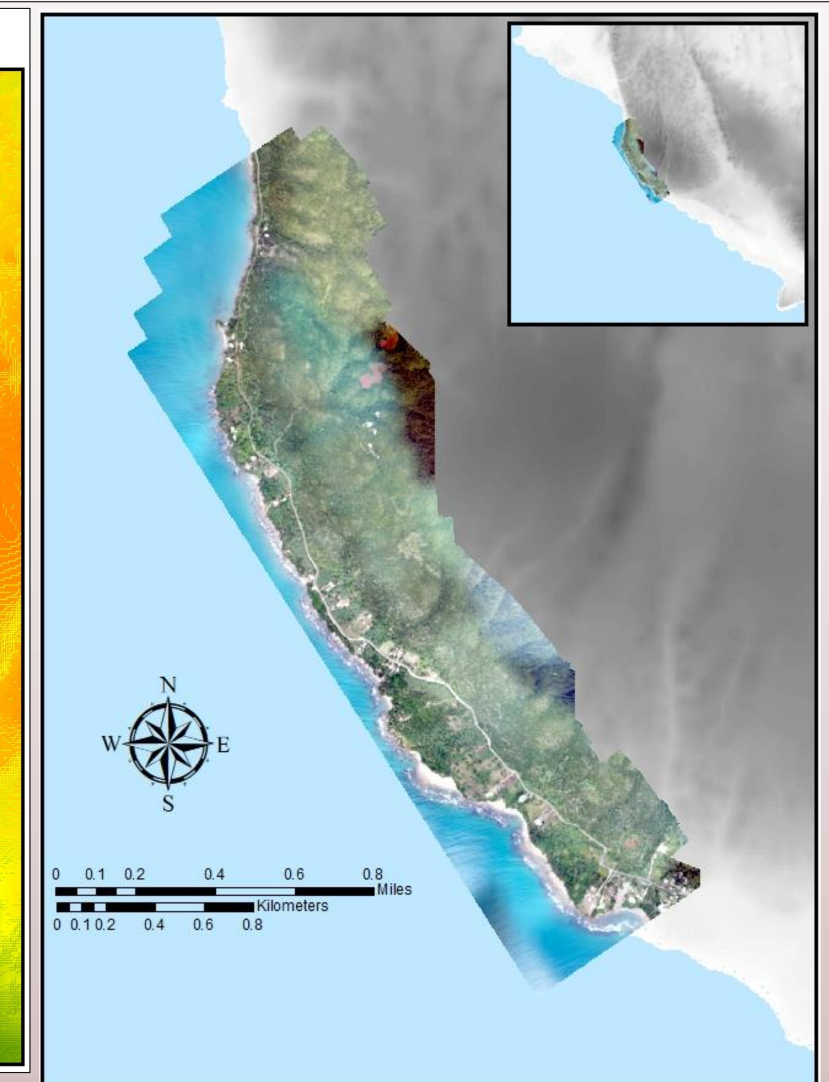

Figure 3. Orthomosaic image generated from drone photos. Inset map shows area of data collection.

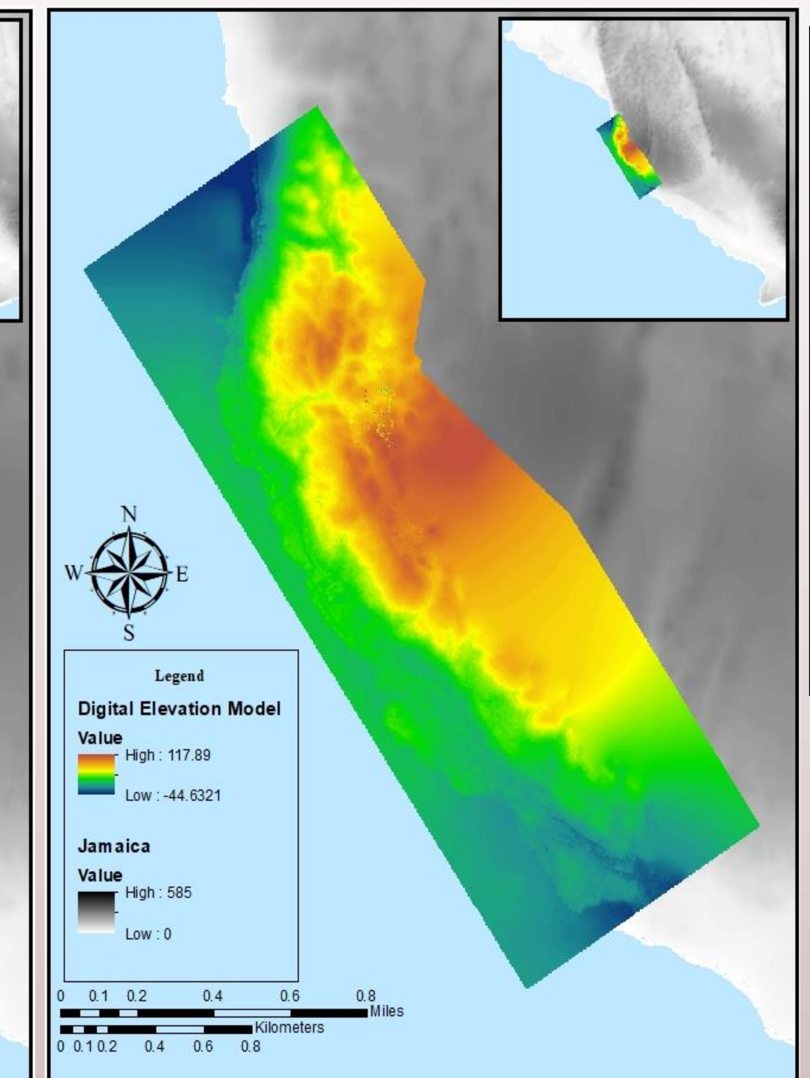

Figure 3. Digital Elevation Model generated from drone photos. Inset map shows area of data collection.

Sample Description	Age (ka)	Method	Source
East Rio Bueno Falmouth Formation corals (*Acropora*, *Orbicella sp.*, *Siderastrea*, *Colpophyllia*: one sample collected at +1 m (125 ka), one from a cave 300 m inland at +5m	140 – 117	Alpha-counting U-series techniques	Moore and Somayajulu, 1974 Also, Moore, 1969 (personal communication, *in* Land and Epstein, 1970)
Falmouth Formation corals from an upper and a lower unit, separated by a zone of heavy algal encrustation	Lower unit: 134 – 127 Upper unit: 124 - 199	U-series dating of pristine coral	Precht, 1993
North Coast Shelly material and coral from lowest terrace between Discovery Bay and East Rio Bueno	ca. 120	Radiometric dating	R.V. Cant (personal communication *in* Horsfield, 1972)
Oracabessa Aragonitic corals of the lowest terrace, occurring as high as 17 m (Horsfield, 1975)	ca. 120	U-Th dating (unspecified)	Cant, 1972
Port Morant Port Morant Formation corals (*Solenatrea bournoi and Solenastrea radians*) from the upper part of the unit	132 - 125	ESR dating techniques	Mitchell et al., 2000

Table 1. Published ages of the Falmouth Formation in Jamaica. (Modified from Skrivanek et al., 2017)

Figure 5. Coral cobble-boulder rudstone unit that was sampled for ESR analysis

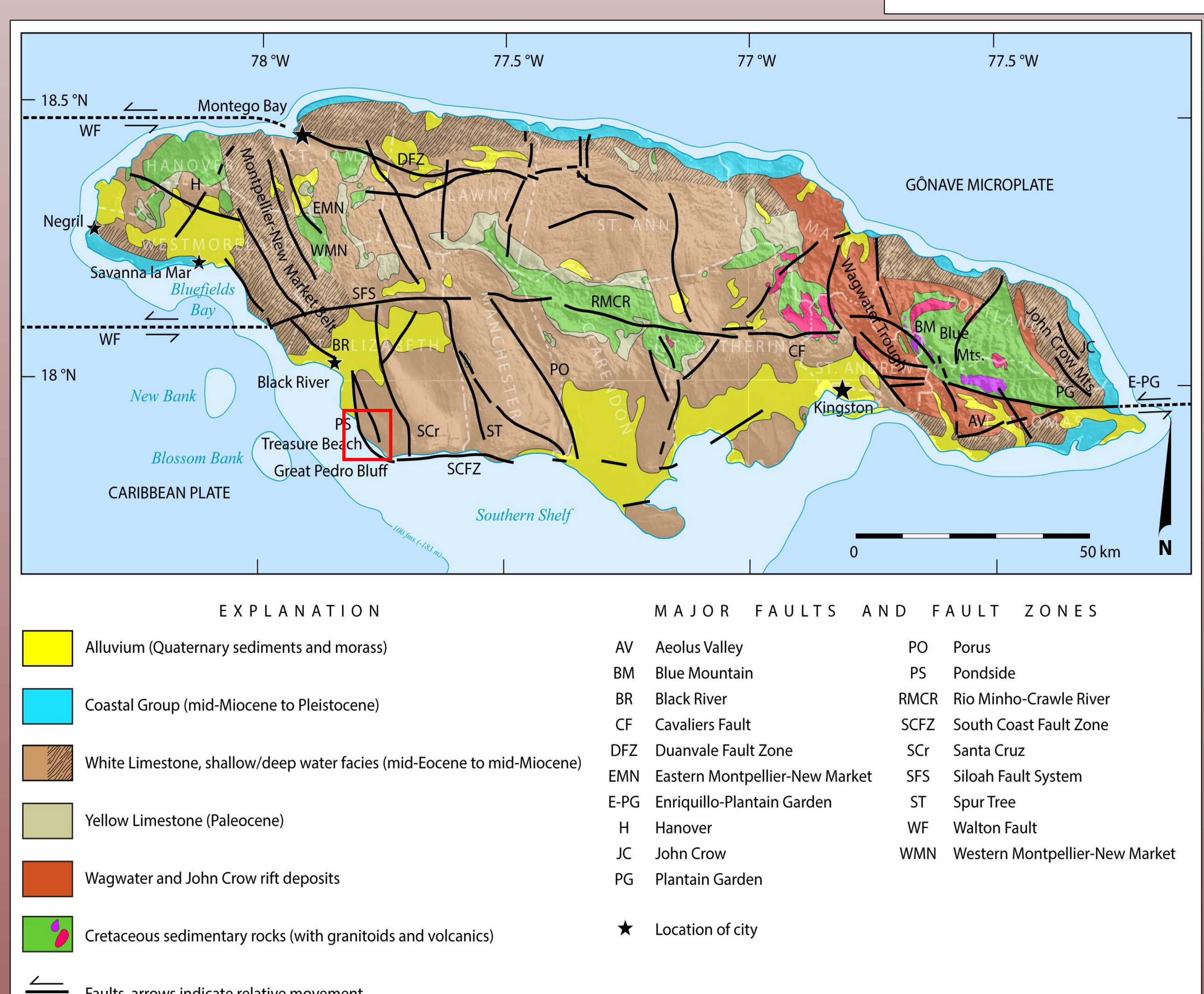

Figure 1. Geologic map of Jamaica. Red box marks the study area location. Inset map is Figure 2B.

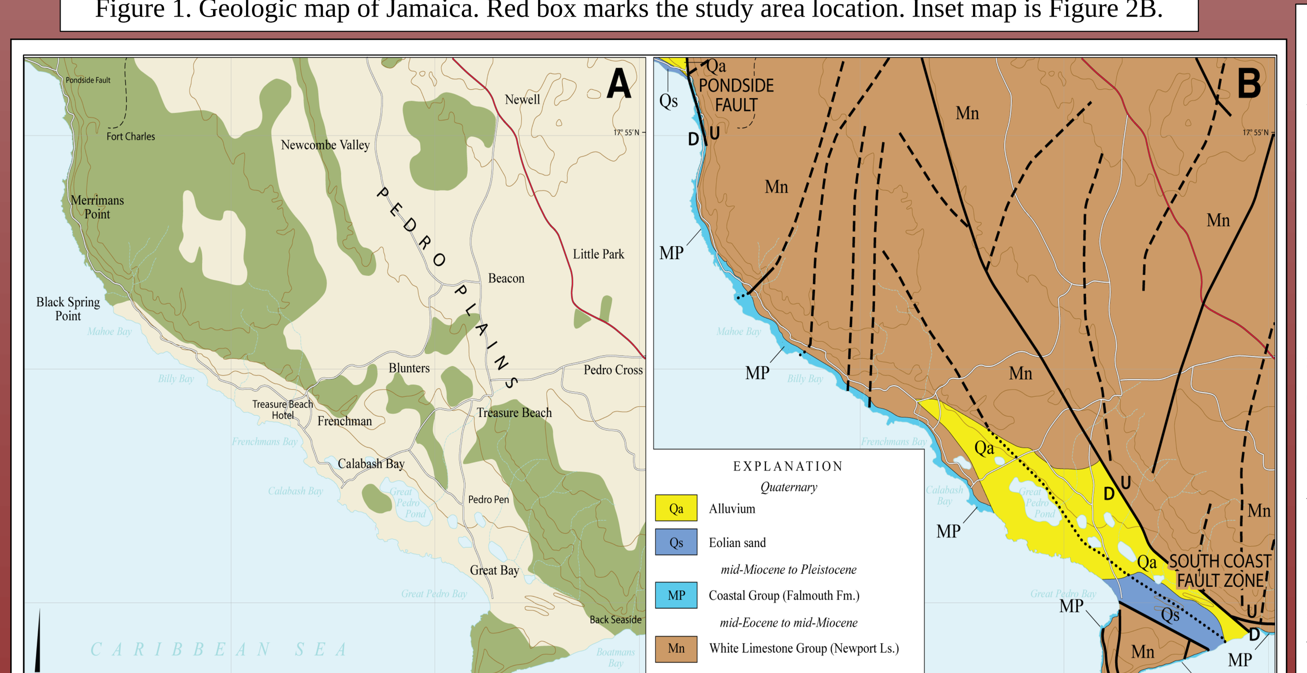

Figure 2. **A)** Geographic map of southwestern St. Elizabeth Parish **B)** Geologic map of southwestern Jamaica showing he distribution of the Coastal Group

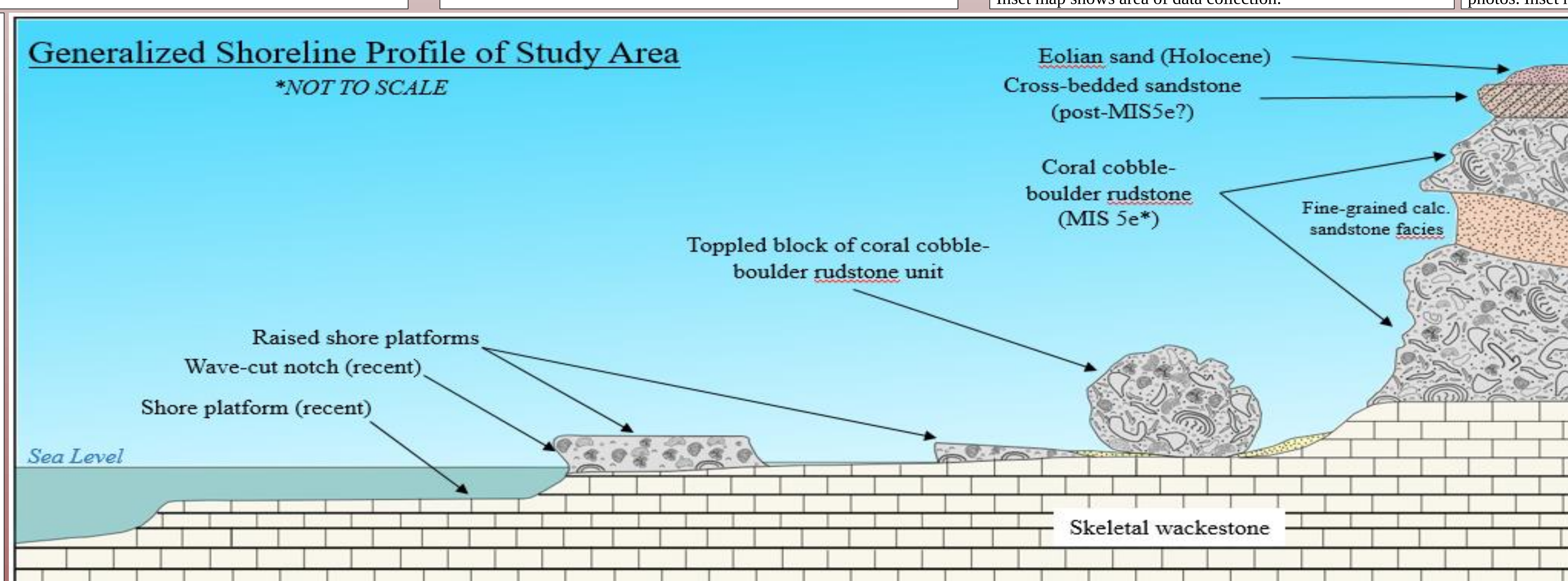

Figure 4. Generalized shoreline profile of the study area in St. Elizabeth parish. Lithology names were placed on the described units rather than formation names. Typically, vertical exposures consisted of the White Limestone Group and the overlying Coastal Group.

Sample	Accumulated dose, A_{Σ} (Grays)	Internal dose rate, $D_{int}(t)$ (mGrays/y)	External dose rate, $D_{ext}(t)$ (mGrays/y)	Age t (kyr)
CD-1	101.0 ± 3.9	511 ± 30	0	70.9 ± 4.0
	101.0 ± 3.9	511 ± 30	150 ± 25	60.5 ±3.5
	101.0 ± 3.9	511 ± 30	300 ± 50	65.3 ±3.6
CD-2	113.3 ± 5.7	285 ± 17	0	137.9 ± 8.9
	113.3 ± 5.7	285 ± 17	150 ± 25	120.1 ± 7.9
	113.3 ± 5.7	285 ± 17	300 ± 50	106.1 ± 7.1
CD-3	26.2 ± 1.6	276 ± 17	0	47.3 ± 3.5
	26.2 ± 1.6	276 ± 17	150 ± 25	38.3 ± 2.9
	26.2 ± 1.6	276 ± 17	300 ± 50	32.0 ± 2.4

Table 2. ESR dating results for corals from the Coastal Group, southwestern Jamaica. Sample CD-2 suggests an age coinciding with the MIS 5e.

Results

Detailed field photography and aerial drone imagery sufficiently documented the regional distribution of the Coastal Group in southwestern St. Elizabeth parish. Field photos taken with a GPS camera provided a reference database for features described in the field and corresponding coordinates for each photograph. Ultra-high resolution orthoimages and DEMs were created from the drone imagery with a total ground resolution of 7.83 cm per pixel. The DEM is able to show submerged, shore platforms that could not be reliably identified during field work.

The eleven stratigraphic sections were drafted to provide an illustrative model to better understand potential sedimentation controls as well as construct regional correlations and reconstruct ancient depositional environments. In general, the measured sections included units that were assigned to the White Limestone Group (skeletal wackestone) and the overlying Coastal Group (coral cobble-boulder rudstone, cross-bedded calcareous sandstone) (Fig. 4). However, the thickness as well as exposure of these units vary in the vertical exposures.

ESR analysis was conducted on three coral samples. Prior to analysis, samples were sent off for NAA to account for total cosmic radiation exposure. Three different exposure scenarios were looked at due to variation in rate of cover accumulation and burial depth, which include no protection, half protection, and full protection. During collection, the three coral samples were assumed to be aragonitic. However, x-ray diffraction spectra showed non-carbonate signals, which suggests potential diagenetic alteration of the aragonite. Therefore, the resulting ages can only provide a minimum age at best. Ages from ESR analysis can be found in Table 2.

Discussion

The coastline of southwestern Jamaica between Great Pedro Bluff and Fort Charles Bay in southwestern St. Elizabeth Parish shows high levels of variability for exposed sedimentary units. This coastline is characterized by laterally discontinuous low cliff exposures, separated by modern beach deposits and tectonically raised shore platforms composed of units assigned to the White Limestone Group (mid-Eocene to mid-Miocene) and Coastal Group (late Pleistocene). One of the three coral samples collected from the coral cobble-boulder rudstone facies yielded an estimated minimum age of approximately 120 ka. This estimated age agrees with previous MIS 5e studies on the Falmouth Formation in northern Jamaica and the Port Morant Formation in eastern Jamaica. The Port Morant formation is believed to be penecontemporaneous with the Falmouth Formation. Based on lithologic descriptions, the vertical exposures may be assigned to the Falmouth Formation and the estimated age date suggests that the coral cobble-boulder rudstone facies was deposited during the MIS 5e (132 ka – 115 ka). Units overlying the coral cobble-boulder rudstone facies likely are diachronous. Significant amounts of sand and silt components are present throughout the Coastal Group exposures.

These vertical exposures cannot be a standard for determining relative mean sea level (RMSL) as they have been tectonically disturbed and the upper surface of the coral facies may have been eroded below cross-bedded sandstones. Due to the widespread variability of sedimentary units both locally and longshore, assignment of existing stratigraphic nomenclature of the Coastal Group to these formations is difficult. While these exposures in southwestern Jamaica cannot serve as a proxy for correlation of MIS 5e strata due to tectonism and siliciclastic influxes, they provide an example of the potential for accelerated sea-level rise with current trends in climate changes.

Future Work

Additional coral samples need to be collected and analyzed in order to confirm the ages of these unit.

This coastline needs to be surveyed in order to account for the rate of regional uplift. By combining the calculated uplift rate with sedimentological features and geochronology, the southwestern coast of Jamaica could potentially be added to the comprehensive global framework of data available for the MIS 5e

Acknowledgements

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