

# History of the investigation of the Cenozoic limestones and associated rocks of Jamaica

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**ABSTRACT.** The nomenclature of the Cenozoic rocks of Jamaica, particularly those of the Yellow Limestone and White Limestone groups, has developed over the last 200 years. This has happened in three main stages: (1) the nineteenth century with the De la Beche survey in 1823–1824, the Barrett–Sawkins surveys from 1859–1867, and those of Hill from 1896–1898; (2) the second geological survey in the early- to mid-1920s; and (3) the interval from the 1950s to present (with the establishment of the Jamaican Geological Survey (now Mines and Geology Department – MGD) and, subsequently the Department of Geology in 1962 [now Geography and Geology] at the University of the West Indies. The relatively pure limestones of the White Limestone also make the development of suitable lithostratigraphic schemes difficult. This paper sets the scene for the remainder of this volume which establishes suitable schemes, based on geological mapping over the last 30 years, to classify the Cenozoic rocks of Jamaica.

**Keywords:** Wag Water Formation, Richmond Formation, Yellow Limestone, White Limestone, Coastal Group.

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## 1. INTRODUCTION

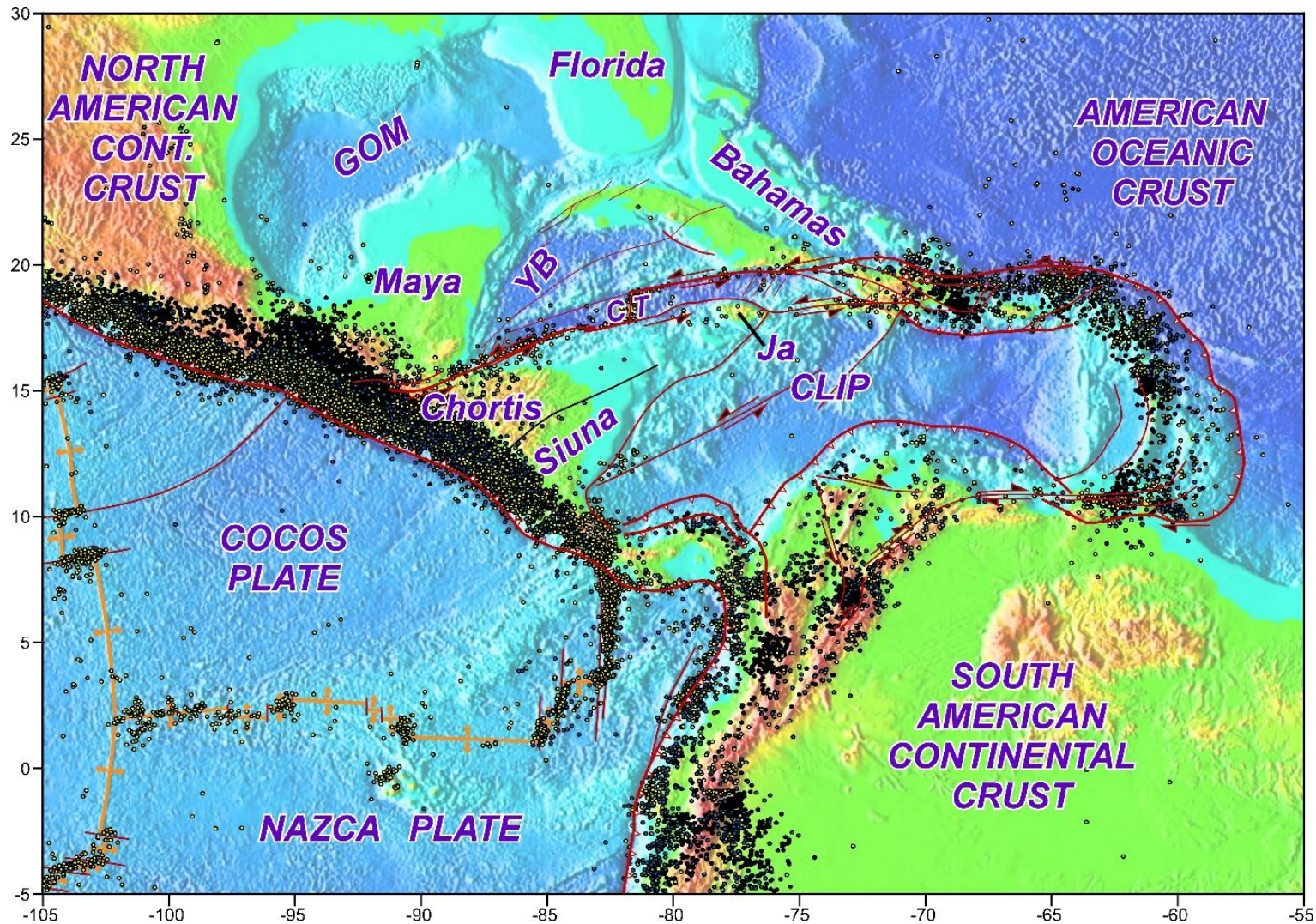
Jamaica is an island with a land area of some 10,990 km<sup>2</sup>, and an offshore area, inclusive of banks, cays and basins, amounting to 257,780 km<sup>2</sup>. Geographically, Jamaica is situated in the middle of the Caribbean Sea and geologically, is adjacent to the northern margin of the Caribbean Plate (**Figure 1**). It has a geological history dating back to at least the late Jurassic with its surface geology comprising rocks of Cretaceous and Cenozoic age. Jurassic rocks are inferred based on the presence of three oil seeps which are geochemically tied to a late Jurassic (Oxfordian) source rock (the ‘Smackover’ source: **Cameron et al., 2004; Matchette-Downes and Mitchell, 2005; CaribX, 2016**). Cretaceous rocks (locally including some earliest Paleocene rocks) are exposed in a series of more than 40 inliers distributed across the island. Cenozoic rocks cover more than two-thirds of the island and comprise clastic rocks, extensive carbonates, bauxite deposits and alluvium found in coastal plains and interior valley fills. The papers in this volume concentrate on the Cenozoic rocks of Jamaica and consider their stratigraphy, age, tectonic development and sedimentology. This volume is necessary because remapping of more than 90% of these rocks across the island and biostratigraphical dating has resulted in a new understanding of the geology. This introduction covers a general history of investigation, which is required to place existing and new units in perspective, and supplements the other papers in this volume. Subsequent papers in this volume describe

the structure setting, the methodologies used, and the Cenozoic geology of the different parts of the island of Jamaica.

## 2. GEOLOGY IN THE NINETEENTH CENTURY AND THE FIRST GEOLOGICAL SURVEY

A series of publications in the nineteenth century set up a broad classification for the Cenozoic rocks of Jamaica. Following a visit to the island in 1823–1824, **De la Beche (1827)** was the first geologist to study the rocks of Jamaica. He produced a map of the eastern part of the island, and named rock units, based largely on their mineralogical content, using terms that he was acquainted with from Europe (France and Switzerland) and England (**Chubb, 1958; Mitchell, 2023**). Later, **De la Beche (1830)** effectively retracted his comparison and stated “*I am more anxious to leave the question of the equivalents of the Jamaica rocks entirely open.*” He did, however, introduce the name White Limestone (**De la Beche, 1825, 1827**), and while he was tempted to equate it with the Permian Zechstein limestones of Europe, instead he correlated it with the Calcaire Grossier of France and the London Clay of England, because of the presence of a species of *Cerithium* (now *Campanile*) which he had found in Jamaica. This may well be the first use of fossils in intercontinental biostratigraphy (**Donovan, 2004a**).

Although it is generally assumed that little geological work, other than mining, went on in Jamaica prior to the Barrett–Sawkins survey from 1859 to 1869 (e.g., **Chubb, 1964**), this is not



**Figure 1.** Location of Jamaica (Ja) on the Caribbean Plate and distinctive features and areas around the plate. The map uses a planimetric grid (in degrees) and uses a gravity-derived water-depth base for marine areas and false-colour elevation for land areas. The distribution of earthquakes is taken from the last 20 years (USGS online earthquake library). CT, Cayman Trough. GOM, Gulf of Mexico. Ja, Jamaica. YB, Yucatan Basin.

actually the case (Mitchell, 2023). The years 1850 to 1863 saw the establishment of copper mining in Jamaica, and many mining geologists visited the island to report on the mines. Most of these reports include little of geological interest, but clearly some of the mining geologists were still relying on the work of De la Beche (1827) for the geology (e.g., Darlington, 1856a, b, c, 1857, see Appendix I; Mitchell, 2023). The establishment of a learned society, The Society of Arts of Jamaica (later to be given royal patronage), saw a series of learned gentlemen starting to examine the geology of Jamaica. James Sawkins, then working for a mining company, reported a Cretaceous coral from the limestones in the Rio Grande Valley (Sawkins, 1856), whereas Richard Hill (Hill, 1856) established that De la Beche's 'Coal Measures' in the Rio Grande Valley were of Eocene age (this was prior to the naming of the Paleocene by French botanist Wilhelm Philippe Schimper in 1874). Richard Hill had clearly helped Charles Baker (C. B.) Adams whilst Adams was collecting marine molluscs and land snails in Jamaica (Adams, 1845a), and Adams' knowledge, as a geologist, was clearly invaluable when looking at rocks in Jamaica (Adams, 1845b). So prior to the start of the Barrett–Sawkins survey of the geology of Jamaica (Sawkins, 1869), the ages of some of the units had been determined.

It was the Barrett–Sawkins survey from 1859 to 1867 (Sawkins, 1869) that established the ground work for understanding the geology of Jamaica (Chubb, 1962; Mitchell, 2023). The parishes were surveyed one-by-one, beginning in the east and progressing towards the west, and the geology was determined and geological maps and cross-sections were produced. The survey saw significant changes in staff, Lucas Barrett died in a diving accident in Kingston Harbour in 1862, and his assistant, James Sawkins, was then placed in charge of the survey (Chubb, 1964). Three assistants would work under Sawkins: George Parks Wall (who led the Trinidad geological survey: Wall and Sawkins, 1860) was in the island at the time of Barrett's death and acted as the assistant for a short period; Arthur Lennox was then recruited, but had to leave due to ill health; and finally Charles Barrington-Brown was appointed and saw out the completion of the survey. The value of the survey to the island was also widely questioned by those in the island: and in 1865 (following the closure of the last copper mine), due to its cost, the survey was to be wound up (Murchison, 1865). As such, the geologists now produced a summary geological map (dated 1865) of the island including the parishes that had been surveyed (Sawkins, 1865), and preliminary results

of reconnaissance investigations of northern and western parishes (Mitchell, 2023). Following the Morant Bay Rebellion in 1865, the Governor of the island reinstated the survey, and the remaining northern and western parishes were mapped and reported on, but the summary map was not updated (Mitchell, 2023).

At the completion of the survey, the reports and maps that had been returned to London were prepared for publication. James Sawkins and Charles Barrington-Brown returned to England prior to their next engagement in British Guiana (Barrington-Brown and Sawkins, 1875), but were not involved with the production of the final volume. Later, Sawkins wrote (Sawkins, 1870): "*I am much displeased and disgusted at the manner in which my report on the island of Jamaica (Sawkins, 1869) has been sent out by the Lord Com[missioner]s – they have rendered the text of the least value by omitting the sections and diagrams referred to. This was done to economise I suppose. I could not superintend its publication and be here [in British Guiana] on duty at the same time. Consequently [I] do not hold myself responsible for the various errors I notice in it.*"

Sawkins (1869) *Geology of Jamaica* did establish a stratigraphic succession for the Cenozoic (a name introduced in 1840 by John Phillips, but not used in Sawkins, 1869) of the island, as follows. The name Carbonaceous Shale and Trappean Series were introduced and placed below De la Beche's 'White Limestone.' The Yellow Limestone was named as a unit at the base of De la Beche's 'White Limestone,' although units stratigraphically above the 'White Limestone' were erroneously included in the Yellow Limestone. The White Limestone was restricted to the middle part of De la Beche's 'White Limestone.' The White Marl and Coast Limestone were introduced for the upper part of De la Beche's White Limestone, between which a series of 'Gravel Beds' was recognized. The ages assigned to different units changed from parish report to parish report as new information was collected, but for the final volume no systematic revision was attempted, and the reports of each parish were included as written. Following the Barrett and Sawkins' (Sawkins, 1869) study of the geology of Jamaica, little significant work on the geology was carried out in Jamaica for the next few decades.

Barbados had not been included in the geological surveys carried out by the West Indian Geological Survey (Wall and Sawkins, 1960; Sawkins, 1969; Barrington Brown and Sawkins, 1975) as the colony was not prepared to lay out the expenditure. Subsequently, the island was surveyed

by Jukes-Brown and Harrison and reported on in the *Quarterly Journal of the Geological Society* (Jukes-Brown and Harrison, 1891, 1892). In these reports thin sections of specimens from the White Limestone of Jamaica were also reported on by William Hill to compare with specimens from Barbados. William Hill recognized two suites of samples (Hill in Jukes-Brown and Harrison, 1891, 1892). Three samples came from Mile Gully (in the northern part of the parish of Manchester) and consisted of crystalline limestone, with one sample containing red algae (identified as *Lithothamnion*) and larger foraminifera (identified as *Amphistegina*). A fourth sample from ‘Belmont’ in the parish of St Elizabeth contained *Orbitoides* (probably lepidocyclinids). Hill likened these specimens to ‘coral limestones’ with the details obscured by crystallization. A fifth sample from the county (= parish) of Hanover was an ‘Oceanic deposit’ containing abundant globigerinæ (planktic foraminifera) (Hill in Jukes-Brown and Harrison, 1891, 1892). Hill, therefore, recognized that the White Limestone of Jamaica contained both shallow-water varieties (his ‘coral limestones’) and deep-water varieties (his ‘Oceanic deposits’).

Spencer (1898) produced a short paper in which he discussed the rocks above the White Limestone in Jamaica. He introduced two new formations: the Layton Formation for a series of marlstones at Low Layton (James-Williamson and Mitchell, 2012), and the Liguanea Formation for the gravels of Liguanea Plain on which Kingston was built. It was Hill’s (1898, 1899a, b, c) work, however, that built extensively on that of the Barrett and Sawkins’ survey. Robert T. Hill had undertaken three trips to Jamaica in the winters of 1895, 1896 and 1897 (Hill, 1898); he did not map, but undertook traverses across the island, including some along new road and railway cuttings to investigate the geology. He set out to correct errors in Sawkins (1869), but in doing so he also introduced new errors in the geological understanding of Jamaica. Although Spencer (1898) had introduced formation names based on geographical localities, it was Hill (1899a) who would propose new names using geographical identifies for most of the geological succession in Jamaica. He renamed the Carbonaceous Shale of Sawkins (1969) the Richmond Formation, and the Yellow Limestone (which had been confused with rocks of the Coastal Group), the Cambridge Formation (consisting of two units, the Catadupa beds, containing an admixture of Cretaceous and Eocene fossils, and the Chapelton beds containing Eocene fossils). In turn the White Limestone of Sawkins (1869) was divided into a lower Oceanic

Series and an upper Coastal Series. Hill (1899a) used William Hill’s (in Jukes-Brown and Harrison, 1891, 1892) thin section observations to separate the Oceanic Series into deep-water chalks of the Montpelier Formation (with globigerinæ or planktic foraminifera) and the shallow-water limestones of his Moneague and Cobre formations. The term Oceanic Series for these three formations is, however, misleading, since it is only the Montpelier Formation that is rich in planktic foraminifera. Hill also thought that his Montpelier Formation was older than his Moneague and Cobre formations, probably due to the presence of extensive turbidite deposits, mistaken for ‘coral limestones’, with abundant larger benthic foraminifera in the succession along the North Coast. The geographical distribution indicated for the Montpelier Formation by Hill (1899a), indicates that he used the presence of both flints and planktic foraminifera to identify it; and his distribution relatively closely matches the mapping of deep-water chalks subsequently (although there are notable differences in eastern Jamaica). For the Moneague and Cobre formations, however, the geographical distribution presented does not correspond in any way to the modern mapping of formations. His Coastal Series, included all the deposits that were younger than the Oceanic Series, and included the: Bowden, Buff Bay, Manchioneal, May Pen, Porus, Kingston (= the Liguanea Formation of Spencer, 1898), Soboruco, Barbican, Hopewell, Falmouth, Montego and Bogue Island formations/beds. It is in the Coastal Series that many problems were created, with Hill (1899a) assigning formation names to different altitudes of elevated coral reefs (Soboruco, Barbican and Hopewell formations), and even to mangrove swamps (Montego Formation) and offshore cays and mangrove stands (Bogue Island Formation). Modern studies would map many of these deposits as superficial deposits without naming them. The various formations introduced by Hill (1899a) for his Coastal Series will be discussed in detail in a later paper in this volume (Mitchell and Rahamut, 2026 [this volume]).

### 3. CHARLES MATLEY, CHARLES TAYLOR TRECHMANN, AND THE SECOND GEOLOGICAL SURVEY OF JAMAICA

In the twentieth century, the Second Geological Survey of Jamaica was commissioned by the Government of Jamaica to look specifically at water resources. Charles Alfred Matley was appointed as the Geologist from October 2021 to April 2024 (Matley, 1929, p. 441) and this was also the time

when the gentleman geologist Charles Taylor Trechmann would leave England to spend the winter months in Jamaica (as well as elsewhere) (Donovan, 2003, 2008). Since the White Limestone had potential as a source for underground water, Matley undertook a study of its stratigraphy and palaeontology. During his work, Matley sent molluscan samples to W. P. Woodring and foraminiferal samples to T. W. Vaughan for palaeontological interpretation, with the results subsequently published (Woodring, 1925, 1928; Vaughan, 1928a, 1928b, 1929). C. T. Trechmann visited Jamaica from the 1920s to the 1960s and wrote a series of papers largely discussing the palaeontology of the Cretaceous and Cenozoic rocks (e.g., Trechmann, 1922, 1923, 1924, 1930). In 1922 he discussed Hill's (1899a) Cambridge Formation and found that Hill's Catadupa Beds (part of the Cambridge Formation) contained admixtures of rudists from the Cretaceous limestone/shale succession and Eocene molluscs from the Yellow Limestone. In consequence, he preferred to retain the name Yellow Limestone over Hill's (1899a) name Cambridge Formation.

Matley returned to Jamaica in the winter of 1926–1927 to map the Kingston District, and in 1929 he published his provisional results recognizing a Pre-Palaeozoic or Palaeozoic Basement Complex intruded by granodiorite and overlain unconformably by late Cretaceous conglomerates (Purple Conglomerate Group: Figure 2) containing granodiorite pebbles, and Cenozoic cover sequence (Matley, 1929). In 1936, Trechmann published his interpretation of the rocks of Jamaica and concluded that there was no Basal Complex and that the granodiorite had been intruded into the White Limestone and was responsible for recrystallization in the lower part of that unit (Trechmann, 1936a). This resulted in a confrontation (Donovan, 2003) with both Matley and Trechmann arguing their views in the *Geological Magazine* (Matley, 1936, 1937; Trechmann, 1936b, 1937, 1942). In fact, neither was right; the granodiorite is now known to be of earliest Paleocene age (U-Pb age of  $65 \pm 3$  Ma; mean  $^{40}\text{Ar}/^{39}\text{Ar}$  of 64.23 Ma) and intruded into the late Cretaceous (mean  $^{40}\text{Ar}/^{39}\text{Ar}$  of  $70.5 \pm 2.1$  Ma) Border Formation (Chubb and Burke, 1963; Harland et al., 1964; Hastie, 2007), and the recrystallization of the White Limestone is likely of Oligocene age based on Sr-isotope ratios (Edwards and Mitchell, 2026, this volume).

Matley (1925, 1951) realized that in order to understand the White Limestone it was necessary to use fossils to zone it, and used the most abundant fossils, the foraminifers (Figure 3). Using this

zonation he demonstrated that Hill's (1899a) Moneague and Cobre formations were shallow-water facies, and that the Montpelier Beds were a deep-water facies (as initially suggested by W. Hill in Jukes-Brown and Harrison, 1891, 1892). From 1942 to 1946, Matley sent foraminiferal samples to L. M. Davies who progressively worked on the material and sent replies back to Matley (Davies, 1952). Matley completed his map of the Kingston district and this was published by the Institute of Jamaica (Matley, 1946). Matley's posthumous memoir on the Kingston District (Matley, 1951) was finally published with Frank Raw editing the work and making his own observations. Matley's (1925, 1946 & 1951) stratigraphy is summarized in Figure 2. Matley (1925) introduced the name Mount Hybla Beds for part of the succession that had previously been assigned to the Carbonaceous Shale or Richmond Formation, preferring a new name as the existing names had also been applied to Cretaceous shales. He also suggested new terms: including, the Wagwater Group (Matley, 1946 – subsequently corrected to the correct geographical spelling Wag Water Group – Matley, 1951), the White Limestone Basement (Matley, 1946), and the August Town Formation (Matley, 1946).

#### 4. BAUXITE, THE GEOLOGICAL SURVEY DEPARTMENT, AND GEOLOGY AT THE UNIVERSITY OF THE WEST INDIES

The discovery of and prospecting for bauxite in Jamaica occurred from 1939 into the 1950s (Young, 1965) and led to new studies on the White Limestone: H. R. Hose undertook investigations for the bauxite companies (Hose, 1951), whereas Howard Versey undertook an M.Sc. study of the same deposits (Versey, 1957a, 1957b). This resulted in a classification of the White Limestone based on microfacies and Larger Benthic Foraminifers (LBF) (Hose and Versey, 1956).

Hose (1951) summarized the Eocene to Miocene geology of Jamaica, recognizing the Carbonaceous Shale, the Yellow Limestone Formation, the White Limestone Formation, the Buff Bay Beds and the Bowden Formation. He stated that there was no lithological or palaeontological difference between Hill's (1899a) Cobre and Moneague formations, but noted that the Montpelier Beds were “*more chalky and contain bands of flints*” (Hose, 1951, p. 20). He also listed foraminifera characteristic of the Eocene (*Dictyoconus*, *Lituonella*, *Alveolina*, *Borelis* and *Camerina* in the Yellow Limestone; and *Dictyoconus*, *Borelis* and *Yaberinella* in the White

		Matley 1929	Matley 1946	Matley 1951
Pleistocene				
		Liguanea Formation	Liguanea Formation	Liguanea Formation
Pliocene				<i>Unconformity</i>
			August Town Series	August Town Series
Miocene			<i>Unconformity</i>	<i>Unconformity</i>
Oligocene				
		White Limestone	White Limestone (upper part weathered forming the St Thomas in the Vale Marls, and a (separate Montpelier facies)	White Limestone (including White Marl of St Thomas-in-the-Vale and a separate Montpelier facies)
Upper Eocene				
			White Limestone Basement	White Limestone Basement
Middle Eocene				<i>Unconformity</i>
		Mount Hybla Beds	Carbonaceous Shales (=Richmond Group, includes Mount Hybla Beds)	Mount Hybla Beds (=Carbonaceous Shales and Richmond Beds in part)
Lower Eocene		Eocene Conglomerates	Good Hope or Halberstadt Lmst	Halberstadt Limestone
			Halberstadt Volcanic Group	Halberstadt Volcanic Group
			Wagwater Group	Wag Water Group
			<i>Unconformity</i>	<i>Unconformity</i>
Cretaceous		Purple Conglomerate Group		

Figure 2. Stratigraphy of the area around Kingston for Matley’s 1929, 1946 and 1951 publications. The ‘intrusive’ Newcastle Porphyry Sill within the Wag Water Group is not shown.

Limestone), Oligocene (*Lepidocyclina*, *Coskinolina* and *Fabularia*) and Miocene (*Amphisorus*, *Archaias*, *Sorites*, *Peneroplis*, *Heterostegina* and *Miogypsina*).

Hose and Versey (1956) recognized different successions of limestones or members in the two

areas of the island that they studied. Around the Central Inlier and on the Manchester Plateau, they recognized five members in the White Limestone: Troy, Somerset, Walderston and Newport limestones and the May Pen Beds (after Hill, 1899a) (Figure 4). Along the North Coast Belt of St

	Matley 1925	Matley 1951
White Limestone	Sorites-zone (Santa Cruz Mountains of St. Elizabeth and large tracts of Manchester)	Amphisorus zone (= Sorites-zone) with <i>Amphisorus matleyi</i> , but lacking <i>Lepidocyclus</i> : Lower Miocene
	Large <i>Lepidocyclus</i> (zone of <i>Lepidocyclus</i> cf. <i>gigas</i> and <i>L. undosa</i> )	Large <i>Lepidocyclus</i> (zone of <i>L. gigas</i> and <i>undosa</i> ): mid Oligocene
	Small lenticular <i>Lepidocyclus</i>	
	<i>Dictyoconus</i> without <i>Alveolina</i>	
<i>Alveolina</i> and <i>Dictyoconus</i>	<i>Alveolina</i> , <i>Dictyoconus</i> and <i>Discocyclus</i> (with some <i>Lepidocyclus</i> ): Eocene	
Yellow Limestone		<i>Operculina</i> , small <i>Dictyoconi</i> , occasional <i>Alveolina</i> , large <i>Orthophragma</i>

Figure 3. Larger benthic foraminiferal zonation from Matley (1925) and Matley (1951).

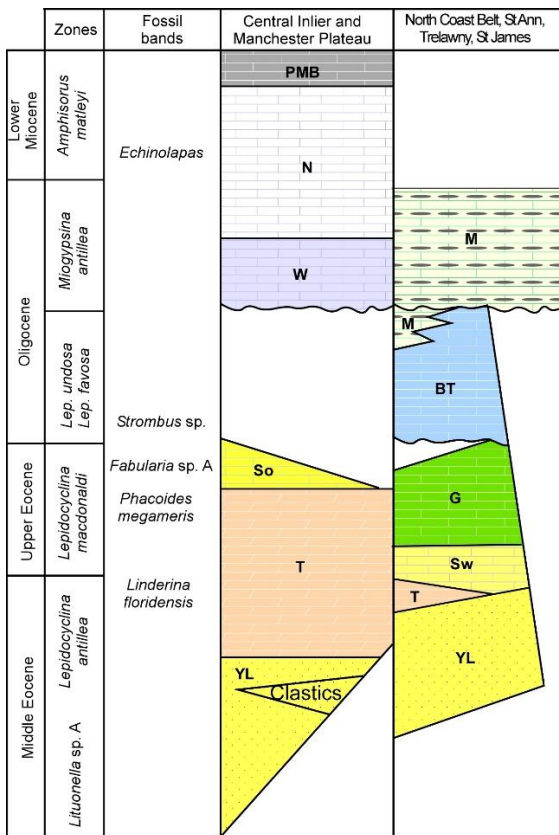


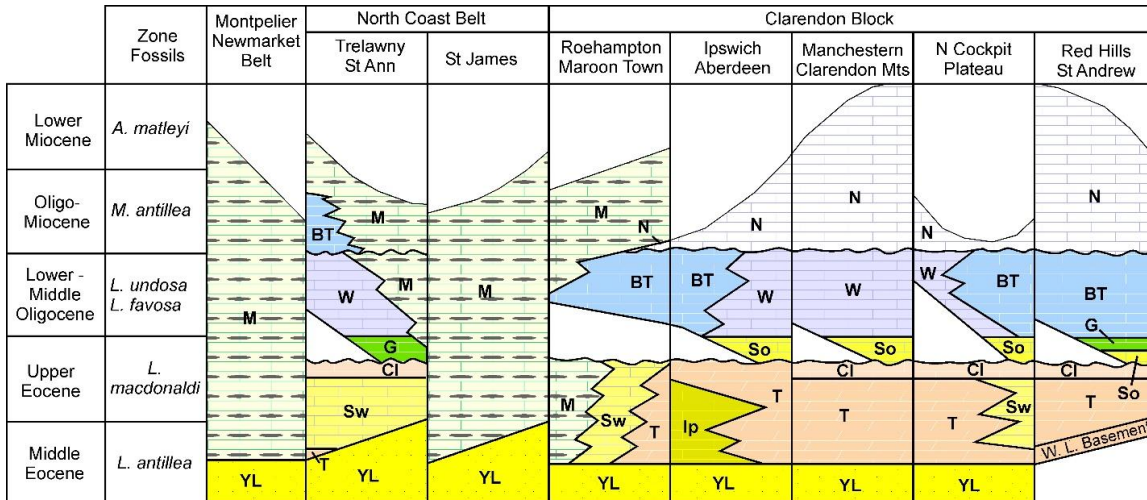
Figure 4. Stratigraphic relationships of the members of the White Limestone as indicated by Hose and Versey (1956). YL, Yellow Limestone; T, Troy Limestones; Sw, Swanswick Limestones; G, Gibraltar Limestones; So, Somerset Limestones; BT, Browns Town Limestones; W, Walderston Limestones, M, Montpelier; N, Newport Limestones; MPB, May Pen Beds.

Ann, Trelawny and St James, they also recognised five units: Troy, Swanswick, Gibraltar, Browns Town and Montpelier limestones (Figure 4). The members were partly based on lithology and partly

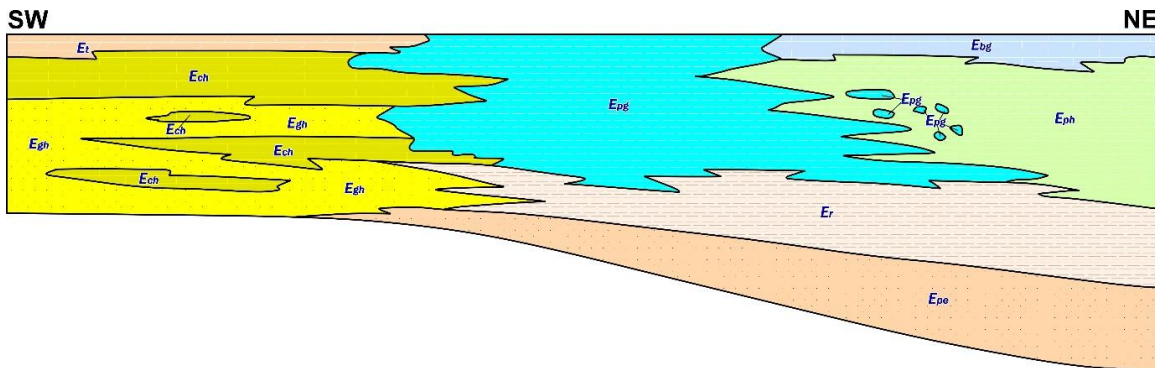
based on the LBF assemblages that were used to define microfacies. Samples of the foraminifers from the Yellow Limestone and White Limestone were sent to W. Storres Cole for analysis, and he subsequently reported on the samples (Cole, 1956).

A new geological map of Jamaica was produced by the Geological Survey Department in 1959 (Zans, 1959), and the bulletin updating the stratigraphy was published in the 1963 synopsis (Zans et al., 1963). On the 1959 map, the Cenozoic rocks were divided into the Wagwater Conglomerates, the Richmond Beds, the Yellow Limestone and White Limestone formations, the Coastal Formations and Elevated Reefs. The 1963 Synopsis separated the Cenozoic rocks into ‘Lower Tertiary conglomerates and shales’ (Wagwater Conglomerate, Halberstadt Limestone, and Richmond Beds) (Robinson in Zans et al., 1963, pp. 21–24), ‘Older Tertiary limestone’ (Versey in Zans et al., 1963, pp. 26–43), ‘Later Tertiary limestones’ (Bowden Series, Manchioneal Formation, Buff Bay Series, and August Town Series) (Robinson in Zans et al., 1963, pp. 44–49), and ‘Quaternary deposits’ (Liguanea Formation and raised reefs, etc.) (Robinson in Zans et al., 1963, pp. 50–54). The Hose and Versey (1956) classification scheme for the White Limestone was revised by Versey (in Zans et al., 1963), with the addition of new members and a revision of those that had been introduced previously (Figure 5). The revised scheme showed a more complex relationship between the members, with the deep-water Montpelier Formation being found within the belts as well as (erroneously) being shown interbedded with and succeeding the Brown’s Town Limestones in the area around Roehampton (Figure 5).

The Ph.D. thesis by Edward (Ted) Robinson (Robinson, 1969a), papers published in the



**Figure 5.** Geographical distribution of the members of the White Limestone after Versey (in Zans et al., 1963) with errors (ornament for Troy Member) corrected (see Robinson et al., 2018, fig. 2). YL, Yellow Limestone; T, Troy Limestone {sic}; Sw, Swanswick Limestone; Ip, Ipswich Limestone; Cl, Claremont Limestone; G, Gibraltar Limestone; W, Walderston Limestone; BT, Brown’s Town Limestone, N, Newport Limestone; M, Montpelier Limestone.



**Figure 6.** Stratigraphic relationship of Eocene rocks in northern St Mary as shown by Burke et al. (1969), with colours added to confirm with current mapping practice. The diagram reconstructs a ramp type margin passing from shallow-water deposits in the SW to deep-water deposits to the NE. Such a reconstruction fits the rocks, although the stratigraphic successions (and their geographical distributions) have been significantly revised. Epe – Pembroke Hall Formation; Egh – Guys Hill Formation; Ech – Chapelton Formation/Ham walk limestones; Etr – Troy Formation; Epg – Palmetto Grove Formation; Eph – Preston Hill Formation; Ebg – Bonny Gate Formation.

Transactions of the 2<sup>nd</sup> Caribbean Geological Conference in Trinidad (Robinson, 1969b; Burke et al., 1969; Coates, 1969) and other works (e.g., Burke and Robinson, 1965; Robinson, 1967, 1969c, 1969d; Porter and Robinson, 1974), led to the next revision of the stratigraphy of the Yellow Limestone and White Limestone of Jamaica. In St Mary, the succession was interpreted to show a transition from shallow-water limestones and sandstones northwards into deep-water marlstones and chalks (Figure 6). New units were established and attributed as members to the Wagwater (Pembroke Hall Member: Burke et al., 1969), Richmond (Langley Member: Burke et al., 1969), Yellow Limestone (Ham Walk, Guys Hill, Preston Hill, and Palmetto Grove: Burke et al., 1969 and

Petersfield Gap member: Burke and Robinson, 1965; Robinson, 1967) and White Limestone (Bonny Gate Member: Burke et al., 1969, Lloyds Member: Robinson, 1967, and Spring Garden Member: Robinson, 1969d) ‘groups’. Lithology was used as diagnostic in determining member or formation status, although the Bonny Gate and Montpelier members were separated on the assumed presence of an unconformity between them. The Yellow Limestone succession in the Central Inlier was attributed to the Chapelton Formation and divided into the Stettin (limestone), Guys Hill (sandstones, with the name extended from St Mary and containing the thin Dump Limestone Lenticle) and the Albert Town members (Coates, 1969; Robinson, 1969c; Porter and Robinson, 1974).

**Table 1.** Lithostratigraphic names used for the White Limestone on the Clarendon Block by the Geological Survey of Jamaica/Mines and Geology Division on the provisional 1:50,000 geological sheets and the 1977 1:250,000 sheet. The Gibraltar-Bonny Gate Formation (which is discussed in the text) is also shown.

Map Sheet	'Lithostratigraphic' units							
	Troy Lmst	Troy-Clarendon Formation	Swanswick Lmst	Troy - Clarendon - Somerset - Swanswick Fm	Gibraltar-Bonny Gate Fm	Somerset Fm	Walderston-Browns Town Fm	Newport Fm
Sheet 3 Montego Bay (Bateson, 1972a)	X				X			
Sheet 4 Newmarket (Bateson, 1972b)	X		X		X			X
Sheet 5 Queen of Spains Valley (Bateson, 1972c)		X	X		X			
Sheet 6 Maggotty (Bateson, 1972d)	X		X		X	X	X	X
Sheet 7 Black River (Bateson, 1972e)					X			X
Sheet 8 Falmouth (Bateson, 1974a)		X	X		X	X	X	
Sheet 9 Balaclava (Bateson, 1974b)		X				X	X	X
Sheet 10 Alligator Pond (Bateson, 1974c)		X				X	X	X
Sheet 11 Discovery Bay (Bateson, 1974d)		X	X			X	X	
Sheet 12 Spaldings (Bateson, 1974e)	X					X	X	X
Sheet 13 Mandeville (Bateson, 1974f)	X						X	X
Sheet 14 St Anns Bay (Henry and Bateson, 1974)		X	X			X	X	
Sheet 15 Kellits (Porter et al., 1974)		X				X	X	
Sheet 16 May Pen (Porter and Bateson, 1974a)		X				X	X	X
Sheet 17 Portland Ridge (Porter and Bateson, 1974b)								X
Sheet 18 Ochio Rios (Henry, 1978)		X	X		X	X	X	
Sheet 19 Linstead (McFarlane, 1974)		X				X	X	X
Sheet 20 Old Harbour (Porter and Bateson, 1974c)		X				X	X	X
Sheet 21 Port Maria (Henry and McFarlane, 1978a)		X			X			
Sheet 22 Hellshire Hills (Green 1972)	X							X
Sheet 23 Above Rocks (Green 1974)	X							X
Sheet 25 Kingston (Green and Holiday, 1974)		X	X			X	X	X
Jamaica 1:250,000 geology map (McFarlane, 1977)				X			X	X

In the 1970s the Geological Survey of Jamaica (subsequently the Mines and Geology Division) completed their provisional mapping of central and western Jamaica and amalgamated some of Versey's (in Zans et al., 1963) White Limestone units into what they considered 'mappable' formations (Table 1) and these were also included (although all the shallow-water Eocene White Limestone was amalgamated) on the 1:250,000 scale geological map of Jamaica (McFarlane, 1977) prepared for a new round of oil exploration in Jamaica (Meyerhoff and Kreig, 1977). Of note is the stratigraphical succession indicated by Wright and Robinson (1974) and Wright (1975), who regarded the Swanswick Formation as a transgressive unit resting on the Yellow Limestone in some areas, the Troy/Clarendon Formation in others and even on the Somerset Formation. Thus similar lithological units of different ages were

being mapped using the same name. The deep-water successions in the White Limestone and their transition into the Coastal Group were investigated by Steineck (1973, 1974 & 1981). He suggested that there was little or no unconformity between the Bonny Gate and Montpelier formations, and divided the Montpelier Formation into a lower unit with cherts (Sign beds) and an upper unit without cherts (using the name Spring Garden Member from the Geological Survey Department, 1960, p. 4, and Robinson, 1969d). Eva and McFarlane (1985) used mapping data to suggest the evolution of the shallow-water Clarendon Block over time.

Successions in eastern Jamaica were also re-explored. Jiang and Robinson (1987) dated the 'Richmond Formation' in the Rio Grande Valley using calcareous nannofossils and found that it was of early Paleocene age. They suggested the name Moore Town Shales for this unit, and the Nonsuch

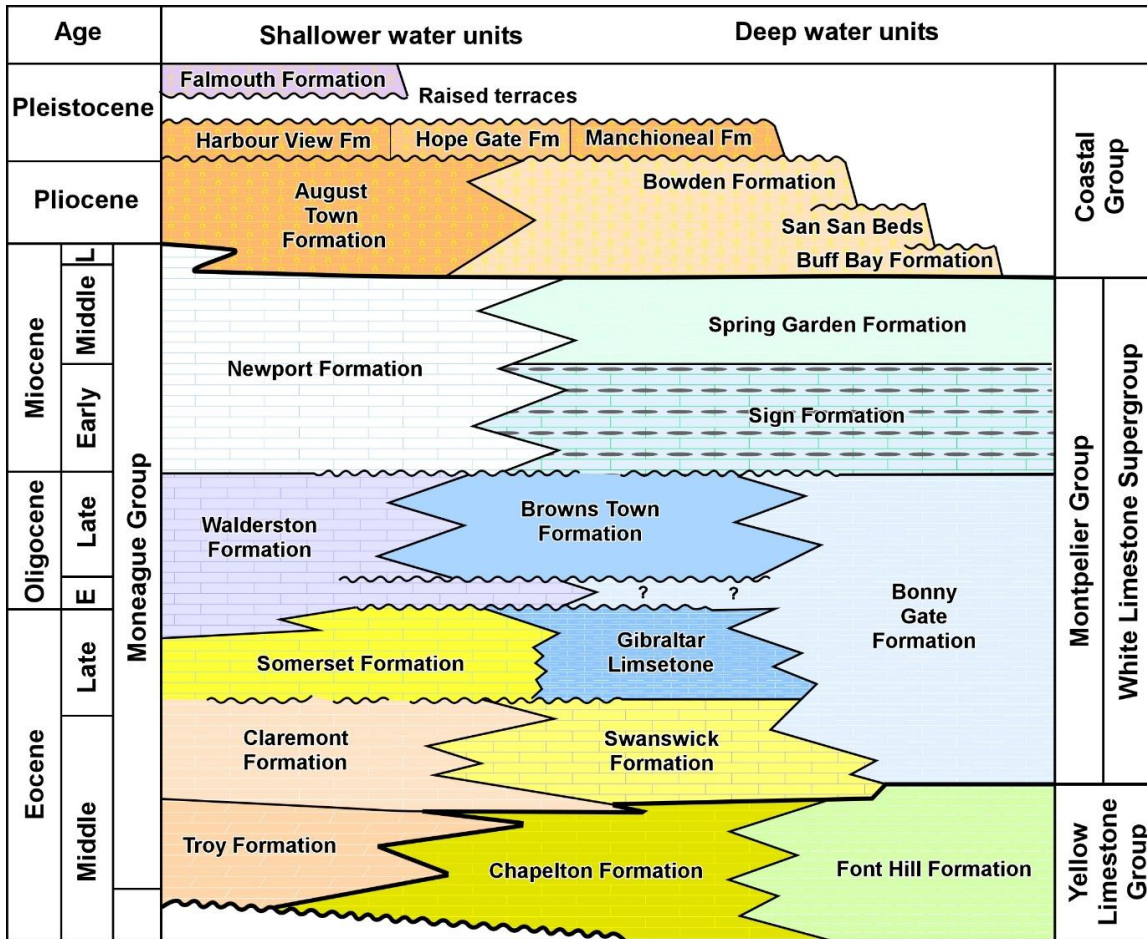


Figure 7. Stratigraphy of the mid Eocene to Recent rocks of Jamaica (redrawn from Robinson, 1994).

Formation for the overlying interbedded marlstones and limestones ('Font Hill Facies') of late Paleocene age, and Sherwood Forrest Formation for the shallow-water White Limestone of early Eocene age in that area. Some workers did not accept this proposal and retained the name Richmond Formation for the Paleocene to early Eocene shales of eastern Jamaica (e.g., Mann and Burke, 1990; Pickerill and Donovan, 1991; Pickerill et al., 1992, 1993; Pickerill and Mitchell, 1999). Robinson and Jiang (1990) also demonstrated that the Chepstow {sic} Limestone in northern Portland was of late Paleocene age; and Mann and Burke (1990) revised the status of the rocks of the Wagwater Belt, introducing several new named (Dry River, Pencars River, Ginger River, Port Maria, Albany, Roadside) members. The status of Jamaican geology in the early 1990s was summarized by Robinson (1994; Figures 7 and 8).

The problems with the lithostratigraphic scheme for the White Limestone were highlighted by Robinson and Mitchell (1999), who noted that

some of the so-called formations were not based on lithological criteria, but only on the presence of certain Larger Benthic Foraminifera (LBF). Robinson and Mitchell (1999) therefore reverted to the use of named members rather than formations. This led Mitchell (2004) to propose a simplified lithostratigraphic scheme for the White Limestone in the White Limestone volume (Donovan, 2004b; Figure 9). Revisions to the zonation of the White Limestone using LBF were also provided by Robinson (1977, 2004) and further revisions to the Yellow Limestone of the Central Inlier with the establishment of the Freemans Hall Beds below the Stettin Formation (Robinson, 1988, 1996).

Engineering problems during the construction of the north-south leg of Highway 2000 in Jamaica in 2005 led to a new impetus for understanding the White Limestone. This resulted in Mitchell starting to map areas of the White Limestone across the Clarendon Block, and undertaking further revisions to the lithostratigraphic scheme (Mitchell, 2013, 2016). The revised scheme was closer to that of

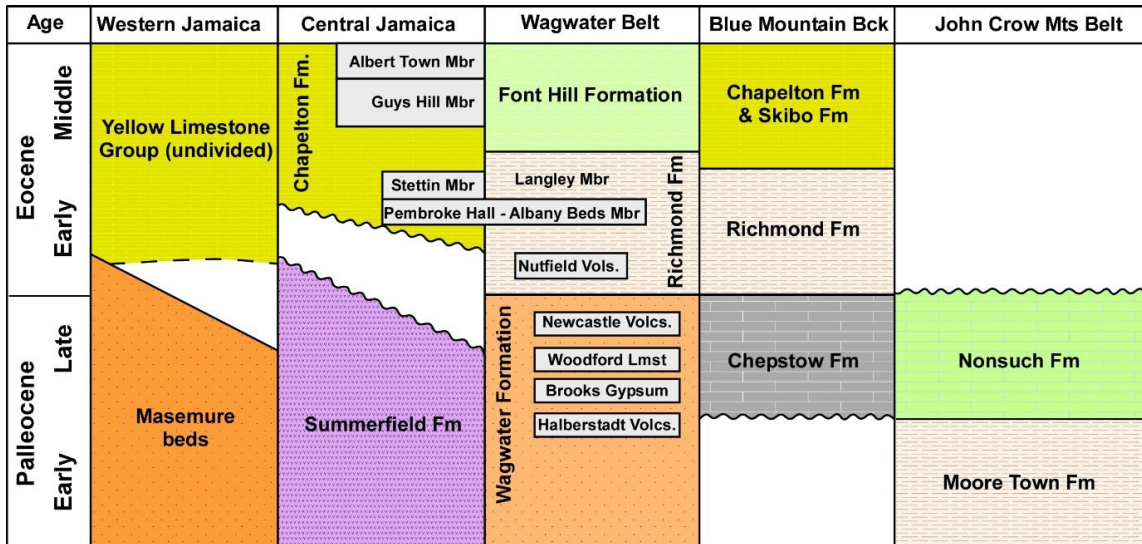


Figure 8. Stratigraphy of the Paleocene to mid Eocene rocks of Jamaica (redrawn from [Robinson, 1994](#)).

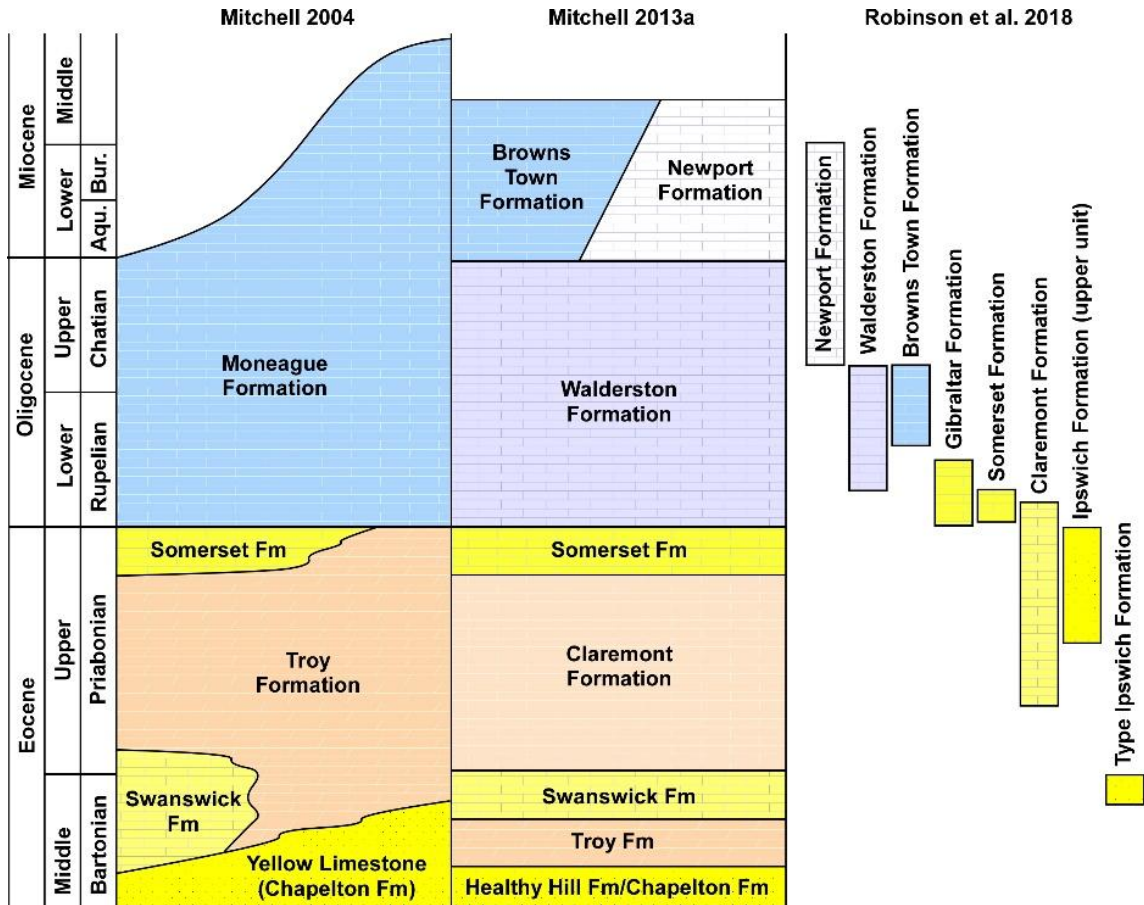
Versey (in [Zans et al., 1963](#)), but with notable differences ([Figure 9](#)). In the field, [Mitchell \(2013\)](#) had difficulty separating the Walderston and Browns Town formations on the northern part of the Clarendon Block, and used a colour change from cream below (with or without *Eulepidina undosa* = Walderston Formation) and white above (with *E. undosa* = Browns Town Formation) to separate them. Yet even this scheme was not easy to use and suggested that the Browns Town Formation of the northern part of the platform was equivalent to a part of the Newport Formation in the southern part of the platform. Revisions to the stratigraphy of the Coastal Group were also undertaken by [James-Williamson and Mitchell \(2012\)](#).

[Robinson et al. \(2018\)](#) revised and provided new strontium isotope derived ages and associated LBF assemblages for the White Limestone of Jamaica in an attempt to tie units to the chronostratigraphy. Their strontium isotope dates were not rigorously scrutinized for diagenetic alteration, and some of their values/dates consequently are suspect. They did reassign ages to the various units in the Oligocene to Miocene White Limestone and some of these were at variance with the results from [Mitchell \(2013\)](#) ([Figure 9](#)).

More recently [Mitchell et al. \(2022, 2024\)](#) and [Mitchell \(2026a\)](#) have established a high-resolution zonation for the Cenozoic of the Americas based on the successions of LBF from Jamaica, and elsewhere, calibrated against the chronostratigraphy using calcareous nannofossils, planktic foraminifers and strontium isotopes. Using this scheme it is now possible to

correlate many of the formations exposed across the Clarendon Block of Jamaica and to understand the distribution of the various lithofacies, microfacies and biofacies in the Yellow Limestone and White Limestone groups. Using the LBF, these correlations can be extended into the deep-water belts and to other parts of Jamaica. This thematic volume contains a series of papers that explores the relationships between the various deep-water basins and shallow-water platforms, the sedimentary facies relationships, microfacies and biofacies, and the tectonic controls on sedimentation. For completeness, the clastic rocks deposited in rift basins (graben) and the stratigraphy of the Coastal Group are also covered. This volume also provides the detailed stratigraphy that is represented on the new series of parish maps. It is hoped that the new information can be applied to other branches of geology, including mineral exploration and underground water resources.

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**Figure 9.** Stratigraphic schemes for the White Limestone of Jamaica from Mitchell (2004), Mitchell (2013), and ‘dates’ derived from strontium isotopes from Robinson et al. (2018). Relationships are shown diagrammatically related to stage boundaries. Geological mapping indicates that the Ipswich Formation lies underneath the basal (Troy) White Limestone unconformity. The samples from the two Robinson samples upper the ‘upper’ Ipswich Formation are now mapped as Ipswich Formation and Appleton Formation (Mitchell, 2026b [this volume]); both are close to the Troy unconformity and have probably been diagenetically altered.

access to properties and private roads. To all of these, I offer many sincere thanks for making this work possible. The reviewers, Edward (Ted) Robinson and Steve Donovan, as well as the editor Sherene James-Williamson, are thanked for their

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## Appendix 1. Transcripts of “Remarks on mining in Jamaica” by George Darlington

It has generally be assumed and reported (e.g., **Chubb, 1958, 1964**) that the only significant descriptions of the geology of Jamaica in the early- to mid-nineteenth century were those by **De la Beche (1827)** and **Sawkins (1869)**. Yet the search for mineral resources in the mid-nineteenth century saw numerous mining geologists pass through Jamaica. Amongst these was George Darlington who was employed by several of the copper mines to investigate their prospects (e.g., **MJRCG, 1856a, b**). George Darlington made his own interpretations, largely following the geology suggested by **De la Beche, 1827**) and sent back four letters to the Mining Journal, Railway and Commercial Gazette outlining his observations. These letters are not available online, and are unlikely to become so in the near future. It therefore seems useful to publish transcriptions of these letters for members of the Jamaican geological community, as well as others interested, to have access to. The letters were sent from Jamaica to England via the Mail Packet service in 1856, however Letter No. 2 was delayed, and was not published until 1857. The letters are included below in the order they were written, rather than in the order they were published in England. The first two letters are the ones that outline the geology, whereas the last two comment more on individual mining operations. All four are included here for completeness, even if the last two contain less remarks concerning the geology. Following the transcripts, a discussion section analyses the contents.

### Transcriptions of the letters

*Word-for-word transcriptions are presented for each letter below. The text is presented in italics and explanations, where necessary, are provided in Roman text.*

#### Remarks on mining in Jamaica. – No. I, by George Darlington (**Darlington, 1856a**)

*“Having now been engaged for some time in enquiring into the geological composition, mineral deposits, and ultimate mining resources of Jamaica, I think it may prove interesting to some of your readers to offer some remarks bearing on the result of my investigation.*

*“In sailing from St. Thomas’s [U.S. Virgin Islands] to Jamaica, a careless observer of geological phenomena cannot but be struck with the general resemblance in the physical character of the various islands which pass under his observation, as well as in the similarity of the rocks which form their littoral margins – Indeed, a geological description of one island can differ in no very material point from that of another; Similar forces have acted upon each, rocks of like character occur, and bear generally an uniform relation. It is not, therefore, surprising that if in one metallic minerals are found another should also possess them; this is known to be the case from Virgin Gorda [British Virgin Islands] to Jamaica, - but with this important difference, that except*

*in Cuba all attempts at obtaining ores in remunerative quantities have hitherto been unattended with success.*

*“My own observations have led me to conclude that this hitherto unprofitable result is not owing to the strata being non-metalliferous, but to a want of perseverance, proper management, and a right understanding of true mining knowledge; combined with those illegitimate practices which too frequently characterise our foreign adventures. The stratified beds of Jamaica belong to the Silurian series but large areas in the island are occupied with porphyry, granite (both albitic and syenitic), trap and greenstone, with gneiss and chloritic slate. The general arrangement of these rocks are somewhat thus – Silurian limestone occupies those elevated areas nearest the sea, and are usually flanked towards the interior by the various igneous and metamorphic rocks; while shales, slates, and sandstone form the true interior area.*

*“The island is a remarkable instance of general upheaval, evidently caused by intense action, arising either from subterranean, volcanic, or other igneous forces, the more elevated strata rising at angles of from 40 degrees to a vertical position, the elevation so formed obtaining the height of more than 8,000 feet, as in the Blue Mountains, and from 4,000 to 6,000 feet in the range north of Kingston, of which St. Katharine’s Peak forms the extreme highest point. The eastern, or windward, end of the island appears to be chiefly composed of Silurian shale, slate, and limestone, with an extensive series of silicious beds, precisely resembling the chert of the English mines; limestone, as is usual, forms the littoral rocks. This set of beds is well illustrated in the mine worked some time since by the Jamaica Mining Company, the Mount Vernon property, in Lucky Valley. This position is 13 miles from Kingston, on the Windward-road, and from the bare rocks, and the workings effected by this company, very good sections of this stratification are exposed. In a future letter, when treating on the mines in the island, I shall have occasion to further remark on these.*

*“The beds at Mount Vernon lie at high, but various, angles, beside the silicious set; considerable areas of shale and slate [Richmond Formation] also occur, which have a more uniform bearing and dip, the angle of which bedding is more horizontal than usual, being at about 18° of elevation. If from this point we pass westward towards Port Royal Mountains, we find limestone to occur again, but underlaid by granite and porphyritic rocks. At Hope, in St. Andrew’s, chlorite rocks occur, with much dark red sandstone and conglomerate; epidote occurs in large masses, forming a kind of epidotic rock, while the road from Botanic Gardens to Newcastle presents some very fine natural sections of red sandstone rock, gneiss, and Silurian slate; these, however, do not appear to be metalliferous. Further west, in stony hill, we have limestone, while in Mount Salus, adjoining, granite, porphyritic and metamorphic rocks, highly metalliferous occur. Similar formations occupy the intervening area between Mount Salus and the Clarendon Mines while to*

the west ward of these mines very large tracts of crystalline limestone occur, which appear to be totally devoid of mineral ores, and in which no mining operations have yet been carried on.”

**Remarks on mining in Jamaica. – No. II, by George Darlington (Darlington, 1857)**

“Having noticed the general arrangements of the rocks and strata of Jamaica, I now proceed to give some details of the phenomena attending their occurrence, and also of the lodes and mineral deposits generally. The mineral lodes occur in the following parishes:- St. Andrew's, Port Royal, St. David's, Portland, St. Thomas in the Vale of St. George's, Clarendon; while various deposits, and apparently accidental masses, are found in other parts of the island, as in Metcalfe, St. Mary's, &c.

“The granite of Jamaica, the existence of which is now proved beyond a doubt, occurs, as far as yet known, immediately on the junction of the crystalline limestone, with Silurian shale and slate, and is usually highly decomposed. I have, however, only observed this rock in two places viz., on the flank of one of the Port Royal Mountains, composed of lime-stone, where it has a very limited area, and on the western side of the Liguanea Mountains, where it occupies a larger space. In the latter locality it is not one uniform mass, but is divided into several sections by bands of porphyry and gneiss. A kind of albitic granite also occurs in St. Andrew's parish, near Hope.

“Porphyry occurs in many localities. This formation also appears to lie in contact with the limestone, and occupies considerable areas of the island. It is either in this stratum or the preceding one that the metalliferous lodes appear to occur, and these, as I shall have occasion to remark hereafter, seem to run continuously from one set of rocks to the other wherever they lie in contact. The porphyry of Port Royal parish [=Newcastle Porphyry], where it has a limited distribution, is unusually felspathic and decomposed. In St. Andrew's it is less so, but very much jointed, and broken into laminae, which render it easy for exploitation; at the same time, it does away with the necessity of heavy and expensive timbering. In Clarendon parish, the varieties of porphyries are usually sandstone and limestone [porphyry at this time also included sedimentary rocks!], and are frequently expensive to work, being sometimes very “heavy” as the miners term it, or else excessively hard. The sandstone porphyries are dark red, and frequently veined with gypsum [Brooks gypsum], which exists in branches of from one-sixteenth to three inches thick, while occasionally a vein of steatite [talc or soapstone] also traverses them.

“The existence of gneiss I have proved in a few instances, but the area occupied by it is inconsiderable, and, geologically speaking, unimportant.

“Trap-rocks [essentially lava flows and sills] occur to a considerable extent on the south flank of the Blue Mountains for about 30 miles in length. The specimens which I have seen are excessively hard and fine-grained, and their existence in this locality will probably tend to account for the intense disturbance and violent upheaval

of the whole of that part of the island with which they are in proximity. The trap breaks through the Silurian shales, and frequently influences them in a remarkable manner, sometimes converting them into a kind of metamorphic rock, at other times fusing the line of contact; and in all cases where these eruptive masses occur the strata are much warped and contorted.

“The Silurian shales and slate form the greater part of the stratified rocks of the island. The limestone, although occurring in greater area, does not appear to have any determinate and true lines of bedding. The strata are those which form those vast elevated tracts of mountain land in the interior of the island. Minerals are not unfrequent in these rocks, as lead at Hope, cobalt at Bloxburgh, copper in Lucky Valley, Newcastle Botanic Gardens, Abbey-green, Silver-hill, &c., but do not appear, as far as yet proved, to occur in any large quantities or in any strong and well-defined lodes. These strata are often much contorted, even where immediate igneous action does not appear to exist, are usually in thin beds, sometimes very “tight” and hard, but generally of a more facile character for exploitation, arising from numerous fractures and planes of cleavage. Silurian shales of a black colour also exist in places interstratified with the slaty beds; this shale is frequently bituminous, and affords by distillation empyreumatic [burnt, charred, or smoky] oils, with ammonia compounds.

“The limestone formation of Jamaica [White Limestone] occupies the littoral margin of the island, as also nearly the whole of the interior of its central portions. This rock exhibits no bedding, and as far as road cuttings and other small excavations have determined, it occurs in irregular blocks, jointed together by ferruginous [bauxite] and argillaceous matters; it is generally very spongy and honeycombed, contains a considerable percentage of silica [flint or chert in the deep-water limestones], and where it lies in contact with the granite and igneous rocks of Mount Salus estate (St. Andrews), has been either entirely or partially converted into a friable mass of native lime. The formation has, by abundant trials, been frequently proved to be entirely destitute of any valuable metallic minerals, although considerable quantities of magnetic iron ores occur in it, in the parish of St. David, about 14 miles from Kingston.

“The dark red sandstone and conglomerate occupy a long narrow strip lying between the porphyritic and Silurian rocks of those central mountains of the island lying immediately behind Kingston [the Wag Water Belt]; small quantities of various ores have been from time to time found in these strata, but they have not proved the existence of any regular deposit of mineral. This conglomerate is bedded, but lies at very high angles; its composition is a mass of porphyritic, epidotic, and Silurian rock pebbles, embedded in a very ferruginous sandstone, its colour is very dark, and it is a rock which, under the influence of the atmosphere, rapidly disintegrates and crumbles away. Small quantities of coal measure strata are said by Sir H. De la Beche to exist in the parish of Portland, but I have not had an opportunity of verifying his observations.

“There are two extinct volcanoes in the island, although I only find one marked in Sir Henry De la

Beche's map, but the existence of another in the Port Royal mountains, about five or six miles north-east of Flamstead, I have determined, It rises in a crater-like cone to an elevation of 4870 feet, and its summit is about one-fourth of a mile wide, perfectly bowl-like, while volcanic ashes, cinders, and lava circumjacent, abundantly prove its former activity. The ascent to the summit is very tedious and difficult, and not entirely without danger, yet the magnificent view to be obtained from thence, and the numerous geological phenomena to be observed, abundantly reward the tourist who shall be sufficiently enterprising to gain the top of the crater. I may possibly at some future day offer a more extended notice of this phenomenon than is proper for the limits of this paper.

"Diluvium exists in the plains bordering the sea, and to a considerable depth, I have not, however, been able to find that any borings have proved the subjacent strata.

"The copper lodes of Jamaica have various strikes, but those at present determined range chiefly from about 10° east of north to 50° west of south. One lead lode, at Hope, has a direction of about 10° east of north and west of south; - and is, therefore, somewhat caunter to the mean course of the copper lodes. The copper lodes of the island are frequently disturbed by small heaves. The lodes have usually well-defined walls, but in most instances the ordinary vein stones and gangue of the Cornish lodes do not exist, but are replaced by porphyry and allied minerals; an exception to this rule, however, occurs in some of the lodes of Mount Salus, where gossan [iron oxides and hydroxides], quartz, and priany [clays due to hydrothermal alteration] material largely occur. The underlie of the lodes is almost invariably to the north-east, but is very various in its amount. On the backs of the hills the inclination is sometimes more flat than at greater depth, which may proceed from some very slow slipping action of the hill, which being usually excessively steep and frequently very loose ground, may probably warp the lodes with it. Some of the lodes carry strong "backs," and may be readily traced for some distance; as for instance Simpson's lode on Mount Salus, which has been proved continuous for 700 fathoms, while others again, as those in Port Royal parish, appear tolerably well defined and regular for a few fathoms, and then suddenly dwindle away.

"The lodes of Jamaica usually continue from one set of strata to another. At Mount Salus they traverse granite, porphyry, and gneiss, without being apparently affected by the change of "country." Whether these different rocks will have some effect in depth upon the continuous strike of the veins, or in any way determine their productions, is a question which can only be solved by efficient explorations.

#### **Remarks on mining in Jamaica. – No. III, by George Darlington (Darlington, 1856b)**

"In my former letters, I remarked upon the general geological and metalliferous strata, of Jamaica: in this and sequent ones, I purpose describing the various mines which have come under my observation.

"At the present time, the parish of Clarendon is one

possessing much interest to the English public, both for the amount of money at stake in the Clarendon and Jamaica Mines, and also for an opinion which seems to have made some impression upon the home adventurers — viz., that it is to these mines we must look for the earliest solution of the question as to whether mining in Jamaica will ever become profitable. The mines in Clarendon parish are three in number—Clarendon Consols, Wheal Jamaica (Charing Cross Mine), and Orange Brook.

"The first of these is a powerful company, having a capital of 80,000l. [Guineas]. It may, consequently, be inferred that, if the mines fail, it will not be for lack of money, or those special adjuncts to the prosecution of mining explorations which ample funds will command. The Clarendon Consols have been working between three and four years. The lode is large, but frequently disturbed, and may be considered as composed in mass of porphyry, quartz, and siliceous matter, with spots of yellow ore [chalcopyrite]; some mundic [pyritic] also occurs, but the lode is usually rather hard, and has not to the present time afforded any large quantity of ore. It is, however, powerful enough to make a valuable mine in depth, in which direction the workings should be prosecuted. The lode of the Charing Cross Mine is supposed to run through the western part of the sett, and caunter to the course of the Clarendon lode. This fact, if correct, would prove a valuable feature in the future prospects of the mine, and should, I consider, be at once definitely determined. The staff on the mine is large and effective.

"Wheal Jamaica, or Charing Cross Mine, is situated on the south-eastern flank of the mountain upon which the Clarendon Consols are located. This mine was started as a private adventure by several of the more wealthy and respectable inhabitants of Jamaica, with the legitimate object of proving the mineral wealth of the island. At Charing Cross Mines, the workings are confined to one lode. This lode is from 4 to 5 ft. wide, and underlies at a regular angle, about 10 inches or 1 foot in a fathom; the walls are also regular and well-defined. Operations have been carried on by means of adit levels in the side of the mountain in which the lode runs, and which rears itself, at a high angle, to an elevation of about 800 feet above the valley. Hence the adits rapidly gain a good "back," or height. Several levels have been extended on the course of the lode at vertical distances, averaging 12 or 13 fms. apart. In each level good ore has been found running in regular branches, chiefly on the footwall of the lode. In the upper levels the ore is of a somewhat ferruginous nature. In depth it alters to a compact ore, free from gossan [iron oxides and hydroxides], but very quartzose. In the 58 fm. or bottom level, at the time of my visit, the ore was of a very good quality, and ran in branches, some of them at least a foot wide. The ore occurring in these mines is almost entirely yellow pyrites, often finely iridescent, and breaking upon crystalline planes into small rhomboidal lumps, black on the faces, but consisting of solid ore; small quantities of green and blue carbonate [malachite and azurite], resulting from

the decomposition of the yellow ore, as also a minute quantity of grey ore [chalcocite], is found in the upper level. The geology of the surrounding rocks belongs to the porphyritic series, being chiefly sandstone and limestone porphyries. The ground is in some places hard, but cannot upon the whole be deemed excessive in this respect, and may be considered tolerably favourable to the existence of metallic minerals. The lode is generally very soft and easy to work, and can be stoped away at a low price per fathom. It is of a priany nature [clays due to hydrothermal alteration], with branches of yellow ore and quartz running through its whole extent, and from the bottom level a considerable quantity of water issues. At the time of my examination the stopes were worth from 4l. to 15l. per fm., while the back of the 58 fm. level would give ground worth in some places 25l. per fm. The prospects of the mine are of a highly encouraging character, but here, as elsewhere, sinking below the base of the hills must probably be resorted to before any permanent profit over and above all working expenses can be looked for. The capital of the concern is nominally 100,000l.; of this, 35,000 shares of 1l. have been issued, and upon 25,000 of these about 12s. per share has been paid, leaving 10,000 free shares, which have been disbursed in payments for the sett, lease, preliminary expenses, &c. It has been proposed to raise further capital in order to sink deeper: I would endorse this proposal.

“At Orange Brook, an adit level has been driven on the course of the lode, which is chiefly composed of copper and iron pyrites. The works are at present, and have been for some time, in statu quo, for want of capital, but the specimens of ore which I saw induced me to think somewhat favourably of the property. I had not an opportunity of personally inspecting the workings, from the level mouth having fallen together, and therefore cannot give any detailed description of them. In my next letter, I intend making some remarks upon the mines in the parish of St. Andrews.

**Remarks on mining in Jamaica. – No. IV, by George Darlington (Darlington, 1856c)**

“ST. ANDREW'S PARISH, --- The mines and localities offering mineral indications in this parish are numerous, but in the present letter I shall confine my remarks to the most extensive of the series — the Mount Salus Mines. This mineral sett is situated on the western side of the Liguanea Mountains, being a run of very elevated limestone hills, attaining an altitude of from 2000 to 3000 ft. These are flanked by porphyritic, syenitic, and granitic rocks, which are broken up by channels of gneiss and trap. The surface of the ground is here, as elsewhere, very hilly and precipitous, diversified by valleys and deep ravines. As this property possesses excellent chances of ultimate success, I shall describe at length its geological and mineral features. The various rocks which occur are entirely igneous, or metamorphic, the former exist as porphyry, granite, and trap; the latter as gneiss. At the south-eastern boundary of the sett, on the top of a very high hill, Silurian limestone

exists, but at a few fathoms below granite occurs; this rock throughout the sett is highly decomposed, and answers to the “growan” [coarse-grained granite or grit] of Cornwall. The granite does not occupy any extensive area, but is immediately succeeded by large masses of minutely crystalline garnet rock [hornfels?], which, however, sometimes displays crystals of a larger and more distinct character. This deposit of garnet rock contains some small spots of yellow copper ore [chalcocopyrite], and was considered by many persons, during the mining fever which existed in Jamaica, some three or four years ago, to contain tin ore [cassiterite]; it contains, however, none of the characteristics of that mineral. This rock is in turn replaced by decomposed porphyry, through which run numerous branches of micaceous and magnetic iron ore [specularite and magnetite], spotted with yellow copper [chalcocopyrite], and coated with “greens” [malachite].

“Proceeding east, a very large mass of gossan [iron oxides and hydroxides] is found, spotted with greens [malachite], and offering other indications of the existence of copper ore, appears to be the back of a large copper lode, but nothing has as yet been done upon it to show its value or prospects. From this point the road continues for 250 fathoms over decomposed granite, which is traversed by numerous strings and veins of feldspar [former spelling of feldspar]. On the side of another high hill, but not more than 30 fms. above its base, is Hart's lode; this lode varies in width, at the first point of intersection it is from 4 to 5 ft. wide. An adit level has been driven about 16 fms on its course, which has shown some good stones of ore. The ground is very soft, formed of decomposed porphyry; the strike of the lode is about north-north-west by south-south-east. At the distance of a few fathoms another lode exists, apparently about 5 or 6 ft. wide, but which has not been explored. It appears to run parallel with Hart's lode. Its mineral is strongly coated with green and blue carbonate of copper [malachite and azurite].

“Within a distance of 70 fms. west of this place courses Julia's lode; it is apparently about 4 ft. in width, of a very promising character. At an elevation of 40 fms. above the base of the hill an adit has been commenced, which at the onset exposed some considerable branches of yellow ore [chalcocopyrite]. These have continued as far as explorations have yet been carried, and the lode has yielded an average value of 10l. per fm. The stratum is decomposed porphyry, of a character highly congenial to the existence of ore, and in the area between this and Hart's lode numerous veins of a cupreous character occur; these strings appear to be feeders to Julia's lode. This lode has been proved for some considerable distance. About 300 fms. north-north-east of the present level, upon the strike of the lode, a mass of gossan [iron oxides and hydroxides] has been exposed by the breaking away of the ground; this deposit appears to be running in the direction of Julia's lode, and is probably connected with the same. It occurs on the top of a hill about 20 fms. high.

“Due east-of Julia's lode a large area of gneiss and felspathic trap occurs; the latter is veined with strings of the proto-sulphide of copper, which exists in very large quantities. Many specimens have afforded me from 1 to 2 per cent. of copper. The stone, per se, is very fusible.

“North-east of Julia's lode, another lode occurs, to

which the name of Simpson's has been given. This lode is one of the finest upon the property it has a nearly parallel run to that of the other lodes, being about south-east by north-west. Its width is about 5 feet, and is composed of yellow copper [chalcopyrite], gossan [iron oxides and hydroxides], and granite. It runs in very regular walls, which underlie to the north-east about 1½ foot per fathom. An adit has been driven about 20 fathoms on its course, and the end has been well spotted with ore for the whole distance. This lode has proved continuous for about 250 fms., and maintained its high promise and character throughout. The circumjacent country is growan [coarse-grained granite and grit], of a very easy character for cross-cuts, while the lode itself can be wrought cheaply. It discharges a large stream of water.

“Next in order is Bailey's lode; its dimensions have not yet been satisfactorily determined. An adit level upon its course, and a level to cross-cut the lode, have been driven, but as yet they have only proved that the lode is irregular in its width. Its composition consists chiefly of a mass of gossan [iron oxides and hydroxides] on its back, which at no great depth changes into mundic [pyritic], prian [clays due to hydrothermal alteration], and peach. Some considerable quantities of yellow and red ores (the latter the sub-oxide of copper) [chalcopyrite and cuprite] were found on commencing the adit level, but the present end is entirely free from cupreous minerals. This lode is about 8 ft wide on its back, and can be traced for 400 fms. Its bearing is the same as that of the other lodes in the sett — north-north-west by south-south-east, and it is many respects a very promising feature in the property.

“Eighty fathoms south-west of Bailey's lode, Thompson's lode occurs. From the explorations which have been made, it is about 5 feet wide; its strike is caunter to most of the other lodes in the sett, being south-south-east by north-north-west; it is composed of yellow siliceous material, spotted with yellow ore [chalcopyrite]. The ground here, and at Bailey's, is decomposed porphyry, but a slide appears to exist which has heaved Thompson's lode and broken it up, and otherwise disturbed its regularity. To the east of Thompson's, and parallel with it, there is another lode; this has not yet been completely proved; its composition is bog and magnetic iron ores, peach [xxxxx], prian [clays due to hydrothermal alteration], granite, and flookan [clays], with spots of yellow copper [chalcopyrite] — its

appearance is very promising. Further east reposes a mass of syenitic granite, and the sett is finally bounded by crystalline limestone.

“The mines belong to a few gentlemen of the island, and are conducted as a private adventure, strictly on the Cost-book System; operations were begun about three months ago. The fact of such an extensive property (it being 2 miles long and ¾ mile wide), being commenced at a time when mining in Jamaica has reached such a low ebb in public estimation, speaks loudly in favour of the valuable prospects of this property. The company have a capital of 5000l., with power to raise 5000l. more, but, if a much larger sum were paid up at once, there would be ample and bona fide grounds for its employment.”

## Discussion

Darlington's discussion of the geology of Jamaica leans heavily on the published work of [De la Beche \(1827\)](#). It demonstrates that De la Beche's work was still being used in Jamaica, even though De la Beche himself has already effectively retracted his own remarks ([De la Beche, 1830](#)). Darlington had clearly been to the areas he described and he adds descriptive comments to many of the mining areas that relate to the geology. Amongst some of the most important, are the orientations of the mineral veins, and this is something that has not been subsequently followed up upon. While the terminology has changed, the report is important in showing what practicing geologists of the day were using. Clearly, at the same times the members of the Society of Arts of Jamaica were forming new opinions as to the ages of the rocks of Jamaica ([Hill, 1856](#); [Mitchell, 2023](#)), yet this information does not seem to have been available to many of the mining geologists.

[Darlington's \(1857\)](#) description of a second extinct volcano also deserves some mention. While he describes what sounds like an extinct volcano, no subsequent mapping has identified anything similar. Apparently in this, he was mistaken.

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