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ORIGINAL ARTICLES.

The Scotland Beds of Barbados.

By C. T. Trechmann, D.Sc., F.G.S.

(PLATES XXI–XXIV.)

BARBADOS, occupying as it does the position of the most easterly and isolated and the furthest out in the Atlantic Ocean of all the West Indian Islands, deserves special attention from geologists. Its rocks consist essentially of three units each separated from the other by an important unconformity, namely in descending order the Coral Rock, the Oceanic Series, and the Scotland beds.

The most conspicuous formation is the Coral Rock which covers six-sevenths of the island and rises in a number of well-marked terraces with intervening plains or gentle slopes up to the highest points, which occupy a curved ridge 1,000 to 1,130 feet in height, extending for some miles around the north-eastern area. The portion of the island below the Coral Rock escarpment where the older beds are exposed is known as the Scotland district, a name given to it by the early settlers on account of its rugged character.

The Coral Rock.

An excellent account of the Coral Rock and other formations of Barbados has been given by Sir J. B. Harrison and A. J. Jukes-Browne[1] and I can add but little to their account. My observations entirely support their view that the Coral Rock is of Pleistocene and Recent age. Even at the highest levels of about 1,000 feet, where most of the shells and corals have been dissolved away and the calcite of the rock recrystallized as a dense mass, one can recognize such familiar recent mollusca as *Strombus gigas*, *Livonia pica*, *Astralium imbricatum* and other large shells which have here and there survived the dissolving process. The deposition of this thick and elevated and in places strongly altered mass of Coral Rock evidently represents a considerable period of geological time, but it seems to be entirely a Pleistocene feature.

[1] *The Geology of Barbados.* An explanation of the Geological Map, published by the Barbadian Legislature, 1890.

The Oceanic Series.

As regards this series I have little to add to the stratigraphic and microscopic studies of Harrison and Jukes-Browne. Large fossils are exceedingly rare in these beds except at one or two localities. One of these is at Bissex Hill, where an outlier of the Oceanics rests on Scotland beds. It seems to indicate a somewhat shallow water phase of the Oceanics and comprises several beds of light-coloured limestone some of them compact, massive, and blue-hearted, others thin and friable and made up of small fossils. These include *Globigerinae*, echinoderm spines, small turbinate corals, shark's teeth, etc. Mollusca are rare and poorly preserved, and I have not been able to gather much information from them. I do not think that beds of the Bissex Hill type pass up into the Coral Rock or are in any way related to it.

Mr. R. J. L. Guppy recorded from this locality *Echinolampas anguillae* Cotteau which should be Oligocene if the identification were correct. The famous supposed deep water echinoderm, *Cystechinus crassus* Gregory,[1] was found in a well sinking at Haynesfield and is a fossil of comparatively recent aspect. The age of the Oceanic Series is still in doubt, but from their comparatively slight disturbance and from other facts I am inclined to think they are not older than Pliocene. In this case they may be equivalent to the Manchioneal beds or Pteropod marls of Jamaica, but there is not yet any fossil evidence to support this correlation. Perhaps some evidence on this point may be forthcoming in the future.

The Scotland Beds.

The present paper is intended mainly as a contribution towards determining the age of the Scotland beds, the great and thick series of very strongly folded, contorted, and faulted rocks that forms the basement of the island, and doubtless underlies the Coral Rock and Oceanics everywhere. A very good general description of the Scotland Beds has been given by Harrison and Jukes-Browne, and I have no doubt that the sequence of the various clays, sand stones, grits, and conglomerates that they quote on pages 12 and 13 is essentially correct for the part of the Scotland area to which it refers, but a complete enumeration of the rather monotonous alternation of beds that form the Scotland series has not yet been published.

These authors, from the few fossils they observed tentatively express the view on page 15, that the Scotland beds are Miocene in age, a conclusion that is revised in the present paper, as the fossils are certainly of rather high Eocene aspect. They also estimated the thickness of the Scotland beds at about 500-600 feet, but I imagine the thickness of the series to be very much in excess of this.

[1] *Q.J.G.S.*, xlv, 1889, pp. 640–50.

FIG. 1.—Locality sketch map of Barbados. Sc., Scotland beds; Oc., Oceanics; the remainder is Coral Rock. $\overset{\uparrow}{\underset{B}{\ }}$ indicates roughly the position of the strike and dip of the fossiliferous conglomerate bed "b". The position of the two occurrences of the fresh-water sandstone bed is indicated by "a". The faults in the Scotland district are taken from the map of Harrison and Jukes-Browne, but there are evidently other faults not yet mapped. Haynesfield is the place where *Cystechinus crassus* Gregory was found in Oceanics below the Coral Rock. Views on Pl. XXI are taken from Chalky Mount and Ragged Point.

Neither the base nor the top of the Scotland Series can be observed in the small area afforded by their exposure, and faulting and zigzag folding of the thinner and softer beds makes their thickness very difficult to estimate, but I think it cannot be less than 2,000 feet at the least.

Before detailing my observations on the sections and fossils of

the Scotland Series I must acknowledge the assistance I received from Mr. Beeby Thompson, F.G.S., F.C.S., and Mr. A. Menzies. Before I had the pleasure of meeting these gentlemen I had searched several times for fossil-bearing beds in the Scotland district but with very little success. It was during his detailed work on the area for purposes of oil location that Mr. Menzies traced the two chief fossil beds, one of which crosses the Scotland area and was found to be of great value in elucidating the stratigraphy. He kindly pointed out several of the fossiliferous localities to me so that I was able to spend many subsequent hours in the agreeable pastime of fossil collecting.

Other fossil-bearing beds occur, but those just referred to seem to be the only two in the whole series that yield recognizable mollusca. Harrison and Jukes-Browne, for instance, mention a bed No. 4, rather low down in their sequence on page 13, consisting of 18 inches of calcareous sandstone with broken shells. Another bed of concretionary sandy grit containing very fragmentary unrecognizable shells can be seen near the shore some distance north of Chalky Mount. The two chief fossil-bearing beds of the Scotland Series are as follows :—

Bed "a".—A very hard indurated sandstone a few feet thick, often impregnated with pitch or oil containing large Lamellibranchiata (*Unio, Cyrena,* etc.), and large Gasteropoda (*Ampullaria*) and some smaller fossils also of fresh-water aspect, all of them fresh and unbroken but very difficult to break out of the matrix. This bed has not been observed in situ but is found as isolated masses that seem to have travelled down the valley slopes some distance from their point of origin. Several masses of it occur on the slope below Turner's Hall where portions of it may be in place; and a large piece full of fossils is seen in a stream below the conglomerate next to be described on the Spa estate. Judging from their present position these masses should occur in place some distance, possibly 150 feet or more, below the bed of conglomerate.

Bed "b".—A beach-like or shallow-water bed of unassorted conglomeratic material, which generally yields numerous fossils, the larger ones invariably in fragments, the smaller ones either quite fresh or more or less rolled and broken. It occurs apparently rather above the middle of the great mass of grits, shaly sandstones, and other beds that build up the Scotland Series, but it generally shows an angular discontinuity with the more regularly bedded series above and below it. It crops out at various places in the Scotland area, and seems to be the bed that is mentioned by Harrison and Jukes-Browne in their sequence on page 13 as bed No. 11, and again on page 15 as occurring on the Spa estate. I have examined this fossiliferous conglomerate and the beds above and below it at the following among other localities. It is remarkably rich in species, and every visit seems to yield a new addition to the list, but the specimens as a rule are somewhat small.

Description of Localities.

The Ridge between Spa Estate and Cane Garden.

The fossiliferous bed "*b*" here forms part of a steep and precipitous ridge made up largely of the more resistant conglomerate which strikes west-north-west and east-south-east, and dips almost vertically. The sequence appears as follows in descending order :—

	Thickness in feet.
1. White sandstones with marly partings and alternations of shaly sandstones	Several hundred.
2. Thick dark irregular sandstones	20 (?)
3. Impure nodular sandy limestone . . .	3
4. Conglomerate with fossils	12–20
5. Coarse dark petroliferous grits and sandstones, the grains rounded	100 (?)
6. Sandstones and shales with ferruginous concretions	Several hundred.

The conglomerate (No. 4) is made up chiefly of rounded quartz pebbles and sand grains and pieces of derived sandstone and shale. Small claystone nodules of round or elongated form often broken also occur, some of which show a concentric structure while others have grown partly round crab claws, or more rarely around a shark's tooth or other organism. Oyster shells of a dark colour, broken and rolled, sometimes embedded in a sandstone matrix, evidently derived from a somewhat older dismantled formation, are also found. Small rolled pieces of sandstone or clay limestone full of Foraminifera (*Nummulites* and *Orthophragmina*) derived from an older, but apparently not very much older bed together with small rolled corals and rounded masses of *Lithothamnion* are also rather frequent. Shells of various mollusca occur sharp or more or less rolled and are evidently contemporaneous with the conglomerate bed. Although a careful search was made no trace of igneous or metamorphic derived rocks was seen in any of the Scotland conglomerates, nor any trace of derived fossils except those from the above-mentioned rather older Eocene bed or series of beds which must have been undergoing denudation during the deposition of the conglomerate.

The Ridge near Sunbeam Estate below the foot of Turner's Hall Wood.

The fossiliferous bed here comprises several bands of conglomerate each a few feet thick, made up of pieces of quartz and clay-limestone and other material interbedded with shales and sandstones. The constituents of the conglomerate are very similar to those at Spa. The series strikes east-north-east and west-south-west and dips at very steep angles about north-west. The sequence appears as follows in descending order :—

1. Sandy shales.
3. Very thick white sandstones with shales.
3. Conglomerates with fossils.
4. Sandy shales with ironstone nodules and large selenite crystals.

The conglomerate (No. 3) in this locality is seen twice on the

path which leads along the ridge, the repetition is apparently due to faulting.

Ragged Point.

Beds low down in the Scotland Series are well seen at Ragged Point lighthouse in the south-east corner of Barbados, where they are partly covered by a thin layer of Coral Rock, the Oceanics being absent just here. They dip north-west at about 30°, but no fossils were seen in any of them. I enumerated the beds exposed in this locality as follows :—

	Approximate thickness in feet.
Coarse sandstones with rounded grains	60
Sandy shales with ferruginous partings	10
Sandy blue shales	10
Fine-grained well bedded grit	25
Sandy blue shales	12
Ferruginous grit	5
Sandy blue shales	10
Ferruginous sandstone	15
Sandy blue shales	5
Soft grit	2
Soft blue shales	3

Chalky Mount

There is nothing chalky in the composition of the rocks of this locality, but the thick precipitous and jagged steeply dipping white sandstone that forms the highest part of the elevation seems to have given rise to the name. The beds strike approximately between east and west and north-east and south-west, and dip at 70°–80° to the north. The sequence is as follows :—

	Thickness in feet.
1. Coarse white sandstone with gritty beds and ferruginous partings and concretions	over 300
2. Alternating shales and sandstones	30
3. White sandstone	20
4. Fossiliferous conglomerate bed	12–20
5. Alternations in thin bands of brown or white soft sandstones and beds of coarse grit with thin bands of Selenite crystals along the bedding planes	over 300

The conglomerate band here is compact and resistant and is made up of elongated rolled masses of sandstone up to a foot in length, rolled pieces of a sandy limestone with rather large *Ostrea*, and here and there small rounded fragments of rock containing small *Nummulites*. The contemporaneous fossils are similar to those at Spa and Sunbeam, but most of them are very friable and fragmentary. I collected a specimen of the variety of *Clavilithes solanderi* on the highest point of the conglomerate outcrop.

This easily recognizable fossil-bearing conglomerate maintains a thickness of 12–20 feet, and can be traced dipping steeply across

the massif of Chalky Mount where it crosses the ridge and descends the precipitous southerly slopes and passes out to the sea under the waters of the Atlantic Ocean with a nearly vertical dip. North of Chalky Mount, along the coast a bed of coarse sandstone with broken fossils, mostly pieces of small *Ostrea*, occurs among beds some 200 feet higher than the white sandstone that forms the summit of Chalky Mount.

Conclusions and Correlation.

The only recognizable fossils in the Scotland beds seem to occur at two small horizons not very far removed vertically from one another, so that conclusions as to the age of the beds refer to this portion of the series, while the very considerable thickness of beds above and below may be appreciably newer or older. The whole succession of beds seems to be of shallow water, and in some cases of estuarine origin. The hard sandstone (bed "*a*"), which has been mentioned as not occurring actually in situ, contains mollusca only of fresh-water origin. The conglomerate band (bed "*b*") is the only bed that yields well-preserved marine fossils, and the rolled condition of these, mixed as they are with a number of fresh- and brackish-water forms, points to the temporary invasion of a shallow water or littoral formation among the thick mass of unfossiliferous shales and grits above and below.

Exponents of the hypothesis of an Eocene continental land mass, "Antillia" or "Atlantis", may take courage from the occurrence of beds full of large fresh-water mollusca in this small and isolated island where now scarcely a stream and much less a river occurs. Curiously, however, no trace of any old rocks other than quartz pebbles has been observed in the Scotland Series so that the nature and position of the land whence the material was derived is unascertainable.

The fragmentary condition of many of the Scotland fossils and the small area afforded for collecting them makes it advisable to wait till more material is at hand before undertaking an exhaustive study of the fauna. Enough fossils have, however, already been collected to show clearly the general nature of the fauna and to indicate that it has much affinity with the Claiborne facies of Alabama, the Eocene of Nigeria found at Ameki, and the Lutetian and probably more to the Bartonian of Europe. The horizon of the fauna seems to be high in the Middle Eocene, or rather low in the Upper Eocene (Lutetian-Auversian-Bartonian). For the convenience of those geologists interested in West Indian stratigraphy I have made a somewhat preliminary determination of the fossils I collected and have photographed as many of them as space permits.

Comparison of this fauna with that of the Yellow Limestone in Jamaica is inconclusive because the Yellow Limestone fauna lived in situ, while the Scotland conglomerate is a washed-up

or assorted shallow-water bed. The absence of *Velates*, large *Cerithia*, large *Lucinae*, and other forms common in the Yellow Limestone may be noted. In all probability the Scotland fossils belong to a higher horizon than the Yellow Limestone, and may correspond in time with some part of the lower White Limestone in Jamaica, such as the Claremont and Goschen beds which contain a prolific and unstudied fauna but which so far as I could observe, bears no similarity to that of the Scotland beds.

As regards Trinidad, the Scotland fauna seems to have some affinity with that found at Soldado Rock, an islet off the south-west corner of Trinidad characterized by *Venericardia planicosta* Lam. and correlated with the Midway Eocene of Mississippi, Georgia, and Alabama.[1] The Scotland fauna, however, appears to be considerably later.

Description of Fossils.

Voluta cf. *pyruloides* Conr. (Pl. XXII, Fig. 3.)

Shell pyriform, smooth, with four very strong slanting anterior columellar folds. Length 34 mm., width 18 mm. From Spa. It resembles *Voluta* (*Caricella*) *pyruloides* Conr. (*De Greg.*,[2] pl. v, figs. 27 and 28), but the shell is narrower than in fig. 27 and the spine is broader and more elongated and the columellar folds stronger, closer together, and more anteriorly situated in the Barbados than in the Alabama form.

Voluta cf. *petrosa* Conr., var. *gracils* Lea. (Pl. XXIV, Fig. 4.)

This shell from Sunbeam closely resembles the above variety figured by De Gregorio (pl. iv, figs. 54 and 55). It has three or four small columellar folds.

Ficula (?) *scotlandica* sp. nov. (Pl. XXIV, Fig. 19.)

Shell of six whorls, fragile, with sharp spire, early whorls rounded with longitudinal ridges, the penultimate whorl keeled. The body whorl is large, tabulate and keeled below the suture, the middle part smooth, the anterior part decorated with very fine close-set parallel spiral ribs. Length 15 mm., width 8 mm. It comes near *F. juvenis* Whitf. of the Claiborne beds, but has no nodes and only one keel on the body whorl.

Mitra scotlandica sp. nov. (Pl. XXII, Fig. 2.)

Shell of seven or eight whorls, fusiform, sutures shallow, whorls rather flat, the last one somewhat tabulated below the suture, the anterior canal produced, aperture elongated. The inner lip has three or four thin and weak posteriorly directed folds, and is rather

[1] Carlotta J. Maury, *Acad. Nat. Sci. Philad. Jour.*, ser. 2, vol. 15, 1912, pp. 25–112, pls. 5–13.

[2] Monographie de la Faune Éocénique de l'Alabama. *Annales de Géol. et Pal*, liv, 7me Livraison, 1890.

Pleurotoma (*Strombina* ?) sp. (Pl. XXIV, Fig. 21.)

This specimen from Spa appears to come near to *Strombina gemmata* Conr., a reproduction of whose figure is given by De Gregorio (pl. i, fig. 84). It may, however, be a new species.

Cryptoconus sp. (Pl. XXIV, Fig. 23.)

Several smooth or nearly smooth forms occur at Spa. A slender fusiform species is 16 mm. long and 6 mm. wide, and resembles *C. evulsus* Desh. of the Cuisian (*Iconogr.*, pl. xlix, fig. 216-7) but in the Barbados shell the apertural sinus seems wider and shallower. Another rather large and stout species with the spire missing, 20 mm. long and 10 mm. wide, is more like *C. denudatus* Desh. of the Lutetian (*Iconogr.*, pl. xlix, fig. 216–10).

Cryptoconus barbadensis sp. nov. (Pl. XXIV, Fig. 6.)

Shell of eight whorls, rather solid, spire produced, sutures well impressed, whorls gently rounded, rather tabulate below the suture. Body whorl rather longer than the spire, narrowing rapidly anteriorly. Length 24 mm., width 11 mm. This species has rather the shape of *C. approximatus* Desh. of the Lutetian (*Iconogr.*, pl. xlix, fig. 216–9) but is stouter and has more tabulate whorls. Spa, five specimens.

Borsonia sp. (Pl. XXIV, Fig. 32.)

Specimens from Spa resemble *B. brevicula* Desh. of the Lutetian and Bartonian or *B. minor* Desh. of the Lutetian (*Iconogr.*, pl. xlix, fig. 218), but seem to be considerably larger.

Solarium sp. (Pl. XXIV, Figs. 38*a* and *b*.)

This small narrowly umbilicated form from Spa comes very near *S. bonneti* Cossm. from the Bartonian. (*Iconogr.*, pl. xvi, fig. 104–21.)

Serpulorbis sp. (Pl. XXIV, Fig. 31.)

Irregular masses and detached fragments of the tube resemble *S. ornatus* Lea. (De Greg., pl. x, figs. 34–38.)

Dentalium sp. (Pl. XXIV, Fig. 30.)

Shell rather thick, with numerous faint longitudinal rounded ribs crossed by faint growth interruptions giving under a lens a reticulate pattern. This form, common at Spa and Chalky Mount, has the shape of *D.* (*Entaliopsis*) *grande* Desh. of the Bartonian.

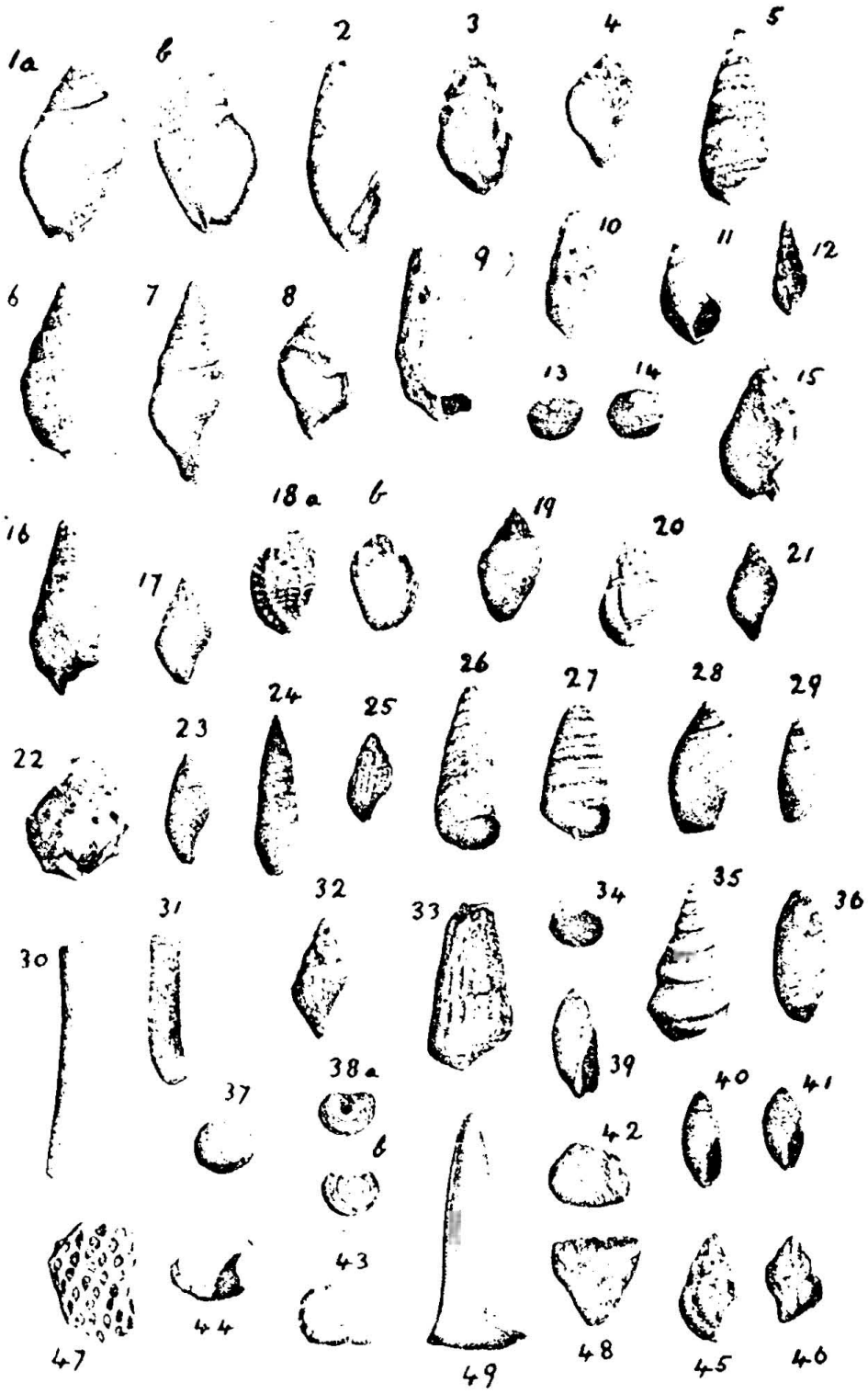
Ostrea cf. *sellaeformis* Conr. (Pl. XXIII, Fig. 4.)

Two right valves about 19 mm. long, and a fragment of a rather larger one agree with figures of this Alabama shell, especially De Gregorio, pl. xviii, figs. 21 and 22, and pl. xix, fig. 13, var. *divaricata* Lea. They also resemble some varieties of *O. flabellula* Lam. of the English Eocene, a form that De Gregorio quotes as a mutation of *O. sellaeformis*.

FIG.
7.—*Nucula* sp. (near *N. magnifica* Lea) Spa.
8.—*Nucula* sp. (near *N. mixta* Desh.). Spa.
9.—*Nucula* sp. (near *N. bisulcata* Sow.). Spa.
10.—*Cypraea* (*Bernayia*) cf. *inflata* Lam Spa.
11.—*Ampullaria* (*Euspira* ?) sp. Spa.
12.—*Natica* (*Lunatia*) cf. *semilunata* De Greg. Spa.
13.—*Natica* (*Neverita*) cf. *mamma* Lea. Spa.
14.—Ditto, another specimen, showing umbilicus. Spa.
15.—Ditto, another specimen, umbilicus less calloused. Spa.
16.—*Cypraea* sp. Fragmentary specimen. Spa.
17.—*Siphonalia* sp. From Sunbeam.
18.—Ditto. Another specimen with more conspicuous striae. **Sunbeam.**
19.—*Ancilla* cf. *scamba* Conr. Spa.
20.—*Sigaretus* (*Sinum*) cf. *clathratum* Gmelin. Spa.
21.—*Nasseburna* cf. *calli* Aldrich. Spa.
22.—*Siphonalia* (*Pseudoneptunea*) sp. Spa.
23.—*Parvisipho* (?) sp. Spa.
24.—*Terebralia* sp. Spa.
25.—*Rostellaria* (?) sp. Spa.
26.—*Mesalia* sp. Spa.
27.—*Turritella* cf. *hybrida* Desh. Spa.
28.—*Turritella* cf. *interposita* Desh. Spa.
29.—Ditto, another variety. Spa.
30.—Ditto, another variety. Spa.
31.—*Pleurotoma* sp. Spa.
32.—*Pleurotoma* (*Coronia*) sp. Spa.
33.—*Diplodonta* (?) sp. Spa.
34.—*Diplodonta* sp. Spa.
35.—*Leda* (near *L. claibornensis* Conr). Spa.
36.—*Thersitea barbadensis* sp. nov. Spa.
37.—Ditto. Apical view of a rolled fragment. Spa.
38.—Ditto. A specimen with the spire completely calloused. **Spa.**
39.—Ditto. A specimen with the spire free. Spa.

PLATE XXIV.

1 *a*, *b*.—*Pseudoliva scotlandica* sp. nov. Spa.
2.—*Bayania* sp. Spa.
3.—*Lithasia* (?) sp. Spa.
4.—*Voluta* cf. *petrosa* Conr. var. *gracilis* Lea. From Sunbeam.
5.—*Tympanotonus* sp. Spa.
6.—*Cryptoconus barbadensis* sp. nov. Spa.
7.—*Pleurotoma* (*Bathytoma*) sp. Spa.
8.—*Mitra* sp. Spa.
9.—*Potamides* (?). Spa.
10.—*Terebralia* sp. Spa.
11.—*Bayania* sp. Spa.
12.—*Melanatria* sp. Spa.
13.—*Nerita tricarinata* Lam. Spa.
14.—Ditto. Another specimen. Spa.
15.—*Nassa* sp. Spa.
16.—*Cerithium* (*Tiaracerithium*) sp. Spa.
17.—*Pleurotoma* (*Clavatula*) cf. *desmia* Edw. Spa.
18 *a*, *b*.—*Oniscia scotlandica* sp. nov. Spa.
19.—*Ficula* (?) *scotlandica* sp. nov. Spa.
20.—*Siphonalia* (?) sp. Spa.
21.—*Pleurotoma* (*Strombina* ?) sp. Spa.
22.—*Plicatula polymorpha* Bellardi. Spa.
23.—*Cryptoconus* sp. Spa.
24.—*Pleurotoma* (*Eopleurotoma*) cf. *bicatena* Lam. Spa.



C. T. T., *photo.*

SCOTLAND FOSSILS, BARBADOS.