CHAPTER IV.

Tenerife to St. Thomas—St. Thomas—St. Thomas to Bermuda—The Brachiopoda—Gulf Weed Fauna—Description of Bermuda—Bermuda to Halifax—The Gulf Stream—Halifax to Bermuda—The Tunicata.

Tenerife to St. Thomas Island, West Indies.

The Challenger left Santa Cruz, Tenerife, on the evening of the 14th February. The weather was bright and pleasant, with a light breeze from the northeast. A south-westerly course was pursued for a few days, until well within the northern limit of the trade wind, after which the route followed was, as nearly as practicable, in a straight line

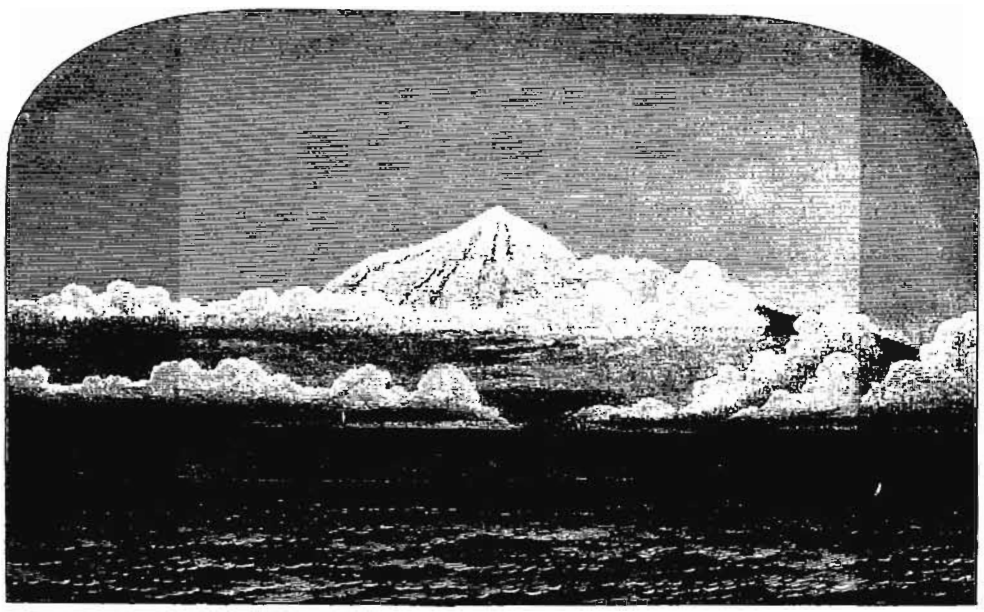


Fig. 48.—Peak of Tenerife from the N.W., 40 miles.

to Sombrero Island, the outlying sentinel at the northeast extremity of the Lesser Antilles. On the 14th March the island of St. Martin was sighted, and the last sounding on the Tenerife-Sombrero section obtained, after which a course was shaped to pass between Sombrero and Dog Island, and on the 15th three soundings and three dredgings were obtained in from 450 to 590 fathoms southwest of Sombrero. On the 16th, at 1.30 P.M., the ship arrived at St. Thomas Island, and anchored in the Gregerie Channel, so as to enjoy the full benefit of the sea breeze during the stay in the port.

On this section twenty-four soundings, fifteen dredgings, two trawlings and thirteen serial temperature soundings were taken (see Diagram 1 and Sheet 6). The sounding line parted on one occasion, owing to the spring of the Hydra rod failing to disengage the sinkers; and on another occasion the rod when it reached the surface had nearly 100 fathoms of sounding line entangled around it, owing, in all probability, to the perfect stillness of the water for some considerable distance over the bed of the sea, so that the quantity of line allowed to run out in excess of the depth (necessary to obtain by the time intervals a proof that the bottom had been reached) descended exactly on the sounding rod, and remained entangled by the last coil hitching itself round the other parts before "heaving in."

Of the fifteen dredgings five were unproductive, the dredge having come up empty twice and foul thrice. One of the most successful dredgings in this section, so far as procuring a large sample of the deposit from the bottom was concerned, was obtained by sinking the apparatus with 3 cwt. of sinkers attached to a Hydra rod at the bottom of the dredge net, the depth being 3150 fathoms. The bag came up with a large quantity of mud in it. The temperature of the mud was found to be the same as the bottom temperature given by the deep-sea thermometers, and some champagne was cooled by placing the bottles in it. The first trawling in 1950 fathoms, the deepest up to that time attempted, was unsuccessful, as the beam of the trawl, which was of fir, was broken at the bottom, whilst the pressure of the water was sufficient at that depth to crush the softer parts of the wood to such an extent that, when the beam was brought to the surface, the knots were standing out nearly three quarters of an inch beyond the general surface of the wood.

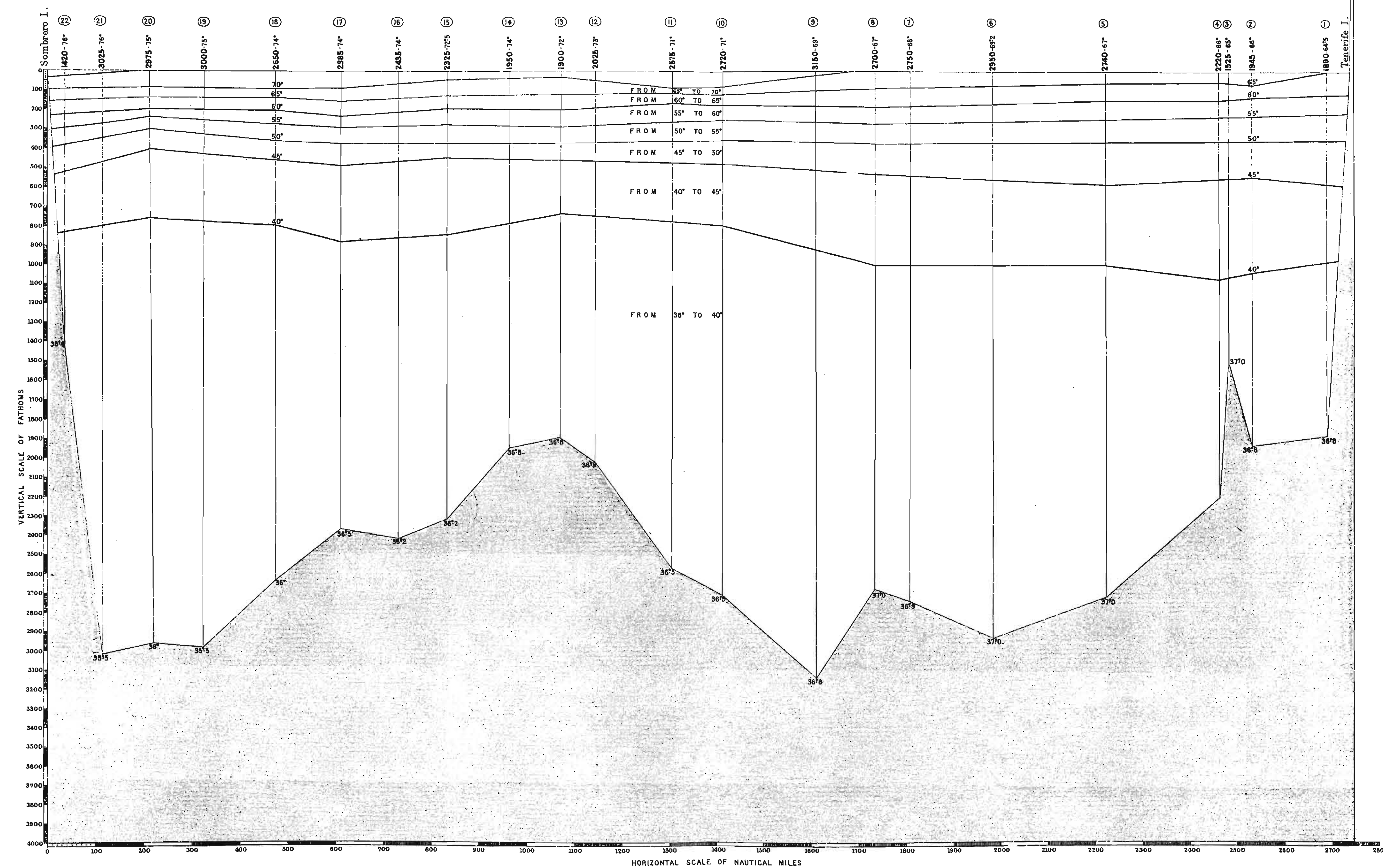
This section (see Diagram 1) shows a remarkable rise in the bed of the Atlantic from 2000 to 1525 fathoms, at a point about 160 miles S.W. of Ferro Island (see Sheet 6). This elevation, which appears to be of small extent, is probably of volcanic origin. Westward of it the bed of the ocean sinks until a depth of 3150 fathoms is reached 1100 miles from Tenerife, after which it gradually rises to 1900 fathoms 1650 miles from Tenerife, and again sinks to 3000 fathoms (which depth it retains for 200 miles, until within 100 miles of Sombrero Island). In short, the soundings clearly indicate the existence of depressions on each side of the section, separated from each other by a gradual submarine elevation of over 1000 fathoms (6000 feet). As the United States surveying vessel "Dolphin" had obtained some soundings on this elevation in 1851, it was named the "Dolphin Ridge."

The temperature of the water at the bottom was, at all depths exceeding 1800 fathoms, exceedingly uniform, varying only 1°·5, or from 35°·5 to 37°·0; but although this range is small, it is sufficient to indicate a decided difference between the bottom temperatures on the eastern and western sides of this section. For instance, the twelve temperatures on and to the eastward of the Dolphin Ridge only vary half a degree, from 36°·5 to 37°·0, the mean being 36°·8; whilst the mean of the seven temperatures west of

DIAGRAM I

ATLANTIC OCEAN Longitudinal Temperature Section Tenerife I. to Sombrero I.

For Explanation of Symbols see Appendix 1.



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the ridge is 36°·0, or 0°·8 below those on the east side ; their range being 1°·0, or from 35°·5 to 36°·5 ; so that the highest bottom temperature registered in this section west of the ridge was the same as the lowest obtained on the eastern side.

The thirteen serial temperature soundings obtained showed that the water gradually cooled from the surface to 40°·0 at an average depth of 900 fathoms ; and as the mean depth of the ocean between the Canary and Virgin Islands was found to be 2400 fathoms, it follows that for an average height of 1500 fathoms (9000 feet) from the bottom, or two-thirds of the whole depth, the water is below the temperature of 40°·0 (see Diagram 1). The range in the depth occupied by the isotherm of 40° was considerable, being as much as 300 fathoms, but although the greatest depth it attained was near the eastern extremity of the section, and the least near the western, the change was by no means gradual, for it was found to occupy a mean depth of 1000 fathoms for 1000 miles west of Tenerife, whilst for 1700 miles east of Sombrero Island its mean depth was only 800 fathoms, the change occurring in the intermediate 300 miles. At the depth of 380 fathoms the temperature of 49°·0 was found constant the whole way ; from the surface to that depth the water became gradually warmer towards the West Indies, the alteration being due principally to a change of 10° in latitude, viz., from 28½ at Tenerife to 18½ at Sombrero Island.

The specific gravity of the surface water rose rapidly on leaving Tenerife from 1·0272 to 1·0277 in mid ocean, and diminished again to 1·0269 as the West Indies were approached. The ship had thus passed through the saltest water found anywhere in the open ocean. The specific gravity of the bottom water varied from 1·0260 to 1·0275. Serial determinations of specific gravity showed that in mid ocean the saltest water was at the surface, but nearer the West Indies, where the surface water instead of 1·0277 showed a specific gravity of only 1·0269, the specific gravity of the water was 1·02712 at 50 fathoms, 1·02740 at 100 fathoms, and 1·02752 at 150 fathoms, falling off to 1·02682 at 200 fathoms and 1·02613 at 500 fathoms.[1]

The current drag was tried occasionally on the passage to St. Thomas. On the 17th February, at Station 2, it was lowered to 200 fathoms, and the watch buoy attached ; and as no movement of the water past the buoy was perceptible, it was concluded that either there was no current, or that the whole body of water, to the depth of 200 fathoms, was moving in the same direction and with the same velocity. On the 18th February, at Station 3, the drag was lowered to 100 fathoms with the same result. On the 26th February, at Station 9, the drag was lowered to 200 fathoms, and the surface water was found running past the watch buoy to the S.S.W. (true) at the rate of 0·3 mile per hour. On the 3rd March, when lowered to 250 fathoms, at Station 12, the surface water ran past the watch buoy in a W. by S. (true) direction at the rate of 0·3

[1] The specific gravities quoted in this volume are reduced to their value at 60° F. (15°·56 C.) and referred to that of distilled water at 39°·2 F. (4° C.) as unity ; see Phys. Chem. Chall. Exp., part ii., 1884.

mile per hour, and on the 13th March, at Station 21, the drag was lowered to 100 fathoms, when no movement of the water could be detected.

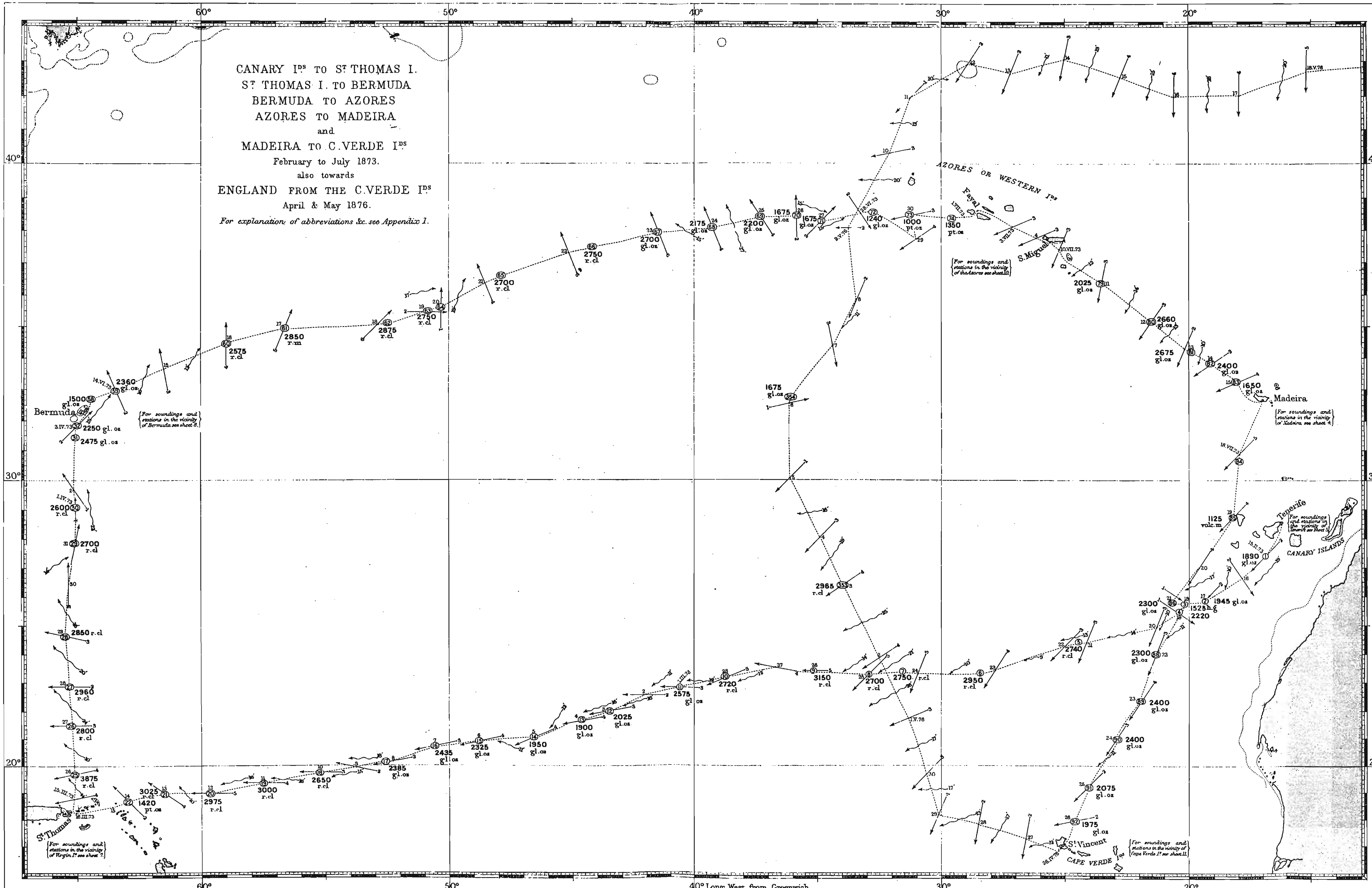
Anemometer observations were obtained whenever circumstances were favourable, that is, when the ship was stationary whilst sounding, and the instrument was not masked by an awning, a sail, or any part of the rigging. When first used it was placed on the top of the small deck charthouse on the pilotage bridge; but as it was in that position so frequently masked by the awnings or rigging, it was shifted to the top of the foremost davit of the weather quarter boat, where it was quite clear of such obstructions. On the 17th February, at Station 2, the force of the wind being registered as 2 in the Meteorological Register, the velocity by the anemometer was 10 miles per hour. On the 21st, at Station 5, the force of the wind being registered as 3, the velocity by the anemometer was 16 miles per hour from noon on that day to 8.40 A.M. on the 22nd. On the 23rd, at Station 6, from 4 to 6 P.M., the velocity was 30 miles per hour, and the force was registered as 5 to 6. On the 24th February, at Station 7, from 3 to 6 P.M., the force of the wind 4 to 5, the velocity was 17 miles per hour. On the 25th February, at Station 8, the force of the wind being 4 to 5, the velocity was 19 miles per hour; and on the 26th February, at Station 9, the force of the wind being registered as 5, its velocity was 23 miles per hour.

The observations with respect to the position of the ship, wind, currents, temperature, and depth, are represented graphically on Sheets 6 and 7, and Diagram 1. With respect to the Diagrams accompanying this Narrative, they are designed with a view of showing the distribution of temperature in the part of the ocean traversed, and the horizontal and vertical scales have been chosen accordingly. Horizontal lengths or distances from Station to Station are on a scale of 200 miles to the inch, which gives the diagram a convenient length; and depths are on a scale of 500 fathoms to the inch, which separates the isothermal lines to a convenient distance from each other. Hence, depths or heights, as compared with horizontal distances are exaggerated in a proportion of 400 to 1. In looking, therefore, at the plan as one of the bed of the area, it must be remembered that the inclines as observed were 400 times less steep than they are represented. The diagram shows the isotherms for every five degrees. The positions of the isotherms for each whole degree as represented were found by plotting the observations and drawing the curve as referred to in the preceding chapter[1] (see page 120).

The dredgings and trawlings in the deeper water of the Mid Atlantic did not yield a large number of animals. An Annelid (*Myriochele*) was obtained from 2975 fathoms, several Polyzoa and two small Lamellibranchs from 2740 fathoms, and Sponges, Brachiopods, Polyzoa, small Lamellibranchs, and Gasteropods, and several Crustaceans from 1900 and 1950 fathoms. In 450 fathoms, however, close to Sombrero Island, a large number of animals—Alcyonarians, Echinoderms, Annelids, Molluscs, Crustaceans, and Fishes—were obtained.

[1] See Phys. Chem. Chall. Exp., part iii., 1884.

SHEET 6



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On the 18th February a dredging was taken in 1525 fathoms, about 160 miles S.W. of Ferro Island (see Sheet 6, Station 3), which has proved to be one of the most curious during the whole cruise. Two soundings were taken at the same spot, giving 1520 and 1525 fathoms. The Hydra tube in both cases came up empty, but was marked on the outside with black streaks. The dredge was lowered at 10 A.M., with 2200 fathoms of line, and 2 cwt. of sinkers 300 fathoms from the dredge, and at 5.30 P.M. it was hauled up, and contained some large branches of an Alcyonarian Coral allied to *Corallium.*[1] Some of the larger branches were nearly an inch in diameter. The central portion of the axis was very compact and of a pure white colour, while the surface was glossy black. The bases of the Coral were attached to large fragments of what turned out to be portions of manganese-iron concretions, which appeared to have been torn away from still larger masses. The whole of the Coral was dead, and appeared to have been so for a long time, as its surface was everywhere covered by a deposit of peroxide of manganese. It is not improbable, however, that the Coral lived at the depth at which it was dredged, at the time the deposit of the manganese was going on, inasmuch as the flattened bases of the Coral were seen between the concentric layers of manganese nodules to which they were attached.

Attached to the branches of the Coral there was a magnificent specimen of a Hexactinellid sponge, allied to *Hyalonema*, which has been described by Professor C. Wyville Thomson under the name of *Poliopogon amadou*[2] (see p. 439). The basal portions of the sponge had some patches of Globigerina ooze attached to them, made up of pelagic Foraminifera, Pteropods, Heteropods, Coccoliths, Rhabdoliths, otoliths of Fish, fragments of Echinoderms, and a good many particles of volcanic minerals. An Ophiurid, portions of a *Brisinga*, several Annelids, several Polyzoa, and one or two Corals came up in the same dredge.

With the exception of a few stormy Petrels and an occasional Puffin, no birds approached the ship while making this passage of the Atlantic. This was in striking contrast with experiences in more northern and southern latitudes, where large numbers of sea birds usually followed in the wake of the ship. The tow-net was frequently used, but not so constantly or systematically as in the latter part of the cruise; and while the vessel was engaged in sounding and dredging operations, boats were frequently lowered to enable the Naturalists to pick up the animals on the surface of the sea, but life was not found so abundant in this trade wind region as during the voyage from Gibraltar to Madeira. Towards the western portion of the Atlantic, large masses of Gulf Weed were passed, and frequent excursions made to these patches in boats in order to examine the animals living upon them (see p. 136). Dead shells of *Spirula* were frequently

[1] Mr. S. O. Ridley of the British Museum, who has examined specimens of this Coral, believes that they belong to a species of *Pleurocorallium*, Gray, probably the white or cream-coloured species *Pleurocorallium johnsoni*, Gray, which occurs at Madeira.

[2] Voyage of the Challenger, The Atlantic, vol. i. p. 175, London, 1877.

found on the surface, and were generally covered with small Cirripeds, whilst in some instances they were completely enveloped by species of *Acineta* and *Podophrya*.

The character of the deposits in this section presented considerable variety. With the exception of the hard ground already referred to, composed of manganese and coral, all the deposits in depths less than 2500 fathoms contained more than 50 per cent. of carbonate of lime. For these the names Globigerina and Pteropod oozes have been adopted, the latter being confined to two deposits from the depths of 1420 and 450 fathoms on the western side of the section, in which occurred very many Pteropod and Heteropod shells, in addition to pelagic and other Foraminifera, and in which the proportion of carbonate of lime was the greatest, being 80 to 84 per cent. Only a few fragments of Pteropods were found in the Globigerina ooze, from depths ranging between 1890 and 2500 fathoms, the carbonate of lime being made up chiefly of the dead shells of pelagic Foraminifera. In depths greater than 2500 fathoms, the quantity of lime decreased as the depth increased, and below 3000 fathoms there were only traces of carbonate of lime in the deposit.

Siliceous organisms, such as spicules of Sponges, Radiolarians, and Diatoms, were not abundant; generally they did not appear to make up more than 1 or 2 per cent. of the whole deposit, with the exception of the two deposits at 1420 and 450 fathoms, above referred to, where the proportion rises to about 6 per cent.

The mineral particles, which were mostly of volcanic origin, seldom exceeded 0·15 mm. in diameter, and consisted of felspars, hornblende, augite, magnetite, glassy fragments, and palagonite. In the deposits from the eastern portion of the section there were numerous small rounded particles of quartz covered with ologist, which would appear to be mostly wind-borne particles, carried by the Harmattan and other winds from the coast of Africa.[1] The Red Clays from the greater depths were almost entirely composed of argillaceous matter and fine mineral particles not exceeding 0·05 mm. in diameter. In the dredging on the 7th March in 2435 fathoms, there were several round compact manganese nodules, pieces of pumice several millimetres in diameter, and three or four Sharks' teeth coated with peroxide of manganese.

St. Thomas, Virgin Islands.

As the ship steamed towards the harbour at St. Thomas, Frigate Birds soared high overhead, with their long tail feathers stretched widely out. A number of brown Pelicans (*Pelecanus fuscus*) were flying at a moderate height near the shore, and every now and then dashing down with closed wings into the water on their prey like their close allies the Gannets. Often several of the birds dashed down together at the same instant.

The island of St. Thomas itself, as well as the outlying islets, is covered with a wild bush

[1] See Darwin, Journal of Researches during the Voyage of H.M.S. "Beagle," p. 5, ed. 1879.

growth, which at first sight might perhaps be taken for indigenous vegetation, but is composed of plants that have overrun deserted sugar plantations. It is only in a few remote parts of the island, and in small streaks of broken ground bordering the water-courses, that any original forest exists. The whole of the available land in the island itself, and in all the adjoining islands, was planted with sugar cane until the emancipation of the slaves in 1833; since that time the ground has been allowed to run wild. There was only one estate partly under cultivation at the time of the ship's visit, and the owner of it, Mr. Wyman, said that he made no sugar, but found sufficient sale for his canes in the raw state to be cut up and resold for chewing. The consumption of cane for this purpose must be considerable, for chewing cane appears to be the constant occupation of the negroes of both sexes and all ages. Mr. Wyman was nearly ruined by the emancipation, and said that the planters received only 50 dollars per head compensation for the loss of their slaves, and that after the lapse of three years.

The shore is covered with corals bleached white by the sun, and amongst these occur quantities of Calcareous Seaweeds (*Halimeda opuntia* and *Halimeda tridens*), branching masses composed of leaf-shaped joints of hard calcareous matter articulated together. These are all quite dry and bleached white, and hard and stiff, like corals. Seaweeds belonging to two very different groups of algæ thus secrete a calcareous skeleton, *Halimeda* and its allies, belonging to the Siphonaceæ—green coloured algæ; and *Lithothamnion* and allied genera belonging to the Corallinaceæ, which are red coloured algæ. These lime-secreting algæ are of great importance from a geological point of view, as supplying a large part of the material of which calcareous reefs and sand rocks are built up. At St. Thomas the Siphonaceæ are especially abundant, whereas at other places, as at St. Vincent, Cape Verde Islands, the Corallinaceæ appear to supply most of the calcareous matter separated from the sea water by plants.

There is only one kind of Humming Bird at St. Thomas, but it is very common, and is constantly to be seen poised in the air in front of a blossom or darting across the roads. It is remarkable how closely Humming Birds resemble in their flight Sphinx Moths, such as our common Humming Bird Sphinx, so named from this resemblance. They make in their flight exactly the same rapid darts, sudden pauses, quick turns, and the same prolonged hovering over flowers. The most conspicuous land bird in the island is commonly called the "Black-witch" (*Crotophaga ani*). These birds are usually to be seen in flocks of three or four, in constant motion amongst the bushes, and screaming harshly when they apprehend danger. They behave very much like Magpies, but are somewhat smaller than the English Magpie and black all over. They belong structurally to the family of the Cuckoos (Cuculidæ).

Two Snakes, one a species of *Typhlops* and the other apparently referable to the genus *Coronella*, were obtained, as also specimens of Lizards belonging to the genera *Anolis* and *Ameiva*.

A large ground Spider (*Lycosa*) is very abundant in the island, inhabiting a hole in the ground about six inches in depth, and from half an inch to an inch in diameter, with a right-angled turn at the bottom to form a resting chamber. Negro boys take a delight in digging the Spiders out; they believe their bite to be poisonous, and that they feed on Lizards, leaving their holes at night to search for them. They are great, heavy, venomous-looking brutes, about three inches across. Their holes were so common, that on one tolerably clear patch of about an acre in extent, they were dotted over the entire area at only about one or two feet distance from one another, and were quite conspicuous.[1]

A species of White Ant (*Termes*) is very common. It makes large globular nests of a hard brown comb, as much as two feet in diameter, perched high up in the fork of a tree. From the bottom of the tree covered galleries about half an inch in breadth lead up on the surface of the bark to the nest, looking like long, narrow, brown streaks upon the tree trunk. The galleries usually follow a somewhat irregular course up the trunk to the nest, reminding one of the curious deviations which are always to be seen in footpaths, traced by people walking across fields, in their endeavours to go straight from one point to another. The galleries, or rather tubular ways, for they have bottoms to them, are made of the same tough brown substance as the nests, and are cemented firmly to the bark. Though they are so broad as to allow numerous Ants to pass and repass, they are only high enough for the Ants to walk under. When one of these galleries is broken, a number of soldier Termites come out and begin biting the marauder's hands, and though hardly making themselves felt, they are as brave as if they had a sting. A considerable length of the gallery has to be broken before any of the working Termites' beds are reached, as they retire from the scene of danger. A new species of Wasp (*Polistes madoci*, Kirby) was found.[2]

An Agouti, a species of Rodent (*Dasyprocta*), occurs in the island, and Mr. Wyman said that it was common in the gullies near his sugar plantation.

A shooting excursion to the opposite side of the island was organised in pursuit of wild goats, pigs, guinea fowl, and the domestic fowl which breed in the wild condition in various parts of the island, having sprung, in most instances, from stock which has escaped

[1] The Lepidoptera collected on this island included the following species (Butler, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xiii. pp. 183–187, 1884).

Anosia leucogyne, Butler.
Dione vanillæ (Linn.).
Junonia cœnia, Hübner.
Heliconius charithonia (Linn.).
Tmolus columella (Fabr.).
Appias poeyi (?), Butler.
Ganoris cleomes (Boisd. and Lec.).
Callidryas sennæ (Linn.).
Terias euterpe (Ménét.).
Papilio polydamas, Linn
Goniuris proteus (Linn.).
Goniuris dorantes (Stoll).
Proteides amyntas (Fabr.).
Pamphila pustula (Hübner).
Pyrgus syrichtus (Fabr.).
Composia sybaris (Cramer).
Deiopeia ornatrix (Linn.).
Margaronia flegia (Cramer).
Botys (?) *onophasalis*, Walker.

[2] *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xiii. p. 411, 1884.

and been scattered during the hurricanes. The feral fowls are very wary, like their progenitors, the Indian Jungle-fowl, and are not at all easy to shoot. The entire bag consisted of only one wild fowl. Flights of the brown Pelicans were met with passing over-head, flying one after another along the shore almost always exactly over the same spot on their way from one feeding ground to another.

The late Dr. R. von Willemoes Suhm states in his diary, that the doctor of the garrison assured him that of the human internal parasites, only *Ascaris* and *Oxyuris* were common; *Tænia* was very rare, and found, not among the natives, but usually among foreign sailors. *Phthirius pubis* and *Pediculus capitis* were both known but also very rare; when upon negroes they have a dark colour, a curious fact already known with regard to these parasites on several dark human races, which recalls the correspondence between the colour of the species of Anoplura, and that of the feathers of the birds they infest.

One day a party landed on one of the small outliers of St. Thomas, Little Saba Island, about a mile and a half distant from the main island. A Puffin (*Puffinus* sp.) was nesting in holes amongst the grass, laying a single large white egg; the birds allowed themselves to be caught in the nest with the hand. In the beach of the island there was being formed a reddish conglomerate sandstone rock, composed of the débris of the rock of which the higher parts of the island consist, cemented together by calcareous matter derived from the corals, and calcareous sand. This rock, which was hard and compact, contained embedded in it plenty of the various corals from the beach and large *Turbo* shells (*Turbo pica*), with their nacre quite fresh in lustre, and their bright greenish colour unimpaired. In St. Thomas large examples of these *Turbo* shells, as much as two inches in diameter at the base, are carried up far inland by terrestrial Hermit-crabs. A large number of them were seen amongst the bush at an elevation of 1000 feet, some of them containing crabs, many empty. These large heavy sea shells occurring in abundance at great heights, puzzled geologists, until it was found that they were carried up by the crabs. On the shore at Little Saba Island grew a number of plants of *Guilandina bonduc*. This plant bears a pod covered with prickles, containing nearly spherical beans of about the size of a hazel nut, which have a perfectly smooth, as it were, enamelled surface, and are flinty hard. These seeds float, and are carried by ocean currents to distant shores, and in Tristan da Cunha and Bermuda are known as "Sea-beans," and supposed to grow at the bottom of the sea; they are also found occasionally washed up at the Azores.

The stay at St. Thomas extended to eight days, which time was fully occupied, as far as the naval staff was concerned, in refitting and coaling the ship, in obtaining magnetic and other observations on shore, and in correcting the charts. The evidences of the destruction caused at St. Thomas by the hurricanes and occasional earthquake waves, more especially by that of 1867, were everywhere conspicuously apparent. Numbers of small houses were constructed partially with the bulkheads of wrecked ships; and even in 1873, six years after the last hurricane, there were a few wrecks still on the shore.

It having been reported during the stay that a distressed British ship had anchored in the sound between the islands of St. Thomas and St. John, the ship proceeded to her assistance and towed her into harbour. She proved to be the "Varuna," an iron ship of 1300 tons, abandoned by the crew two months previously, about 350 miles N.N.E. of Bermuda; she was taken charge of by the mate and nine of the crew of the ship "Roundtree," and navigated to St. Thomas, having only her foremast and foretopmast

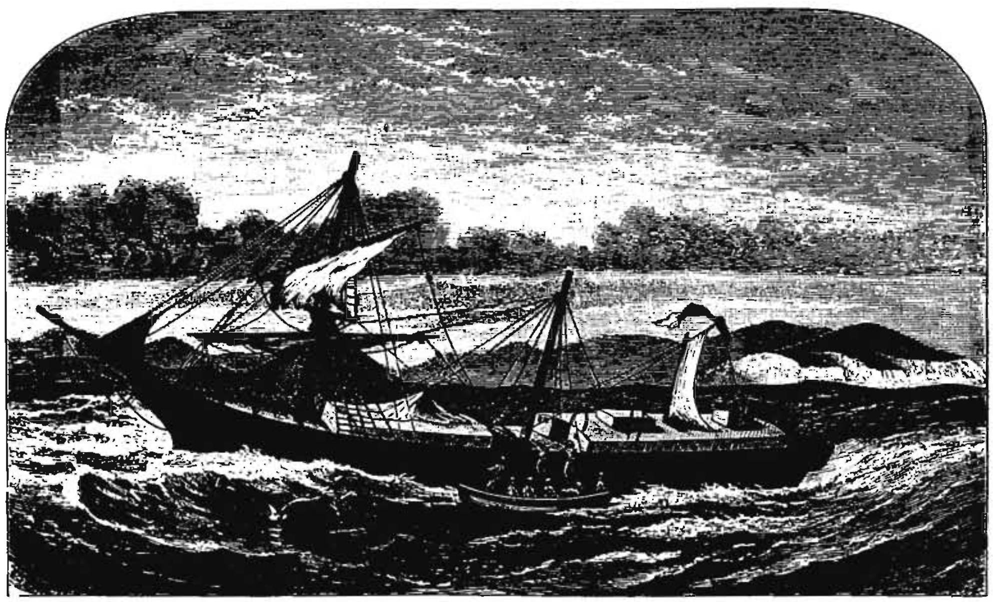


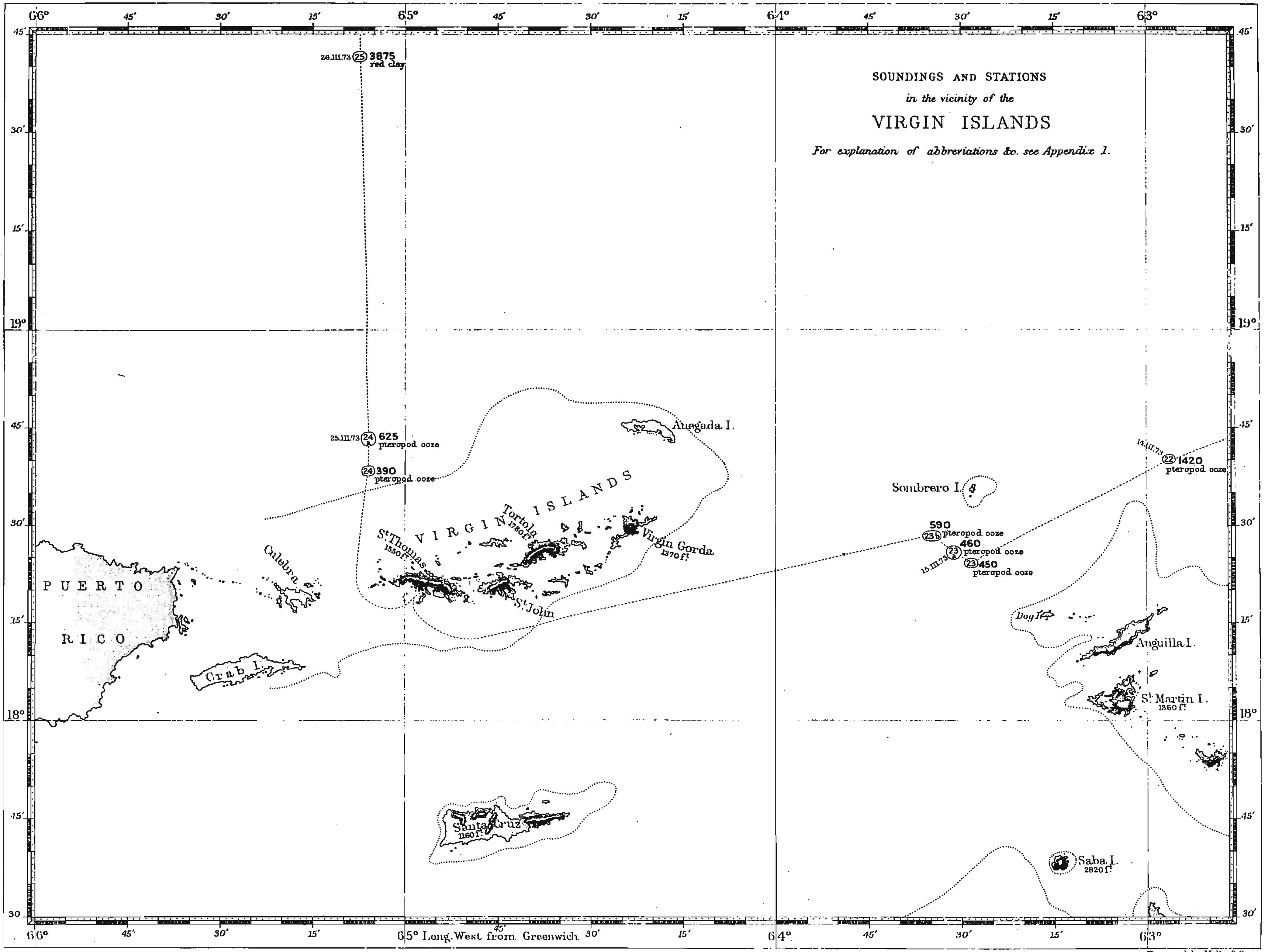
FIG. 49.—Boarding the wreck of the "Varuna," off Cabrite Point, St. Thomas.

standing. These men deserve great credit for bringing the "Varuna" to port, and it is to be hoped that they got a handsome amount of salvage, although they distrusted the motives of the Challenger in coming to their assistance, thinking they were to be deprived of some of their hardly-earned recompense, and had to be reassured on that point before the vessel was taken in tow.

St. Thomas to Bermuda.

On the 24th March the Challenger sailed for Bermuda; the 25th was spent in dredging off the northern edge of the Virgin Island bank, in 390 and 625 fathoms (see Sheet 7), and a large number of animals were obtained, resembling, in most respects, those taken in 450 fathoms off Sombrero. In addition to these there were three species of Brachiopoda, which are referred to in the following résumé, by Thomas Davidson, Esq., F.R.S., of his Report on the Brachiopoda collected during the Expedition:[1]—

[1] Zool. Chall. Exp., part i., 1880.



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"*The Brachiopoda* are a most interesting and important class among the Invertebrata, from the fact that they represent the earliest known forms of life, and have continued to exist under a variety of more or less allied species up to the present time. They appear, however, to be much localised, for although the dredge or trawl had been put down by the Challenger Expedition at about 250 stations, Brachiopoda were brought up 38 or 39 times only.[1] Out of about 120 known recent species, 34 only were obtained, and out of this number 27 were dredged at depths varying from 2 to 600 fathoms, and the remaining 7 from 1035 to 2900 fathoms. The investigations carried out by the Challenger Expedition tend to prove that abyssal forms are less localised than those that occur in seas of moderate depth; but deep-sea species, as far as our present experience goes, are of small size, and specifically few in number. Their shell is

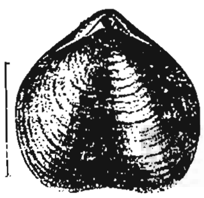


FIG. 50.—*Terebratula wyvillii*, Dav., enlarged.

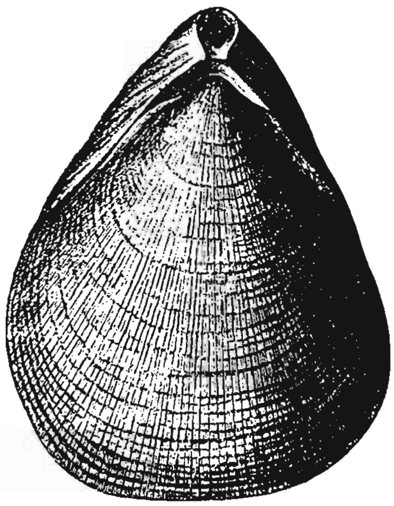


FIG. 51.—*Terebratulina wyvillii*, Dav., natural size.

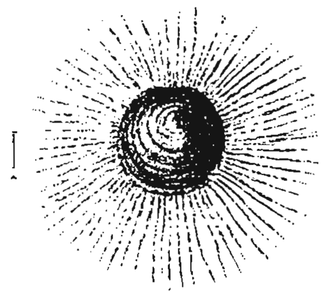


FIG. 52.—*Discina atlantica*, King, enlarged.

extremely thin, glassy, and semi-transparent, as in *Terebratula wyvillii*, *Terebratula dalli*, *Waldheimia wyvillii*, *Waldheimia tenera*, *Terebratella frielii*, *Atretia gnomon*, *Discina atlantica*, and one or two others.

"The three most interesting species brought home by the Expedition were *Terebratula wyvillii*, *Terebratulina wyvillii*, and *Discina atlantica*.

"*Terebratulina wyvillii*, Dav., is the largest species of the genus, either recent or fossil, hitherto discovered. One specimen only was dredged, on the 25th March 1873, off Culebra Island, to the northwest of St. Thomas in the West Indies, Station 24, depth 390 fathoms.

"*Terebratula wyvillii*, Dav., is one of the most remarkable of the series of small abyssal

[1] In the opinion of the Naturalists of the Expedition this may, to some extent, be due to the nature of the instrument used, whether dredge or trawl.—J. M.

forms brought back by the Expedition. It was obtained at six different Stations, and appears to abound over a wide geographical area, occurring at depths varying from 1035 to 2900 fathoms,—the greatest depth whence any living Brachiopod has been brought up. None of the specimens procured exceeded 7 lines in length by 9 in breadth; its shell is extremely thin and brittle, almost transparent, smooth and glassy. It bears much resemblance in shape to more than one Tertiary, Cretaceous, and Jurassic species.

"*Discina atlantica*, King, is another of the widely spread abyssal forms, and was brought up by the Challenger at six or seven different Stations. Its shell is small, very thin, and semi-transparent. The cirri proceeding from the edges of the mantle are of great comparative length, equalling the diameter of the shell.

"Only a small number of the species brought home by the Challenger Expedition are positively known to occur in the upper Tertiaries. Those that are both recent and fossil are *Terebratulina caput-serpentis*, *Terebratula vitrea*, var. *minor*, *Terebratella dorsata*, *Megerlia truncata*, *Platydia anomioïdes*, and *Argiope decollata*. None of the abyssal forms have yet been found in the fossil condition; but if we take into consideration the 120 known species of recent Brachiopoda, 26 of these occur both recent and fossil. The chief object of the Challenger Expedition being to dredge in open seas in various longitudes and latitudes, much time could not be devoted to searching coral reefs and shallow rocky bottoms, where the larger number of species are to be found, and where they often congregate in great number and variety. Thus, for example, about 30 species have been obtained from Japanese and Korean Seas; a large number also are to be found in New Zealand waters, near the Cape of Good Hope, &c. In deep seas with muddy bottoms it is rare to find more than one, two, or three species living at the same spot, and this was amply confirmed by the Challenger Expedition."

An unfortunate accident occurred on board on the morning of the 25th. Owing to the rugged nature of the ground over which the dredge was dragging, the strain on the dredge rope increased on one occasion so suddenly, that before it could be relieved the hook of one of the spans, to which the leading blocks were secured, broke, and the block striking W. Stokes, a boy, fractured his leg, and otherwise injured him so severely that he died in the afternoon.

On the 26th March when barely 100 miles from land, the depth was found to be 3875 fathoms. Such a rapid increase in the depth not having been expected, only 3 cwt. of sinkers had been attached. After 3000 fathoms had run out, there was some uncertainty as to the time that should be occupied by the weights in descending, as hitherto the deepest cast had not much exceeded that depth. Twice, the intervals appearing longer than they should be, the line was checked; but the strain on it, as indicated by the stretching of the accumulators, showed in a most satisfactory manner that the bottom had not been reached. Finally, when the sinkers did strike the ground, the intervals occupied by the line in running out increased so considerably, that no doubt was felt as to the accuracy of the result. The time each 50 fathom mark entered the water was registered from 3000 fathoms to the bottom; and the following intervals obtained just before and after the sinkers touched the ground, may prove interesting, as they show how quickly the speed of descent of the line slackens when the weight of the sinkers is no longer felt:—

Depth.	Time.			Interval.		Rate per 100 Fathoms.	
	h.	m.	s.	m.	s.	m.	s.
3800 fathoms	7	57	22	1	15	2	30
3850 „		58	40	1	18	2	36
3900 „	8	0	19	1	39	3	18
3925 „		1	18	0	59	3	56
3950 „		2	23	1	5	4	20

The time the line occupied in descending the first 3800 fathoms will be found on page 67.

Two thermometers and a slip water-bottle were sent to the bottom. The thermometers were broken, and the mode in which the fracture occurred is in itself curious, and has an important bearing upon the use of these instruments at extreme depths. A valuable instrument which had been used for some time, whenever for any reason great accuracy was required, was shattered to pieces (fig. 53 A). The other instrument was externally complete, with the exception of a crack in the small unprotected bulb on the right limb of the U-tube, whilst the inner shell of the protected bulb was broken to pieces (fig. 53 B). In both of these cases there seems little doubt that the damage occurred through the giving way of the unprotected bulb.

In the first case its upper part was reduced to a powder like table salt, and the fragments packed into the lower part of the bulb and the top of the tube. The large bulb and its covering shell were also broken, but into larger pieces, disposed as if the injury had been produced by some force acting from within. The thermometer tube was broken through in three places; at one of these, close to the bend, it was shattered into very small fragments. The creosote, the mercury, and bubbles of air were irregularly scattered through the tube, and it is singular that each of the steel indices had one of the discs broken off. The whole took place no doubt instantaneously by the collapse of the small bulb, which at the same time burst the large bulb and shattered the tube.

In the other a crack only occurred in the small bulb, either through some pre-existing imperfection in the glass or from the pressure. When the pressure became extreme the crack yielded a little and the sea water was gradually forced in, driving the contents of the thermometer before it, and, taking it at a disadvantage from within, breaking the shell of the large bulb, which was unsupported on account of the belt of rarefied vapour between it and its outer shell. The pressure was now equalised within and without the instrument, and the injury went no farther. Alcohol, creosote, mercury, and sea water were mixed up in the outer case of the large bulb with the débris of the inner bulb, and one of the steel indices lay uninjured across its centre.

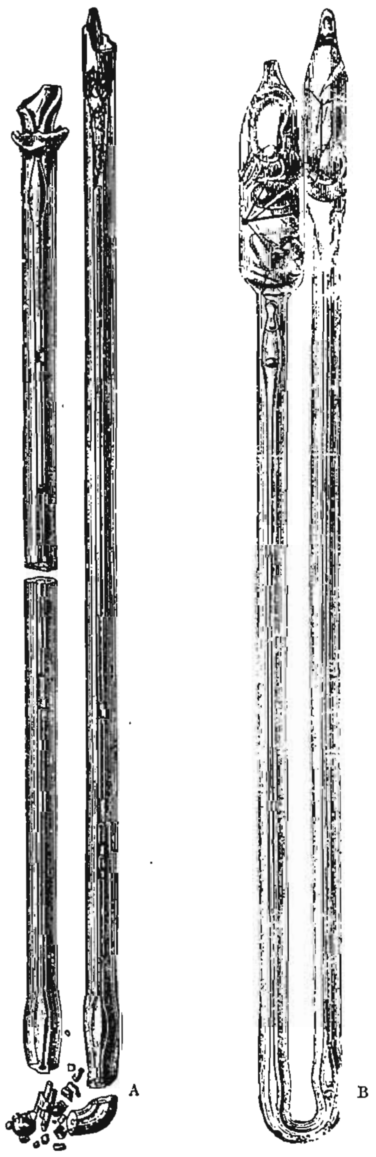


FIG. 53.—Thermometer tubes broken by pressure at a depth of 3875 fathoms (Station 25).

As this was the deepest sounding yet taken, it was desirable to try whether the dredge would still prove serviceable. The small dredge was accordingly lowered at 10.30 A.M., with the usual bar and tangles, and from the centre of the bar a Hydra sounding tube, weighted with 4 cwt., was suspended about 2 fathoms below the dredge. A 2-inch rope was veered to 4400 fathoms; a toggle was stopped on the rope 500 fathoms from the dredge, and when the dredge was well down, two weights of 1 cwt. each were slipped down the rope to the toggle. Heaving in was commenced about 1.30 P.M., and the dredge came up at 5 P.M., with a considerable quantity of reddish-grey ooze. The mud was carefully examined, but no animals were detected, except a few small calcareous Foraminifera, and some, considerably larger, of the arenaceous type.

The officers of the United States Coast Survey have recently obtained depths of 4561 and 4223 fathoms about 50 miles to the west of this sounding of 3875 fathoms; so that this, the deepest part of the Atlantic, is probably a depression of considerable extent, with its longest diameter running east and west. On the 27th, 100 miles north of the 3875 fathoms sounding, the depth had decreased to 2800 fathoms.

On this St. Thomas-Bermuda section, twelve soundings, five dredgings, and five serial temperature soundings were obtained (see Sheet 6).

The ocean bed rises gradually from the deep depression just referred to towards Bermuda, the depth being 2475 fathoms at a distance of 50 miles from that island (see Diagram 2).

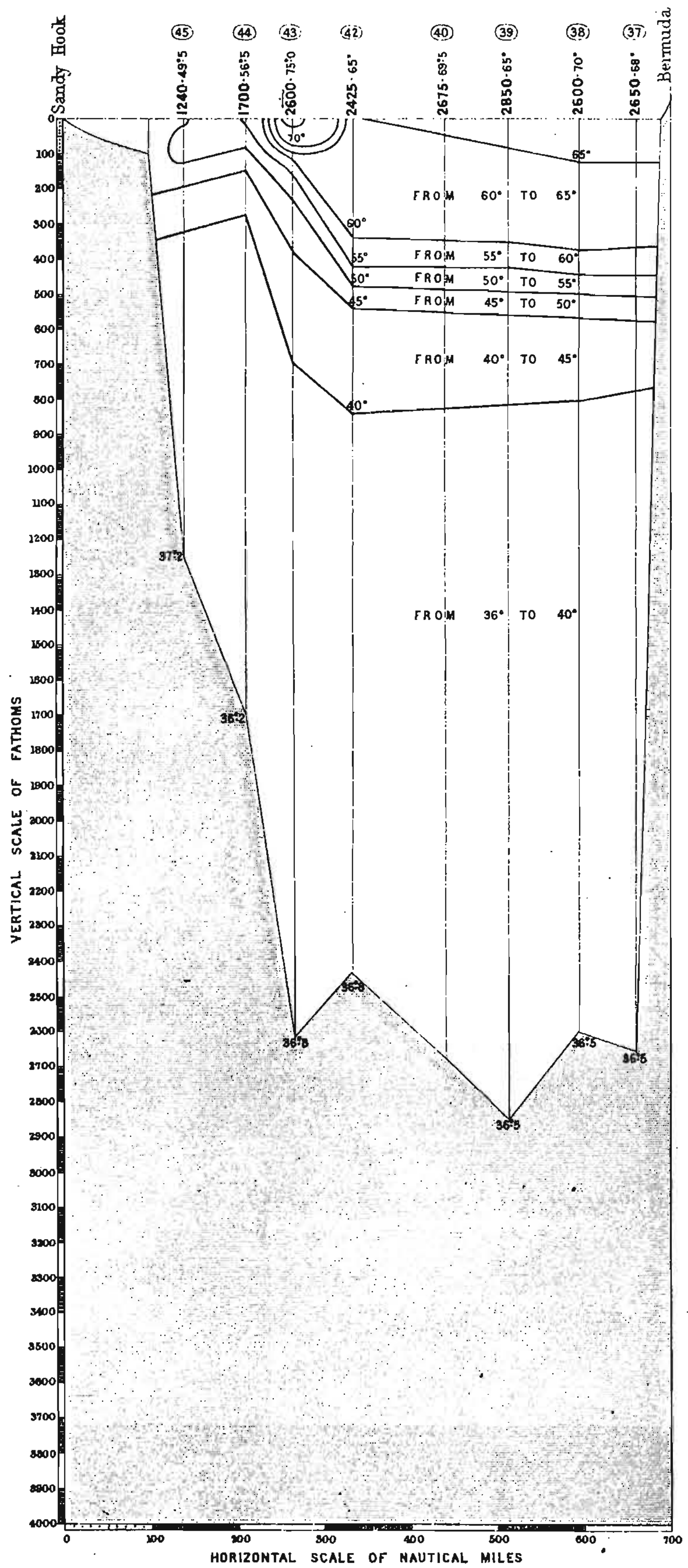
The temperature at the bottom ranged from 36°·2 to 36°·7, the mean being 36°·4.

DIAGRAM 2

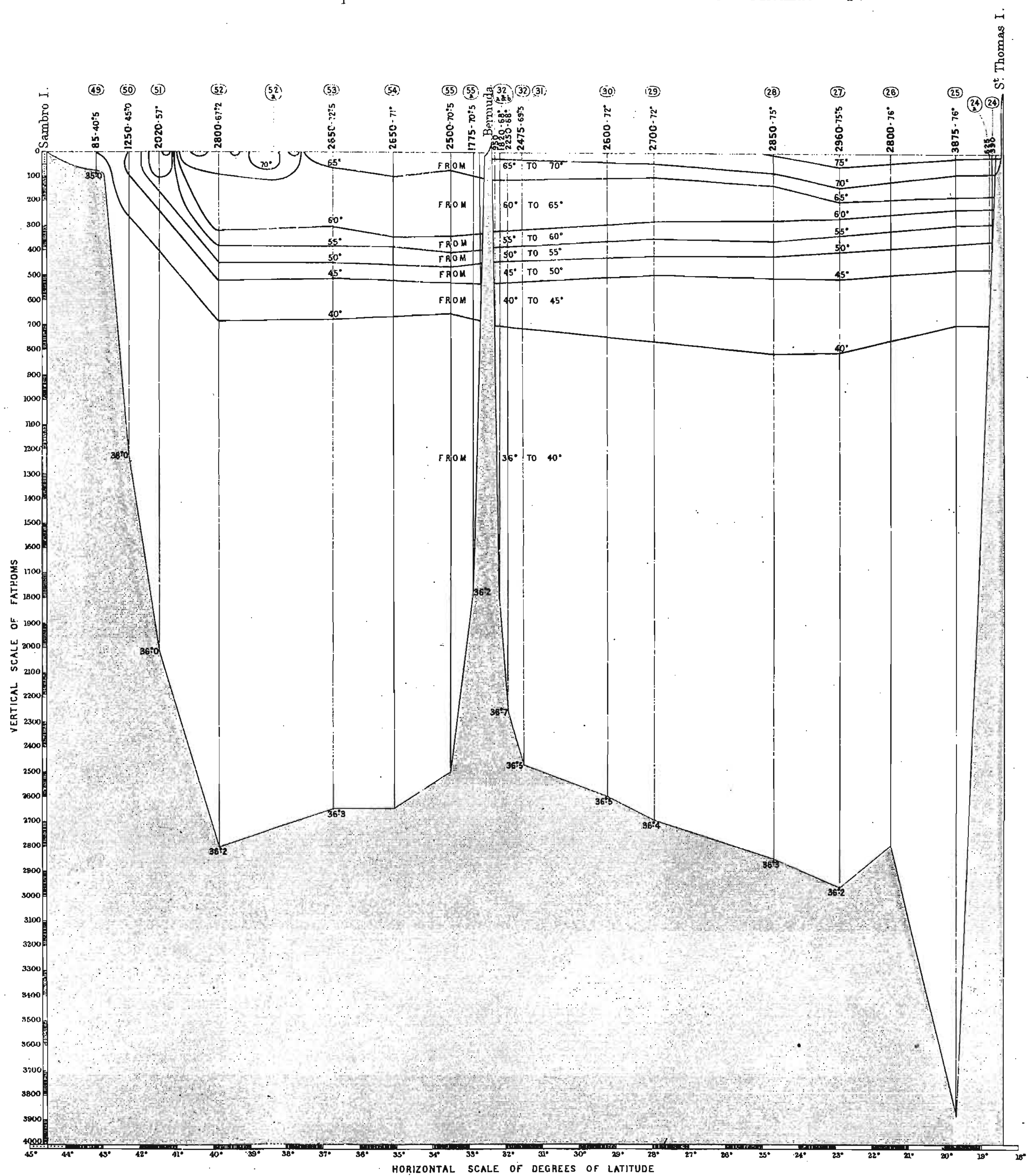
ATLANTIC OCEAN

For explanation of Symbols see Appendix 1.

Diagonal Temperature Section. Bermuda towards New York.



Meridional Temperature Section Halifax to St Thomas Id.



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The isotherm of 40° was found to occupy a mean depth of 750 fathoms (ranging from 700 to 800 fathoms), or nearly the same depth as in the western portion of the Tenerife-Sombrero section. The isotherm of 60° descended steadily from 200 fathoms at St. Thomas to 310 fathoms at Bermuda, although the surface temperature decreased from 76° at the former to 68° at the latter place.

The specific gravity of the surface water rose from 1·02712 off St. Thomas to 1·02732 off Bermuda, that of the bottom water being about 1·0260. The serial determinations on the 31st March showed a similar distribution to that observed before reaching St. Thomas; the surface being 1·02739, the water at 100 fathoms 1·02782.

On the 28th March, at Station 27, a boat, anchored by the lead line with the sinkers on the bottom, found the surface current running N.W. half a mile per hour, agreeing in direction though not in rate with the current determined by the ship's reckoning. On the 2nd April, at Station 30A, the current drag showed that the water, to the depth of 100 fathoms, was moving in the same direction and with the same velocity as that at the surface. From 100 to 300 fathoms the velocity decreased, until at the latter depth there was no perceptible current.

The deposits at the depths of 625 and 390 fathoms on the plateau to the north of the Virgin Islands were Pteropod oozes, with 69 and 73 per cent. of carbonate of lime, containing a few small mineral particles and some argillaceous matter. The deposits from depths greater than 2700 fathoms contained only 4 or 5 per cent. of carbonate of lime, which consisted of a few broken shells of pelagic Foraminifera, and was mostly confined to the surface layers. A few inches beneath the surface the deposit showed only a very slight sign of effervescence when treated with weak acid. At 2700 fathoms there was 22 per cent. of carbonate of lime, at 2600 fathoms 29 per cent., and at 2475 fathoms 54 per cent. The deposits immediately surrounding the island of Bermuda in some instances contained as much as 93 per cent. of carbonate of lime, the percentage being greater the nearer the reef and the less the depth. The mineral particles in all the deposits in this section were exceedingly minute, rarely exceeding 0·07 mm. in diameter, and consisting of fragments of pumice, felspars, magnetite, and augite.

The dredgings in depths less than 500 fathoms, north of St. Thomas and around the island of Bermuda, yielded a large number of interesting animals; but the deep water dredgings were singularly unproductive, only a few Foraminifera and a few shrimps being obtained.

Floating masses of Gulf Weed were frequently met with, and were usually visited in boats while the ship was engaged in sounding and dredging. Besides the ordinary *Sargassum bacciferum*, isolated specimens of another weed, *Fucus vesiculosus*, were occasionally picked up. The following is a complete list of the animals that have been collected on the Gulf Weed, compiled chiefly from the Challenger collections :—

Plumularia obliqua, *Aglaophenia latecarinata*,[1] *Desmoscyphus pumilus*.[1]

Stylochus mertensi, *Stylochus pellucidus*. *Spirorbis* sp.

Pontia atlantica. *Lepas anserifera*, *Lepas pectinata*, *Lepas anatifera*, *Conchoderma virgatum*. *Amphithoë pelagica*, *Vibilia pelagica*, an Amphipod of the family Hyperidæ. *Idotea metallica*, *Idotea whymperi*, *Bopyrus squillarum*, *Bopyroides latreuticola*. *Siriella* sp. *Sergestes oculatus*, *Tozeuma stimpsoni*, *Palæmon pelasgicus*, *Palæmon fucorum*, *Leander tenuicornis*, *Hippolyte tenuirostris*, *Hippolyte ensiferus*, *Virbius acuminatus*, *Alpheus* sp., *Caridina sargopæ*. *Lupea* sp., *Nautilograpsus minutus*, *Neptunus sayi*.

Patina tella, *Patina pellucida*, *Lepeta cæca*, *Ianthina rotundata*, *Litiopa melanostoma*. *Phylliroë atlantica*, *Scyllæa pelagica*, *Scyllæa pelagica*, var. *marginata*, *Æolidella occidentalis*, *Spurilla sargassicola*, *Fiona marina*, *Cuthona pumilio*, *Glaucus atlanticus*, *Doto pygmæa*. *Creseis spinifera*. *Onychia caribæa*.

Membranipora tuberculata, *Flustra membranacea*, *Flustra tuberculata*, *Flustra peregrina*.

Antennarius marmoratus, *Dactylopteris volitans*, *Syngnathus pelagicus*.

The nest of *Antennarius*, an ally of the common Angler of British seas, though very unlike it in its habits, was frequently procured; it is composed of bunches of the Gulf Weed bound together by means of long sticky gelatinous strings formed by the fish for this purpose, and is filled with eggs.

The Gulf Weed fauna, as is well known to naturalists, is a peculiar one, and presents many remarkable instances of protective resemblance. The Crustacea, Molluscs, and Fish are all bright yellow or orange in colour with white spots, thus imitating very perfectly the Gulf Weed with the white patches of *Membranipora* and Cirripeds. A similar fauna, comprising species of some of the same genera (*e.g. Antennarius*), inhabits the floating weed in the Pacific Ocean. Oscillatoriæ were very abundant on the surface throughout this trip, and at times were sufficient to discolour the water for several miles.

On the 3rd April the Bermudas were sighted at 2 P.M., and that day and the greater part of the 4th were occupied in obtaining soundings and dredgings off the group. In the afternoon of the 4th, the ship proceeded to the anchorage in Grassy Bay.

BERMUDA.

At, and in the neighbourhood of, this interesting group of islands, the Challenger remained from the 4th to the 23rd April, and from the 28th May to the 13th June.

The group, with its outlying reefs, is in the form of an ellipse, the major axis of which

[1] Professor Allman says that these two species are destitute of gonosomes, a fact probably connected with the floating habit of the plant, which is itself never provided with reproductive organs in the Sargasso Sea.

lies in a N.E and S.W. direction, and it is described generally as a coral atoll; but any one who has visited coral atolls in the China Sea, Pacific, or Indian Oceans, will be at once struck with some remarkable differences between these and Bermuda. The typical atoll consists of a low, more or less circular, strip of land enclosing a lagoon, into which there is usually a well-defined opening on the leeward side. In Bermuda the land is 260 feet in height at one point, and is massed to the southeast side of the atoll, with the exception of a small outlier known as the "North Rock" (see Sheet 8), which is composed of the same "Æolian" rocks as the mass of land to the southeast, and this

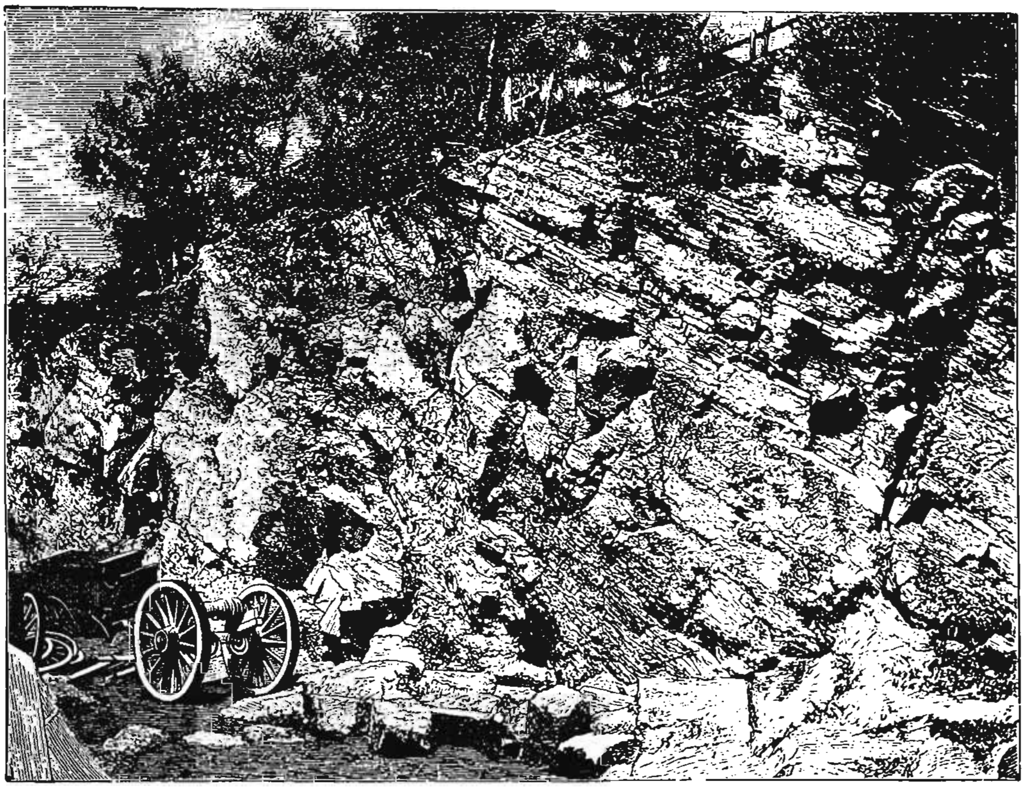


FIG. 54—Stratified "Æolian" Rocks, Bermuda.

indicates an extension of the land surface of the atoll in this direction at a former period. Although the outer reef is almost continuous, there is no well-defined lagoon as in a typical atoll. The whole of the northwest portion of the banks is crowded with coral flats and heads, with intervening lanes and spaces of coral sand, with a depth of usually 4 or 5 fathoms and nowhere more than 10 fathoms. The basins, known as Great Sound, Little Sound, and Castle Harbour, are almost completely enclosed by the Æolian rocks, and have evidently been formed by the solvent action of the sea water on these rocks. Navigators have remarked upon the light blue colour of the water when compared with the deep blue of southern atolls. This arises most probably from the particles of calcareous matter suspended in the water whenever there is the slightest motion. Owing to the shallowness of the lagoon channels, the water becomes quite turbid when there is much wind, thus rendering the navigation of the narrows very difficult. The Æolian rocks are found below the level of low water at many points of the islands.

A satisfactory proof of at least a local subsidence was given a few years ago. In preparing a bed for the great floating dock it was necessary to make an excavation in the Camber, extending to a depth of 50 feet below low water. First there came in the cutting, at a depth of 25 feet below the surface, a bed of calcareous mud, 5 feet thick, forming the floor of the basin; next, loose beds, 20 feet thick, of what has been called "coral crust"—coral sand mixed with detached masses of *Diploria* and isolated examples of smaller corals and of many shells,—passing into "freestone,"—the coral sand cemented together but somewhat loosely coherent. Beneath this, at a depth of about 45 feet, there was a bed of a kind of peat, and vegetable soil containing stumps of cedar in a vertical position, and the remnants of other land vegetation, with the remains of *Helix bermudensis*, and of several birds; the bed of peat was ascertained by boring to lie upon the ordinary hard "base-rock."

A microscopical examination of the deeper rocks of this section showed that a deposition of crystals of calcite had taken place between the calcareous fragments forming the rock. There are no freshwater lakes or ponds on the island, indeed, the wells contain brackish water, except on the surface immediately after rain. The whole atoll is filled with sea water like a sponge; large quantities of carbonate of lime are dissolved and precipitated again in crystals of calcite. It is not improbable that this action may be a cause of subsidence of the land without any subsidence of the primary atoll or sea floor having taken place.

The fine chalky mud which fills the lagoon channels and basins consists of 90 to 95 per cent. of carbonate of lime, which is made up of the comminuted fragments of Corals, calcareous Algæ, Foraminifera, Echinoderms, *Serpulæ*, and Molluscs. The residue, after the removal of the lime, consists of organic matter, Diatoms, and siliceous spicules, and some very fine mineral particles. This coral mud is called a "clay" by navigators, and is so tenacious that ships seldom, if ever, drag their anchors, even in exposed positions, such as Murray's Anchorage, where it is said one vessel, the sloop "Driver," rode out a gale although she carried away her bowsprit by pitching it under her cable.

Large parts of the Bermuda reefs are formed of *Serpula*-tubes, and along the south coast there are numerous miniature atolls, from 2 to 20 feet in diameter, entirely formed by *Serpulæ*. The outer rim is the highest part of these atolls, and at low tide one can see that it is composed of living *Serpulæ*, whereas in the inner part, dead tubes only are found. The lagoons are filled with water at low tide, and in the larger ones the depth is 2 or 3 feet. The bottom is covered with a fine calcareous sand, and in some parts of the lagoons living Actiniaria, Hydroids, &c., are found growing. These little atolls were evidently formed without subsidence, and at once suggested the possibility that the larger atolls of the Pacific and Indian Oceans might have been formed by a somewhat similar mode of growth.

Attention was directed during the stay to defining, as far as practicable, the edges and slope of the bank or atoll, carrying the soundings down to 1500 or 2000 fathoms, in fact, to oceanic depths. No information on these points had as yet been ascertained, but it was believed—from the fact of H.M.S. "Ariadne" having obtained a cast of 11½ fathoms 4 miles frôm the breakers or rocks awash, and from the statement that banks existed in a S.W. direction from the island,[1] which had been surveyed by H.M.S. "Columbine" in 1829—that the bank on which the islands and reefs are situated was really of much larger extent than was generally supposed. By the kindness of Captain Aplin, then in charge of the dockyard, who placed one of the yard tugs at the disposal of the Expedition, and gave assistance in other ways, it was possible to commence this work at once. It was found that on the southeast edge of the bank the 100 fathom line of soundings was at an average distance of 1¼ miles from the rocks awash, and that the depth increased rapidly from 30 to 350 or 400 fathoms, the slope being at an angle of about 20° from the horizontal, but from that depth to 1000 fathoms the slope varied from 7° to 15° from the horizontal. On the northeast edge of the bank the 100 fathom line of soundings was at an average distance of 3 miles from the rocks awash, and the slope was much more gradual. On the southwest side of the bank the 100 fathom line of soundings appears to extend at one point nearly 5 miles from the rocks awash.

About 4 miles southwest of the southwest extremity of the 100 fathom edge of the Bermuda Bank the Challenger sounded and anchored on the "inner bank" of the "Columbine," in 30 fathoms, with Gibb's Hill lighthouse, N. 54° 14′ E. (true), distant 13 miles. The boats were employed one day in obtaining soundings on this bank, but owing to the rough weather rendering the men sick,[2] and to the barometer falling, the officers were unable to define its limits or to look for the "outer shoal," out of sight of land, on which the "Columbine" anchored in 1820, and on which soundings were also taken by the "Larne" in 1836. From the depths obtained, the inner or Challenger Bank appears to be of some extent, certainly not less than 10 miles in circumference, the shallowest water found being 24 fathoms, and it is quite possible that it joins the outer or "Columbine" Bank, or that at any rate the depths between the two do not much exceed 100 fathoms.

In the depression, 3½ miles wide, between the Challenger Bank and the southwest extremity of the Bermuda Bank, the soundings, in all probability, do not exceed 1000

[1] Dana, Corals and Coral Islands, London, 1872; Findlay, North Atlantic Memoir, London, 1856.

[2] Seamen unused to the work of surveying ships are very often sea-sick in boats.

fathoms, as a cast of 1075 fathoms was obtained just east of the northwest part of the depression and another of 1250 fathoms just west of it.[1]

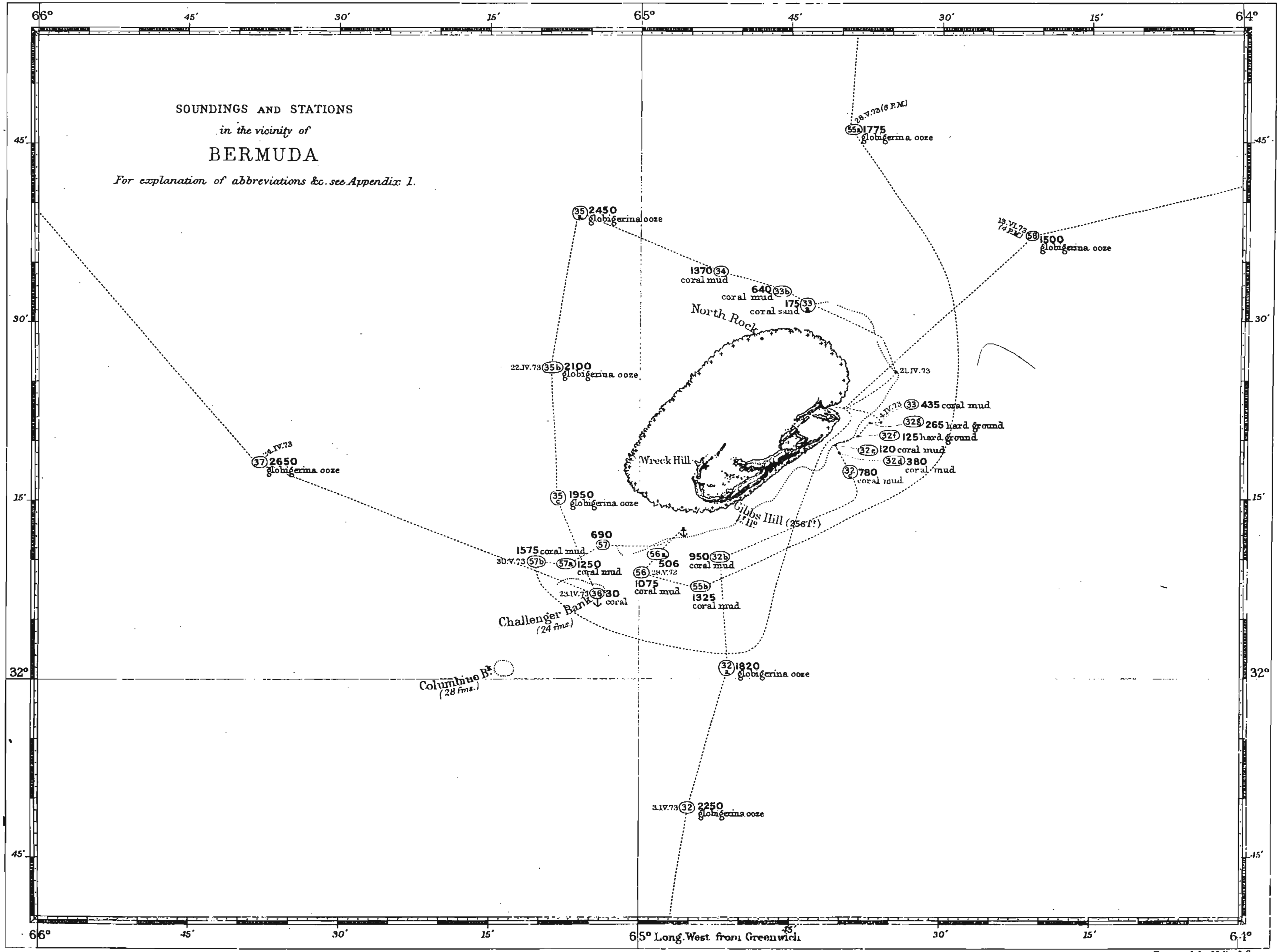
Circumstances did not permit of the definition of the edge of the 100 fathom bank on the northwest side of the Bermudas, but a cast of 1370 fathoms was obtained at a distance of 6 miles from the rocks awash, and one of 2100 fathoms at a distance of 10 miles. The deepest sounding obtained close to the atoll was one of 1950 fathoms, 5½ miles west of the extreme west point of the rocks awash (see Sheet 8).

Another important point to which attention was directed was the magnetic condition of the islands. Observations made by the Governor, General Lefroy, at his official residence, differed considerably from the Admiralty charts, and, consequently, instructions were received from the Hydrographer to ascertain whether those charts were in error or not. The observations made by the Expedition showed that the variation differed in various parts of the island as much as 6°, ranging from 4° W. to 10° W., the smallest amount being found at a small islet just under the lighthouse on Gibb's Hill, and the greatest at the point on the west side of Clarence Cove. The correct variation was found by swinging the ship on all points of the compass, and ascertaining its errors by azimuths of the sun, and the result so obtained agreed precisely with the Admiralty chart. It does not appear that before the visit of the Expedition this peculiarity of the Bermuda group was known, as the islands were said to consist entirely of calcareous rocks, derived from comminuted shells and corals, although Lieutenant Nelson, R.E., noticed on the island small pieces of oxide of iron of very questionable origin. It is, however, evident from these observations[2] that some disturbing cause exists in the neighbourhood of the islands which vitiates magnetic observations taken on shore.

At a depth of 200 fathoms, about 2 miles from the reefs, the deposit was composed of large fragments of Coral, Foraminifera, Echinoderms, Polyzoa, Molluscs, Algæ, and concretionary lumps, some of which were 2 or 3 centimetres in diameter. At 380 fathoms, 3 miles from the reefs, the fragments were smaller, and, in addition to the above, there were many Pteropod and Heteropod shells. At 950 fathoms, 4 miles from the reefs, the particles were still smaller, and there was a considerable admixture of pelagic Foraminifera. At 1950 fathoms, 5 miles from the reefs, the deposit was a nearly pure Globigerina ooze, made up chiefly of pelagic Foraminifera, with only a small proportion of species living on the bottom, and fragments from the reefs. All these deposits contained from 85 to 91 per cent. of carbonate of lime. The residue, after treatment with weak acid, consisted of a few siliceous spicules, fragments of felspar, augite, magnetite, and glassy rocks; none of the mineral particles exceeded 0·07 mm. in diameter. At 2600 fathoms, 30 miles from the reef, the deposit was a Globigerina ooze, containing only about 50 per cent. of carbonate of lime.

[1] Since this was written the outer bank, over which the least depth is 10 fathoms, has Been surveyed by H.M.S. "Argus," and named after that vessel, the depth between it and the Challenger Bank being about 500 fathoms.

[2] Narr. Chall. Exp., vol. ii. p. 25, 1882.



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Bermuda and its outlying banks are thus situated on the summit of a large cone with a wide base, rising from the submerged plateau of the Atlantic, which is, in this region, three miles (2600 fathoms) beneath the surface of the sea. It is very probably an ancient volcano, now completely covered with a white shroud, composed of the skeletons and shells of organisms.

The late Sir C. Wyville Thomson was of opinion that the "red earth" which largely forms the soil of Bermuda had an organic origin, as well as the "red clay" which the Challenger discovered in all the greater depths of the ocean basins. He regarded the red earth and red clay as an ash left behind after the gradual removal of the lime by water charged with carbonic acid. This ash he regarded as a constituent part of the

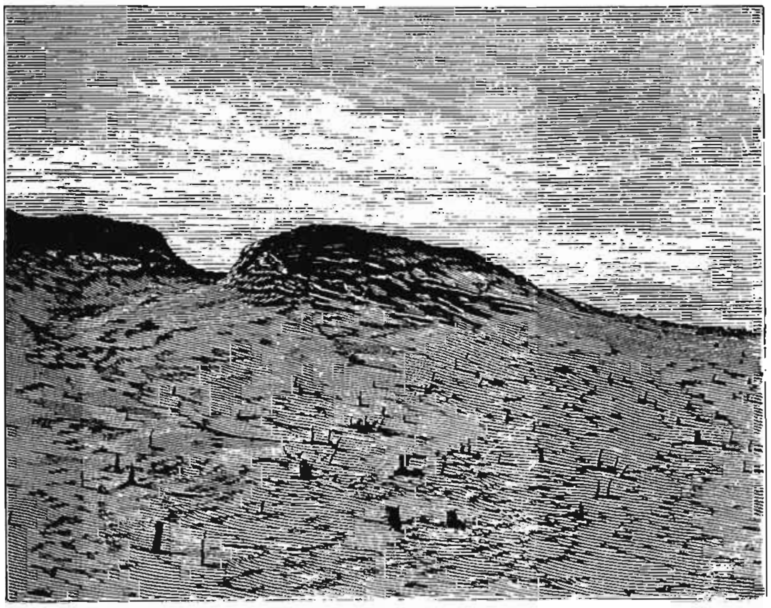


FIG. 55.—"Æolian" Limestone Beds in process of formation, showing stratification, and the remains of a grove of Cedars which has been overwhelmed. Elbow Bay, Bermuda. (*From a Photograph.*)

shells of Foraminifera, skeletons of Corals, and Molluscs.[1] This theory does not seem to be in any way tenable. Analysis of carefully selected shells of Foraminifera, Heteropods, and Pteropods, did not show the slightest trace of alumina, and none has as yet been discovered in coral skeletons. It is most probable that a large part of the clayey matter found in red clay and the red earth of Bermuda is derived from the disintegration of pumice, which is continually found floating on the surface of the sea.[2] The Naturalists of the Challenger found it among the floating masses of Gulf Weed, and it is frequently picked up on the reefs of Bermuda and other Coral islands. The red earth contains a good many

[1] Voyage of the Challenger, Atlantic, vol. i. p. 316.

[2] Murray, On the Distribution of Volcanic Débris over the Floor of the Ocean, *Proc. Roy. Soc. Edin.*, vol. ix. pp. 247–261, 1876–77.

fragments of magnetite, augite, felspar, and glassy fragments, and when a large quantity of the rock of Bermuda is dissolved away with acid, a small number of fragments are also met with. These mineral particles most probably came originally from the pumice which had been cast up on the island for long ages (for it is known that these minerals are present in pumice), although possibly some of them may have come from the volcanic rock, which is believed to form the nucleus of the island.

The land surface of the islands is almost entirely composed of blown calcareous sand, more or less consolidated into hard rock. In several places, and especially at Tuckerstown and Elbow Bay, there exist considerable tracts covered with modern sand dunes, some of

FIG. 56.—"Sand-Glacier" overwhelming a garden. Elbow Bay, Bermuda. (*From a Photograph.*)

which are encroaching inland upon cultivated ground (see fig. 56), and have overwhelmed at Elbow Bay a cottage, the chimney of which only is now to be seen above the sand (see fig. 57). The constant encroachment of the dunes is prevented by the growth upon them of several binding plants, amongst which a hard prickly grass (*Cenchrus*), with long, deeply penetrating root-fibres, is the most efficient. When these binding plants are artificially removed, the sand at once begins to shift.

The scenery of Bermuda is in some respects not unlike that of certain northern lake districts, for the numerous small islands which are dotted over the sounds and land-locked sheets of water are covered with vegetation down to the water's edge. The dark colour of the Juniper (*Juniperus bermudiana*, a species peculiar to these islands and the West Indies), called in the island "Cedar," the prevailing foliage, not unlike that of Pines in appearance, gives the landscape a northern aspect, and on cloudy days, the island, as viewed from the sea, looks cold and bleak. The extreme lowness of all the land, however, is characteristic and distinctive. Most conspicuous, next to the Juniper as a general feature in the vegetation, is probably the Oleander (*Nerium oleander*), which, having been introduced, flourishes everywhere. A large portion of the uncultivated land is covered with a dense growth of another introduced plant, *Lantana camera*, a most troublesome weed.

The most refreshing and beautiful vegetation in Bermuda is that growing in the marshes and caves. The marshes or peat bogs lie in the inland hollows between two ranges of hills, and are covered with a tall luxuriant growth of ferns, especially two species of *Osmunda* (*Osmunda cinnamomea* and *Osmunda regalis*). Some ferns are restricted to particular marshes; one salt marsh fern (*Acrostichum aureum*) grows

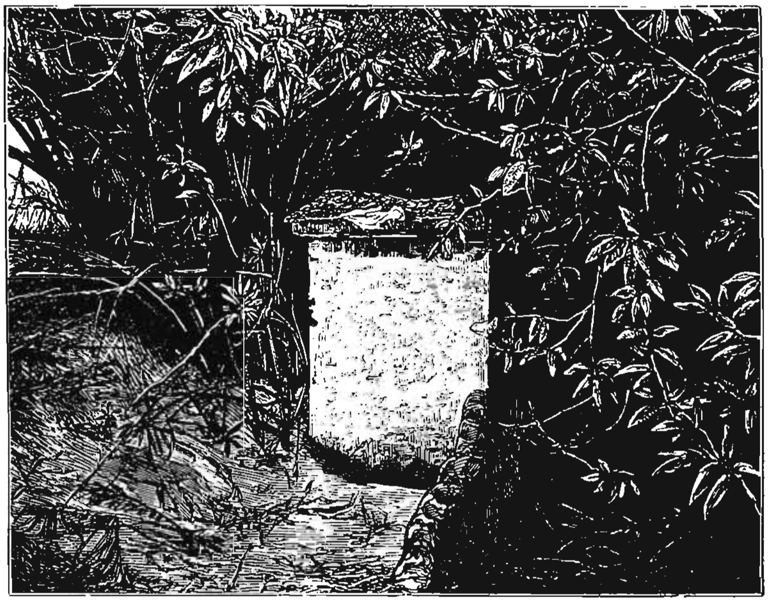


FIG. 57.—Chimney of a Cottage which has been buried by a sand-glacier. Elbow Bay. (*From a Photograph.*)

densely to a height of 4 or 5 feet. Together with the ferns grows the Juniper, which thrives in the marshes, and a species of Palm (*Sabal blackburniana*), thus giving a pleasing variety to the foliage.

A very careful collection of the plants of the islands was made during the stay, and this, together with a most valuable series of specimens collected by General Lefroy after prolonged exertions extending over the whole period of his residence in the group, forms the basis of the treatise on the flora of the islands which forms one of the Botanical Reports of the Expedition.[1] It is there shown that the group possesses far more vegetable forms peculiar to itself than had hitherto been suspected. It is probable that the occurrence of North American plants in the islands is connected with the fact that

[1] Bot. Chall. Exp., part i., 1884.

the islands are visited from time to time by immense numbers of migratory birds from that continent, especially during their great southern migration. Of these the American Golden Plover (*Charadrius marmoratus*) seems to visit Bermuda in the greatest numbers, but various other birds frequenting marshes—gallinules, rails, and snipes—arrive in no small quantities every year. These birds have possibly brougbt a good many plants to Bermuda, as seeds attached to their feet or feathers, or in their crops. Some of the most conspicuous of the present land birds of Bermuda, such as the "Red Bird," or Cardinal, have been introduced for ornamental effect.

The birds most interesting to the naturalist encountering them for the first time,

FIG. 58.—Natural Swamp-Vegetation, Bermuda. (*From a Photograph.*)

are the "Boatswain-birds" (*Phaëthon flavirostris*). They are white, a little smaller than the commonest English Gull, and shaped more like a Sea-swallow or Tern, though allied to the Gannets and Cormorants; in the tail are two long narrow feathers of a reddish tint, which, as the bird flies, are kept extended behind, and give it a curious appearance. The birds breed, more or less gregariously, in holes in the rock formed by the weathering out of softer layers; it is easy to secure them in the hole by clapping a cap over its mouth, when both male and female can often be caught together. It is, however, quite a different matter to get hold of them for skinning: their bills are very sharp and strong, and they fight furiously, screaming all the while. Only one egg is laid, and it is of a dark red colour like that of the kestrel.

The corals of Bermuda may be seen growing to great advantage by the use of a water glass. The species are, as will be seen by the list below, as far as is yet known, 25 in number, of which 23 are Anthozoan and 2 Hydrozoan; the latter (species of *Millepora*) are very abundant, and contribute largely to the reef formation. While some species, such as the great Brain Coral (*Diploria cerebriformis*), which is conspicuous

FIG. 59.—Group of Palms on the croquet-lawn, Mount Langton.

at the bottom as a bright yellow mass, appear to prefer to grow where the water is lighted up by the sunshine, other species, such as *Millepora ramosa* and *Isophyllia dipsacea*, seem to thrive best in the shade. One species, *Agaricia fragilis*, occurs growing in colonies in great abundance in water from a foot to a fathom in depth, inside small caverns, and forms very thin and fragile plate-like laminæ, which when bleached are almost the loveliest of corals.[1]

[1] *Reef Corals of Bermuda.*—Mr. J. J. Quelch, B.Sc., of the British Museum, who is engaged in the preparation of a Report on the Challenger collection of Reef Corals, contributes the following note:—"The structure and position of the Bermudas give a special interest to the reef-corals which are found there, the more so as those hitherto obtained have been confined to a few species. A list of these has been given by Dana (Corals and Coral Islands, p. 114) and includes the following:—Of the Astræa tribe, *Isophyllia dipsacea*, *Isophyllia rigida*, *Diploria cerebriformis*; of the Oculina tribe, *Oculina diffusa*, *Oculina pallens*, *Oculina varicosa*, *Oculina valenciennesi*; of the Fungia tribe, *Siderastræa radians*, *Mycedium fragile*; of the Madrepora tribe, *Porites clavaria*; also the Hydroid coral *Millepora alcicornis*.

The following notes are from the late Dr. R. v. Willemoes Suhm's Journal, June 1873:—

"On looking at the Blue and Red Birds of the island (*Sialia wilsoni* and *Pitylus cardinalis*), one would imagine them to be in the most suitable and natural habitat, and that their existence here was not due to artificial introduction; yet we are told that the red bird was introduced only some thirty years ago. When we remember the swarms of

"To these should have been added the *Oculina bermudensis* of Duchassaing and Michelotti. With the exception of *Oculina valenciennesi*, these were all obtained by the Challenger; and, in addition, *eleven* other species of true corals, and one Hydroid coral; thus doubling the number formerly known.

"*Astræa* proper (*Favia*) and *Mæandrina* are *with certainty* recorded for the *first* time from this locality, there being two species of the former and three of the latter genus. To the species of *Isophyllia*, four others have been added, one of which, according to Milne-Edwards and Haime, occurs both in the Atlantic and Pacific. Three other species of *Oculina* were obtained, one of these being a new one.

"The complete list of the reef-corals with revised synonymy includes the following:—

Isophyllia dipsacea, Dana.
" *strigosa*, Duch. and Mich. (=*Isophyllia rigida*, Verrill).
" *australis*, M.-Edw. and H.
" *knoxi*, Duch. and Mich.
" *marginata*, Duch. and Mich.
" *cylindrica*? Duch. and Mich.
Mæandrina strigosa, Dana.
" *sinuosissima*, M.-Edw. and H.
" *labyrinthiformis*, (Linn.) Ell. and Sol.
Diploria cerebriformis, Lamk.
Astræa ananas, Ell. and Sol.
" *coarctata*, Duch. and Mich.
Agaricia fragilis, Dana.
Siderastræa galaxea, Ell. and Sol.
Porites clavaria, Lamk.
Oculina diffusa, Lamk.
" *pallens*, (Ehrb.) Dana.
" *varicosa*, (Les.) Dana.
" *speciosa*, M.-Edw. and H.
" *coronalis*, n. sp.
" *bermudensis*, Duch. and Mich.

"To these must be added *Pentalophora decactis*, Lyman, and the *Oculina valenciennesi*, mentioned by Dana, making a total of twenty-three species which are now known from the Bermuda Reefs; besides the two Hydroid Corals—

Millepora alcicornis, Linn.
" *ramosa*, Pall.

"It will be seen that the species not previously found are *Isophyllia marginata*, *Isophyllia australis*, *Isophyllia knoxi*, *Isophyllia cylindrica*; *Mæandrina strigosa*, *Mæandrina sinuosissima*, *Mæandrina labyrinthiformis*; *Astræa ananas*, *Astræa coarctata*; *Oculina speciosa*, *Oculina coronalis*, and *Millepora ramosa*.

"*Mæandrina labyrinthiformis* was recorded from this locality by Dana in the "Zoophytes," but it has been omitted in his later work; and although General Nelson, in his paper read before the Geological Society in 1834, on the structure of the Bermudas, speaks of large, massive, and perfect *Mæandrina* as being found in the chalk conglomerate, yet there is no certainty as to whether *Diploria*, *Mæandrina* proper, or even *Manicina* was intended, since the *Mæandrina* of Lamarck included the three; while his obtaining the *Mæandrina areolata* from a large block of reef in the solid rock, 15 or 20 feet from the surface, indicates that *Manicina* has flourished in this locality, although no representative of the genus has been found living on the Reefs.

"Taking into consideration the large increase in the number of species of reef-corals occurring at Bermuda which has resulted from the Challenger Expedition, it cannot be doubted that a lengthened stay in this interesting group would yield still greater results."

lizards which inhabit the walls and rocks of Italy, it is astonishing that here, where there are plenty of insects, only one little Scincoid, a species of *Mabouya*, is now and then to be met with under a stone. In some brackish water there was a little Mugiloid. The Mugilidæ are known to live in all kinds of water, from fresh to salt; they are found in the Lagoon of Venice, in brackish, salt, and fresh water. Cyprinoids, true freshwater forms, have

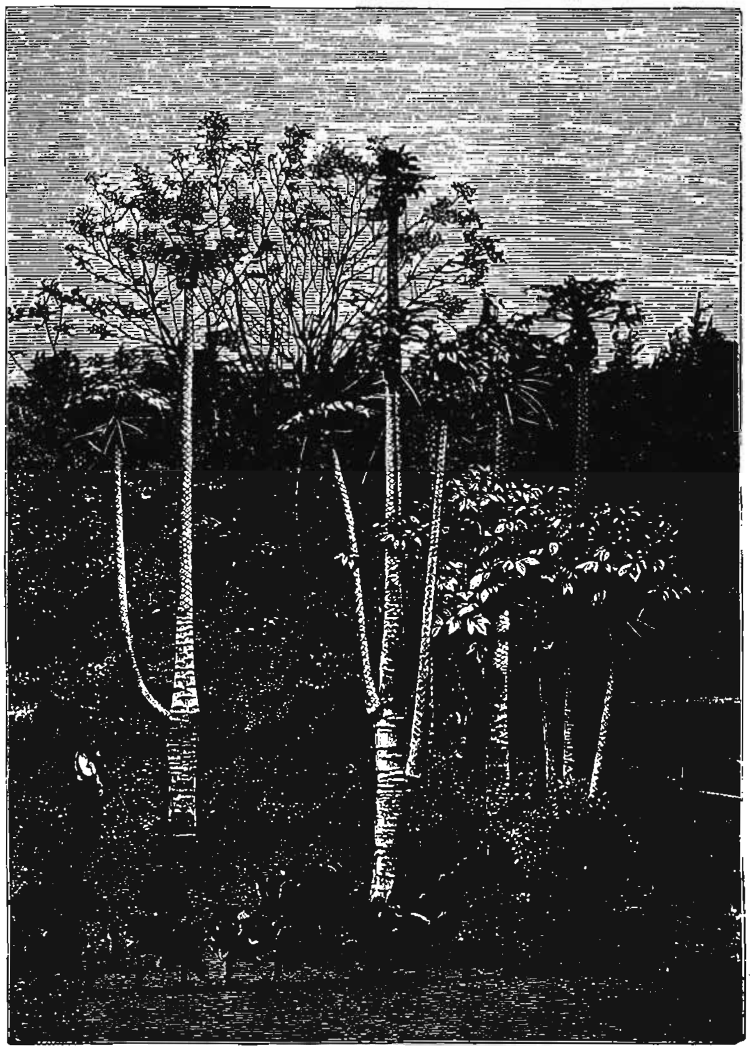


FIG. 60.—Papaw-trees (*Carica papaya*), in the Governor's garden at Clarence Hill. (*From a Photograph.*)

not been introduced here, with the exception of the gold-fish; and the *Anguilla*, which in other islands, as the Azores, Færöes, and Tahiti, ascends into the lakes, does not seem to inhabit the coasts of these islands, the whole fish fauna of which, as well as the invertebrate fauna generally, has a decidedly West Indian character.

"Since our last stay here many insects have come out which we did not see before, spiders, beetles and butterflies, the latter, however, being very scarce.[1] The scarcity of Hemiptera is astonishing, for besides the Green-bug (*Rhaphigaster*) only a few small Cicadas, found on the cedar trees, were observed. Under the stones I always found a few land shells,[2] several species of *Blatta*, and very often a *Gryllus*. Flying beetles are rare. When returning at night from our excursions, we observed no insects filling the air as they do in Europe, with the exception of some Sphingidæ, and no Bats were observed. It is true that bats have been found here, but they all belong to American species, which have either been brought over in ships transporting wood, or have been driven over by storms.

" I visited Hungry Bay specially with the intention of watching and obtaining specimens of a Crab, which is well known to the Bermudians, from its habit of ascending the Mangrove trees. This is the *Grapsus cruentatus*, Latr., known from Brazil and the Antilles. It inhabits the holes seen everywhere in the soft and moist brown earth near the Mangrove trees. The larger of these holes have a diameter of three to four inches, and they go down to a depth of three or four feet, as deep down, indeed, as the moist earth itself. Wet mud was found at the bottom of each hole, so that when the Crabs are sitting in these, there is plenty of moisture for their gills, and when on the Mangrove trees, they are noticed from time to time retiring into the pools which are met with under each tree. This explains the astonishing, and, as far as I am aware, unknown fact, that a member of the Grapsoidea has been able to take up the habits of a Gecarcinoid, without having the anatomical apparatus, which from Milne-Edwards' dissections is well known in the latter. The gills of this *Grapsus cruentatus* do not differ, as I ascertained by dissection, from those of the Brachyura of marine habits. *Grapsus* has, however, not assumed all the habits and manners of land crabs, for though it is seen walking on the land and climbing up the trees, it spends most of its time in the water, or in moist media, and does not seem to be nocturnal, like *Gecarcinus*. On walking over the place where these crabs have their holes, one disturbs hundreds of the younger ones, and the larger ones may be noticed watching attentively from the entrances to the holes, and retiring in the greatest hurry when approached. Many full-grown specimens were caught, and among these a female carrying its eggs. Animals which have assumed

[1] The Lepidoptera collected on the islands include the following species (Butler, *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xiii. pp. 184–188, 1884):—

Junonia cœnia, Hübner.	*Plusia ou*, Guénée.
Chærocampa tersa (Drury).	*Remigia marcida*, Guénée.
Leucania antica, Walker.	*Thermesia monstratura*, Walker.
Laphygma macra, Guénée.	*Margaronia jairusalis*, Walker.
Perigea subaurea, Guénée.	*Stenopteryx hybridalis* (Hübner).

[2] The following terrestrial Mollusca were collected at the Bermudas (E. A. Smith, *Proc. Zool. Soc. Lond.*, p. 277, 1884):—

Helix bermudensis, Pfeiffer.	*Bulimus ventrosus*, Fér.
„ *circumfirmata*, Redfield.	*Succinea bermudensis*, Pfeiffer.
„ *microdonta*, Desh.	*Helicina convexa*, Pfeiffer.
„ *vortex*, Pfeiffer.	*Melampus gundlachi*, Pfeiffer.

The common European *Limax gagates*, Drap., was also found, and has not been previously recorded from this locality.

altered habits from those of their congeners, and live in different media, usually have an accelerated embryological development, because the medium necessary for the early stages of the larvæ has been relinquished by the parent. Crabs are known to live in three media,—in the sea, in fresh water, and on the shore. The mode of propagation of the sea crabs, passing through a zoea stage, must be considered their normal way of development. In *Telphusa*—as I discovered after carefully investigating these freshwater crabs in the mountains of Italy—the newly hatched young ones remain attached to the abdomen of their mother. They have no metamorphosis, and as their mode of life

FIG. 61.—Cedar Avenue, Hamilton, Bermuda. (*From a Photograph.*)

has many resemblances to that of the *Grapsus* found here, one may fairly conjecture that in this Crab also no metamorphosis occurs.

"The Mangrove swamp is a hot and damp place, especially favourable for tropical animal life. Large Dragon-flies (*Libellula* and *Agrion*) fly about, and a little *Cicindela* is perpetually flitting from one place to another, and many other insects can be captured. Under stones two specimens of another land crab were procured, which evidently belongs to the Telphusidæ, the freshwater crabs, and comes nearest to the genus *Boscia*, found in Brazil and South America, from which it differs, however, in some slight respects. There was no fresh water near the place where I found the specimens. With regard to its habits, it is far from having the agility of the *Grapsus*, is easily caught, and seems to live in holes under stones. Some specimens of *Ocypoda rhombea* and *Gecarcinus* *lateralis,* as well as two very large specimens of *Cardiosoma guanhumi* (known as the "crabe blau" in the Antilles), were procured by the other naturalists. These latter crabs had been caught by torch-light in the sand hills of the interior, as they leave their holes only at night. We also procured large specimens of what is known as the Soldier-crab (*Grapsus pictus*), and which can be seen living and fighting in great numbers on the rocky shores of the south coast of Bermuda, where in April we saw many of their cast-off skins.

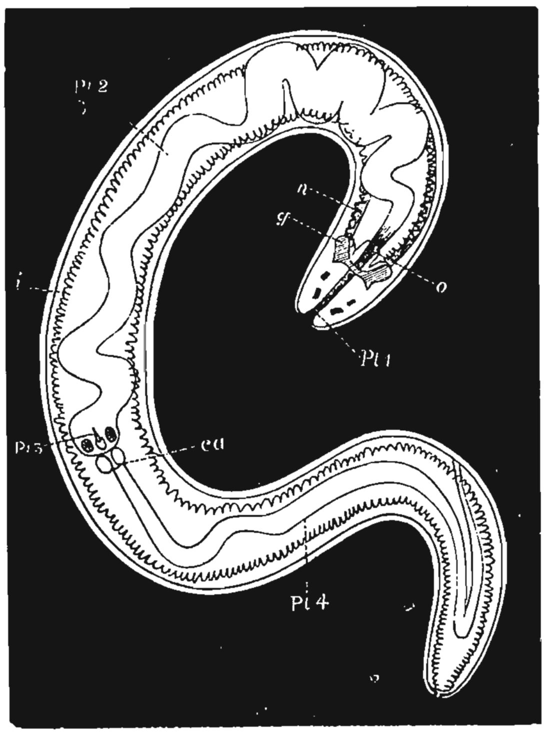


FIG. 62.—Land Nemertine, *Tetrastemma agricola*, Suhm (young male). Pt 1-4, Successive portions of the proboscis; 1, entrance; 2, papillary portion; 3, pouch of stylets; 4, glandular portion; *ca*, muscular entrance of glandular portion; *o*, mouth; *i*, intestine; *g*, ganglion; *n*, lateral nerves.

"In the moist brown earth, near the edges of the Mangrove swamp, I found besides a *Lumbricus*, a white slimy worm, shooting out a proboscis when touched, which showed clearly that it was a Land Nemertine (fig. 62). It belonged to the genus *Tetrastemma.* It differs little from the *Tetrastemma obscurum* described by Max Schultze from the Baltic; I have named it *Tetrastemma agricola.* Only two other terrestrial Nemertines are as yet known, one discovered by Semper in the Philippine Islands, and a second found in hot-houses in Europe, evidently imported from some unknown tropical region.[1] When irritated the worm darts out its armed proboscis as an aid in progression, fixing its tip to a distant point and then drawing the body up to the point by contracting the protruded organ. The animal is ciliated all over, and has two pairs of eyes. The earth in which it lives contains a good deal of salt. It is very probable that these Nemerteans live in the tropics in the same regions as do the land Planarians, but, owing to their being less conspicuous, they have hitherto been overlooked. A good many, both old and young, were caught, and kept alive for some time in glasses, in some of the earth in which I found them.[2]

"I made an excursion to Harrington Sound, with the view of looking for specimens of the *Nebalia* (*Paranebalia*, Claus)[3] which Murray had found there in April, and was fortunate enough to find, under stones and on the under surface of *Agaricia fragilis,* many females and some males of this interesting Crustacean, which are likely to throw some

[1] Others have been discovered, since the above was written, in the Mascarene Islands and elsewhere.

[2] On a Land Nemertean found at the Bermudas, *Ann. and Mag. Nat. Hist.*, ser. 4, vol. xiii. pp. 409–411, pl. xvii., 1874.

[3] This species has since been erected into a new genus, under the name *Paranebalia longipes*, by Claus, Grundzüge der Zoologie, 4th ed., 1880, p. 576.

light on the morphological value of different parts of the animal. The male is only known in one species (*Nebalia geoffroyi*), in which it is but little more slender than the female, and has the first pair of antennæ only slightly larger and the second pair much longer than

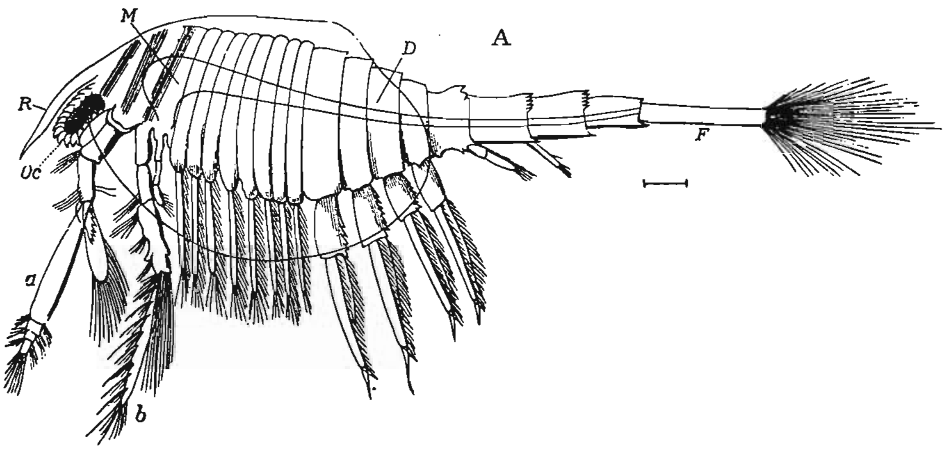


FIG. 63, A.—Female of *Nebalia (Paranebalia) longipes*, Suhm, magnified about 20 diameters, from a drawing by von Suhm. *a*, first antenna; *b*, second antenna; *Oc*, eye; *R*, rostrum; *M*, stomach; *D*, intestine; *F*, furcal process.

is the case in the female. In this Bermudian *Nebalia* (*Paranebalia*), which differs in many ways from any *Nebalia* hitherto known, the male is only half the size of the female, and has the first pair of antennæ changed into strong prehensile organs, whilst the second pair

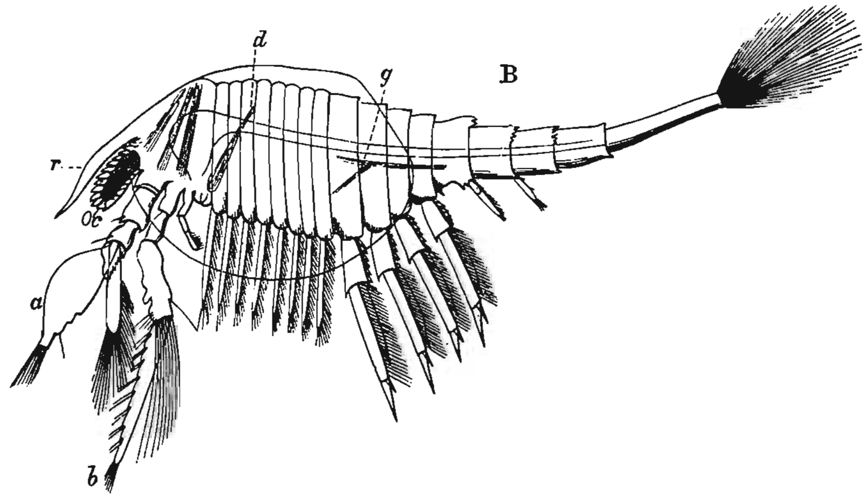


FIG. 63, B.—Male of the same, magnified about 35 diameters.. Letters as in A. *d*, palp of the first maxilla ("Putzfuss," Claus); *g*, ductus ejaculatorius.

does not differ from that of the female. In both cases the genital opening is at the base of the eighth pair of pectoral limbs. These differences in the males of the two species are so considerable that, according to the principles adopted for the classification of other groups, for example the Copepods, it would be necessary to make another genus of this

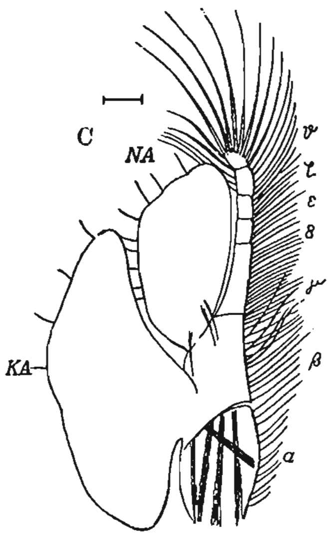


FIG. 63, C.—Phyllopod-like thoracic limb of *Nebalia geoffroyi*, from Suhm, after Claus. *α*, basal joint with branchial appendage (*KA*); *β*, second joint with lateral appendage (*NA*); *γ*, main branch; *δ–θ*, successive joints of the same.

new form; but in *Nebalia*, I think, this would not be advisable, as our knowledge of this singular little group is only beginning, and many discoveries of new forms are to be expected which will better fix its systematic position. The pectoral feet of this species are of great interest, as confirming the opinions of Claus[1] and Mecznikoff that the genus *Nebalia* should be associated with the Schizopods rather than the Phyllopods. The pectoral limb of *Nebalia geoffroyi* (fig. 63, C) shows very clearly the two leaf-like appendages KA and NA, which led earlier observers to place it in the latter group; in the corresponding member of *Nebalia* (*Paranebalia*) *longipes* (fig. 63, D) one of these KA is represented only by a small rudiment, and the other has lost its flattened form and become a rounded limb comparable with one branch of the typical Schizopod appendage, such as that of *Lophogaster typicus* (fig. 63, E).[2] Had this been the first form of *Nebalia* made known, the group would probably never have been classed with Phyllopods. From a Darwinian point of view this form, which I propose to call *Nebalia longipes*, represents a more advanced stage of these strange creatures, which are the connecting links between Phyllopods and the higher Malacostraca (Schizopods)."

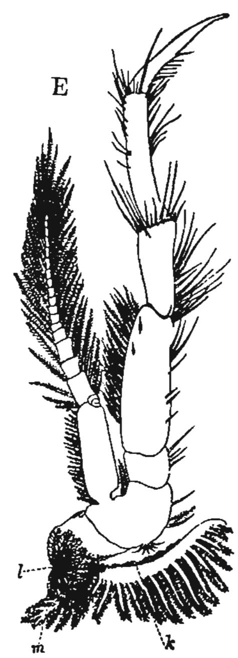


FIG. 63, E.—Thoracic limb of *Lophogaster typicus*, from Sars, for comparison.

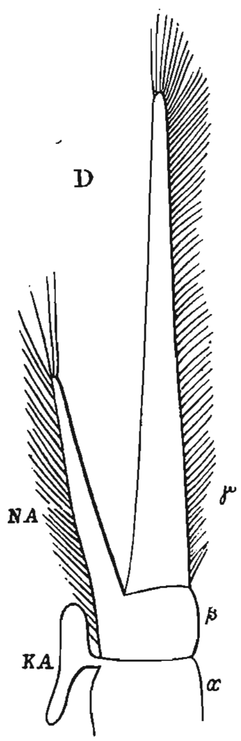
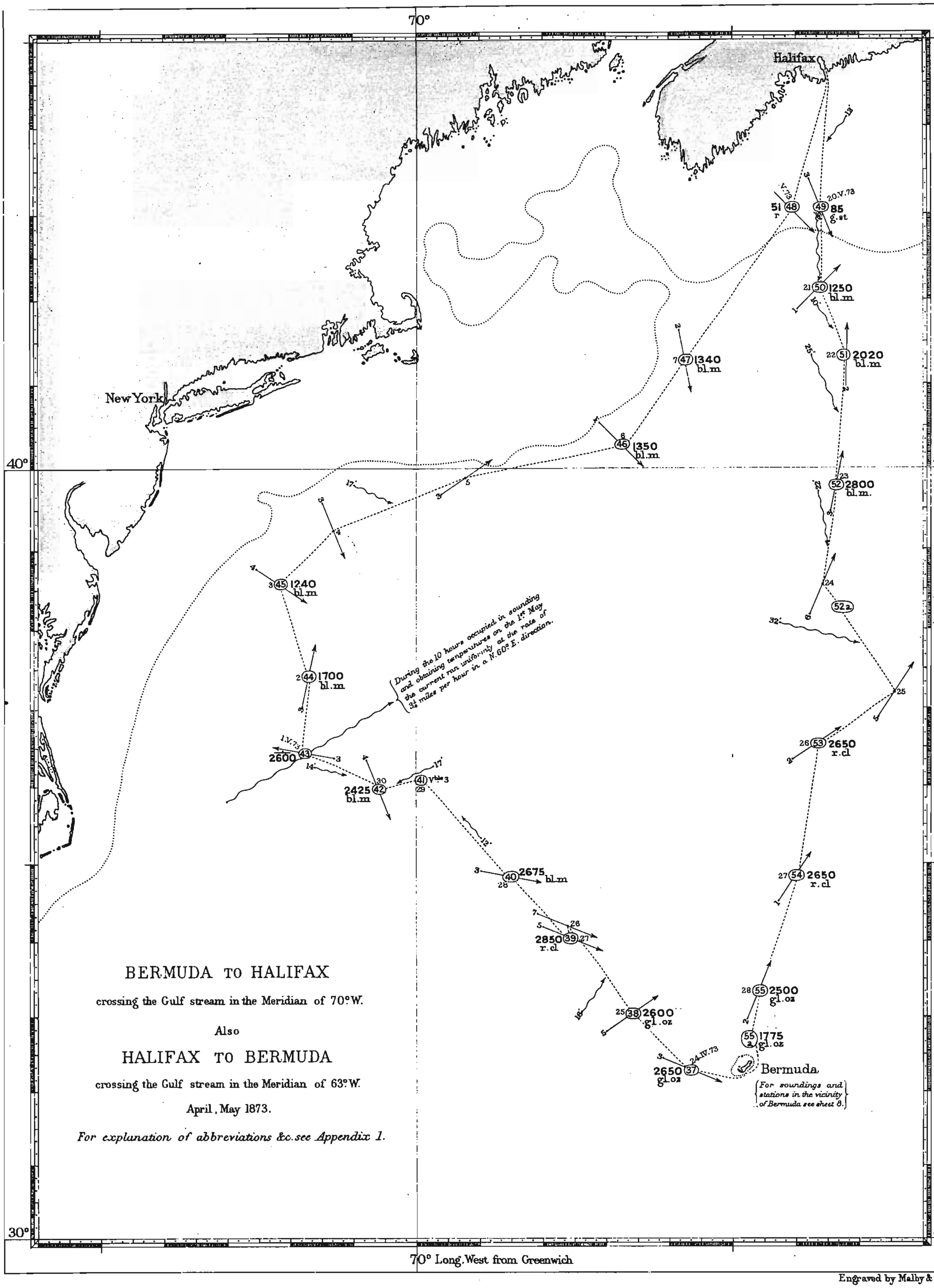


FIG. 63, D.—Corresponding limb of *Nebalia* (*Paranebalia*) *longipes*, from Suhm. Letters as in C.

A large number of invertebrates were collected on the reefs and on the sandy patches between the coral clumps. Professor Wyville Thomson[3] found, in the collection of an amateur naturalist, a small worn cup of the rare Crinoid *Holopus*. He looked carefully in all the dredgings about Bermuda for living specimens of this genus, but in vain. Dr. P. H. Carpenter gives the

[1] Claus, *Zeitschr. f. wiss. Zool.*, Bd. xxii. p. 323, 1872. [2] Sars, M., Beskrivelse over Lophogaster typicus, tab. ii. fig. 35.
[3] The Atlantic, vol. i. p. 321, 1877.



BERMUDA TO HALIFAX

crossing the Gulf stream in the Meridian of 70°W.

Also

HALIFAX TO BERMUDA

crossing the Gulf stream in the Meridian of 63°W.

April, May 1873.

For explanation of abbreviations &c. see Appendix 1.

Engraved by Malby & Sons.

following note about *Holopus*,[1] which, unfortunately, was not obtained in any of the Challenger dredgings :—

"*Holopus* is one of the most curious of the recent Crinoids, and appears to be sessile throughout life. The basals and radials enclose a tubular chamber, in which the viscera are contained; and this is attached directly to the rock on which it rests by a spreading calcareous expansion, instead of being borne on a stem, as most other Crinoids are, for the whole or part of their life. The central mouth is protected by five triangular oral plates, as in *Hyocrinus* and *Thaumatocrinus*, and surrounded by five massive arms, which are articulated in pairs to five axillary plates that rest on the edge of the cup. Only half a dozen specimens are known, most of which have been brought up by fishermen's lines in the neighbourhood of Barbados. One very young individual was obtained by the U.S. Coast Survey steamer 'Blake,' in 100 fathoms, off Bahia Honda, and a fragment of a larger one in 110 fathoms off Montserrat. The genus is not known to occur out of the Caribbean Sea, and was not dredged by the Challenger. It is closely allied to a remarkable fossil known as *Cyathidium*, which occurs in the upper Chalk of Faxöe in Zeeland, and also to some singular sessile Crinoids characteristic of the Middle Lias in central and western Europe. Certain Palæocrinoids and Cystideans also seem to have been sessile like *Holopus*, and not stalked like most of the Pelmatozoa."

BERMUDA TO HALIFAX, NOVA SCOTIA.

The vessel left the neighbourhood of Bermuda on the 21st April, and at first a course was shaped towards New York. After crossing the Gulf Stream and obtaining soundings and temperatures to the edge of the 100 fathom bank off the American coast (see Sheet 9), the ship was steered to the northeastward for Halifax, Nova Scotia, arriving there on the 9th May. The usual dirty weather was experienced on the passage towards New York: occasional strong winds, amounting sometimes to a gale, with light breezes intervening, and after crossing the Gulf Stream thick fogs, with rain, until close in to the land.

On the 28th April the sounding line parted as it was being hove in, but later on the dredge brought up a specimen of the bottom. On the 29th the sea was so short and heavy that in keeping the ship head to wind, in order that a sounding might be obtained, the rudder took charge and carried away the wheel ropes, so that the attempt had to be abandoned for that day.

On the 30th April at 2 P.M. the temperature of the surface water, which, since leaving Bermuda, had varied between 65°·0 and 70°·0, rose to 71°·5, and continued at a temperature of from 71°·0 to 73°·0 until 6 A.M. on the 1st May, when it rose to 75°·0. At that hour

[1] See Zool. Chall. Exp., part xxxii., 1884.

the ship was stopped to sound and obtain temperatures, and a good set of observations of the sun were taken at 6.40 A.M., and as its bearing was E. 6° N. (true), a considerable error in the latitude was of but little consequence to the resulting longitude. From these observations it appeared that from noon on the 30th April to 6 A.M. on the 1st May, when the sudden increase of surface temperature took place, little if any current had been experienced, the longitude from Dead Reckoning being 72° 8′ W., and that by observation 72° 4′ W. This result was also confirmed by an observation at 4.40 P.M. on the 30th April, the longitude by chronometer at that time agreeing with the D.R. longitude.

At 6 A.M. on the 1st May the wind was from the N.E., force 3 to 4, with a considerable swell, and owing to the rise of surface temperature to 75°·0, the opinion was formed that the vessel was in the Gulf Stream. In sounding the sinkers were lowered over the side of the ship without, as usual, keeping head to wind. When 250 fathoms of line were out, it trended rapidly to the W.S.W., and made it necessary to put the ship before the wind to keep exactly over the descending weights; in fact, the vessel had to steam W.S.W. (S. 60° W., true), at the rate of 3 miles per hour, to keep the line perpendicular, and even then could only do so by constantly checking, as when it was allowed to run out freely the surface drift of 3 miles per hour carried the bight rapidly astern. It will, therefore, be readily understood that the speed of the line as it ran out over the ship's side was the speed of descent of the sinker plus the rate at which it was being carried away by the current, and that, therefore, the time intervals were of little value in determining the moment at which the weights struck the bottom. When 2600 fathoms were out, the line was checked and was apparently perpendicular; but as the accumulators showed what was believed to be a decrease in the strain, and the line did not readily come up and down, it was concluded the bottom had been reached. This was a mistake, for on being hove up, it was found that the sinkers had not disengaged, nor was there any sign of mud on the rod.

A serial temperature observation obtained at this position showed that the warm water was quite superficial; at 60 fathoms the temperature was 71°, at 80 fathoms 68°, at 100 fathoms 65°, and at 125 fathoms 57°. To obtain these results a weight of 2 cwt. had to be attached to the bottom of the line to keep it perpendicular; with a less weight the bight of the line was carried away, forming a bow.

With the current drag lowered to a depth of 100 fathoms a very slight motion of the surface water past the watch buoy was apparent, but when lowered to a depth of 250 fathoms the surface water ran past the watch buoy at the rate of $1\frac{3}{4}$ miles per hour. It is therefore probable that at that depth, even if not at a less, the current drag was in still water, as the force of the 3-knot stream on the watch buoy and the upper portion of the current line was, probably, sufficient to move the drag through the water at about the rate of a mile per hour.

In investigating the strength and direction of ocean currents, such as the Gulf

Stream, when out of sight of land or unable to anchor a boat, observations of the heavenly bodies are the only resource, and when the weather is clear, so that these observations can be obtained at short intervals, and especially when stars have been taken at sunrise and sunset, with a well-defined horizon, so that both latitude and longitude are determined at the same instant *twice* during the day, a very accurate estimate can be formed, by astronomical observations alone, of the rapidity of the stream. If star observations cannot be obtained, the operation is by no means so simple; and is sometimes impossible, as then the latitude cannot be determined at the same instant as the longitude,[1] double altitudes of the sun not being available owing to the want of knowledge of the alteration in the position of the ship between the times of observation; the latitude, therefore, can only be got at noon by meridian altitude of the sun.

Unfortunately, nearly all the great ocean streams, the phenomena of which it is most desirable to investigate, have in their neighbourhood cloudy, thick weather, with short, sharp gales, rendering their exploration at all times difficult. The officers were so far fortunate in the weather in the Challenger, whilst taking temperatures, soundings, &c., in the Gulf Stream from 6 A.M. to 5 P.M. on the 1st May, as to be able to obtain frequent observations of the sun, although the sky was too cloudy to permit the determination of the position by star observations at sunrise or sunset. It was therefore only possible to obtain one latitude at noon by meridian altitude of the sun. The positions of the ship at various times during the day were determined in the following manner:—A set of observations for longitude was taken at 6.40 A.M., when the bearing of the sun was E. 6° N., or nearly on the prime vertical, and another at 4.27 P.M., when its bearing was W. 1° S., or almost exactly on the prime vertical. Any error, therefore, of the latitude used in working these observations would have but a slight effect on the longitude. Now, the resulting longitude at 6.40 A.M. was 72° 4′ W., and at 4.27 P.M. 71° 31′ 30″ W., it is, therefore, evident that between those hours the drift in longitude experienced by the ship was 32½ minutes. But in keeping the sounding line perpendicular it was found necessary to steam W.S.W. (S. 60° W. true) at the rate of 3 miles per hour, from which it is evident that the direction in which the stream was running was N. 60° E. Having then the direction in which the current was going, and the alteration of longitude due to it in a given time, it was possible to calculate the speed at which it was running, which amounted to 3¼ miles per hour, or very nearly the same rate at which it was necessary to steam in a W.S.W. direction whilst sounding.

If this conclusion as to the direction and rate of the current be correct, it is evident that by applying the amount due to a given interval of time, the longitude of the ship at that time, as determined by this method, should agree with the longitude obtained by actual observation. By taking a proportion of the whole alteration in the longitude between 6.40 A.M. and 4.30 P.M., it was found that the longitude at noon was 71° 45′ 54″ W.,

[1] Unless the moon is visible, or Venus or Jupiter passes the meridian during the day.

the observed latitude being 36° 23′ 30″ N. At 10.20 A.M. a set of sights was obtained, and as the bearing of the sun at that time made it a matter of importance to know exactly the latitude (an error of one mile of latitude causing an error of one mile in longitude), the result given by the observations then taken furnishes a very good test of the accuracy of the deductions. The interval from noon being 1·7 hour, it follows that the position of the ship at the moment, calculated by the known rate of the current from the noon results, will be lat. 36° 20′ 48″ N., long. 71° 51′ 44″ W., and the longitude, calculated from the observations, was 71° 53′ 45″ W. Again, at 8.40 A.M. the position calculated from the noon observation was lat. 36° 18′ 15″ N., long. 71° 57′ 6″ W., and longitude calculated from the observations at the time was 71° 57′ 30″ W. Such an accordance between the calculated positions and those obtained by observation will, in all probability, be deemed a sufficient proof, together with the fact of the rate at which it was necessary to steam to keep the sounding line perpendicular, that this estimate of the strength and direction of the Gulf Stream whilst the vessel was in it is a very close approximation to the truth.

At 5 P.M., these observations being completed, the ship proceeded N.N.W. (N. 30° W. true) at right angles to the direction of the stream. At 9.30 P.M. the surface temperature had fallen from 75°·0 to 69°·0, and the patent log showed that the vessel had gone 10 miles through the water. At 11 P.M. the surface temperature was 67°·5, but at midnight it had fallen to 56°·5, and continued nearly the same the whole of the next day.

On the 2nd and 3rd May the weather was so thick with rain and fog that no observations of any of the heavenly bodies could be obtained. On the 4th May the clouds cleared off, and it was possible to ascertain the position of the ship at 6 A.M., which proved to be lat. 39° 5′ N., long. 71° 55′ W., the position by D.R. at this time being 38° 57′ N., 71° 57′ W., that is allowing for a current of $3\frac{1}{4}$ miles per hour up to 9.30 P.M. on the 1st, at which time the temperature decreased 6°. It will, therefore, be seen that the position by D.R. was 8 miles south of that by observation—a difference due, in all probability, to an error in the leeway allowed from 2 P.M. on the 3rd to 6 A.M. on the 4th, during which time the ship was close hauled ; previously the course had been off the wind.

Recapitulating, then, it appears that on May 1st, at 6 A.M., the temperature of the surface water rose to 75°·0, and that at 6.40 A.M., when soundings, &c., were taken, and when the ship had run 5 miles to N.N.W. from 6 A.M., her position by D.R. and observation showed a difference of but 4 miles in longitude ; that by astronomical observation the ship drifted between 6.40 A.M and 4.30 P.M. $3\frac{1}{4}$ miles per hour in a N. 60° E. direction (true), the temperature of the surface water remaining at 75° ; that from 5 P.M. to 9.30 P.M. the ship proceeded in a N. 30° W. direction (true) for 10 miles, the surface temperature still remaining at 75°·0, but that immediately afterwards it fell to 69°·0, and was at midnight 56°·5 ; and that allowing a current of $3\frac{1}{4}$ miles per hour N. 60° E. (true) during the time the surface temperature remained at 75°·0, the longitude by D.R. agrees with that obtained by observation at 6 A.M. on May 4th, the first time the position of the ship could be ascertained by those means after the temperature of the water fell below 75°·0.

Observations taken below the surface showed that the water retained a temperature of over 70° to 60 fathoms, and that it then decreased rapidly to 57° at 125 fathoms, and then slowly to the bottom.

It therefore appears that the Gulf Stream on the 1st May 1873, in lat. 36° 23′ N., long. 71° 46′ W., was 15 miles in breadth and about 100 fathoms in depth, that its speed was $3\frac{1}{4}$ miles per hour in a N. 60° E. direction, and that it was, at that time, discharging 4·87 cubic miles of water per hour into the North Atlantic basin, equal to 116·88 cubic miles per day, or 42,661 cubic miles per year. Taking into consideration the high specific heat of water some idea may be formed of the vast amount of heat annually carried from the tropics into the North Atlantic.

In the section from Bermuda towards New York eight soundings, seven temperature soundings, and four dredgings were obtained, and from the New York end of the section to Halifax three soundings and three dredgings (see Sheet 9).

The bottom temperature, at depths exceeding 1800 fathoms, was again remarkably uniform, from 36°·5 to 36°·8, the mean being 36°·6, nor was it affected in any way by the cold surface water on the northwest side of the Gulf Stream (see Diagram 2).

The isotherm of 40° was found at a uniform depth of 810 fathoms for 350 miles N.W. of Bermuda, but after crossing the Gulf Stream it rose to 280 fathoms. The other isotherms maintained a position parallel to that of 40°.

On the 24th April, at Station 37, the weather being fine and the sea smooth, a boat was anchored by the dredge to try the current, with the following results :—

On the surface the current was setting			N. 60° E.	0·24	mile per hour.
At a depth of	50 fathoms	,,	N. 75° E.	0·46	,,
,,	100 ,,	,,	N. 87° E.	0·36	,,
,,	200 ,,	,,	S. 70° E.	0·22	,,

Below 200 fathoms there was no perceptible set.

On the 28th April, at Station 40, a boat was again anchored by the dredge and the current tried, with the following results :—

On the surface the current was setting			N. by W.	0·75	mile per hour.
At a depth of	50 fathoms	,,	N. by W.	0·75	,,
,,	100 ,,	,,	N.N.W.	0·6	,,
,,	200 ,,	,,	N.W.	0·6	,,

On the 6th May, at Station 46, the surface current found by anchoring a boat by the dredge was E.S.E., a little over a mile per hour.

The anemometer on the 26th April, when the ship was kept laying-to under double reefed topsails (waiting for finer weather), showed the velocity of the wind to be 38 miles per hour, the force registered being 7 to 9, 39 miles per hour when the force registered was 8, and 30 miles per hour when the force was registered as being 6 to 7. On the 27th April the anemometer showed the velocity of the wind to be 21 miles per hour, the force of the wind being registered as 5.

On the 8th May the ship dredged in 51 fathoms on the Le Havre Bank off the coast of Nova Scotia, and a large number of Cod-fish were caught by hand lines. At 5.10 A.M. on the 9th the land about Sambro Island was sighted, and the Challenger steamed in for Halifax Harbour. The weather was quite calm, and the mirage so great that it was difficult to distinguish the land, so much was it distorted. It was noticed that the new lighthouse at Chebucto was placed on the summit of the hill over the coast—a questionable advantage in a port so subject to fogs as Halifax. At noon the vessel was lashed alongside the dockyard wharf in the harbour.

Halifax, Nova Scotia.

The ship remained at Halifax from the 9th to the 19th May. On the 15th, at 11 P.M., the sky was brilliantly illuminated by an aurora borealis, stretching from north to east, which shot up rays of light to an altitude of 30°. Numerous excursions were made by the naturalists and officers into the surrounding country.

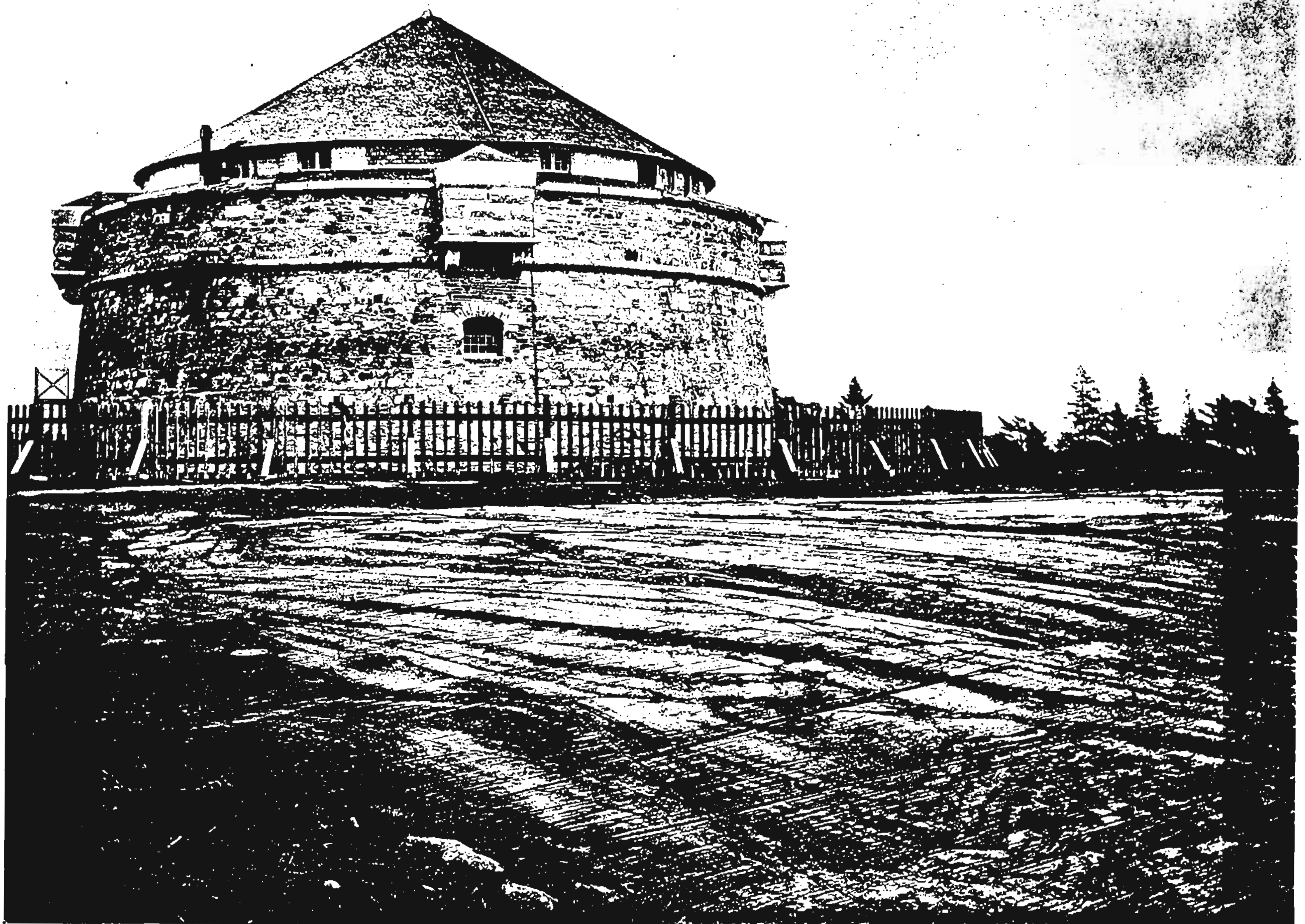
Sir C. Wyville Thomson thus describes the glaciated rocks near Halifax:—"We went with the photographer to 'The Point,' a little way out of the town, where there is a very astonishing exhibition of the action of ice. There is a round tower at the top of 'The Point,' mounting a few cannon, with a guard of soldiers, and this tower stands in the middle of an area of one or two acres, where the rock, a highly altered Silurian schist, is perfectly bare and polished. The undulations and contortions in the foliations of the schist are seen in section on the polished surface; and traversing these sinuous markings there is a wonderful system of parallel ruling in grooves of greater or less depth, cut into the stone by boulders and fragments of rock borne by the ice-cap in its slow progress over it" (see Pl. I.).

Halifax to Bermuda.

On the 19th May, at 5 P.M., the Expedition left Halifax for Bermuda, and fine weather was experienced on the passage, the wind on one occasion only exceeding a force of 5, viz., on the 24th and 25th, on which days a moderate gale was experienced from the S.W., lasting 26 hours.

The phenomenon most noticeable in the section from Halifax to Bermuda was the marked variation in the temperature of the surface water. On leaving Halifax the surface temperature was 39°, and it rose gradually as the ship proceeded to the south-

Plate I.



Horsburgh, Edinburgh. Permanent Phototype.

ROCK WITH GLACIAL MARKINGS,
NOVA SCOTIA.

ward, until it reached 41° on the 21st May in lat. 42° 10′ N., long. 63° 39′ W. From this position the change was more rapid, as at 7 A.M. on the 22nd, in lat. 41° 19′ N., long. 63° 11′ W., the temperature at the surface was 57°·5. It is remarkable that although the ship remained stationary the whole of that day, sounding and dredging, and although no current whatever could be detected whilst so employed, yet the temperature at the surface increased from 57°·5 at 7 A.M. to 62°·5 at 4 P.M. It is true that the sky was clear, and that the power of the sun was therefore great, still it will be seen, by referring to the meteorological register, that the maximum temperature of the air was 61°·0, or 1°·5 below that of the water, although the wind was from the southward.

At 6 P.M. on that day, having completed the observations, the vessel proceeded towards Bermuda, the surface water retaining its temperature of 62°·5 until 8 P.M., after which it fell to 58°·0, and at midnight to 54°·0, but at 1 A.M. on the 23rd May it rose again to 64°·8, and at 1.30 A.M. to 68°. At 4 A.M. the surface water attained a temperature of 70°·5, which it retained until 9 A.M., when a line of ripple on the water was passed, and the temperature fell to 66°·5. At 10.15 A.M. on the 23rd the ship stopped to sound, remaining stationary until 5 P.M.; during this time the surface water, which was ascertained, by astronomical observation, to be running to the southward (confirmed by having to steam to the northward to keep the line perpendicular), varied in temperature from 67°·2 to 68°·0. The position at this time was lat. 39° 44′ N., long. 63° 22′ W., and the serial temperature sounding placed the isotherms of 60°, 50°, and 40° at precisely the depths that they occupied at Bermuda, then distant 450 miles, and these depths they steadily retained for the remainder of the section (see Diagram 2).

At 5 P.M. on the 23rd the course was continued towards Bermuda, and the surface temperature was found to vary from 67°·0 to 71°·2 until 8 A.M. on the 24th, when it rose to 73°·5, and remained steady until 6 P.M. A serial temperature, taken at 4 P.M. in lat. 38° 16′ N., long. 63° 17′ W., showed that the temperature of 73° continued to a depth of 50 fathoms, but that between 50 and 75 fathoms a decrease of 5°·5 took place. The current, as ascertained by difference between the position calculated from D.R. and observation between 9.30 A.M. and 4 P.M. was easterly, its rate being 1½ miles per hour. Unfortunately, the weather on the 24th was unfavourable either for sounding or dredging, so that it was impossible to test the current by mooring a boat.

After 6 P.M. on the 24th the surface temperature again became variable, falling to 64°·5 by 8 A.M. on the 25th, and varying between 64°·5 and 69°·5 until 4 A.M. on the 26th, when it again rose to 70°·5 and at 2 P.M to 73°·5, but the serial temperatures on that day (at Station 53) showed that the warm water was quite superficial, as at 25 fathoms the temperature was 69°, and at 50 fathoms 66°, whereas on the 24th the temperature of 73° was observed at the latter depth.

At 1 P.M. on the 26th, after completing the temperature sounding, the course was resumed, and Bermuda was reached without encountering any other considerable changes in the condition of the surface water, the mean temperature of which for the remainder of the passage was 71°·7, the extremes being 73°·5 and 69°·0.

In the Halifax–Bermuda section eight soundings, five dredgings and two trawlings in deep water, and eight serial temperature soundings were obtained.

On the 22nd May, at Station 51, the dredge rope parted as it was being hauled in, apparently without cause, as the dredge was off the bottom, and the accumulators did not indicate any undue strain. The rope had probably got stranded previously by meeting some obstruction on the bottom.

On the 26th May, at Station 53, the line used in obtaining submarine temperatures became jammed between the rudder and the stern-post, and defeated all attempts to recover it, eventually parting, by which accident seven thermometers were lost. This was the only occasion on which any serious mishap occurred in taking temperature observations throughout the voyage.

The temperature of the water at the bottom in the Halifax–Bermuda section was, as in the previous sections, remarkably uniform when the depth exceeded 1800 fathoms, the mean being 36°·2 and the extremes 36°·0 and 36°·3. One bottom temperature of 35° was obtained in 85 fathoms on the 20th May at Station 49, in the centre of the Labrador Current.

The serial temperature observations indicate in a remarkable manner the influence of the cold water of the Labrador Current on the temperatures below the surface, for it will be seen by referring to the section (Diagram 2) that although that current, judging from the surface temperatures obtained, does not extend more than 100 miles from the land, and is consequently confined in this locality to a depth not exceeding 100 fathoms, yet its lowest stratum apparently flows over the edge of the 100 fathom bank off Nova Scotia, and gradually descends to the bottom of the North Atlantic basin, as evidenced by the parallelism of the isotherms to the contour of the bottom in the immediate vicinity of that bank. The influence of the Labrador Current upon the adjacent water was traced for 150 miles to the southward of its edge, for it will be noticed that the isotherm of 40°, which for 450 miles north of Bermuda occupied the same or nearly the same depth at which it had hitherto been found over nearly the whole of the western part of the North Atlantic, rises almost vertically to the surface 600 miles north of Bermuda.

On the 27th May, at Station 54, the surface current was found to be N.E. $\frac{1}{4}$ mile per hour.

On the 28th May, at Station 55A, the surface current was found to be N. 60° E., $\frac{1}{2}$ mile per hour, and the current drag at 200 and 500 fathoms indicated no movement at those depths, as the surface water ran past the watch buoy at the same rate and in the same direction as when it was anchored, by the lead line, to the bottom.

On the 28th May, at 8 P.M., Bermuda was sighted, and the 29th, 30th, and part of the 31st were spent in sounding and dredging on the south and southeastern sides, proceeding into harbour on the afternoon of the 31st.

The deposits between Bermuda and the coast of North America showed, irrespective of depth, a regular decrease in the quantity of carbonate of lime as the American shores were approached. While over 50 per cent. occurred at 2600 fathoms about 100 miles from Bermuda, only 15 and 16 per cent. was found in 1240 and 1250 fathoms near the American shores. The large pelagic Foraminifera made up the principal part of the carbonate of lime in the deposits around Bermuda, but they disappeared almost completely from the bottom when within the influence of the Labrador Current. Rhabdoliths likewise disappeared from the bottom along with the larger tropical pelagic Foraminifera, while Coccospheres were found in the deposits under the Labrador Current.

The mineral particles increased in size and number as the American continent was approached, where they consisted of fragments of quartz, monoclinic and triclinic felspars, hornblende, augite, magnetite, mica, and glauconite. On the 7th May a large block of syenite weighing 490 lbs., which had become jammed between the arms of the dredge, was brought up from 1340 fathoms. In this and the other dredgings within the influence of the Labrador Current, over 100 miles from the shore, many stones were dredged, most of these being rounded pebbles or large grains with rounded angles; nearly two-thirds of the smaller fragments were milky quartz, whilst the larger fragments were quartzite, compact limestone, dolomite, mica-schist, and serpentine rocks, some of them with glacial striations. The deposits along the American coast were blue muds with a reddish surface layer, in which quartz and fragments of ancient rocks were abundant, making up over 60 per cent. of the deposits in 1240 and 1350 fathoms, while these minerals were not detected in the deposits around Bermuda.

The dredgings and trawlings in very deep water around Bermuda were not very productive: in 2650 fathoms six *Ophioglypha bullata*, one *Amphiura verrilli*, two *Calymne relicta*, some empty worm tubes and a few Shrimps were obtained; in 1075 fathoms there were *Bathyactis symmetrica*, *Deltocyathus italicus*, *Ophiacantha segesta*, *Amphiura duplicata*, several species of *Trochus* and other Molluscs, a Pagurid, Galatheids, several Shrimps and siliceous Sponges; in 435 fathoms *Caryophyllia cylindracea*, *Axohelia dumetosa*, *Cladocora arbuscula*, *Ophiomusium cancellatum*, *Ophiopyren longispinus*, *Ophiacantha troscheli*, *Ophiomitra chelys*, *Astroschema brachiatum*, a species of *Crania*, several Molluscs, Alcyonarians, Crustaceans, and Sponges. In depths of less than 50 fathoms a large number of genera and species were obtained.

The dredgings and trawlings in 1700, 1240, 1350, 1250 fathoms and lesser depths along the coast of North America yielded a very large number of genera and species, the fauna having a decidedly Arctic character, many of the species being identical with those dredged on the northern coasts of Europe. The relative abundance of genera and species in these dredgings, compared with those at similar depths around Bermuda, was remarked, and will be referred to again when comparing the dredgings along continental shores with those at similar depths around oceanic islands. A *Boltenia*-like Ascidian, belonging to the new genus *Culeolus*, was taken for the first time in the dredging in 1700 fathoms, and is referred to in the following notes by Professor W. A. Herdman of University College, Liverpool, on the Tunicata collected by the Expedition :—

The Tunicata.—" The large collection of Tunicata made during the Expedition has added greatly to our knowledge of this interesting group, especially as regards its distribution. The pelagic Tunicates (the Salpidæ, the Doliolidæ, and the Pyrosomidæ), which form such an important constituent of the surface fauna of the ocean, have, on account of their abundance and the comparative ease with which they may be obtained, been much studied in many parts of the world. Hence the Challenger collection of these forms contains few novelties, but is of great value, since, from the constancy and care with which tow-net observations were conducted, and their results preserved, it affords much additional information as to the distribution of these pelagic Tunicates horizontally, and to a less degree vertically.[1]

" The remarkable new genus *Octacnemus* described by Mr. Moseley[2] (see fig. 64), of which two species are known, seems to be an abyssal and considerably modified ally of the pelagic Salpidæ.

" The collection is rich in Compound Ascidians, but although many of them are new species, the great majority belong to common and well-known genera. This can be accounted for by the fact clearly brought out by the Challenger Expedition, that the Ascidiæ Compositæ form essentially a shallow water group, the bulk of the collection having been obtained close to land, or at localities, such as Kerguelen Island and Port Jackson, where the shore fauna was investigated. A few Compound Ascidians were, however, obtained from great depths, such as 1600, 2050, and 2900 fathoms; but they show no notable morphological peculiarities.

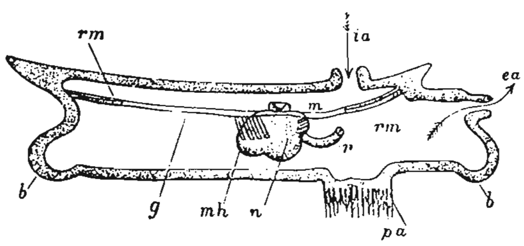


FIG. 64.—*Octacnemus bythius*, Moseley. Schematic, vertical, and longitudinal section, through the animal, along the middle line. *ia*, Mouth ; *m*, opening of the œsophagus ; *r*, rectum and anus ; *ea*, cloacal aperture ; *rm*, *rm*, radiating muscles ; *n*, nucleus ; *mh*, muscles of the nucleus ; *g*, respiratory membrane ; *b*, thickened margin of the base ; *pa*, pedicle of the attachment. (After Moseley.)

" The horizontal distribution of the group is very wide, representatives being found in all the great oceans and in almost all latitudes.

[1] For details, see the forthcoming Report on the Tunicata, Part II.

[2] Moseley, *Trans. Linn. Soc. Lond.* (Zool.), ser. 2, vol. i. p. 287, 1877; see also Report on the Tunicata, Part I., Zool. Chall. Exp., part xvii., 1882.

"Among the Ascidiæ Simplices, the most important new forms constitute a small group of pedunculated Cynthiidæ, apparently confined to deep water, and characterised by several striking peculiarities. They are more nearly allied to *Boltenia* than to any other previously known genus, and have been placed in two closely related new genera—*Culeolus* (see fig. 65) and *Fungulus*, the former containing six species and the latter one. Their most important morphological feature is the very remarkable condition of the branchial sac, which is simplified, apparently, by the total absence of the system of fine interstigmatic vessels; the result being that the large meshes are not divided into

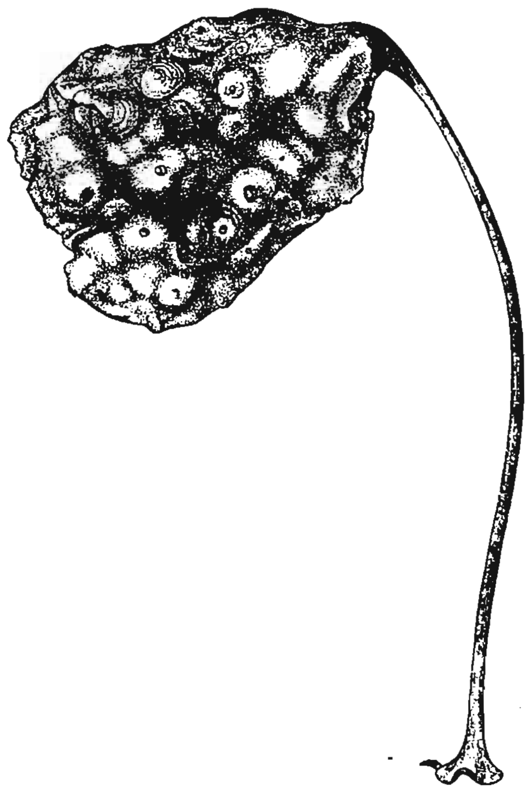


FIG. 65.—*Culeolus wyville-thomsoni*, Herdman. Seen from the left side; natural size.

stigmata, as they are in a typical Simple Ascidian (see fig. 66). In *Culeolus* the branchial sac is strengthened by the development in the walls of the vessels of a system of rather gracefully branched and curved calcareous spicules, marked internally by a series of 'contour' lines.[1] These are quite different in appearance from the fusiform echinated spicules found in *Cynthia pallida*, Heller, and in the two new species, *Cynthia complanata* and *Cynthia papietensis*. Another noteworthy feature in the anatomy of the genus *Culeolus* is the condition of the blood-vessels of the test in

[1] Zool. Chall. Exp., part xvii. p. 95, 1882.

some of the species. In *Culeolus murrayi* the terminal twigs of the vessels open into large vesicles placed just below the surface of the test, and only separated from the external medium by a very delicate membrane. In several of the species there are

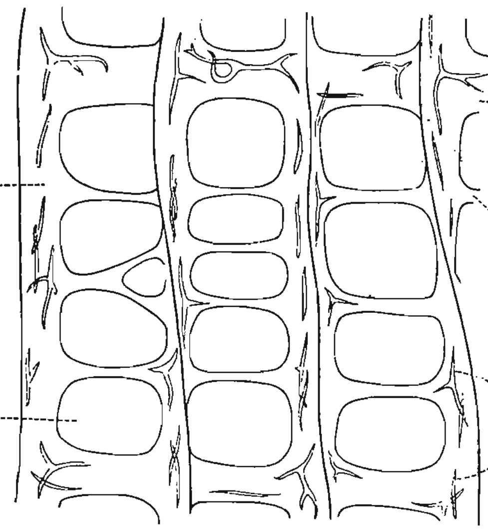


FIG. 66.—The Branchial Sac of *Culeolus wyville-thomsoni*, Herdman, from the inside; magnified about 50 diameters. *tr.*, large transverse vessel; *tr'.*, smallest size of transverse vessel; *i.l.*, internal longitudinal bar; *mh.*, mesh; *sp.*, spicules.

thin-walled hollow papillæ or projections from the surface of the test, and these are in free communication with either the large vesiscle or the ends of the vessels. This is obviously an accessory respiratory apparatus, permitting the blood circulating in the test (which when the heart contracts dorso-ventrally is impure) to be brought into such close relation with the external water as to ensure a certain amount of oxidation.[1]

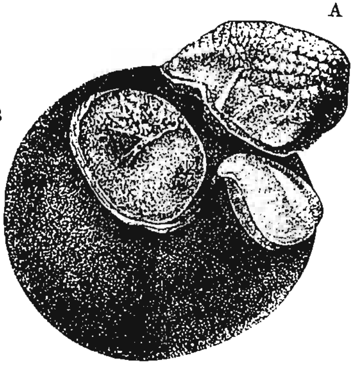


FIG. 67.—A, *Styela squamosa*, Herdman, and B, *Styela bythia*, Herdman (natural size), attached to a manganese nodule, from 2600 fathoms.

"A large number of other new species of Cynthiidæ were obtained, but the only other one which cannot be referred to a known genus is *Bathyoncus mirabilis*, a form which agrees with the typical Styelinæ in having simple tentacles, but differs from them in having a branchial sac of the skeleton type found in *Culeolus* and *Fungulus*. The large and well-marked genus *Styela* is remarkable on account of its very extended bathymetrical range. Most of the species are found in shallow water, some few between tide marks; while six species in the collection are from between 100 and 600 fathoms, and two, *Styela bythia* and *Styela squamosa* (see fig. 67), both fairly typical members of the genus, were obtained at a depth of 2600 fathoms.

[1] For further details the reader is referred to the Report on the Tunicata, Zool. Chall. Exp., part xvii. pp. 93, 276.

"In the Family Molgulidæ, beyond the two gigantic pedunculated forms, destitute both of hair-like processes from the test and incrusting sand, which have been placed in the new genus *Ascopera*, no very striking novelties were discovered. In the Ascidiidæ, however, there are three noteworthy new genera—*Corynascidia*, *Abyssascidia*, and *Hypobythius*, all from deep water. Of the last, one species, *Hypobythius calycodes*, was described by Mr. Moseley,[1] and a second, *Hypobythius moseleyi*, agreeing with the first in the simple structure of the branchial sac, but differing in the body form and some other details, was afterwards found in the collection. *Corynascidia suhmi* (see fig. 68) is, like so many other of the abyssal forms, supported upon a peduncle. The position and course of the intestine are peculiar,[2] and the branchial sac is one of the most beautiful and delicate known. The third genus, *Abyssascidia*, is a connecting link between the well-known genera *Ascidia* and *Corella*. It resembles the latter genus in the position and especially in the course of the intestine, while in the structure of the branchial sac it differs greatly from *Corella*, and exhibits the simpler arrangement found in *Ascidia*, from which again it differs in the condition of the dorsal lamina, and in the large number of lobes surrounding the branchial and atrial apertures.

FIG. 68.—*Corynascidia suhmi*, Herdman. Seen from the right side, natural size.

"A little group of three species, for which the new genus *Ecteinascidia* has been founded, forms a connecting link between the previously known Clavelinidæ and the Ascidiidæ, and shows that the group of Social Ascidians, established in 1828 by Milne-Edwards, must now be merged in the Ascidiæ Simplices.

"The geographical distribution of the Simple Ascidians is very wide, but it appears from the Challenger investigations that they are not abundant in the northern hemisphere, and are comparatively scarce in tropical latitudes, while they attain their greatest numerical development in southern temperate regions. The bathymetrical range is also wide, extending from the littoral zone down to 2900 fathoms. Out of 82 species, 47 were found between the shore and 50 fathoms, and only 7 at depths over 2000 fathoms. The tables given in the

[1] Moseley, *Trans. Linn. Soc. Lond.* (Zool.), ser. 2, vol. i. p. 287, 1877.
[2] See Report on the Tunicata, Part I., Zool. Chall. Exp., part xvii. p. 283.

Report (see especially p. 273) show that although the Ascidiæ Simplices extend into very deep water, and are fairly well represented in the abyssal zone, still they are mainly a shallow water group, and are found in greatest abundance immediately around the coasts in a few fathoms of water."