CHAPTER VI.

Cape Verde Islands to St. Paul's Rocks and Fernando Noronha—Balanoglossus—The Echinoidea—Description of St. Paul's Rocks and Fernando Noronha—Coast of Brazil—Bathypterois—Surface Fauna of Guinea and Equatorial Currents—The Radiolaria—Bahia.

Cape Verde Islands to St. Paul's Rocks.

The Expedition left Porto Praya at 8 P.M. on the 9th August, and a course was shaped for St. Paul's Rocks. Owing to the season of the year in which the passage was made, the course was necessarily somewhat erratic; the ship proceeding to the southeastward along the African coast until the S.E. trade was reached in lat. 3° 8′ N., long. 14° 49′ W., and then standing over to the westward for St. Paul's Rocks. The soundings and temperatures obtained must, therefore, be divided into two sections,—1st, the southeasterly section towards the equator; and 2nd, the equatorial section.

From Porto Praya to the parallel of 7° N. the wind varied from W. by N. to S. by W. with cloudy, squally, rainy weather; from thence to the position where the S.E. trade was met with, viz., in lat. 3° 8′ N., long. 14° 49′ W., the wind was from S.S.W. to S., with fine weather, and from that position the S.E. trade was retained to St. Paul's Rocks.

On the section to the southeastward from Porto Praya to a position in lat. 3° 8′ N. long. 14° 49′ W. six soundings, eight serial temperature soundings, and one dredging and one trawling were obtained (see Sheet 12).

The surface temperature varied from 77°·7 to 79°·5.

The bottom temperature when the depth exceeded 1800 fathoms still continued remarkably uniform, the mean being 36°·5 and the extremes 36°·6 and 36°·4.

Serial temperature soundings showed that the isotherm of 40°, which was at a depth of 800 fathoms at St. Iago, rose gradually to the southward to 500 fathoms in the parallel of 3° N. The isotherm of 50° maintained an average depth of 180 fathoms, varying from 150 to 200 fathoms; but the isotherm of 55° approached at Station 96 to within 40 fathoms of the surface, although the surface temperature was 79°; thus showing a decrease of 24° in 40 fathoms.

On the 16th, at Station 100, the dingey was anchored by the sounding line, and the surface current was found running N. 70° E. half a mile per hour. The current drag at 50 fathoms indicated a set of 0·45 mile per hour, N. 17° E.; at 100 fathoms, N. 15° E. 0·3 mile per hour; and at 200 fathoms, N. 17° E. 0·2 mile per hour. On the 19th, at Station 101, the cutter was anchored by the trawl, and the surface current

SHEET 12

C. VERDE ISLANDS TO BAHIA

touching at

ST. PAULS ROCKS AND FERNANDO NORONHA

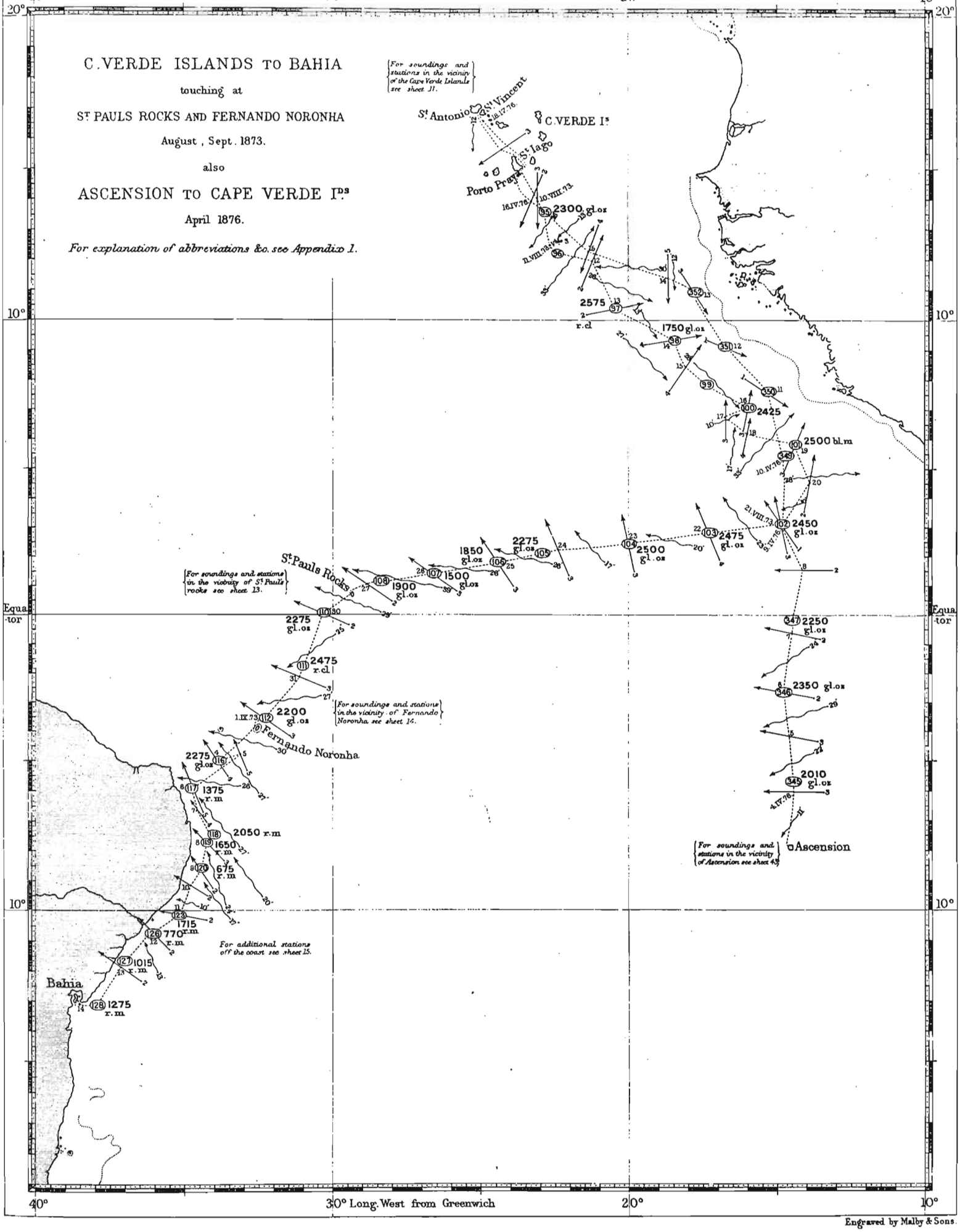
August, Sept. 1873.

also

ASCENSION TO CAPE VERDE Is

April 1876.

For explanation of abbreviations &c. see Appendix 1.



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found running N.E. 1·3 miles per hour. On the 21st, at Station 102, the dingey was anchored by the lead line, and the surface current was found running N.W. 1·25 miles per hour. These results confirm the existence of the current as ascertained by difference between D.R. and observations. From Porto Praya to the parallel of 12° 30′ N. a S.W. current was experienced; from thence to the parallel of 4° 40′ N. the current was easterly, trending sometimes north, and sometimes south, by east. The total drift experienced between the parallels of 12° 30′ and 4° 40′ was 146 miles in a N. 88° E. direction (true), or at an average rate of three quarters of a mile per hour. Southward of the parallel of 4° 40′ N. the current was westerly. The temperature of the easterly or Guinea Current was 79° or 1°·5 higher than the Equatorial or westerly Current.

In the equatorial section from the position in lat. 3° 8′ N., long. 14° 49′ W. to St. Paul's Rocks, seven soundings, four serial temperature soundings, and three trawlings were obtained (see Sheet 12).

The surface water maintained an average temperature of 78°.

The bottom temperature at depths exceeding 1800 fathoms varied 0°·8 or from 36° to 36°·8, the mean being 36°·4.

The serial temperature soundings showed a rapid cooling of the water near the surface, for the isotherm of 60° was at an average depth of 70 fathoms. Below 70 fathoms the temperature fell more slowly, the isotherm of 50° occupying an average depth of 150 fathoms, varying from 130 to 180 fathoms, and that of 40° being at an average depth of 520 fathoms, varying from 430 to 550 fathoms (see Diagram 4).

On the 23rd August, at Station 104, the cutter was anchored by the trawl, and the surface current found to run west (true) 1·2 miles per hour. On the 25th August, at Station 106, the cutter was again anchored by the trawl, and at 10.30 A.M. the surface current was running west (true) 2 miles per hour, but in the afternoon its velocity had decreased to 1 mile per hour. The current drag at 10 A.M. at 75 fathoms showed no current, at 50 fathoms a current of half a mile per hour, and at 15 fathoms three quarters of a mile per hour, all to the west, thus showing how very superficial the Equatorial Current is. On the 26th August, at Station 107, the cutter was again anchored by the trawl, and the surface current found to be running west (true) 1·5 miles per hour, and it continued to run at that rate throughout the day instead of slacking in the afternoon as on the 25th.

The following anemometer observations were taken when, the ship being stationary for sounding or dredging purposes, a favourable opportunity presented itself for ascertaining the velocity of the trade wind :—

On August	21,	at Station	102,	velocity of wind was	13	miles per hour; force registered	2 to 3
„	22	„	103,	„	15	„ „	2
„	23	„	104,	„	12	„ „	2
„	24	„	105,	„	11	„ „	2
„	25	„	106,	„	15	„ „	3
„	26	„	107,	„	12	„ „	3
„	27	„	108,	„	13	„ „	3
„	28	at St. Paul's Rocks[1]		„	9	„ „	3
„	29	„		„	10	„ „	4

On the 27th August, at .2 P.M., St. Paul's Rocks or islets were seen from the masthead at a distance of 18 miles, and at 3 P.M. from the deck, at a distance of 9 or 10 miles.

The depths in the section along the African coast varied from 2575 fathoms to 1750 fathoms. From the point where the course of the ship was turned to the westward a nearly level plateau extends for 500 miles, the depth being from 2300 to 2500 fathoms, after which a gradual elevation takes place to 1500 fathoms 150 miles east of St. Paul's Rocks, and then a depression to 1900 fathoms at a distance of 60 miles from the rocks.

The deposits at the two depths, 2575 and 2500 fathoms, near the African coast, contained respectively 30 and 6 per cent. of carbonate of lime, the small percentage in the latter being due to continental debris, but at all the other Stations there was over 50 per cent., and at 1850 fathoms in Mid Atlantic the amount reached 90 per cent. In all the deposits the carbonate of lime consisted chiefly of pelagic Foraminifera, Coccoliths, and Rhabdoliths, with a few fragments of Echinoderms and other organisms. An analysis of the mud from the dredge at Station 102 (2450 fathoms) gave 83 per cent. of carbonate of lime. A careful examination of a large quantity of this deposit showed that nearly the whole of the carbonate of lime present consisted of the dead shells of surface organisms, and it was estimated that of the 83 per cent. of carbonate of lime, 75 per cent. was due to pelagic Foraminifera, 6 per cent. to Coccoliths, and 2 per cent. to other calcareous Foraminifera, fragments of Echinids, and Ostracodes. *Pulvinulina menardii* and its variety *tumida* were the most abundant forms, but *Globigerina sacculifera*, *Globigerina dubia*, *Globigerina conglobata*, and *Sphæroidina dehiscens* were also very abundant. It is worthy of notice that the majority of the shells were very large; and the more delicate surface forms, as *Hastigerina* and *Candeina*, appeared to be quite absent. The typical *Globigerina bulloides* did not appear to be present. The Foraminifera here were thick-shelled and of large size, and it was precisely in this region that the largest specimens of pelagic Foraminifera were obtained on the surface by means of the tow-net. Many of the shells were broken and appeared to be in a crumbling con-

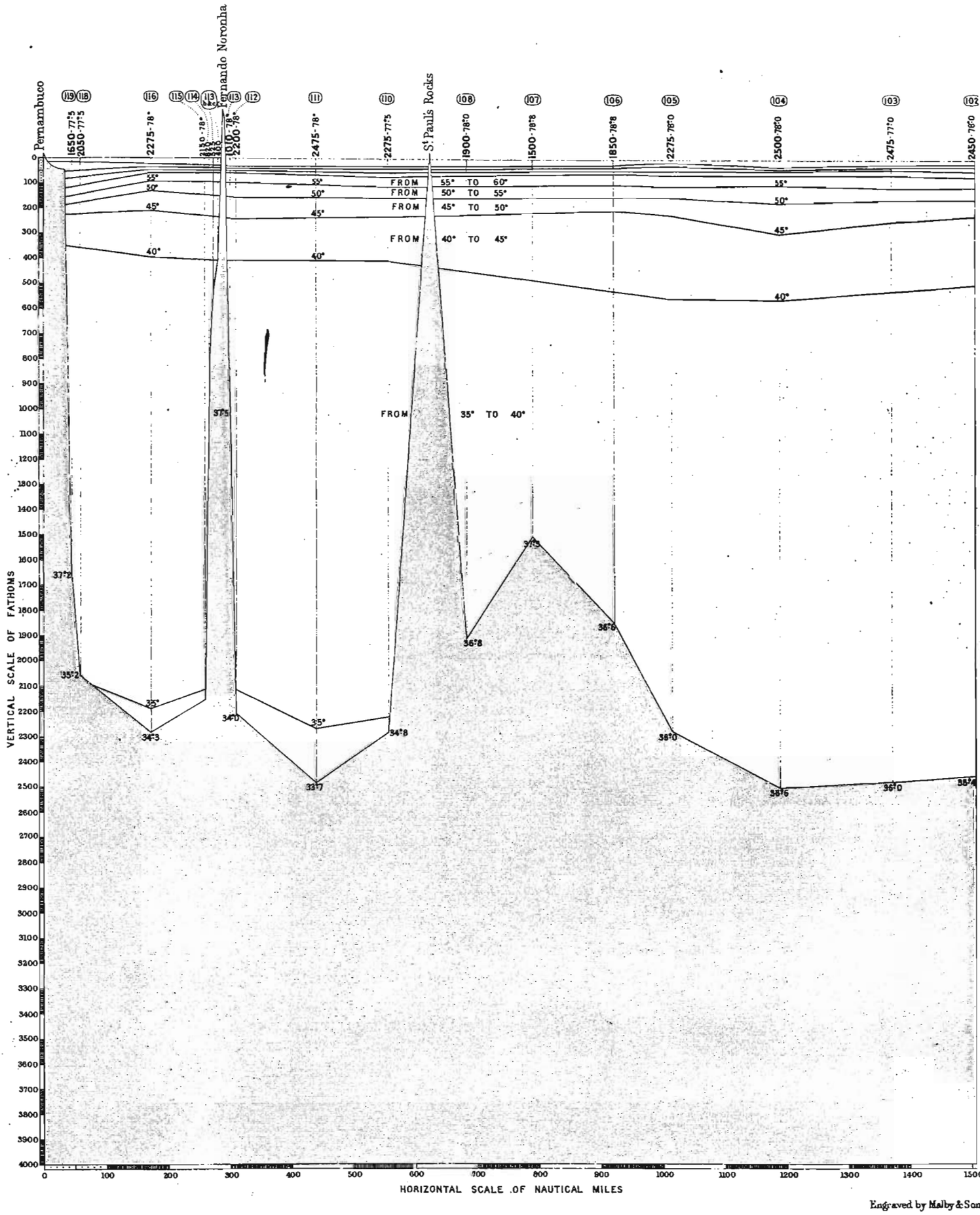
[1] The velocities at St. Paul's Rocks may be affected by the land to windward.

DIAGRAM 4.

ATLANTIC OCEAN

Longitudinal Temperature Section. From a position in Lat. 3°8′ N. Long. 14°39′ W. to Pernambuco.

For explanation of Symbols see Appendix 1.



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dition. The finer and smaller fragments were almost wholly made up of broken pieces of larger shells. The small specimens and primordial chambers, so common in shallower deep-sea soundings, were nearly absent. In the same way Rhabdoliths were not complete, if present at all, and the Coccoliths were very minute. The mineral particles in the soundings along the African coast sometimes reached 0·7 mm. in diameter, but in Mid Atlantic they seldom exceeded 0·05 mm. Quartz and glauconite were present only in the deposits near the African continent, the mineral particles in the other deposits consisting of fragments of felspars (sanidine), magnetite, hornblende, and glassy rocks. Radiolarians, Diatoms, Sponge spicules, and arenaceous Foraminifera never made up more than 3 per cent. of the deposits, which were of a red or rose colour, except in a few of the soundings near the African coast, where they had a black or slate colour, owing, apparently, to the presence of fine mud or river detritus.

Pelagic organisms were very abundant at or near the surface throughout this trip, and the sea was brilliantly phosphorescent, especially on the evenings of the 14th and 16th August, off the African coast. The trawlings at 2500 fathoms and 1850 fathoms yielded many interesting deep-sea species, some of which are referred to in the following notes.

Balanoglossus. Dr. v. Willemoes Suhm writes as follows:—"Station 101, 19th August 1873, 2500 fathoms. Among the worms there is a fragment of *Balanoglossus*. Originally discovered by Delle Chiaje in Naples, this worm remained unknown for a long time, until Kowalewsky came to that place and made astonishing discoveries in its anatomy, showing that *Balanoglossus* is an animal in which the beginning of the intestinal tube is in connection with a branchial apparatus similar to that which is found in Ascidians. There are, besides, so many peculiarities in the structure and anatomy of *Balanoglossus*, that Gegenbaur established for it a special order among the class of worms. The interest in *Balanoglossus* was subsequently increased when, four years ago, Metschnikoff published a paper in which he stated that *Tornaria*—the larva discovered by Joh. Müller, and since that time believed to be an Echinoderm-larva—was really the larva of *Balanoglossus*.[1] Another paper confirmed this supposition,[2] and quite recently A. Agassiz has shown more fully, in an American species of *Balanoglossus*, the metamorphoses which *Tornaria* undergoes.[3] Two additional species are known from Naples, and one from Hellebek near Copenhagen. The one we got to-day was

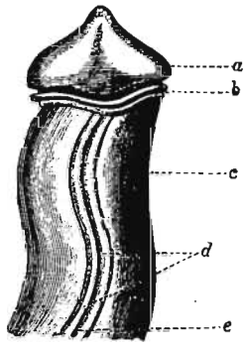


FIG. 78.—Fragment (head) of *Balanoglossus*, n. sp.; natural size. Station 101, August 19, 1873; lat. 5° 48′ N., long. 14° 20′ W.; depth, 2500 fathoms; *a*, proboscis; *b*, collar-like neck; *c*, body; *d*, walls of the branchial apparatus; *e*, median vessel. From a drawing by v. Willemoes Suhm.

[1] *Nachricht. v. d. Georg.-Aug. Univ. zu Göttingen*, No. 15, p. 287, 1869.
[2] *Zeitschr. f. wiss. Zool.*, Bd. xx. pp. 131–144, pl. xiii., 1870.
[3] *Amer. Acad. Mem.*, vol. ix. pp. 421–436, 1873.

probably of considerable length, but owing to the extreme softness of the tissues, only the anterior part remained in the dredge when hauled on board; it was distinguished by very lively colours, the proboscis *a* being yellow, the collar-like ring *b* bright red, and the body *c* yellowish-red. In the latter the two longitudinal folds *d* are the outer walls of the branchial apparatus, and between them *e* the so-called median vessel. In the lower part the beginning of the ovary was also observed. From

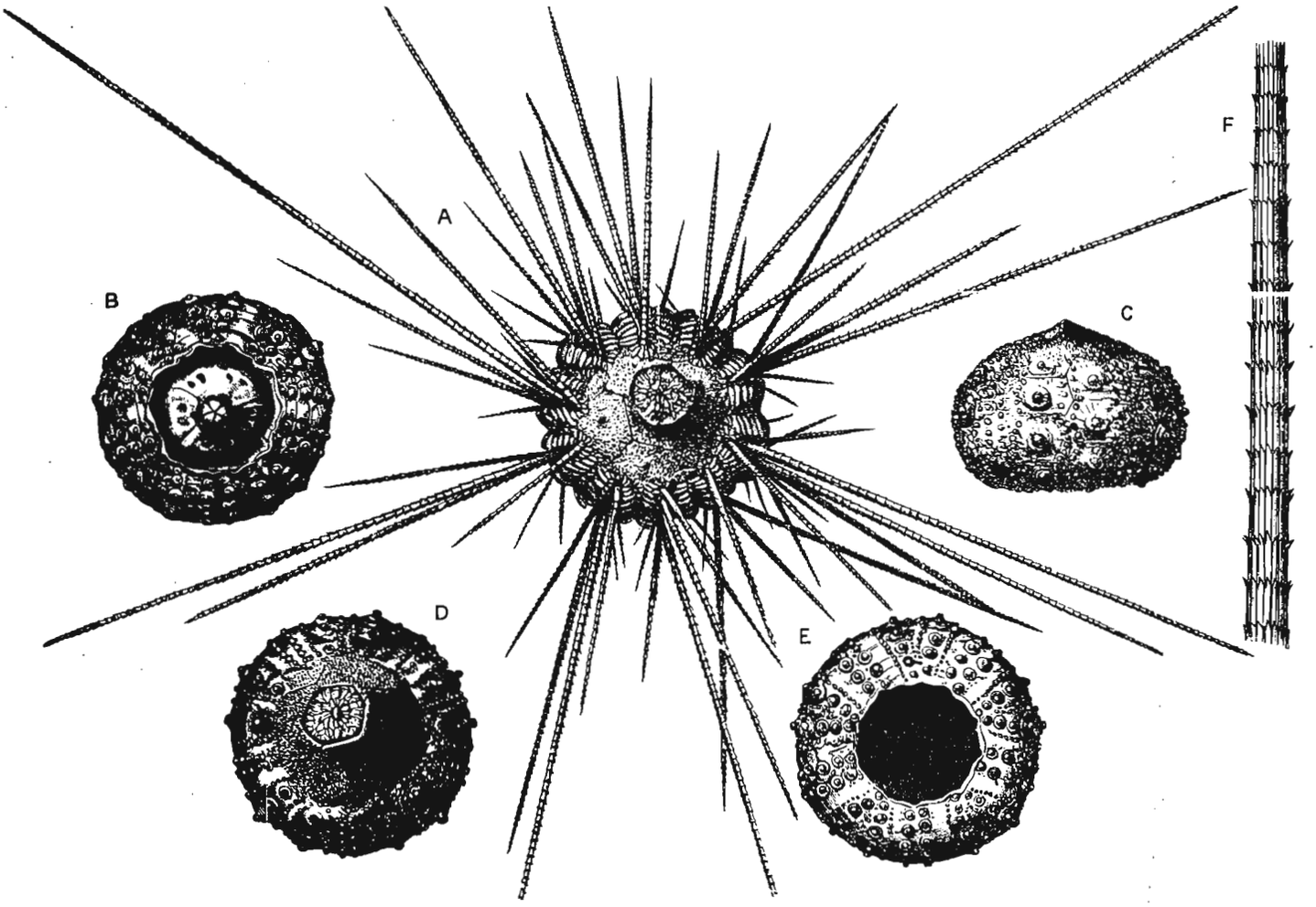


FIG. 79.—*Salenia hastigera*, A. Ag.

A, Abactinal view of specimen, measuring 14 mm. in diameter; B, young specimen, measuring 9 mm. in diameter, seen from the actina side; C, specimen seen in profile, denuded of spines, 13 mm. in diameter; D, the same, seen from the abactinal side denuded; E, the same seen from the actinal side; F, magnified portion of primary spine.

this fragment it would hardly be permissible to establish a new species. *Balanoglossus* is likely to be found often in deep-sea dredging, and even the shallower water species may be met with, since they are always inhabitants of deeper water of the coasts and true mud animals. Head 18 mm. wide, 11 mm. high.

"At Station 106, 25th August 1873, 1850 fathoms, there were again in the trawl

red fragments of *Balanoglossus*, which show that the whole animal must have been of great length, at least 6 inches.

"Again, at Station 147, 30th December 1873, 1600 fathoms, large reddish fragments of a *Balanoglossus* were also brought up, in one of which the collar was preserved. Apparently these latter specimens belong to the same species, the head of which was obtained in the deep sea in the tropics. The whole animal must have had a length of from 3 to 5 inches, and have measured nearly $\frac{3}{4}$ths inch across the body."

The above extracts from Dr. v. Suhm's Journal, being of considerable interest as the only record which has been preserved of these deep-sea specimens, are inserted here, although since it was written great additions have been made to the knowledge of the structure and development of *Balanoglossus*, and the animal has assumed an importance which has rendered it familiar to all students of animal morphology.

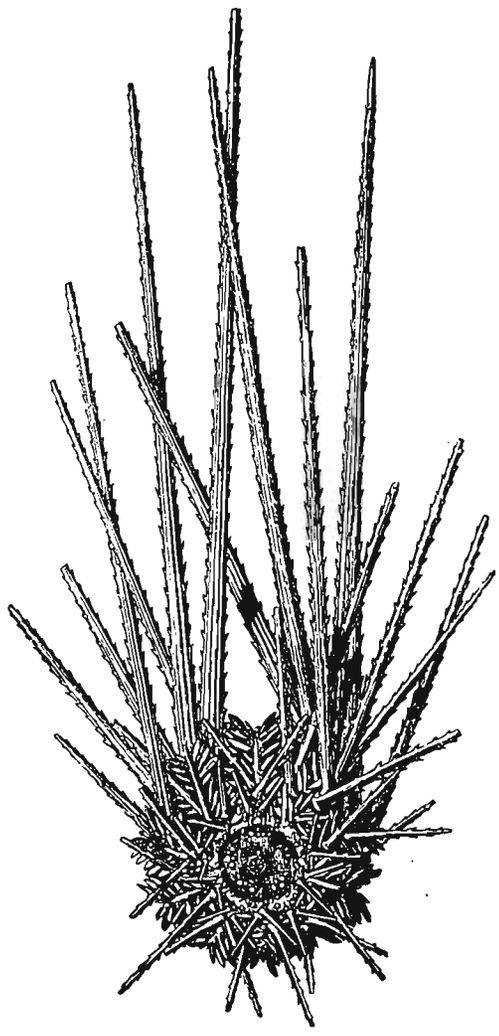


FIG. 80.—*Salenia varispina*, A. Ag.; four times the natural size.

The Echinoidea.—At 1850 fathoms there were two fine specimens of a new species of *Salenia*, described under the name of *Salenia hastigera* (see fig. 74) by Mr. Alexander Agassiz, who gives the following notes on the Echinoidea collected by the Expedition. "The importance of the additions made to our knowledge of the Echini by the Challenger collection is well shown from the fact that at the time Mr. Agassiz wrote his Report[1] the hauls of the Challenger presented no less than forty-nine new species out of a total of 297 known species. Although no new families were added to those discovered by the earlier expeditions of the U.S. Coast Survey, of the Swedes, and of the English, yet the number of new genera and species added to the lists were of the greatest importance in elucidating the affinities of a number of recent and fossil forms.

"The number of new Cidaridæ was not great, but the dredging of a new *Porocidaris*, with its curved actinal spines and its long, smooth,

[1] Report on the Echinoidea of the Challenger Expedition, by Alexander Agassiz, Zool. Chall. Exp., part ix., 1881.

primary spines, was an interesting discovery. The existence of a new species of *Salenia* (*Salenia hastigera*) in the tropical Pacific has increased the number of living species of that genus to four, and we now have a fair knowledge of a type which has played an important part in the Echinoidal fauna of the Jurassic and Cretaceous periods. The singular structure of the apical system of the genus, consisting of large plates soldered together, and recalling the condition of the apical system in embryonic Echini, has led to important systematic comparisons.

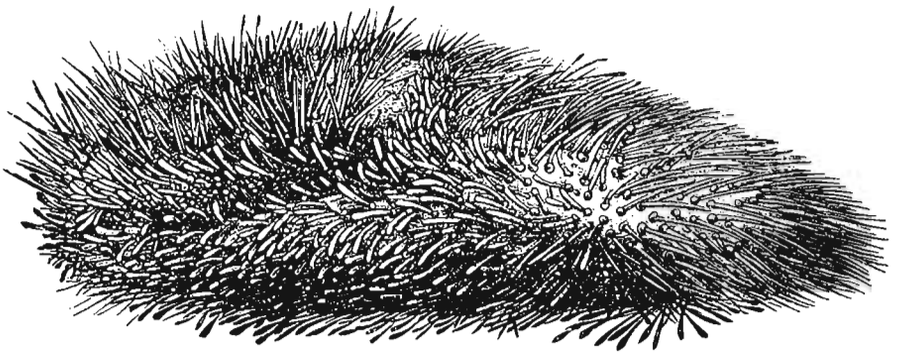


FIG. 81.—*Aërope rostrata*, Wyv. Thoms. Seen in profile; natural size.

"A number of specimens of *Cœlopleurus maillardi* were collected; their examination has thrown new light on the nature of the cap which tips the spines of the Arbaciadæ. In this genus it becomes developed to an extraordinary extent, four or five times the length of the spine proper. The immense triangular and curved spines thus formed probably served to raise the test as it were, on stilts, and enabled the sea-urchin to move with con-

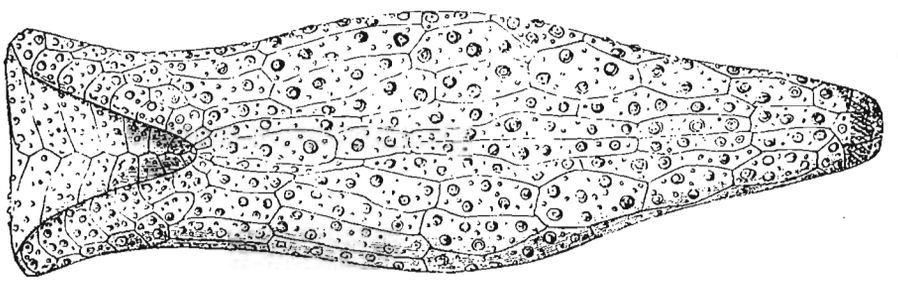


FIG. 82.—*Pourtalesia phiale*, Wyv. Thoms. Seen from the actinal side (denuded); four times the natural size.

siderable rapidity. We find in several of the species of Echinothuridæ another form of development of the tip of the primary spines. In *Phormosoma hoplacantha*, for instance, the radioles of the actinal surface are tipped with broad conical shoes, which must give to these soft-tested Echini a sufficient number of points of support to raise them above the ground. This species is probably the largest sea-urchin known; it must have measured no less than 312 mm. in diameter when fully expanded. The Echinothuridæ, to which *Phormosoma* belongs, all have a more or less flexible test, made up

of imbricating plates both on the actinal and coronal areas, a structural feature which in the Palæozoic Echini was quite common, and which is retained in modern Echini only in the bevel between adjoining plates. Many of the Echinothuridæ assume, when fully expanded, a globular outline, and when placed on deck the flexibility of the test

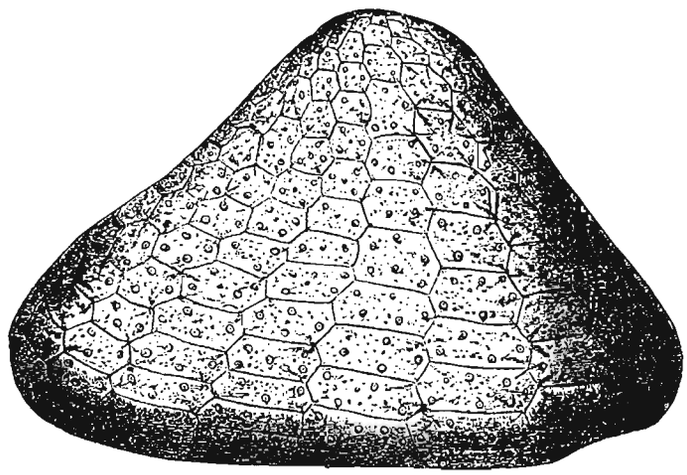


FIG. 83.—*Cystechinus wyvilii*, A. Ag. Seen in profile (denuded); natural size.

gives them peculiar vermiform movements. Their sharp spines, like those of the Diadematidæ, inflict serious wounds, and the sting of these huge Echini is very painful.

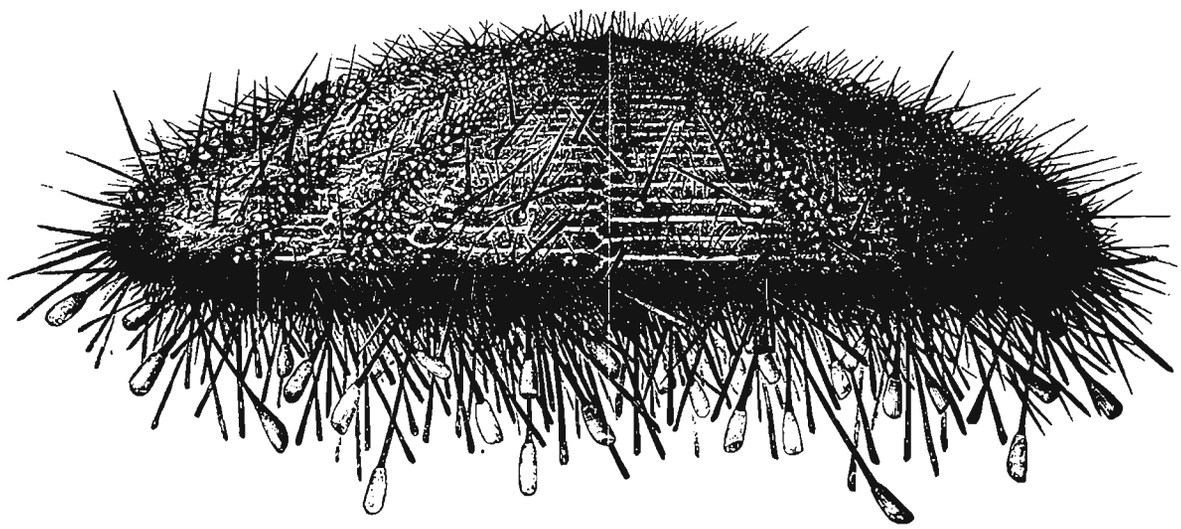


FIG. 84.—*Phormosoma luculentum*, A. Ag. Seen in profile; natural size.

This stinging property is not due to the action of the sharp spines alone, but also in part to the effect of the contents of the baggy envelopes which in a few of the species surround some of the sharp spines.

"The absence of the Clypeastroids from the deeper waters is interesting, indicating that they probably developed rapidly during the Tertiary period, and have always been (as they are to-day) inhabitants only of shallow seas.

"By far the most interesting Echini collected by the Challenger belong to the strictly deep-sea types, the Pourtalesiæ and Ananchytidæ, families of which the nearest allies were known only as fossils before the days of deep-sea dredging. The first family, Pourtalesiæ, was discovered by the late Count Pourtalès in the trough of the Gulf Stream, between Key West and Havana. The Challenger has added no less than twelve new species to this family. Some of the genera are of the most extraordinary shape, and, like the original Pourtalesiæ, seem to have little in common with the normal Spatangoids as we know them from their living and fossil representatives. The slipper-shaped *Echinocrepis*, and the *Galerites*-like *Urechinus* remind us of types which flourished in the Cretaceous Seas. One of the species of *Cystechinus*, with its thin flexible test, looks in alcohol more like a

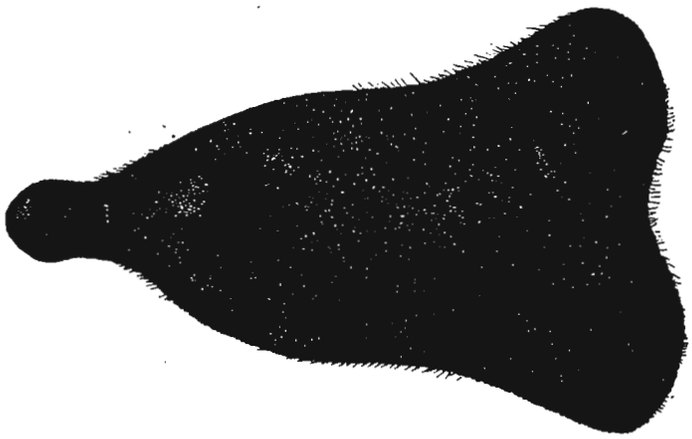


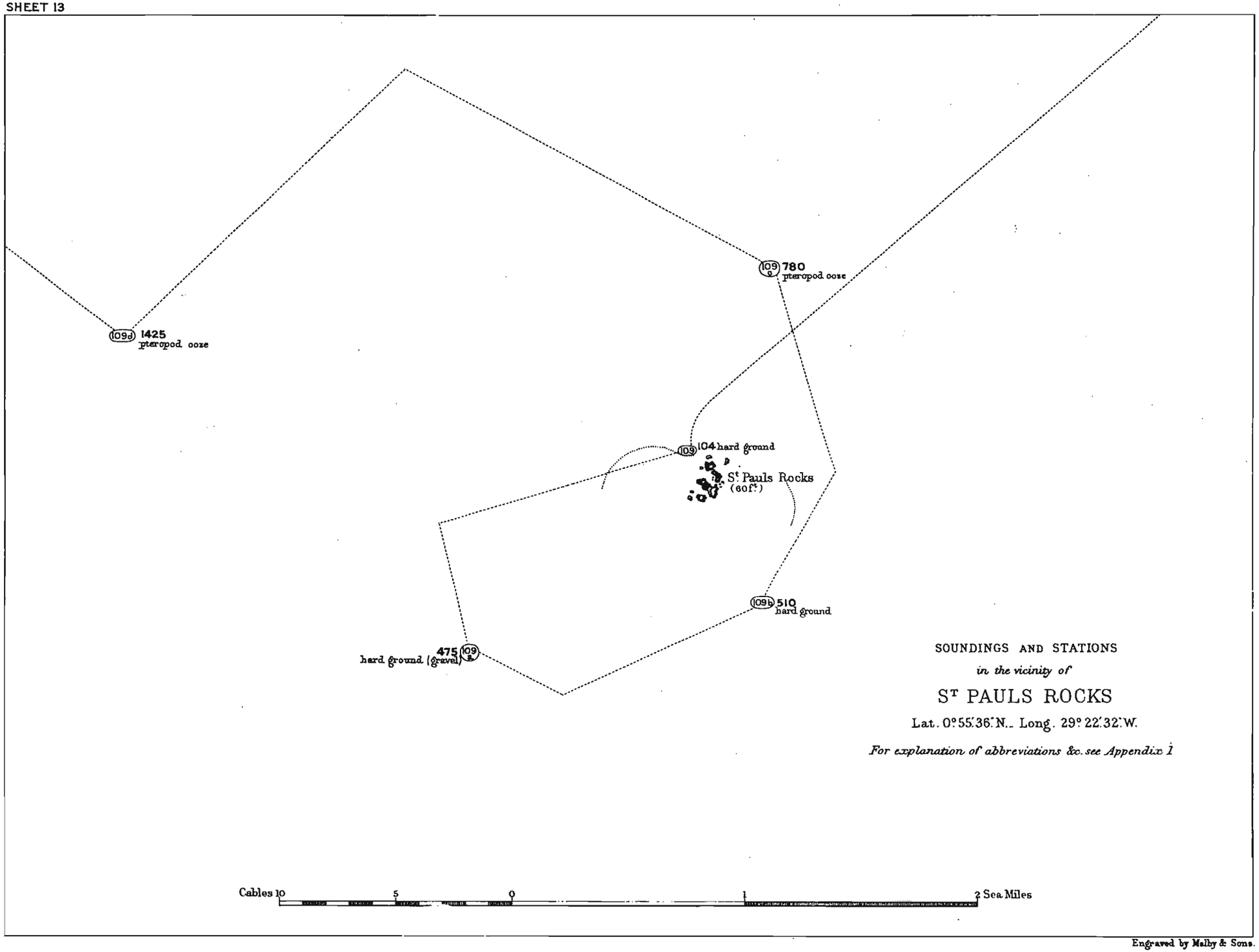
FIG. 85.—*Pourtalesia ceratopyga*, A. Ag. Seen from the abactinal side, covered with spines; natural size.

diminutive battered felt hat than the graceful sea-urchin it must have been judging from its hard-tested congener.

"No less than five new species of Ananchytidæ were brought home, a family once numerous in the time of the Chalk, and remarkable, like the Pourtalesiæ, for their imperfectly developed and simple ambulacra, and for the uniform size of the plates composing the ambulacral and interambulacral areas of the test. These two families are also noted for the absence or slight development of the fascioles, so characteristic of nearly all recent Spatangoids, but absent in many of the more recent fossil types and in all the other forms of extinct Spatangoids.

"Interesting from an embryological point of view are such novel and strange forms as *Aërope* and *Aceste*, which have assumed a facies absolutely identical with that passed through by the young of the Brissina of to-day. In these two genera the odd anterior

SHEET 13



SOUNDINGS AND STATIONS

in the vicinity of

St PAULS ROCKS

Lat. 0° 55′ 36″ N. Long. 29° 22′ 32″ W.

For explanation of abbreviations &c. see Appendix 1

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ambulacrum is immensely developed, its suckers are of a gigantic size, entirely out of proportion to the rudimentary ones of the paired ambulacra.

"The colouring of the majority of the deep-sea species is a dark violet; those of shallower waters are more brilliantly coloured, and such species as *Cœlopleurus* and some of the *Saleniæ* are perhaps among the most beautiful and strikingly marked Echini."

The bathymetrical distribution of the Sea-urchins and their relationship to the previous Echinoid faunæ are fully discussed in Mr. Agassiz's Report.

St. Paul's Rocks.

As the rocks were approached, it was noticed that the equatorial current running past them, the velocity of which from observation was $1\frac{3}{4}$ miles per hour, caused a considerable ripple, amounting almost to a race, on each side. These ripples united at

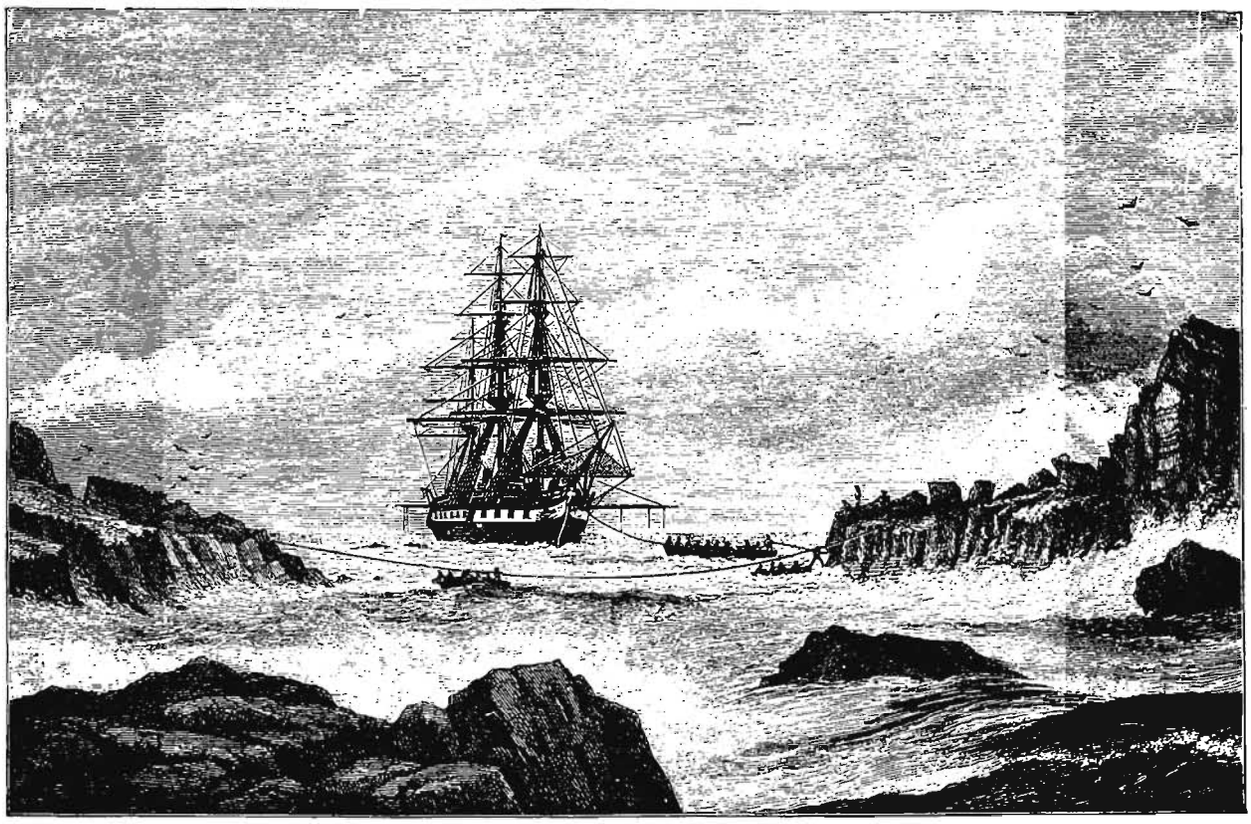


Fig. 86.—H.M.S. Challenger at St. Paul's Rocks.

a distance of about a mile to the westward, raising a confused sea, and leaving a cone of comparatively smooth water, immediately to leeward of the islets.

As the wind and current concurred in direction, the islets were circled until the ship

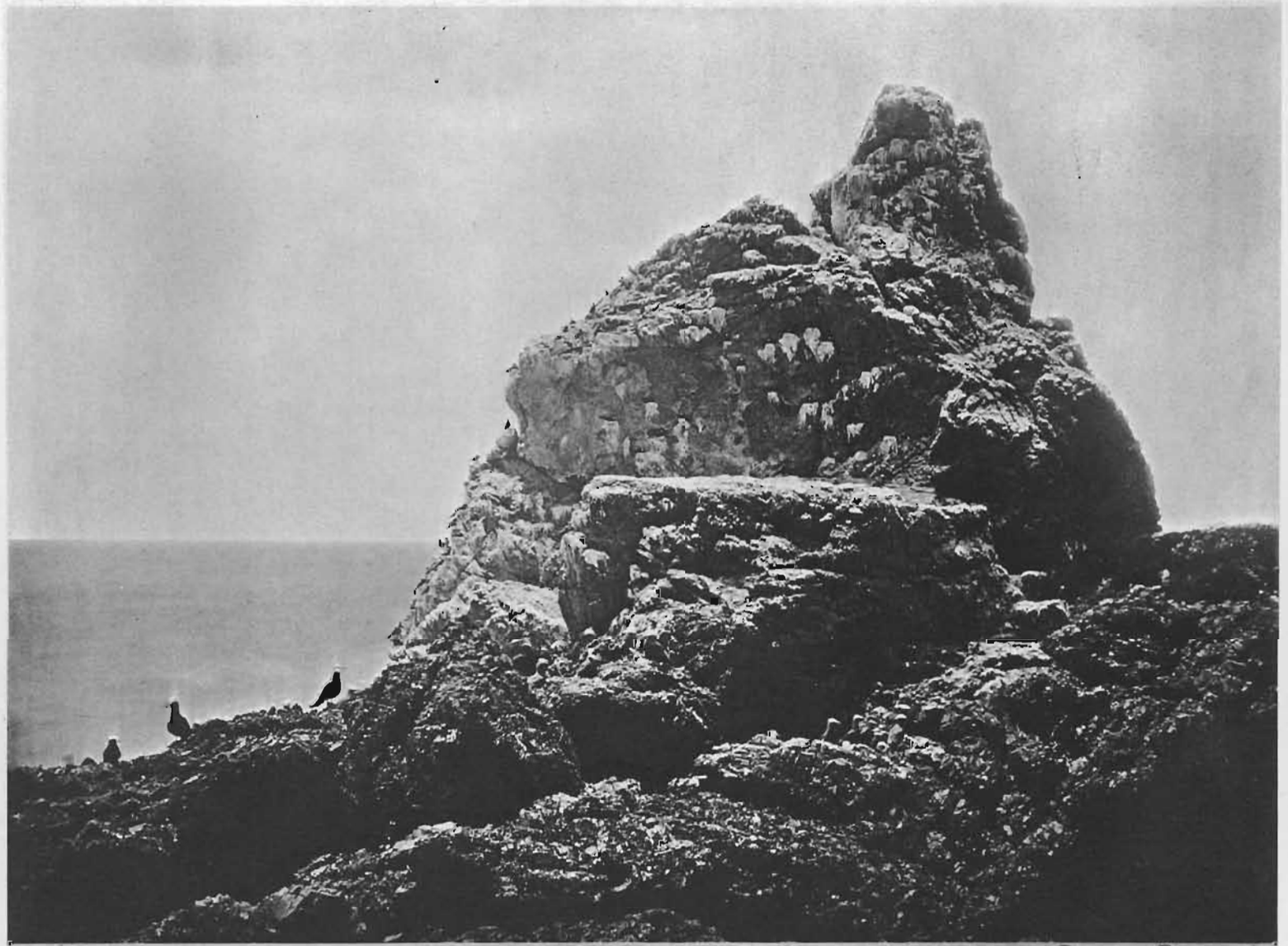
was directly to leeward of them, and in the cone of still water. The vessel then steamed slowly towards them, sounding without success. When within a cable's length of the S.W. point, midway between the ship and the shore, a sunken rock was observed from the foretop, which appeared to have about 3 fathoms over it, so the vessel was steered to the northward; experience proving that it was safe to steam close to the rocks, the vessel was secured by a hawser to a knob on the point of the northeast side of the little cove (see fig. 86). When so secured the bow was in 104 fathoms half a hawser's length from the shore. The Challenger remained quietly secured in this manner until the morning of the 29th, but it must be borne in mind that the circumstances which rendered it prudent to run the risk of remaining in such a position were peculiarly favourable: the wind being steady in direction and light in force; the sea moderate, although sufficient to cause a considerable break on the weather side of the rocks; a current coinciding in direction with the wind, of sufficient force, even to leeward of the rocks, to keep a uniform tension on the hawser; and the season of the year rendering it highly improbable that any change would take place.

St. Paul's Rocks consist of a number of small islets separated from each other by deep chasms (see Pls. III.–VI.) through which the sea is constantly pouring, as wave after wave strikes against this ocean pinnacle. The whole group occupies a space of two cables in length in a N.N.E. to S.S.W. direction, and one cable in breadth; its highest point is 64 feet above the level of the sea. The N.W. and S.E. sides are steeper than the S.W. side, for whereas depths of 500 fathoms are found nine cables from the islets in each of the former directions, the 500 fathom line of soundings is at a distance of over 2 miles to the S.W., and there appear to be also some shallow soundings (that is, soundings under 100 fathoms) at a distance of half a mile in that direction (see Sheet 13).

Between the two largest islets is a small cove 300 feet in length and 170 feet across (at its entrance), the depths in which vary from 5 to 10 fathoms. Constant rollers, produced by the swell recurving round the islets, enter the cove, and, meeting with the almost continuous stream of water coming through the narrow chasms, separating the islets, make a very confused sea, consequently, as the only landing is in the cove, it is necessary to be cautious. When once a man has succeeded in jumping on shore, a rope stretched across the entrance renders the operation comparatively easy, as then the boat can be steadied by the rope as it rises and falls with the swell.

Excellent astronomical and magnetic observations were obtained on shore, but no tidal register could be taken owing to the swell.

During the time the ship remained at these islets their dangerous character was more than ever apparent, for although their white guano-covered peaks when lit up by the moon, were plainly visible from the ship 100 yards distant, they were not sufficiently distinct to be recognised as land at a distance of over a mile, and, without the moon, would probably not be seen more than a quarter of a mile; in short, the sound



HORSBURGH, EDINBURGH. PERMANENT PHOTOTYPE.

ST PAUL'S ROCKS.

of the breakers might be the first notice given to a passing ship, of their proximity. The birds, numbers of which make these islets their home, were remarkably quiet during the stay, and it was evident that no dependence could be placed on their giving warning; it is true that no lights were shown at night, lest a passing ship might be drawn into danger, and it is well known that birds are generally attracted by a ship's lights, round which they circle uttering their discordant cries, still, it would be an imprudent thing to trust to their doing so always, nor would they probably be attracted by a ship's lights until she was in dangerous proximity to the rocks. Under these circumstances, and looking to the fact that the islets are situated in the strength of the Equatorial Current, it is evident that nothing but their small extent has prevented their becoming the scene of numerous shipwrecks, for the lead is not of the slightest use in their vicinity.

A lighthouse erected here would be of great advantage to passing ships, for, not only would it divest the rocks of their present dangerous character, but it would render them of positive benefit to the navigator, as, owing to the depth of water surrounding them, ships would be able to run boldly for them, either by night or day, and so correct their chronometers. Nor would there be much difficulty in erecting a building, as there is a level space 100 by 40 feet on the large S.W. islet, which would afford ample room, and would require little preparation for the foundation. A derrick rigged out from the shore, or better still, a light bridge thrown across the cove, would render landing sufficiently easy in all weathers likely to be experienced in this locality, so that the work might proceed uninterruptedly. By erecting the lighthouse on the summit of one of the small rocky islets, an additional elevation of some 30 feet would be gained, but considerable labour would be required to cut a suitable flat for the foundations. Should a lighthouse ever be erected here, arrangements for condensing water would have to be made, as the only fresh water that could be possibly obtained on the rocks would be from passing showers.

Fish are plentiful and good,[1] and afford good sport with the rod, but the fishing line must not be weighted. Birds were seen hovering in thousands over the rocks as they

[1] In his Report on the Shore Fishes (Zool. Chall. Exp., part vi. p. 4, 1880) Dr. Günther gives the following list of the species collected :—

Holocentrum sancti-pauli, Günth.
Caranx ascensionis, Forst.
Glyphidodon saxatilis, Linn.
Cossyphus rufus, Linn.
Platyglossus cyanostigma, Cuv. Val.
Enchelycore nigricans, Bonnat.
Balistes buniva, Lac.

He states "evidently many more species might have been collected during a longer stay. The fauna is composed of West Indian forms, with some of the species found at Ascension and St. Helena. It is not surprising that a distinct, and apparently undescribed, species of the widely spread genus *Holocentrum* should prove to be peculiar to this isolated locality."

were approached. Only three species occur on them, two noddies and a booby. The Noddies (*Anous stolidus* and *Anous melanogenys*) are small terns or sea swallows, black all over, with the exception of a small white patch on the head. The Booby (*Sula leucogastra*) is a kind of gannet; the full-grown birds are white on the belly, with a black head and throat; the black ending on the neck, where it joins the white in a straight conspicuous line; the back is dark. The younger birds are brown all over. A few of both birds soon came off to have a look at the ship as she approached the rocks. On landing, the rocks were found to be covered with noddies and their nests, some containing eggs, whitish in colour, with red spots at the larger end, and others with young in them, little round balls of black down. The air was full of noddies and boobies circling about, and screaming in disgust at the invasion of their home.

The noddies' nests are made of a green seaweed (*Caulerpa clavifera*) which grows on the bottom in the bay and around the rocks, and which, getting loosened by the surf, floats, and is picked up by the birds on the surface of the water. The weed is cemented together by the birds' dung, and the nests, having been used for ages, are now solid masses, with a circular platform at the summit, beneath which hang down a number of tails of dried seaweed. The older nests, placed on the faces of the cliffs, project from the sheltered sides of the rocks, like brackets, having been originally commenced, as may be seen by the complete series of gradations existing, by a pair of birds laying an egg on a small projecting ledge of rock and adding a few stalks of weed. A series of these nests are seen in the photograph (Pl. III.), appearing like white patches on the perpendicular surface of the low cliff. If these white patches be closely examined, each will be seen to represent a bracket-like nest with dependent fringe, and in most cases to have a black noddy with a conspicuous white patch on its head sitting on it. A greater number of the noddies, however, place their eggs on the bare flat rocks in any slight hollow or chink. The two species of noddy are so nearly alike that it was not noticed during the stay of the Expedition that more than one was present, and it appeared as if, the cliff surface on the rocks being limited, only the stronger noddies were able to maintain their position in the bracket-like nests, whilst the weaker had to put up with the more exposed open rocks; but probably more careful examination would have shown that the bracket-like nests of seaweed belonged to one species of *Anous* only and the bare nests of the horizontal rocks to the other. A white peak on the western side of the bay forms the home of the boobies, which are not nearly so numerous as the noddies, and seem to be almost restricted to this one peak, out of the five of which the rocks are made up.

The whiteness of the rock is caused by the birds' dung, which in some places forms on the rocks, as described by Darwin, an enamel-like crust, which is hard enough to scratch glass. Some of this was found at about 45 feet above sea level. The rock is steep on the sheltered sides, and is there hung all over with the bracket-like nests of

Plate IV.

HORSBURGH, EDINBURGH. PERMANENT PHOTOTYPE.

ST PAUL'S ROCKS.

"Near this spot the officers of H.B.M.S. Challenger took magnetic observations, August 29th, 1873, dip 22–32. Caught plenty of fish."

A few successful dredgings were obtained by laying out the dredge in a boat astern of the ship while secured to the rocks, and heaving it back.

The soundings close to St. Paul's Rocks showed a hard or rocky bottom, or a Globigerina ooze containing numerous fragments of the rocks and olivine, enstatite, serpentine, magnetic grains, and actinolite.

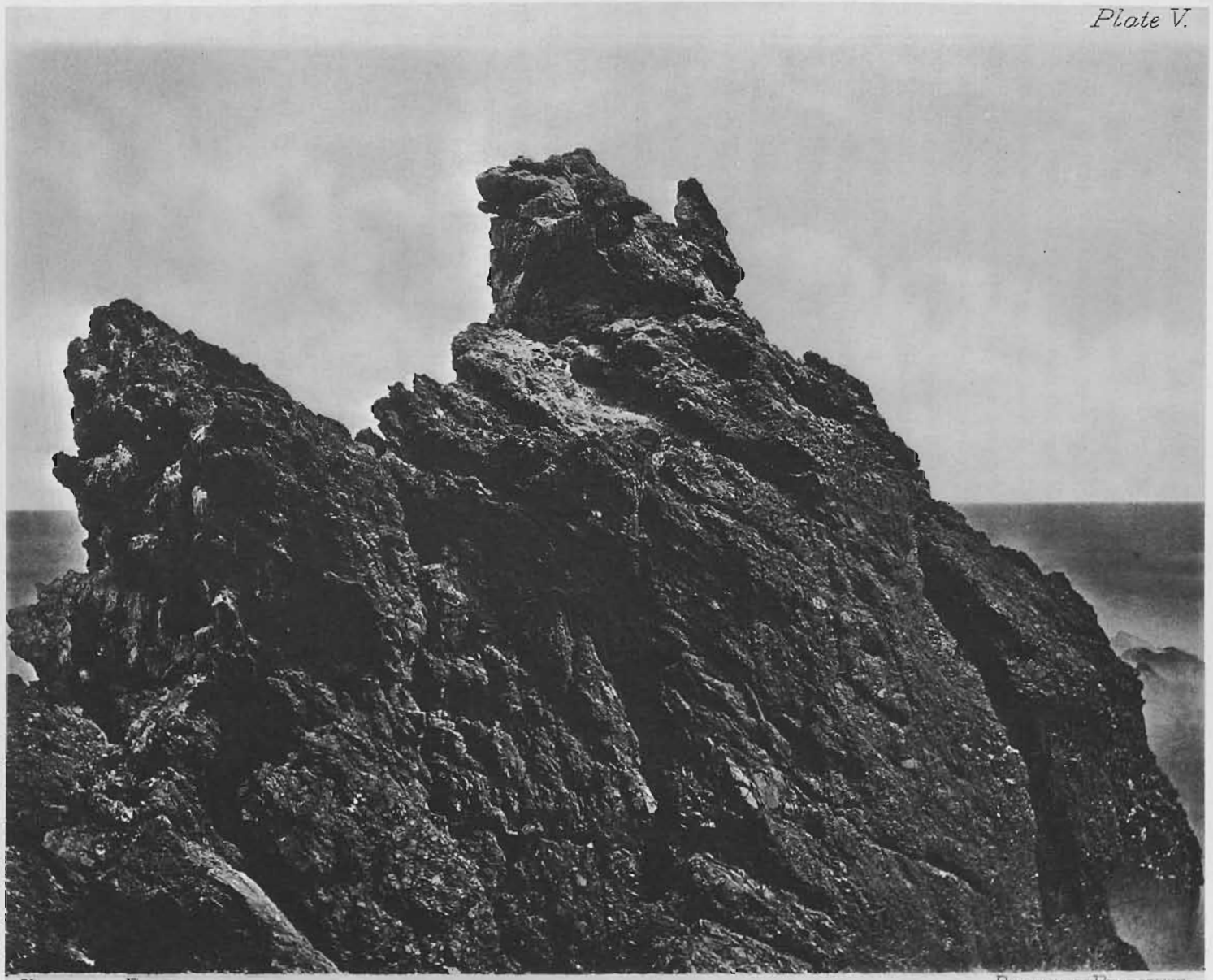
A detailed Report on the Petrology of St. Paul's Rocks has been published in Volume II. of the Narrative of the Cruise,[1] to which the Reader is referred for details. The following note, giving the chief results of the investigation, has been furnished by Professor Renard, F.G.S.:—

"The position of St. Paul's Rocks, far removed from any continent, together with their aspect and lithological characters, caused them to be considered as the last trace of some vast district lost by submergence. Darwin, struck by the peculiar character of the mineral mass, denied its volcanic origin. He says:[2]—'It is not of volcanic origin, and this circumstance, which is the most remarkable in its history (as will hereafter be referred to), properly ought to exclude it from the present volume.' Speaking of the lithological character of these islets, he described them as composed of rocks unlike any which he ever met with, and would not characterise them by any name. He considered the northern rock of the group to be formed of a sort of "harsh stone," which breaks up into fragments so regular as to be mistaken for blocks of altered orthoclase, and, moreover, saw what he considered to be veins of serpentine running through the whole mass. The observers of the Challenger Expedition, following Darwin, classed the rocks composing the group as serpentine. In doing so they have placed them very nearly in the class they should occupy in the lithological series. Mr. Buchanan ascertained during the voyage that the rock contained magnesia, alumina, and peroxide of iron, and that many specimens gave off water on heating in a closed tube. The naturalists who have visited the island have drawn attention to the fact that the rocks to the south are covered over with a substance that gives them at a distance a dazzling white appearance. This is due in part to the excrement of an immense multitude of seabirds that gather on the rocks, and in part to a coating of a white, hard, brilliant material which will be described hereafter.

"The olivine rock of St. Paul's Rocks presents in general an unusually fresh appearance; showing signs of decomposition only along the crevices. This peridotite is perfectly homogeneous to the naked eye and very compact. Its colour is blackish-grey, bordering to green and black; splinters of the rock are translucent on the edges and of a greenish tint. The lustre varies from subvitreous to resinous; the splinters redden before the blowpipe, and are infusible; the streak is grey or greenish; in hardness it is inferior to felspar. An analysis by Dr. Sipöcz has given SiO_2, 43·84; Al_2O_3, 1·14; Cr_2O_3, 0·42; FeO, 8·76; MnO, 0·12; NiO, 0·51; CaO, 1·71; MgO, 44·33; H_2O, 1·06 = 101·89. On calculating this analysis we find that the rock contains 75 per cent. of olivine and 25 per cent. of enstatite. Thin sections from slightly decomposed specimens show that the rock is composed of olivine, enstatite, and chromic iron.

[1] Report on the Petrology of St. Paul's Rocks, by the Rev. A. Renard, Narr. Chall. Exp., vol. ii., App. B.

[2] Darwin, Volcanic Islands, p. 32, 1851.



HORSBURGH. EDINBURGH.

PERMANENT PHOTOTYPE.

ST PAUL'S ROCKS.

The structure is microgranitoid; rarely the sections of olivine or enstatite assume dimensions large enough to produce a microporphyritic structure, which passes into a banded structure, the minerals constituting this rock never have crystallographic contours, but are elliptical or irregular. This feature and the banded structure give rise to a sort of lenticular arrangement, which resembles the so-called gneissic structure peculiar to some schists. Without entering on a detailed description of the individual minerals that constitute the rock, it may be stated that the microscopic examination of the specimens shows that the rock mass is almost entirely composed of granular olivine, thus confirming the deductions drawn from the chemical analysis.[1] After the olivine the most frequent ingredient is chromite; the sections of this mineral are generally transparent yellow or chestnut-brown and isotropic. Among the minerals playing a secondary part in the composition are hornblende and a rhombic pyroxene. The hornblendic mineral must be referred to the variety actinolite, of which it seems to possess the most characteristic properties; the rhombic pyroxene, on the other hand, must be classed as enstatite. These ellipsoidal sections of enstatite are polysynthetic, and composed of lamellæ of a rhombic pyroxene, between which are intercalated other lamellæ of a clinorhombic pyroxene.

"Certain features of the olivine, and more especially those shown in the enstatite sections, deserve attention. In some microscopic preparations of the rocks, with banded structure, the larger sections of olivine and enstatite are placed with their vertical axes in a line with the direction of the bands. At first sight it looks as if this disposition had been brought about by the motion of a plastic mass. In one case, where the fragments were in the direction of the band, a crystal has undergone a remarkable process of folding or curling back upon itself by fracture and displacement, it seems to have been partially softened, and looks as if a current had drawn it along and bent it into the shape of a U. The lamellæ composing the crystal are fractured at the summit of the arch of the curve, and the space between the fractures is filled up with the ground mass of the rock. Sections presenting the same appearance may, however, be found abundantly in the family of the schists. Among the analogies of microscopic structure between the schists and the peridote of St. Paul's Rocks may be enumerated the ellipsoidal form of the crystals, their entwinement by the bands in the fundamental mass, the disruption of the larger individuals, as well as their curvature and folding.

"Some of the specimens are highly altered. Along the capillary fissures cohesion diminishes, and serpentinous matter with magnetic iron is deposited in them, the rock being traversed at the same time by black, opaque, and slightly lustrous veins. These altered specimens are often composed of fragments of serpentine cemented together by phosphate of lime, which also often coats the external part of the rock, and to this circumstance these altered portions owe a particular stalactitic appearance. The white enamel that gives the south rock the dazzling appearance described by Darwin, was removed and subjected to a quantitative analysis. The quantity analysed (0·0175 gramme) was so minute, that the only certain results obtained were phosphoric acid, 33·61 per cent., and lime 50·51 per cent.; iron, magnesia, and sulphuric acid were also present. The composition is, therefore, essentially a tribasic calcic phosphate, with sulphate of lime, and perhaps also carbonate of lime, magnesia, and iron. Darwin and Mr. Buchanan regard this white coating as due to the accumulation of excrement of sea birds, the insoluble residue of which has been exposed during very long periods of time to the action of the sun's rays and of the waves of the ocean. This explanation seems the true one, and is

[1] For the mineralogical description of the Rocks, see Narr. Chall. Exp., vol. ii., App. B.

[2] *Ibid.*, fig. 2 of the plate.

applicable not only to the substance in question, but to all the concretionary phosphates found united with the olivine rock of which the islets are composed.[1]

"Some brecciated specimens of St. Paul's Rocks are coated on both sides with black bands, 7 or 8 mm. thick, presenting the mineralogical characters of manganese. Sir Wyville Thomson [2] describes this breccia. Mr. Moseley points out that MacCormick had already drawn attention to this black coating in the fissures of rock. Sir Wyville says that the coating, when triturated, gives a dirty-looking greenish-grey powder, which effervesces in hydrochloric acid, setting chlorine free, and colouring the acid in the same manner as protoxide of manganese. Moreover, Mr. Buchanan found in these breccias with black incrustation, phosphate and carbonate of lime, carbonate of magnesia, and traces of copper and iron, while the crust itself yielded water in the test-tube. I have been able to recognise traces of manganese in unaltered specimens of the olivine rock.

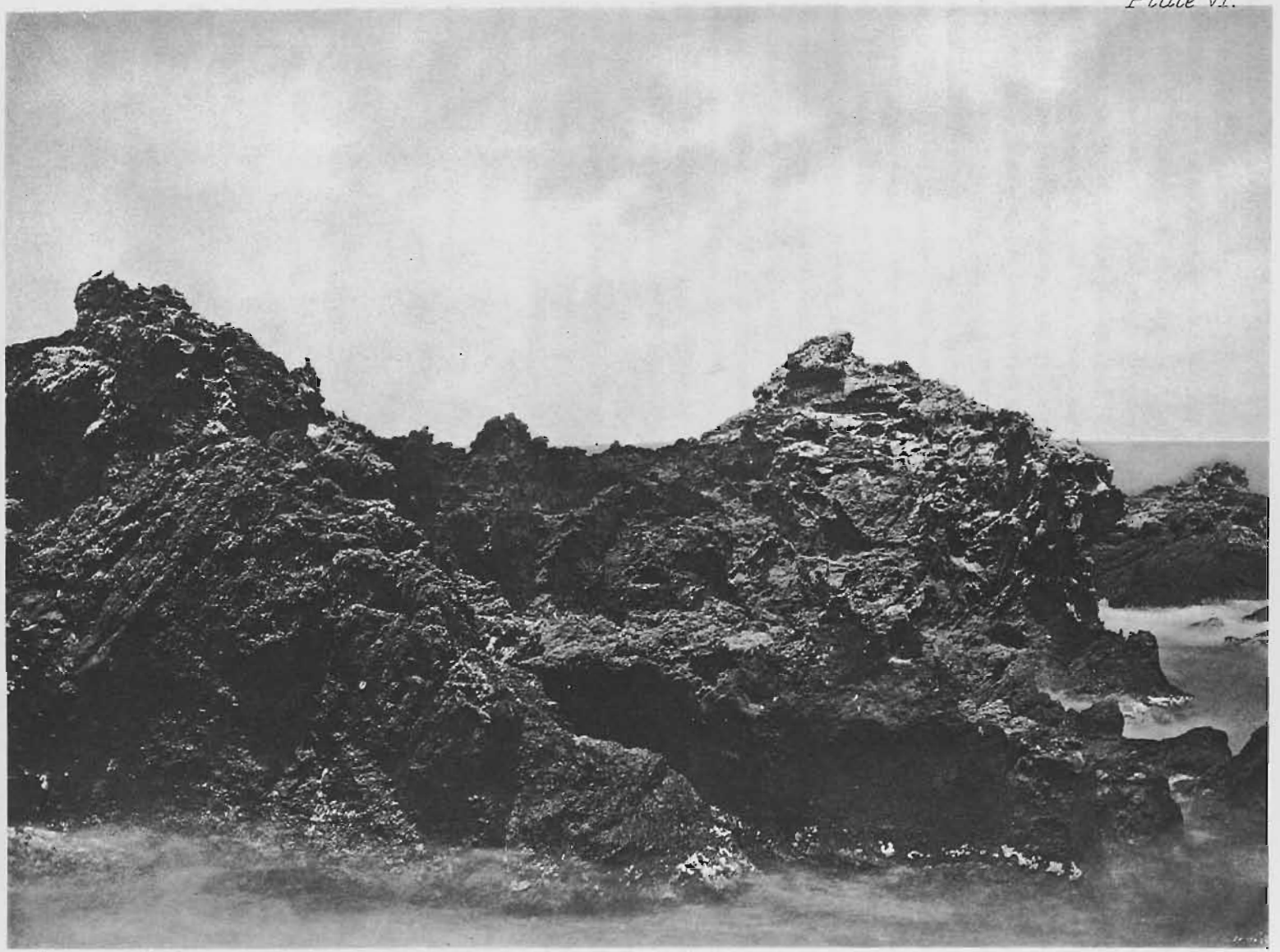
"With regard to the mode of formation of the rock, there are no other positive data than the lithological. Lithological constitution alone cannot always decide the question of origin, the uncertainty increases in proportion as new peridotic rocks are discovered, for fresh discoveries frequently upset views previously entertained. It may be admitted in a general manner that no objections can be raised, *à priori*, against the volcanic origin, pure and simple, of a peridotic rock; olivine can be crystallised artificially with the greatest facility by dry fusion. The igneous origin of this mineral is also proved by its presence in the lavas of active volcanoes, and in older rocks universally admitted to be pyrogenous. Not only can olivine, considered as a mineral, be unquestionably igneous, but some peridotites, if we are to judge from the investigation of competent observers, as Bonney, Hochstetter, &c., present positive characters of eruption. But while some peridotites are eruptive, it is no less true that many masses of olivine rock present characters from which an igneous origin cannot be demonstrated,[3] and it seems certain that very often true peridotites do not occur in the form of injected veins. From the data collected in the Report it is evident that one may admit for the peridotic rocks two modes of origin, and that the question of origin is on the whole to be decided rather by reference to the position of the rocks in relation to those among which they lie, than by mineralogical composition. Unfortunately, however, this very important element of the relation of the rock to those that encircle it is wanting in the case of St. Paul's Rocks. The rocks stand alone in mid-ocean, and of their connection with other rock masses we can state nothing definite.

"The reason that pleads in favour of the eruptive theory is the law of analogy. We know indeed that the small oceanic islands are either of volcanic or coral formation. May not the peridotite of St. Paul's Rocks be assimilated to the group of crystalline rocks represented by the syenite, diabase, and melaphyres forming the base of several volcanic islands of the Atlantic? An obvious argument in favour of an eruptive origin is afforded by the fact that the bottom of the Atlantic has been for long ages, in many points, the theatre of volcanic manifestations; and in particular, the region in which St. Paul's Rocks are situated has in comparatively recent times shown signs of eruptive phenomena. The isolation of these rocks might be adduced as a further proof of their eruptive origin. The soundings taken between St. Paul's Rocks and the nearest continent and other

[1] See analysis of a decomposed specimen impregnated by phosphate of lime, in Narr. Chall. Exp., vol. ii., App. B., p. 18, 1882.

[2] The Atlantic, vol. ii. p. 106.

[3] See the résumé of the results arrived at by the observers who have described peridotites found as regular intercalations in various formations, in Narr. Chall. Exp., vol. ii., App. B, p. 24, 1882.



HORSBURGH, EDINBURGH. PERMANENT PHOTOTYPE.

ST. PAUL'S ROCKS.

islands, tend to show that they possess a purely local character, in perfect harmony with the theory of volcanic formation.

What can now be advanced to support the idea that this peridotite belongs to the schisto-crystalline series? We have stated that a great number of peridotites belong to the schisto-crystalline series, and that in respect of their mode of origin they cannot be separated from the rocks with which they are associated. In the peridotite of St. Paul's Rocks the banded structure, the position assumed by the crystals in the mass, their form, in short, all the peculiarities above-mentioned, are characteristically those of the schists. On the supposition that the rock belongs to the schists, we must suppose an upheaval of the earth's crust to have taken place. The beds, of more or less considerable thickness, which formed, on this supposition, the entire mass in which the peridotite was encased, must have risen above the water, and then being attacked by the erosive action of the waves, the outer portions which covered the peridotites have been disintegrated and removed, leaving behind them as a fragment of the primitive mass what we now see as St. Paul's Rocks. It may thus be supposed that, at the point now occupied by these rocks, there formerly rose a mass of ancient rocks, the dimensions of which may have been successively diminished by mechanical and chemical phenomena. Such an interpretation of the history of the locality is opposed neither to the nature of the rocks, nor to the details, still very incomplete, of their geological structure and relations. It is scarcely necessary to add that the opinion which tends to see in St. Paul's Rocks an outcrop of ancient strata, is not antagonistic to that which assigns to the oceanic basins a constancy in the general disposition, maintained during long geological ages. In regard to the possibility of the existence of a continental mass in the Atlantic at periods not very remote from our own, with which St. Paul's Rocks might be supposed to have been connected, it must be confessed that soundings have shown no trace of it, and that St. Paul's Rocks afford no proof of subsidence. There are no sedimentary formations, either fresh water or marine, to point to a greater extent of land surfaces in former geological ages."

Professor A. Geikie[1] and Mr. M. E. Wadsworth[2] have expressed opinions in favour of the probable volcanic origin of St. Paul's Rocks. To Mr. Wadsworth's criticism on his petrographical determinations, Professor Renard has already replied.[3]

St. Paul's Rocks to Fernando Noronha.

On the 29th August, at 7 A.M., the ship cast off from St. Paul's Rocks and proceeded round the islets to obtain soundings, leaving an officer on shore to take the bearing of the ship and masthead angle at each cast of the lead, the only method of fixing the correct position of the soundings. Whilst so employed observations were obtained on board with the dipping needle, and in the afternoon the ship was swung by azimuths of the sun to ascertain the deviation. At 3 P.M. the officer on the islet was recalled, and at 6 P.M. sail was made for Fernando Noronha.

On this section four soundings and two serial temperature soundings were obtained (see Sheet 12).

[1] *Nature*, vol. xxvii. p. 25. 1882.

[2] *Science*, vol. i. pp. 590–592, 1883.

[3] *Bull. Soc. Belge de Microscopie*, pp. 165–178, 1883.

The surface temperature remained nearly uniform at 78°.

The bottom temperatures varied with the depth, the coldest water being found at the deepest sounding, a result quite different from that hitherto obtained in the North Atlantic, where the temperature remained the same, or nearly the same, below 1800 fathoms no matter what the depth was. The lowest temperature registered in the section was 33°·7, the depth being 2475 fathoms.

The serial temperature soundings showed that the isotherms maintained a position as nearly as possible parallel with the surface, the isotherm of 40° being at a depth of 400 fathoms, that of 50° at a depth of 150 fathoms, and that of 60° at a depth of 70 fathoms.

On the 30th August, at Station 110, the velocity of the wind was 15 miles per hour by the anemometer, the force registered being 2. On the 31st, at Station 111, the velocity was 11 miles per hour, the force registered being 2 to 3. During the night of the 1st September, whilst at anchor at Fernando Noronha, the velocity was 9 miles per hour, and during the day on the 2nd, 15 miles per hour.

Between St. Paul's Rocks and Fernando Noronha there is a deep depression, the greatest depth recorded being 2475 fathoms. At this depth there was 36 per cent. of carbonate of lime in the deposit, while at the depths of 2275 and 2200 fathoms there were respectively 72 and 81 per cent. This is a good instance illustrating the diminution of carbonate of lime in the deposit with increasing depth, as here the surface conditions were the same, and the character and size of the mineral particles alike in all the soundings. The mineral particles did not exceed 0·05 mm. in diameter, and consisted of felspars, hornblende, augite, magnetite, and vitreous particles. Radiolarians, Diatoms, and fragments of other siliceous organisms made up from 2 to 4 per cent. of the deposits.

On the 1st September, at 6 A.M., the island of Fernando Noronha was sighted, and the day was devoted to obtaining a series of soundings to the shore (see Sheet 14). The ship anchored in San Antonio Bay at 3 P.M.

Fernando Noronha.

The intention was to have remained at this island for a week or ten days, to survey and explore it thoroughly, but, no previous notice having been given to the Brazilian Government, the Commandant would on no account take on himself the responsibility of permitting collections to be made on shore or soundings to be taken adjacent to the coast, although at first he appeared willing to allow this. Under the circumstances it therefore became useless to remain in the neighbourhood, and the ship left on the 3rd September for Bahia.

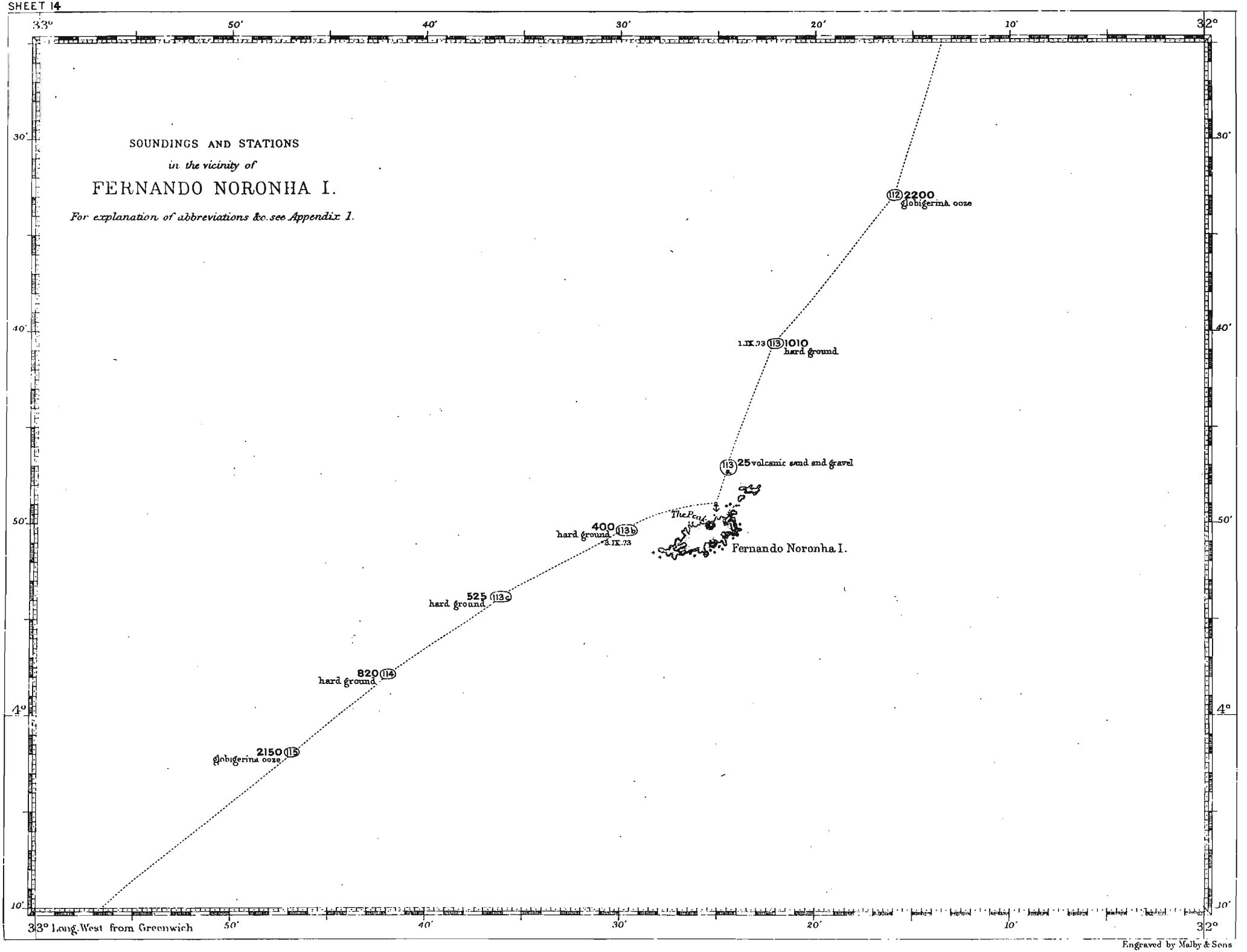
On the 1st and 2nd a landing was effected on the main island, as well as on the

SOUNDINGS AND STATIONS

in the vicinity of

FERNANDO NORONHA I.

For explanation of abbreviations &c. see Appendix 1.



Engraved by Malby & Sons

outlying islands of St. Michael and Rat. The surf that breaks everywhere on the main island renders it difficult of access; in fact, one of the ship's boats was capsized in Chaloup Bay, but on Rat Island the landing is much easier.

The island of Fernando Noronha is used as a penal settlement by the Brazilian Government. On it were about 1400 prisoners, 160 soldiers, and 4 officers, besides the Commandant or Governor, who at the time of the visit of the Expedition was a major in the Brazilian service. The prisoners are not confined in large buildings, but each man erects a hut for himself with laths and mud, so that the settlement occupies a considerable area. Its appearance would be much improved were more care taken in laying it out; at present, beyond leaving a clear road, but little attention has been paid to this matter. All the prisoners muster at morning and evening parade, and are "told off" in the morning for their allotted work during the day; some to attend the sheep or goats, others to labour in the fields, and others again to fish. The contrivance used by the fishermen is a kind of raft or catamaran, formed of four or five logs lashed together side by side, with a small stool on the top to keep the occupant dry; the catamarans are usually only large enough to support one man, but on one occasion a large one with three men on it was seen. There are no boats on the island, so that escape is almost impossible, as the catamarans are too small and unsafe to live in the open ocean.

There are plantations of sugar cane, maize, cassava, sweet potatoes, bananas, pumpkins, and melons on the island. The latter, both water and marsh, are remarkably fine, both in size and flavour; they cost about threepence each, and a large store was purchased.

From Rat Island the sea was seen to break over some rocks in Sponge Bay half-way to the Brothers, and the whole place appeared to be foul with rocks.

At about the middle of the northern coast of the main island is a remarkable column-like mass of bare rock, which projects to a height of 1000 feet, and is well known to navigators as "the Peak": it forms a most remarkable feature in the aspect of the island as viewed from the sea, and appears to overhang somewhat on one side. One other hill in the island is 300 feet in height. The southwestern extremity of the island runs out into a long narrow promontory, composed of a narrow wall of rock, in which, at one spot near high water line, a quadrangular opening is visible through which the sea dashes in a cascade. This opening, known as the "Hole in the Wall," can be seen from a considerable distance. At the opposite extremity the island terminates in a low sandy point with sand dunes upon it, beyond which stretch the outlying islets already referred to.

Fernando Noronha is thickly wooded, and appears beautifully green from the sea. The principal trees are what Webster,[1] who visited the island in 1828, calls the "laurelled Bara," which has dark green laurel-like leaves, and an abundant milky juice, the exact

[1] Webster, Voyage of the "Chanticleer," vol. ii. p. 331, London, 1834.

nature of which is unknown, as no specimen was procured, and a Euphorbiaceous tree, or rather tall shrub, called by Webster "Jatropha" or "Pinhao" (*Jatropha gossypifolia*). It has a pink flower, and at the time of the visit had only single tufts of young

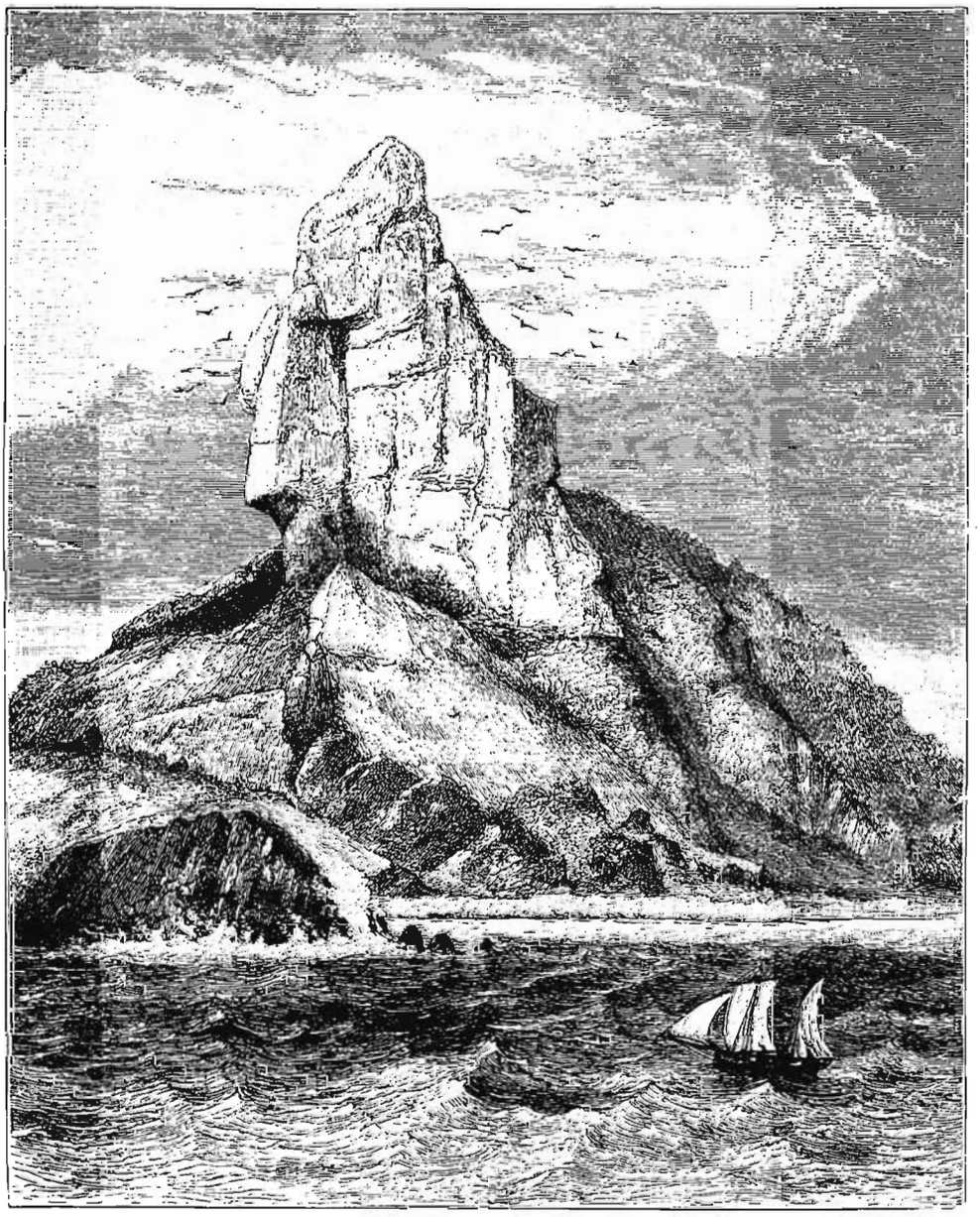


FIG. 87.—The Peak of Fernando Noronha, sketched from the deck of H.M.S. Challenger, Sept. 3rd, 1873.

leaves immediately beneath the inflorescence, although in full flower. Its bare stems and branches render it a striking object amongst the green of the creepers when the forest is viewed from the sea. Webster says that it casts its leaves in July and August,

that is, at the commencement of the dry season. It is evidently the tree mentioned by Darwin as occurring on the Peak.[1]

A horrible pest, a stinging plant, *Jatropha urens*, one of the Euphorbiaceæ, is everywhere very common; it has a thick green stem and leaves, resembling those of our common garden geraniums in shape, and a small white flower, and is covered with fine sharp white bristles, which sting most abominably. To gather specimens they had to be lassoed with a string, kicked up by the roots, and carried on board carefully slung on a stick. The stinging sensation produced by the plant lasts for more than two days, the pain being like that of the nettle, but far more intense.

Mount St. Michael is a conical outlying island mass of phonolite,[2] 300 feet in height. It is comparatively inaccessible, and owing to its steepness has never been cultivated, hence it seemed likely to yield a fair sample of the indigenous flora of the group. Most of the plants collected there proved, when examined at Kew, to be common Brazilian forms, but a Fig Tree (*Ficus noronhæ*) with pendent aerial roots like the Banyan, grows all over the upper parts of the rock, and in favourable spots forms a tree 30 feet in height; it proved to be a new species and peculiar to the island as far as is yet known.[3] A complete investigation of the flora of the group is a most urgent scientific necessity.

There is a dry and a rainy season on the islands, the latter extending from January to July, and the former from July to December. In the dry season there is occasionally want of water, but rain often falls; it rained heavily during the visit of the Expedition on September 2nd.

The principal bird inhabitants of the island were Boobies and Noddies of the same species as at St. Paul's Rocks, but far shyer here, and Boatswain-birds and Frigate-birds (*Tachypetes aquila*); these latter soared high overhead, looking, with their forked tails, like large kites. All these birds nest on the Peak. The woods are also full of flocks of reddish-brown Doves (*Peristera geoffroyi*), a species which occurs in Brazil, and has possibly been introduced into the island. They are in vast numbers, and being scarcely ever shot at, were so tame that stones had to be thrown at them to make them take wing. Many of them had nests and eggs, and they probably breed all the year round.

Two Lizards which are South American in their affinities occur in the islands,[4] *Thysanodactylus bilineatus*, one of the Iguanidæ, occurs also in South America; the genus is distinguished by a scaly projection on the outer side of the hinder toes; this Lizard, which was originally obtained on the island by the officers of H.M.S. "Chanticleer," was not met with. The other Lizard, *Euprepes punctatus*, belongs to the Scincidæ,

[1] Darwin, Journal of Researches during the Voyage of H.M.S. "Beagle," p. 11, ed. 1879.
[2] A typical phonolite composed of sanidine, augite, nepheline, magnetite, noseane, or hauyne and titanite.
[3] D. Oliver, F.R.S., Icones Plantarum, vol. xiii. p. 18, t. 1222.
[4] Gray, British Museum Catalogue of Lizards, p. 193, 1845.

and is peculiar to Fernando Noronha, its nearest ally, *Euprepes maculatus*, inhabiting Demerara; it is very abundant on the main island, and especially so on Mount St. Michael, where it is remarkably tame; some specimens are more than a foot in length. Rev. O. P. Cambridge says that two spiders from Mount St. Michael are *Argiope argentata*, Latr., and *Neon* sp. A new species of Lepidoptera (*Catochrysops trifracta*, Butler) was caught on Rat Island; it is interesting as being of a Malayan type.[1]

The rock at Rat Island is nepheline-basalt. In the southeast part of this island there is a tufa composed of carbonate of lime and of clastic grains of organic and mineral origin. The grains are rounded, and each is bordered with a little zone of calcite; the mineral particles are olivine, basalt, and palagonite. The rock of Platform Island is a felspathic basalt.

Professor Thomson and Mr. Murray dredged during the day in the steam pinnace in depths varying from 7 to 25 fathoms. The bottom was covered with a calcareous sand or gravel, of a mottled red and white colour, the fragments varying from 2 to 3 cm. in diameter, and consisting chiefly of calcareous Algæ with fragments of Echinoderms, Molluscs, Polyzoa, Corals, *Polytrema*, *Amphistegina*, and other Foraminifera.

Fernando Noronha to Bahia.

On the 3rd September, at 9.30 A.M., the ship left Fernando Noronha for Bahia, carrying a line of soundings to the westward to the depth of over 2000 fathoms (see Sheet 14).

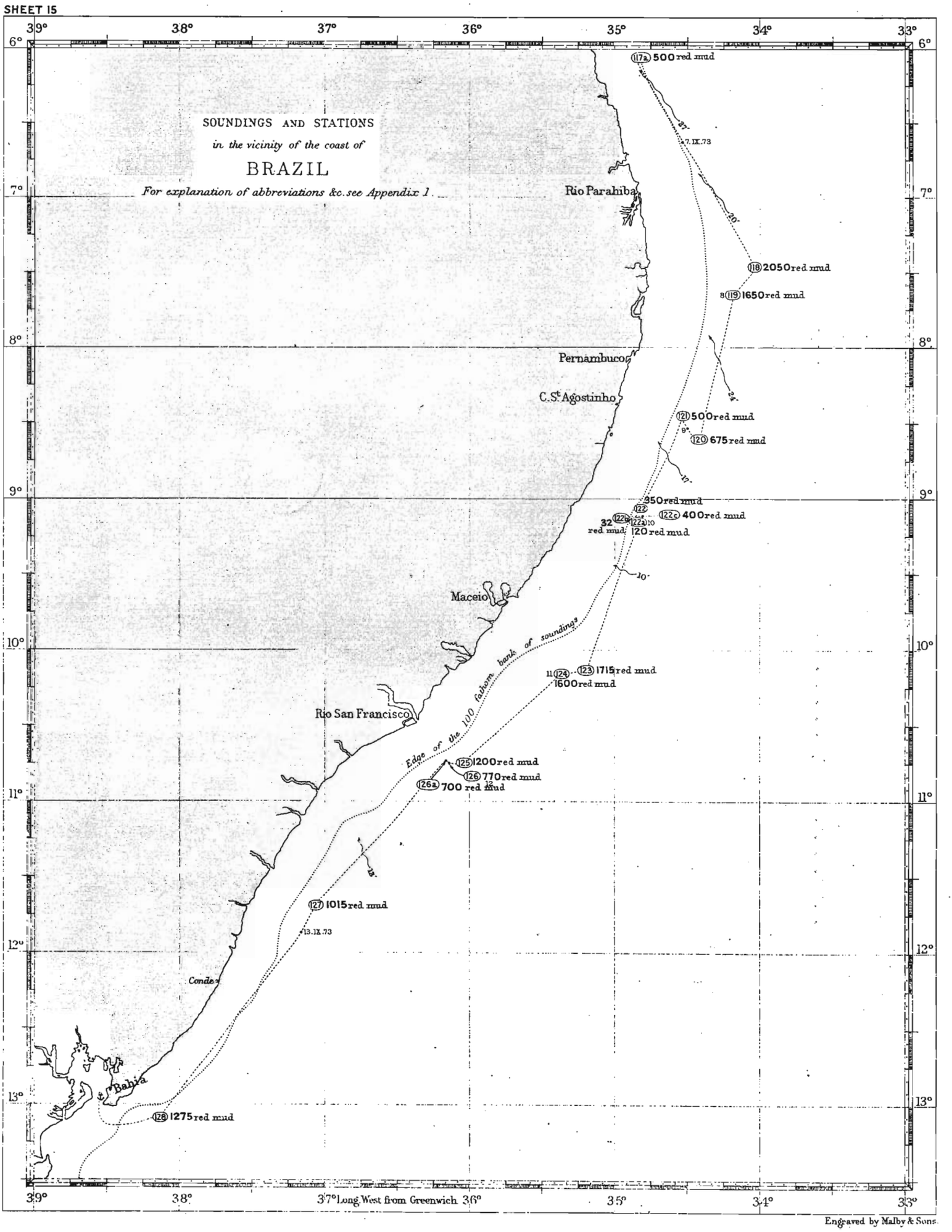
During the passage to Bahia the wind for the first few days hung well to the southward, the average direction being S.S.E., force 4 to 5, squally, with passing showers; after passing the parallel of 8° S. it fell light and came more from the eastward.

In consequence of the trade wind being so far to the southward the ship approached the American coast on the 6th parallel, and then steamed along the land to Bahia, keeping at such distances from the shore as seemed suitable for sounding or dredging, and taking advantage of any slant of wind to economise fuel. Several whales were seen on the course southward.

On the 6th September, at Station 117, the Barrieras do Inferno could just be distinguished from the deck at a distance of 27 miles. From Station 117A, where the depth was 500 fathoms, and the distance from the shore 16 miles, the land could be plainly seen, but there were no objects sufficiently prominent to fix the position of the sounding by bearings. Later on the same day a cast was taken in 18 fathoms, 9 miles east of Point Moleque, with the right extremity of the Barrieras do Inferno N. 42° W. (true),

[1] In Mr Butler's paper (*Ann. and Mag. Nat. Hist.*, ser 5, vol. xiii. p. 195, 1884) this species is accidentally stated to be from "Rat Island, Straits of Malacca."

SHEET 15



Engraved by Malby & Sons.

Point Moleque N. 87° W. (true), and Formosa S. 36° W. (true), but even at this distance these objects were not readily distinguished (see Sheet 15).

On the 7th the ship was off the Rio Parahiba, where the land is better marked, the town of Parahiba standing on the first elevated land south of the river; some cocoanut trees on its northern side, which serve to point it out when the sun is at its back, and the lighthouse on the reef at the entrance of the river, are excellent marks; but the convent of Senhora di Guia cannot be seen unless the sun be shining on it. The Barreta do Arutu is well marked, and readily distinguished from the northward. At 4 P.M. on the 7th bottom was obtained in 16 fathoms, with Parahiba lighthouse S. 72° W. (true), Parahiba church S. 43° W. (true), and Barra Velha Point N. 53° W. (true), and depths of from 16 to 13 fathoms were obtained until 5.45 P.M., when Barreta do Arutu bore S. 23½° W. (true), Parahiba church S. 64° W. (true), and Parahiba lighthouse N. 51° W. (true), after which a course was steered to the southeastward, and the soundings deepened.

On the 8th September two deep soundings were obtained at distances of 45 miles and 34 miles from the shore at Stations 118 and 119. The ship was then steered towards the land, and Olinda Point sighted at 4 P.M. at a distance of 22 miles. At 6 P.M., when 15 miles from the shore, points could be distinguished with sufficient accuracy to fix the position of the ship by bearings. At this time Olinda summit bore W.S.W. (true), the fort on the S.E. point of Itamaraca Island W.N.W. (true), and a village (probably Catuame) N.W. (true). The ship was then in 22 fathoms, with a sandy bottom, and a course was steered S. (true) 12 miles until 9 P.M., when the depth was again 22 fathoms. From this place the course was S. 14° E. (true) until 4 A.M. on the 9th September, when, by observation, the ship was in lat. 8° 37′ S. and long. 34° 28′ W., the patent log showing 36 miles, since 9 P.M. At 10 P.M., 11 P.M., and midnight, soundings were obtained in 26, 26, and 40 fathoms. After sounding and dredging in lat. 8° 37′ S. long. 34° 28′ W. in 675 fathoms (Station 120) the ship proceeded a little further inshore, and sounded in 500 fathoms (at Station 121); from this position Cape San Agostinho could just be distinguished, distant 27 miles.

On the 10th September, at Stations 122, 122A, 122B, and 122C, the land was visible at a distance of about 23 miles, but the only objects that could be distinguished were the white cliffs of Barra Grande, and they disappeared in the afternoon when the sun no longer shone on them. The ground in this locality was foul, for all the nets sent to the bottom were torn. On the 11th September the land was not seen even from the masthead from Stations 123 and 124 at distances of 40 and 33 miles. On the 12th September, at Stations 125, 126, and 126A, the land about the Rio San Francisco was visible from the masthead at a distance of 17 miles, but not from the deck. On the 13th the land was seen at a distance of 12 miles from the deck between the Rio Real and Conde, appearing as a series of low hills marked here and there with white patches, which were very conspicuous, and would be very useful objects for fixing the position of passing

vessels were they shown on the chart. About Conde there is a flat hill with a remarkable tree on its southwest end, and just south of this is a detached hill with a white sandy streak on its face. On the 14th, at Station 128, the sandy hills about Itapua were visible from the deck at a distance of 14 miles.

Between Fernando Noronha and Bahia twenty-two soundings, two serial temperature soundings, and nine trawlings were obtained (see Sheet 15), but for the section between Fernando Noronha and the American coast (Olinda Point, Pernambuco), only seven soundings and the two serial temperature soundings were available, the other depths having been obtained at varying distances from the coast as the ship proceeded southward along the land, from the parallel of 6° S. to Bahia.

The temperature of the surface water averaged from 77° to 78°.

The bottom temperature varied with the depth, as in the section from St. Paul's Rocks to Fernando Noronha, the lowest temperature being obtained at the greatest depth, viz., 34°·3 at 2275 fathoms.

The serial temperature soundings showed that the isotherms of 40° and 45° remained nearly parallel with the surface at depths of 400 and 220 fathoms, but the isotherms between that of 45° and that of 78° at the surface gradually deepened as the American coast was neared.

The current at Fernando Noronha was setting to the westward at an average rate of one mile per hour. On the 9th September, at Station 121, the cutter anchored by the trawl showed the surface current to be running N.N.W. (true), half a mile per hour.

Anemometer observations at Station 115, on September 3rd, showed the velocity of the wind to be 17 miles per hour, its force being registered as 4. On the 4th September, at Station 116, its velocity was 20 miles per hour, the force registered being 3 to 5. On the 6th September, at Station 117, its velocity was 24 miles per hour, and the force registered 4 to 5. On the 11th September, at Stations 123 and 124, its velocity was 9 miles per hour, and the force registered 2.

On the 14th September, at 6 A.M., the land about Bahia was sighted, and after obtaining a sounding the ship was steered in for the harbour. At noon the south end of the San Antonio Bank was rounded, and the coals having come to an end, the sea breeze had to be waited for to carry the vessel into port. Whilst waiting for the wind the ship was surrounded by myriads of butterflies, principally *Heliconius narcæus*, but after the sea breeze set in, at 1 P.M., they nearly all disappeared. At 4.30 P.M. the ship anchored in the harbour.

Between Fernando Noronha and the American coast there is a deep depression, in which a depth of 2275 fathoms was obtained; and comparatively deep water extends to within 30 miles of the American shore.

The deposits along the coasts of Brazil differed in colour from those which the Challenger

found along other continental shores. Here they were red, due, apparently, to the large quantities of ochreous matter carried into the sea by the Brazilian rivers. Usually the colour of deposits along continental shores is blue, with a surface layer of a red or brownish colour. The carbonate of lime in the soundings off this coast varied from 60 to 6 per cent. according to depth, distance from the coast, and whether or not opposite the *embouchures* of rivers. The mineral particles consisted of fragments of quartz, plagioclase, felspars, sometimes kaolinized, epidote, mica, augite, hornblende, fragments of rocks and vitreous particles, the size varying from 0·05 to 1 and 2 mm. in diameter. Radiolarians and Diatoms were nearly, if not quite, absent from these deposits, and when present they, along with siliceous Sponge spicules, did not appear to make up over 0·5 per cent. of the whole deposit. The apparently complete absence of glauconite along this coast was also remarkable.

The various dredgings and trawlings along the coast were very successful, and yielded a large number of new species belonging to nearly all the invertebrate groups. Here the first specimens of a new genus of fish, *Bathypterois*, were procured, of which Dr. A. Günther, F.R.S., remarks :—

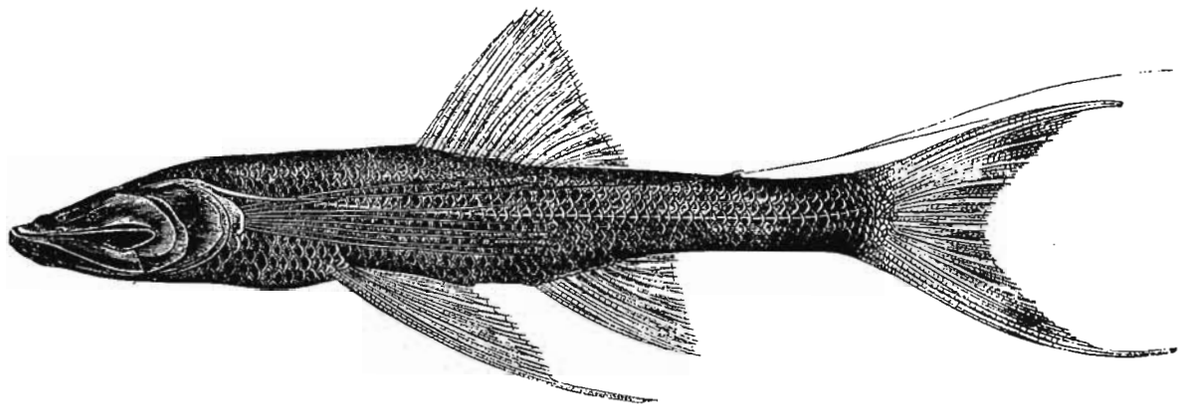


FIG. 88.—*Bathypterois longipes*, Günth.

Bathypterois.—"The fishes of this singular Scopeloid genus have retained much of the outward appearance of surface fishes, and without knowing their origin, we might take them as equally well organised for life in some quiet dark water near to the surface. They resemble somewhat a smelt in general contour of the body, which is covered with cycloid scales, more or less firmly adherent and of moderate size. The head is scaleless, ending in a depressed snout, with wide mouth, the lower jaw projecting beyond the upper. The teeth are very small, in villiform beads; the eyes rudimentary.

"Very curious is the modification of the pectoral rays, which are much elongated, some of the upper even being separated from the remainder of the fin, and forming a distinct division. These rays are evidently tactile organs, by means of which the fish can examine and discriminate objects which are hidden in the ooze, and which it could not

detect with its imperfect organ of vision. Several species were discovered in the South Pacific as well as the South Atlantic, at depths varying from 520 to 2650 fathoms."

When taken from the trawl these fishes were always dead, and the long pectoral rays were erected like an arch over the head, requiring considerable pressure to make them lie along the side of the body; when erected they resembled Pennatulids like *Umbellula*.

On the voyage from the Cape Verde Islands to Bahia the tow-net was worked with greater regularity and more successfully than during the early part of the cruise. The method of lowering and towing it at depths of 50 and 100 fathoms beneath the surface while the ship was dredging and sounding was adopted, and proved a great success. In this way many animals were taken during the day which had previously only been captured on the surface at night.

Except during calm weather, very few animals were found near the surface in the day time. Mr Murray's researches led him to conclude that the great majority of pelagic organisms live at various depths down to, and even deeper than, 100 fathoms during the day time and rough weather, and only come to the surface during the night and in calm weather. In this trip along the course of the Guinea and Equatorial Currents pelagic life was much more abundant and varied, both in individuals and species, than anywhere else in the North or South Atlantic.

The occurrence of the following organisms was noted during the trip. The greatest profusion of life was observed in the Guinea Current during calms, when the sea literally teemed with life, and the most magnificent displays of phosphorescent light occurred at night.

Trichodesmium, and other Oscillatoriæ.
Large specimens of *Coscinodiscus* and other Diatoms, free and attached to Copepods and other organisms.
Rhabdospheres, Coccospheres.
Pyrocystis noctiluca and *Pyrocystis fusiformis*.
Amœba and amœboid particles.
Peridinium tripos (single and in catena), and other species.
Vorticella, *Acineta*, *Podophrya* (on Pteropod shells), and other Infusoria.
Many Radiolaria (compound and simple).
Pulvinulina, *Sphæroidina*, *Globigerina*, *Hastigerina*, *Orbulina*, *Candeina*, and *Pullenia*.
Hydromedusoid stocks (on Pteropod shells).
Hydromedusæ.
Physalia, *Diphyes*, *Velella*, *Porpita*, and many other Siphonophora.
Semper's Cœlenterate larva.[1]
Scyphomedusæ.

[1] *Zeitschr. f. wiss. Zool.*, Bd. xvii. pp. 407–411, 1867.

Bipinnaria (with young starfish).
Echinid, Ophiurid, and Holothurian larvæ.
Planaria, Distoma (on *Sagitta*).
Sagitta (many with *Gregarinæ*).
Sipunculid larvæ.
Terebella, Polynoe, Alciope, Tomopteris, Aphroditacean and other Annelid larvæ.
Tornaria.
Corycæus, Saphirina, Copilia, Setella, and other Copepods.
Cythere, Halocypris, and other Ostracodes.
Hyperia, Phronima, Rhabdosoma and other Amphipods.
Squillerichthus.
Mysis, Euphausia.
Sergestes, Leucifer, Amphion, Phyllosoma, zoeas of Crabs.
Halobates.
Hyalea, Cleodora, Cymbulia, Pleuropus, Spirialis, Pneumodermon, Styliola, and other Pteropoda.
Ianthina, Atlanta, Carinaria, Pterotrachea.
Phylliroë, Acura, Scyllæa, Glaucus, and larvæ of other Gasteropods.
Cranchia, and other small Cephalopods.
Pyrosoma, Salpa, Doliolum, Appendicularia, Fritillaria.
Sternoptyx, small Scopelids, *Leptocephalus,* young Pleuronectids (*Plagusia*), young of *Exocetus,* other larval fish, and fish eggs.

The Radiolaria.—Professor Haeckel, who is engaged in the preparation of a detailed Report on the Radiolaria, which will shortly be published, has revised and amended the following notes on this group by Mr Murray:—"Of all the classes of marine animals, of which our knowledge has been extended by means of the acquisitions gained by the Challenger Expedition, the Radiolaria must be admitted to be, without doubt, amongst the richest and most interesting. Up to the time of the Expedition scarcely more than 600 species of this remarkable class of Rhizopoda had been recognisably described or portrayed, of which about one half were recent and one half fossil.

"The number of new species which Professor Haeckel has hitherto been able to distinguish in the rich collection brought home by the Challenger, amounts to more than three times this number, viz., over 2000. Amongst these are found not only very many highly curious and delicate forms, but also a great number of new types, which throw a bright light on the morphology of the whole class, and, as phylogenetic documents, have a special interest for the students of evolution.

"Our knowledge of the Radiolaria, which now appear to be the richest and most varied in form of all the classes of Protozoa, is scarcely more than half a century old. In

1834, Meyen made the first communication upon two Rhizopoda belonging to this group, *Physematium* and *Sphærozoum*, for which he constituted a special class of Infusoria (Palmellaria). In 1838, Ehrenberg described some fossil siliceous species, under the name *Polycystina*, and made the discovery eight years later (in 1846) that masses of rock in the island of Barbados contained a very large number (more than 300 species) of similar delicately perforated flinty skeletons. Ehrenberg subsequently discovered a great number of other skeletons belonging to this group, some of these being fossil in Tertiary formations, and others being found in deep-sea soundings. He concluded, wrongly, that these were the shells of highly organised animals related to the Polyzoa and Echinodermata.

"The first accurate observations and correct views upon living Radiolarian organisms we owe to Professor Huxley,[1] who, in 1851, carefully described several species, under the name *Thalassicolla*. Those examined by him in a living condition were partly solitary forms (really belonging to the present genus *Thalassicolla*), partly social forms (of the genera *Collozoum*, *Sphærozoum*, *Collosphæra*, *Siphonosphæra*). These Huxley recognised as Protozoa, from their being equivalent to single cells, and rightly described their central nuclei, also the vacuoles in the surrounding jelly, the yellow cells, &c.

"A far greater number of living species was soon after described by Johannes Müller of Berlin, who had observed them alive, during a period of ten years, especially in the Mediterranean. He observed, for the first time, the pseudopodia forming an anastomosing network, and radiating outwards from the unicellular body, and the flowing of the granules along them. This movement he compared, rightly, with that in the Foraminifera. His numerous and important discoveries he collected, shortly before his death, in his classic treatise, which appeared in 1858.[2] All these various forms, the discoveries for the most part of himself, were united by Joh. Müller under the name Radiolaria, and, as siliceous *Rhizopoda radiaria*, placed in opposition to the calcareous *Rhizopoda polythalamia*.

"The knowledge of the Radiolaria acquired by Joh. Müller was greatly extended by one of his pupils, Professor Ernst Haeckel of Jena, who published, in 1862, an exhaustive monograph of this group.[3] He first distinguished, as two principal constituents of the Radiolarian organism, the inner central capsule and the outer extracapsular sarcode with the pseudopodia. He gave the comparative morphology of the skeleton. In his classification fifteen families, containing 113 genera, were distinguished.

"The reproduction of the Radiolaria by means of swarmspores, which arise in the central capsule, was first clearly observed by Cienkowski in 1871.[4] He first propounded

[1] *Ann. and Mag. Nat. Hist.*, ser. 2, vol. viii. pp. 433–442, 1851.

[2] Ueber die Thalassicollen, Polycystinen und Acanthometren des Mittelmeeres, *Abhandl. d. k. Akad. d. Wiss. Berlin*, pp. 1–62, 1858.

[3] Monographie der Radiolarien, Berlin, 1862.

[4] Ueber Schwärmerbildung bei Radiolarien, *Archiv f. mikrosk. Anat.*, vol. vii. pp. 372–381, 1871.

the view, afterwards corroborated, that the yellow cells, which are to be found in the jelly round about the central capsule, do not belong to the organism itself, but are parasites or rather 'Symbiontes,' like the Gonidia of Lichens.

"The histology of the Radiolaria, which offers peculiar and difficult relationships, was first interpreted by Professor Richard Hertwig, a pupil of Haeckel. He published, in 1876,[1] the first accurate account and correct interpretation of their cell-nuclei, and demonstrated that the whole organism, in spite of very peculiar modifications, is to be regarded merely as a single cell. In his work, published in 1879,[2] Hertwig undertook a reformation of the whole classification of the Radiolaria, based upon important discoveries with respect to the structure of the central capsule, and divided the class into six different orders.

"Meanwhile Professor Ernst Haeckel had, in 1876, commenced the investigation of the extraordinarily rich material collected by the Challenger. The preliminary account of his investigations, and the changes which they rendered necessary in the current classification, were published by him in October 1881,[3] shortly before his journey to Ceylon. He then distinguished twenty-four families, including 630 genera. In 1883 Haeckel expounded the relationship of these families, and their arrangement, on phylogenetic grounds, in four primary groups.[4]

"Professor Bütschli gave, in 1882,[5] a good synopsis of all previous observations on the Radiolaria, as well as a number of valuable original investigations upon their siliceous skeletons. St. George Mivart had already, in 1877, given a short review of the subject in the Journal of the Linnean Society.[6]

"The morphology of the Radiolaria is now so thoroughly understood that we are no longer in doubt as to their relationship to the other Protozoa. It is certain that they are true Rhizopoda, distinguished from the other classes of this group (Foraminifera, Heliozoa, Lobosa) chiefly by the remarkable separation of their unicellular body into two principal constituents, namely, the inner 'central capsule' and the externally situated 'extracapsularium.'

"The important central capsule is a highly-organised cell, which is surrounded by a special membrane, and encloses one or more nuclei in its protoplasm, and sometimes other bodies in addition, such as oil-globules, crystals, pigment-granules, &c. At the time of reproduction, numerous swarmspores are developed in it, which are set free by the bursting of the capsule, and swim about by means of a flagellum.

"The extracapsularium consists of a voluminous gelatinous 'involucrum,' which encloses the central capsule, and numerous fine pseudopodia, which radiate through

[1] Zur Histologie der Radiolarien, Leipzig, 1876.
[2] Der Organismus der Radiolarien, *Denkschr. d. med.-nat. Gesellsch. Jena*, Bd. ii. p. 129, 1879.
[3] *Jenaische Zeitschr.*, Bd. xv. pp. 418–472, 1881.
[4] *Jenaische Sitzungsb.*, Feb. 16, 1883.
[5] Bronn, Klass. u. Ord. d. Thierreichs, Bd. i. Aufl. 2, 1882.
[6] *Journ. Linn. Soc. Lond.* (Zool.), vol. xiv. p. 136, 1877.

this outwards, from a thin layer of sarcode immediately surrounding the capsule. Outside the gelatinous envelope the pseudopodia form a network, and show the same granular movement as in other Rhizopoda, by means of which nutrition, locomotion, and perception are carried on. Their extreme terminations are free radial threads. Oil-globules, pigment-granules, vacuoles, &c., not unfrequently occur in the extra-capsularium.

"In many Radiolaria, but by no means in all, are found, in addition to these, scattered round about the central capsule, numerous yellow cells, which contain starch. These have been lately recognised as unicellular Algæ (*Zooxanthellæ*), which live in a state of symbiosis with the Radiolaria, just as do the Gonidia with the Lichens. They also have an independent power of reproduction.

"The inner protoplasm, which is enclosed in the central capsule, is intimately connected in two different ways with the outer sarcode which surrounds it. In the Holotrypasta

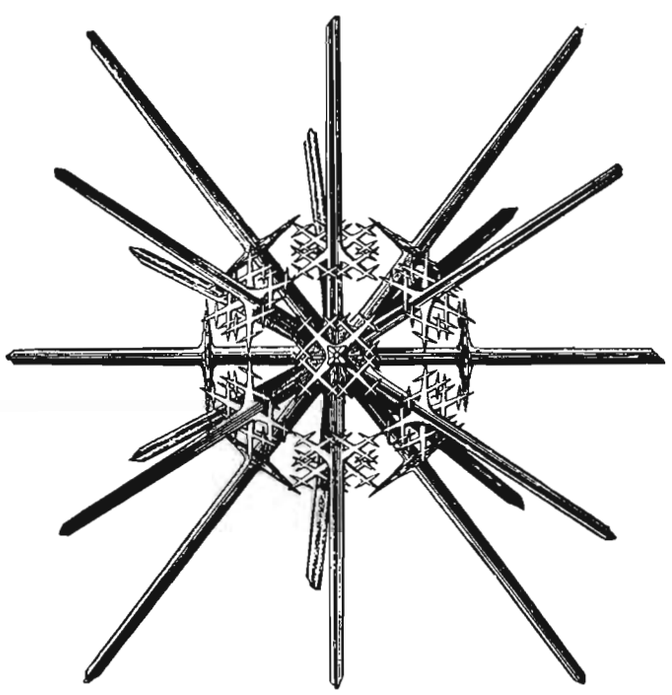


FIG. 89.—*Xiphacantha murrayana*, n. sp.

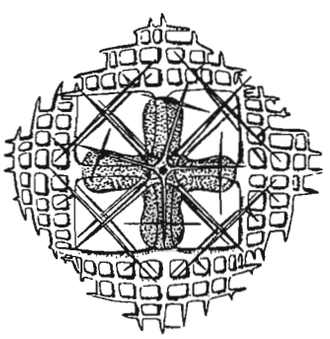


FIG. 90.—*Lithoptera darwinii*, n. sp.

(Acantharia and Spumellaria) the membrane is everywhere perforated by numberless small pores, through which the two communicate. In the Merotrypasta (Nassellaria and Phæodaria), on the contrary, there is only a single large opening in the capsule, through which the pseudopodia protrude. There are, however, not unfrequently found, beside this, two or more small accessory openings.

"The great majority of Radiolarians, with indeed few exceptions, are remarkable for skeletons of the most varied and delicate forms. In one order (the Acantharia) these consist of acanthin, a peculiar organic substance related to chitin; in the other three orders, on the contrary, of silica or an organic silicate. In the Phæodaria the separate siliceous portions which constitute the skeleton are, for the most part, hollow tubes, but

in the Spumellaria and Nassellaria (which are often united under the name Polycystina) they are solid rods or threads. In some cases the skeleton exists only outside the central capsule, whilst in others it is also found within it. The skeleton presents in most cases the appearance of a delicate lattice-work, and is armed with spines often resembling that of Sponges.

"The geometrical figure of the

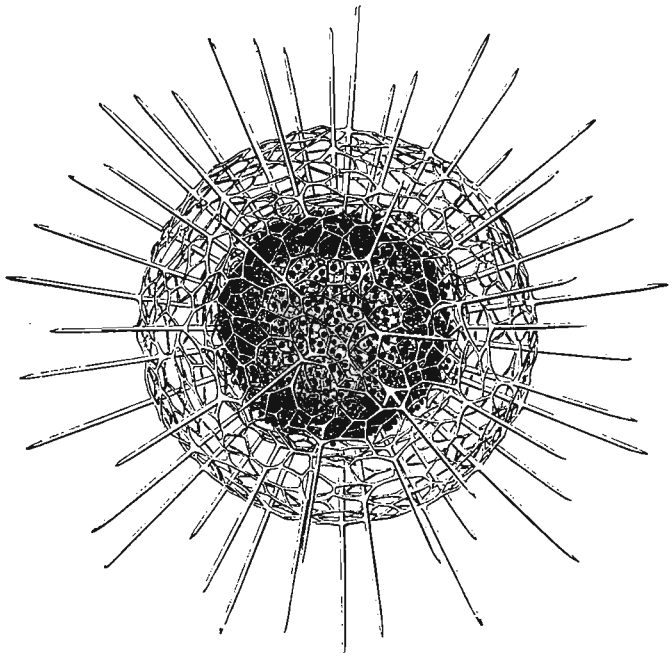


FIG. 91.—*Haliomma wyvillei*, n. sp.

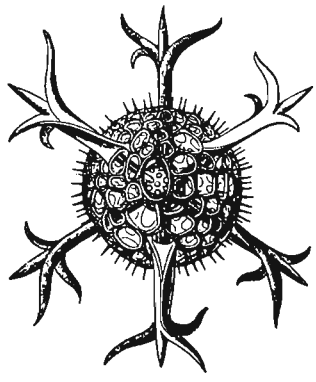


FIG. 92.—*Hexancistra quadricuspis*, n. gen. et sp.

Holotrypasta is fundamentally a sphere (homaxon), but in the Merotrypasta it is conical or egg-shaped (monaxon).

"The Acantharia, which are distinguished from all other Radiolaria by their organised

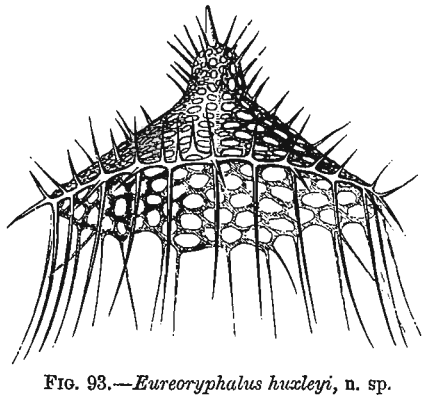


FIG. 93.—*Eucoryphalus huxleyi*, n. sp.

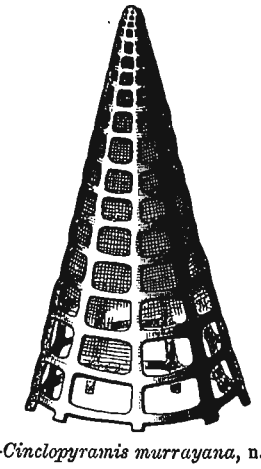


FIG. 94.—*Cinclopyramis murrayana*, n. gen. et sp.

skeleton of acanthin, have, for the most part, a spherical central capsule, whose simple membrane is everywhere perforated by fine pores. Their nucleus becomes early divided into numerous small spore-nuclei; and the skeleton always consists

of numerous radial spines, which meet in the centre of the capsule. In most cases, twenty such spines are present, and in accordance with a curious law, discovered by Johannes Müller, these are geometrically divided into five zones, each containing four of these spines (figs. 89, 90). In the Acanthometræ these give rise to no special perforated shell, whilst in the Acanthophractæ this is developed into many varied and delicate forms.

"The Spumellaria include that large group of Radiolaria whose simple capsular membrane is perforated by minute pores, and whose nucleus divides only at a later

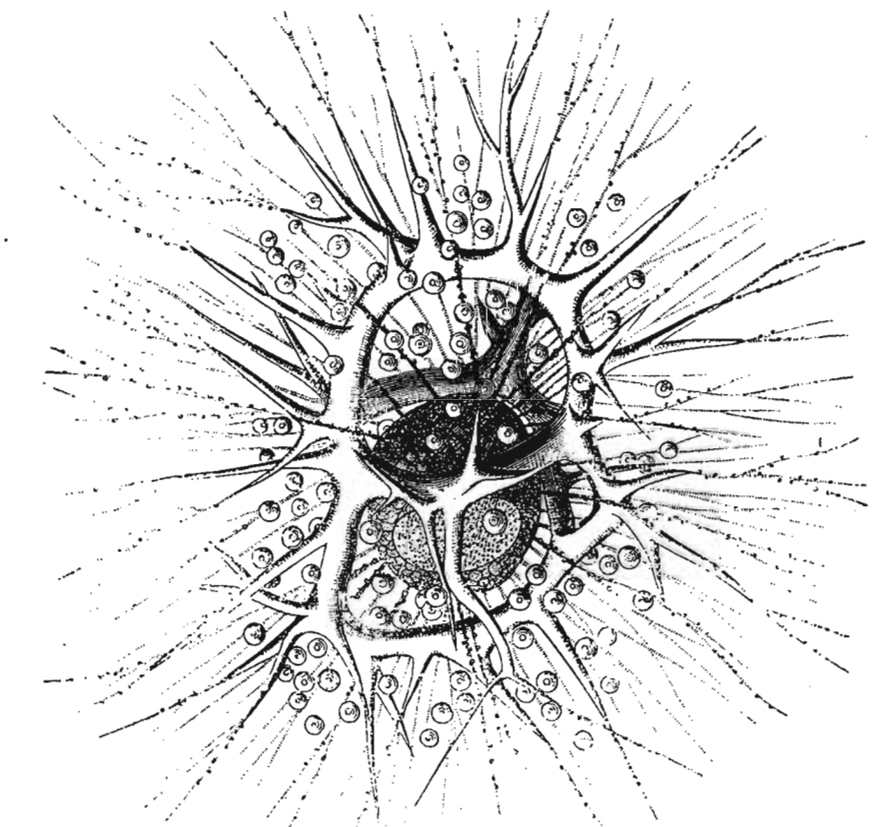


FIG. 95.—*Lithocoronis challengeri*, n. gen. et sp.

stage (at the time of reproduction) into numerous spore-nuclei. In only a few families (Thalassicollida, Collozoida) the skeleton is entirely wanting, or is reduced to single scattered spicules (Thalassosphærida, Sphærozoida). The skeleton usually consists of a latticed sphere (Sphæroida), which is developed into multifarious forms—stars, disks, concentric, sponge-like, flinty shells, &c. (see figs. 91 and 92). These are often rendered conspicuous by radial spines and processes of curious and varied form.

"The Nassellaria are distinguished from the two preceding groups by the peculiar structure of their central capsule, from which the pseudopodia protrude only at a per-

forated spot at one end of the longitudinal axis. The nucleus divides only at a late stage into numerous small spore-nuclei. The variously shaped skeletons consist mostly of a bell-shaped or conical perforated case, as in the Cyrtellaria (figs. 93, 94, 96). More rarely it consists only of a ring, or of a triradiate frame or a loose network of siliceous rods, as in the Plectellaria (see fig. 95). The principal division of this order is constituted by the family Cyrtida, in which the perforated shell is elongated in the direction of the principal axis, and is separated by one, two, or more constrictions into two, three, or more segments (see figs. 93, 94, 96).

"The Phæodaria have, like the foregoing group, only one primary opening for the protrusion of the pseudopodia, but there are usually, in addition, two (rarely, however, more) accessory openings. Around the primary opening, and outside the capsule, there is always a large mass of blackish or greenish-brown pigment, the 'Phæodium.' By means of this and of the double membrane of the central capsule, these are distinguished from all other Radiolaria. They are also, for the most part, much larger, and their flinty skeleton usually consists of hollow tubes. Up to the year 1872 only three genera of Phæodaria were known, namely, those described in 1862 by Professor Haeckel, under the designations *Aulacantha*, *Aulosphæra*, and *Cælodendrum*. During the Challenger Expedition, however, a great number of new genera and species were discovered, many with very curious siliceous skeletons, these being, for the most part, inhabitants of the deep sea. The most remarkable of these are, perhaps, the Challengerida, several forms of which were briefly described and figured by Mr. Murray in 1876;[1] a number of species of two genera (*Challengeria* and *Tuscarora*) are shown in Pl. A. The unicellular, egg-shaped case has a peculiar structure, resembling that of the Diatomaceæ (Pl. A. figs. 1–7), and is, in most cases, armed about the mouth with spines and hollow tubes (Pl. A. figs. 1–12).

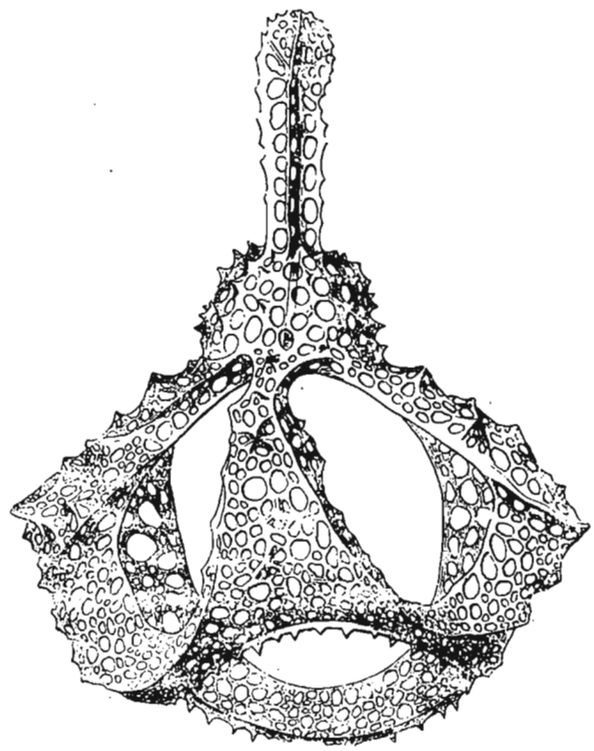


FIG. 96.—*Clathrocanium reginæ*, n. sp.

"The majority of the Radiolaria are found near the surface of the open ocean, where they frequently appear crowded together in large numbers. Many species are, however,

[1] *Proc. Roy. Soc.*, vol. xxiv. p. 535, 1876.

inhabitants of the deep sea. Still more astonishing are the vast numbers of their skeletons and shells which are found in the deposits at great depths, especially between 2000 and 4000 fathoms, and even to the greatest known depths. The area of their richest distribution is the tropical zone of the Pacific Ocean, between latitudes 20° N. and 10° S., and longitudes 140° W. and 140° E. At many of the Challenger Stations (particularly 225, 226, 266 to 274) the chief part of the deposit at the bottom of the sea

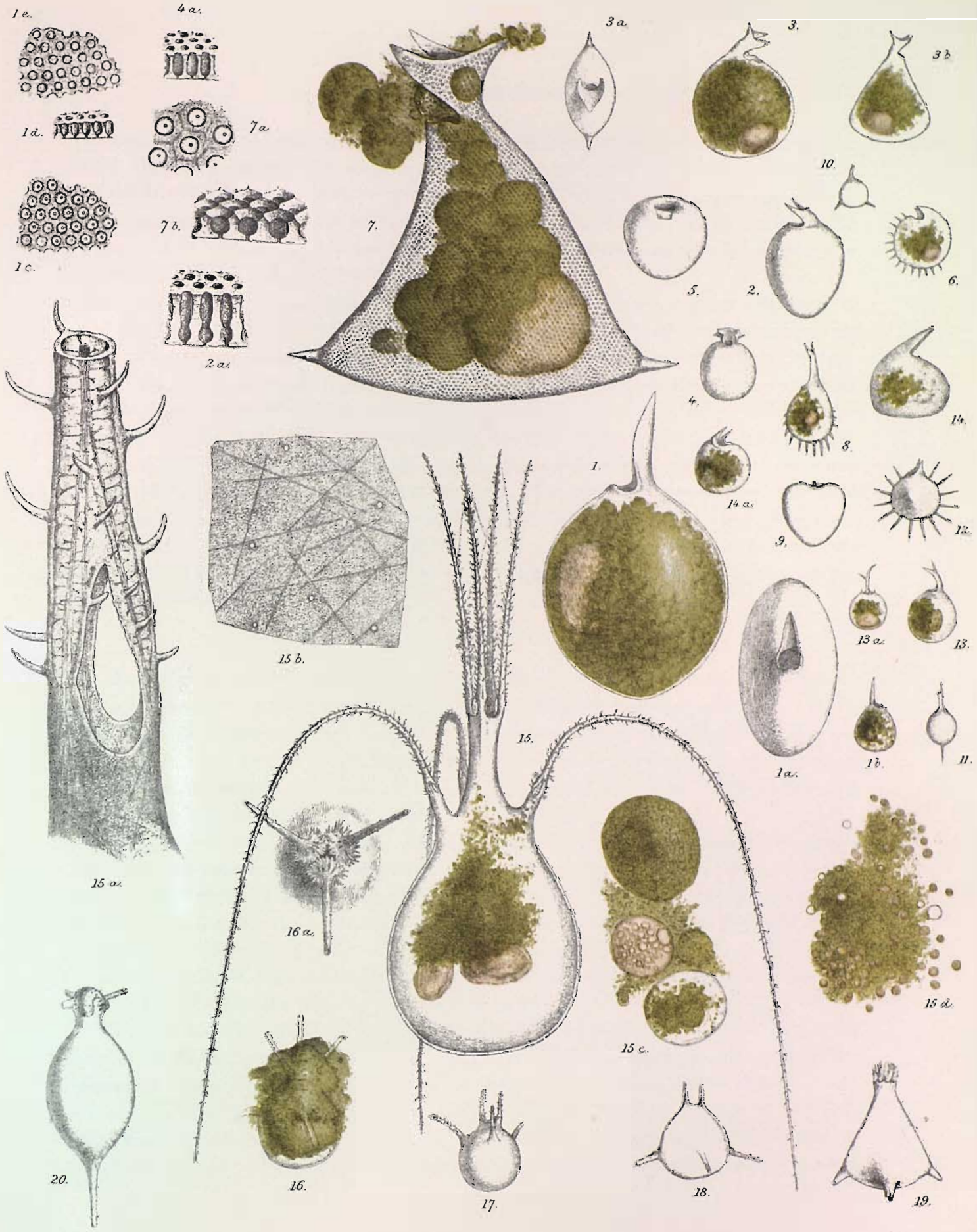
Explanation of Plate A.

Figs. 1–14. *Challengeria.*

Fig. 1. *Challengeria naresii*, seen from the flat side; magnified 60 diameters.
Fig. 1*a*. The same, seen from the upper surface; magnified 60 diameters.
Fig. 1*b*. Dwarf variety; magnified 60 diameters.
Fig. 1*c*, *d*, *e*. Portions of the shell, showing the pores; magnified 940 diameters.
Fig. 2. *Challengeria thomsoni*, seen from the flat side; magnified 60 diameters.
Fig. 2*a*. Portion of the shell, showing the pores; magnified 940 diameters.
Fig. 3. *Challengeria macleari*, seen from the flat side; magnified 60 diameters.
Fig. 3*a*. The same, seen from the upper surface; magnified 60 diameters.
Fig. 3*b*. Variety; magnified 60 diameters.
Fig. 4. *Challengeria aldrichi*, magnified 60 diameters.
Fig. 4*a*. Portion of the shell, showing the pores; magnified 940 diameters.
Fig. 5. *Challengeria bromleyi*, magnified 60 diameters.
Fig. 6. *Challengeria bethelli*, magnified 60 diameters.
Fig. 7. *Challengeria tizardi*, seen from the flat side; magnified 200 diameters.
Fig. 7*a*, *b*. Portions of the shell, showing the pores; magnified 940 diameters.
Fig. 8. *Challengeria carpenteri*, magnified 60 diameters.
Fig. 9. *Challengeria campbelli*, magnified 60 diameters.
Fig. 10. *Challengeria balfouri*, magnified 60 diameters.
Fig. 11. *Challengeria swirei*, magnified 60 diameters.
Fig. 12. *Challengeria channeri*, magnified 60 diameters.
Fig. 13. *Challengeria haverysalli*, magnified 60 diameters.
Fig. 14. *Challengeria harstoni*, magnified 60 diameters.
Fig. 14*a*. Variety; magnified 60 diameters.
The species of *Challengeria* are named after the naval officers of the Expedition.

Figs. 15–20. *Tuscarora.*

Fig. 15. *Tuscarora belknapi*, magnified 20 diameters.
Fig. 15*a*. Basis of a tubular spine, magnified 200 diameters.
Fig. 15*b*. Small portion of the shell, magnified 200 diameters.
Fig. 15*c*. Central capsule and lumps of the phæodium, magnified 400 diameters.
Fig. 15*d*. Granules of the phæodium, magnified 140 diameters.
Fig. 16. *Tuscarora bisternaria*, magnified 10 diameters.
Fig. 16*a*. The same, mouth with three tubular spines, magnified 20 diameters.
Fig. 17. *Tuscarora tubulosa*, magnified 10 diameters.
Fig. 18. *Tuscarora porcellana*, magnified 10 diameters.
Fig. 19. *Tuscarora tetraedra*, magnified 10 diameters.
Fig. 20. *Tuscarora cygnea*, magnified 10 diameters.



Gen. West lith. ad nat.

F. Rath, Lith.

CHALLENGERIDA (PHÆODARIA)

1-14, Various species of Challengeria. 15-20, Various species of Tuscarora.

was composed of the remains of Radiolaria, and these deposits have consequently been called Radiolarian ooze. The well known chalk-like rock from the island of Barbados and the Nicobar Islands resembles in many respects a Radiolarian ooze, and a somewhat similar formation is also found in parts of Greece, Sicily, and other places; it is chiefly made up of the delicate, and in most cases wonderfully preserved, perforated skeletons of Polycystina (Spumellaria and Nassellaria).

"It has been stated (p. 216) that the method of lowering the tow-net and dragging it at a depth of 50 and 100 fathoms proved a great success. No attempt was, however, made to drag the nets at still greater depths till the Expedition reached the western part of the Pacific, south of Japan, when they were lowered to 900, 1000, and even 2000 fathoms, and subsequently these nets were attached to the trawl, the dredge, and different parts of the dredging line. The immediate result of these experiments was the discovery of a large number of Rhizopodal organisms not hitherto met with in the shallower water, the most characteristic of which were the Phæodaria. The net never failed to bring up some of these species when sent down to great depths, in both the Pacific and Atlantic; but, on the other hand, they were never met with when the net was dragged within 100 fathoms of the surface, except on one or two occasions in the Antarctic Ocean."

Bahia.

The Expedition remained at Bahia ten days, the departure being somewhat hastened owing to one of the crew, who had been sleeping on shore, having caught yellow fever, from which he afterwards died. Yellow fever is nearly always prevalent at Bahia, nor can this be wondered at when the absence of sanitary arrangements in some parts of the town is considered, the streets having in many places no drains. Viewed from the sea, Bahia is a charmingly situated place.

Lying here during the stay was a small Brazilian ironclad of about 1000 tons, armed with two 150-pounder rifled guns and two 68-pounder smooth bores. The vessel had been engaged in the Paraguay war, and was reported to be a good one for river work or coasting in smooth water, but a bad sea boat; in fact the sister ship was swamped and went down, but the number of the crew lost could not be ascertained.

San Marcello do Mar, a circular fort built on a detached rock off the landing place, is used as a school for boys entering the Brazilian navy.

Into the wide bay of Bahia, which is twenty miles across in the broadest part, open several navigable rivers, on two of which steamers ply regularly. The Peruaguacu, the largest of these, is navigable for fifty-four miles up to a town called Caxoeira. At Caxoeira a railway was in process of construction. The English engineer of the line, Mr. Hugh Wilson, most hospitably offered to provide free passes by the steamer to Caxoeira, and the use of his own mules, and a guide for a trip thence up country, to any

of the naval officers or members of the scientific staff. The invitation was accepted by Mr. Moseley, whose account of the excursions is as follows :—

"The river steamers are small paddle-boats, old and dirty. The Caxoeira boat was crowded with passengers, mostly Brazilians and negroes, but amongst them several German Jews going up to buy diamonds.

"The bay has all the appearance of an inland lake, there being several islands scattered about in it covered with green to the water's edge. Near its mouth the banks of the river are somewhat low but backed by hills, and here and there are mangrove swamps. As the river was ascended the hills and cliffs on either hand soon became higher. They are thickly covered with vegetation, but with cliffs and occasional rock masses showing out bare amongst it.

"The scenery on the whole is not unlike that of the Rhine, except that there are no castles ; but the white buildings of sugar estates perched here and there on the tops of the lower hills take their place. The far-off hills appear of the usual bluish green due to distance, and successive ranges become gradually yellower as they lie nearer to the eye of the observer, and show more and more plainly the forms of the vegetation clothing them ; only in the actual foreground do the palms and feathery bamboos, planted in long lines as boundaries, distinguish the scenery as tropical. The bamboos are especially conspicuous, from the bright yellow green of their foliage. The steamer left Bahia at 10 A.M., and reached Caxoeira at 4 P.M.

"Caxoeira consists of two towns, one on each side of the river, and both have the usual white-washed houses and two or three churches, one broad street and several narrow ones, with mostly dirty dilapidated two-storied houses, tailing off towards the country into one-storied hovels. On the river, canoes hollowed out of a single tree trunk, simple and trough-like in form and pointed at both ends, and large enough to contain six persons, ply between the town and its suburb.

"The hotel at which the night was spent consisted of a restaurant below and a long barn-like chamber above, with a passage down the middle, and a series of small bed-chambers on either hand, enclosed by partitions about twelve feet in height. As one lay in bed one looked up at the bare rafters and tiles, and was apt to receive unpleasant remembrances from the bats. Sleeping places arranged in the same manner are to be found in an hotel at Point de Galle, Ceylon, and it is closely similar in all Japanese houses. The great disadvantage is that the guest has to put up with the snorings and conversations of all in the hotel.

"In the evening, just outside the town, in a pond, a number of small toads were making a perfectly deafening noise. The sound is like a very loud harsh cat's mew, and it was difficult at first to believe that it could come from so small an animal. It is, however, not unlike the extraordinary moan made by the fire-bellied toad of Europe (*Bombinator igneus*), but much louder and with more distinct intervals between the sounds. The frog

tribe made a horrible noise at night at Caxoeira, a Bull Frog (*Rana pipiens*) shouting the loudest with a deep bass voice.

"The trip commenced the next morning. It was to be to Feira St. Anna, about 28 miles from Caxoeira, to see the great fair held there every Monday, and from thence down to St. Amaro, a town on another river running into the bay, whence steamer could be taken for Bahia. Caxoeira, Feira St. Anna, and St. Amaro form with each other roughly an equilateral triangle, being each distant from the other about eight leagues.

"The guide was a German, who acted as interpreter on the railroad. He spoke English, French, Italian, Spanish, and Portuguese, and had been in Brazil about twelve years. He was a wild sort of young fellow, and had undergone various vicissitudes of fortune, having been once reduced to selling jerked beef, and once having been a dancing-master. He was a capital merry companion, knowing everyone on the road and having a joke for all.

"Our party rode extremely well-broken mules of large size, that ambled along, rendering it no labour to ride. The mules much prefer their natural rough trot to ambling, and try to make a tyro at mule riding put up with it. But a valuable animal would soon be ruined by letting him get into bad habits, and the regular thing to do is to dig in the spurs and jerk back his head with the bit at the same time. This receipt never fails to make the poor brute so thoroughly uncomfortable that he ambles as softly as possible at once.

"The road led up the steep side of the river valley to the table land above. From the top of the hill there is a fine view of the river and its valleys, and the white town below. Some trees, the leaves of which turn scarlet before dropping, set off the green of the rest of the landscape. In their action on foliage and plant life generally, the wet and dry seasons take the place of summer and winter at home, and many plants become bare of their leaves at the dry season, and only burst out again into leaf at the commencement of the wet season. This condition is far more marked in other regions of South America. Humboldt observed that certain trees anticipated the coming wet season, and put out their leaves some weeks before there was any appearance of its approach.

"The road was very much like an English green lane; in places quite a slough of mud, in others dry and sandy; it was broad, but usually more or less overgrown with grass and weeds, with a narrow track picked out along the best ground by the mules. There were numerous cottages along the road, and fields of tobacco, maize, and cassava. Every now and then a bit of wood was passed with beautiful flowers growing about it, and amongst them numerous forms of Melastomaceæ, with their characteristic three-veined leaves.

"Here were seen most of the plants collected at Fernando Noronha growing as road-side weeds. As we rode on, a splendid *Iguana*, about three feet in length, ran across the road, the brilliancy of which was astonishing.

"Every now and then a village was passed. In the first, as it was Sunday, the villagers were enjoying a cock-fight; every villager keeps a fighting-cock. Good Lisbon wine is sold along the road; the drinking-places consist of a hole about a yard square in the

gable end of the usual mud-walled cottage, placed at such a height as to be convenient to a man on horseback, who thus gets his drink without dismounting. Ladies travel along the road either in the saddle or in a sedan chair slung between two horses or mules by means of a long pole.

"A thick growth of myrtles and shrubs which was passed, was pointed out as having been the hiding-place of a notorious highway robber, a negro named Lucas, who used to waylay merchants on their way to the fair at St. Anna; he was the terror of the district, and committed several murders and worse atrocities. Though he was caught and executed in 1859, stories about him are already beginning to assume a mythical dress, and it was said that miraculous flowers grew out from a tree to which he bound one of his victims, a white girl, leaving her to die of exposure.

"Seven and a half hours were consumed over the 28 miles to Feira St. Anna. The town consists of three long parallel streets, with a broad cross street, or rather open oblong space, on which the small dealers erect their booths on fair day. The party rode into the town at about five o'clock in the evening.

"The girls were all dressed in their best, expecting home their several sweethearts who are away all the week in search of cattle, and only come to town on Sundays in time for the fair on Monday Several of them greeted the guide as an old friend, as the party rode up a long street to the other end of the town. Here is an open common-like space surrounded by houses, which acts as tobacco and cattle market. We stopped at an inn close to the market.

"The inn was a one-storied house, consisting of an eating room fronting the street, and two sleeping rooms and a kitchen behind. The eating room had large windows, with jalousies but no glass, looking out upon the market. It had a cement floor, a trestle table at one end for eating on, a small table opposite with a red curtained box upon it, containing the household gods, the Virgin in plaster, and Santa Antoinetta in china, and a half round table with an inkstand for the use of those customers who could write.

"The host, an old Brazilian, greeted us with great politeness, and we bowed according to custom to the assembled guests. The company consisted of about half a dozen cattle dealers, who were in animated discussion concerning the prices of stock. One of them, who was quite black, was evidently the sharpest of the lot, and a wag. Presently there came in a dirty coarse-looking grey-haired man with a black skull-cap on; he wore a dilapidated black garment something like an Inverness cape. He was chief vicar of the town; he was in considerable excitement, and addressed himself to the black cattle dealer, who produced a letter for him. The reverend gentleman had not got his spectacles with him, so the host proceeded to spell out the letter aloud. It appeared that the vicar did a bit of general trading, and had sent some horses, mules, and slaves to a neighbouring fair, in hopes of a good price. The letter was to inform him that he had made a bad speculation, and that no buyer had been found. The vicar was in a

great rage, and made an excited oration about the hardships of his position, and the terrible depreciation in the value of slaves, and left. He was said to receive £60 per annum as stipend, and fees in addition.

"We had some excellent fresh beef for dinner, fried in small pieces with garlic and potatoes and carrots, and with it farinha, the coarse meal made from cassava root, the fine siftings from which are tapioca. The farinha (farina) is universally used here, and is very good with gravy.

"The sleeping apartment was a space about 8 feet square, separated from the front room by a low partition. In it were three light cane-bottomed sofas, one at each end, and one opposite the door; they were packed so close together as to touch one another. A neatly folded small coverlet and a pillow were placed in the middle of each.

"Here we turned in, the third bed being occupied by a very dirty dealer in tobacco. Rendered sleepless by the fleas, I lay awake most of the night, listening to the mingled crying of children, barking of dogs, croaking of frogs in the marsh below, and squeaking and groaning of the axles of the ox-carts bringing merchandise to the fair.

"Though other charges were comparatively cheap, we had each to pay two shillings for our beds, as did also some of the cattle dealers who slept in a small house over the way, rented by the host for that purpose, and to keep the guests' saddles and bridles in.

"At 6 A.M. there was no bustle or signs of the fair, and not till 9 or 10 o'clock did strings of mules, laden each with a pair of bales of tobacco, arrive opposite the inn. The mules carry about seven or eight arrobas (an arroba = 25 lbs.). The tobacco comes to the market compressed and cut into neat rectangular bundles; the merchants test it by pulling some from the bundle and rolling a rough cigar.

"In the broad open street in the middle of the town were rows of small booths, at which farinha, fruit, vegetables, and jerked beef, imported largely from Buenos Ayres, were for sale; the dried beef varies in price from six to two milreis an arroba (1 milreis = 2s.). It seemed singular that it should pay to bring it to a place where fresh meat was so abundant.

"Other stalls offered needles and thread, sweet stuff for children, &c.; but most trying to a naturalist's eye, were stalls where various rodents and other small native animals were for sale, spitted on wooden skewers, roasted and dried for eating. Amongst these I saw at least a dozen of the tree-climbing Ant-eater, the Tamandua, and many Three-toed Sloths: the skulls of all were split open, and they were utterly lost to science. The flesh is supposed to cure various diseases.

"Makers of the long riding boots so fashionable here wandered about the fair trying to sell their handiwork, and I bought from a similar wanderer one of the vaqueiros leather hats, which did me the best of service in thick and thorny forests throughout the remainder of the cruise; with this on my head I could butt my way head first into any bush with impunity.

"Close by the market-place was the church of the vicar already mentioned, which had a mosque-like dome ornamented with variously coloured dinner and tea plates set in patterns in cement, a very original form of decoration.

"In the leather market quantities of skins of leather were exposed for sale, and also tanned puma skins used for saddle-cloths, and boa-constrictor skins also tanned, used to make boots and said to be remarkably waterproof.

"But the great sight of the fair is the cattle market, the situation of which has already been described. The cattle are bred at estates far up the country, where they run wild in the bush and are caught and branded, and drafted for market every two years. The men who look after and drive the cattle are termed 'vaqueiros' in Portuguese. They are of all shades of colour, from black to white; they are dressed when at work from head to foot in undyed red brown leather; they wear leather breeches, high leather boots with huge spurs, a leather coat like a longish jacket, and a leather hat with rounded close-fitting crown and broad brim; they ride small rough horses, which are worth at Feira St. Anna from £4 to £5, with saddles of the form commonly called Mexican or Spanish. The vaqueiros receive as payment from the owners every tenth head of cattle brought to market. They are, of course, extremely expert riders, and it is marvellous what work they get out of their small horses. The breeders rarely bring the cattle to market on their own account, but sell them to dealers, who take them to Feira St. Anna, and hand them over to other dealers again, who sell them in Bahia or Caxoeira. The cattle are driven by the vaqueiros, who use a short leather thong to strike them with. Bands of from 20 to 50 head of cattle were being driven into the market as we approached. A vaqueiro rides in front of each herd, one on each side, and one or more behind, and they keep up a constant shouting, bringing the animals along at a fair pace.

"Every now and then, a beast wilder than the rest, or less exhausted by the long journey from the interior, breaks away, and goes off at full gallop over the open market-place or up the street. Off gallop two or three vaqueiros, in full chase, with outstretched arms, spurring their horses to the utmost. They try to drive the beast back into the herd, and often succeed forthwith. But often it gets in amongst another herd, and then it is wonderful to see how rapidly they manage to single it out, get it on the outside of the herd, and start it afresh. Sometimes the animals are very fresh and wild, and make off at full pace, and cannot be headed. The vaqueiros then strain every effort to come up behind them, catch hold of their tails, and spurring their horses forward so as to get up alongside the beasts, give a sudden violent pull, which twists the animal round and throws it sprawling on its side. The cattle, though they fall so heavily that this expedient is resorted to as little as possible at the fair, because it bruises the meat, are often up after a fall and off again in an instant; but two or three falls knock the breath out of them, and they are then driven back to the herd quietly. Sometimes even this

treatment does not subdue them, and then they are lassoed round the horns and dragged back.

"The various herds were driven in compact bodies against the walls bounding the market, and some of the vaqueiros dismounted, and kept the cattle together by the use of their thongs and shouting; but one at least at every herd remained mounted, ready to chase any animal which might break away. The scene was most exciting. Often three or four cattle were loose at once and careering madly in all directions, jumping over obstacles like deer, and with two or three vaqueiros after each, at full gallop, spurring their little horses to the utmost, twisting and turning with wonderful dexterity. One wild cow went right up the main street. She was very fast, and five vaqueiros had a sort of race after her; now one gained a little, now another, and it appeared as if the beast were going to make off altogether; but at last a big black vaqueiro shot ahead, and threw her sprawling in the road. I kept close to a sheltering corner, ready to retreat round it when a beast came in my direction.

"The cattle dealers rode round from herd to herd, on their mules and horses, and most of the dealing was done on horseback. As soon as a herd was sold, it was driven off, one or more vaqueiros accompanying the drovers, according to the wildness of the cattle.

"In the middle of the open space horses and mules were being sold. The sellers of the horses were mounted on them, and were showing off their paces in an open lane formed amongst a crowd of buyers and on-lookers. The sellers made their horses amble full pace up the lane, turn sharp round, and return: and on reaching the starting-point, stop suddenly, without slacking pace in the least beforehand, in doing which the animals were thrown almost back upon their haunches. The ability to stop thus suddenly when in full pace is one of the points most admired in horses by Brazilians.

"The horses are small, but well made. Good well-trained horses cost about £40. Good riding mules are worth as much or even more. The Brazilians of the better class ride their ambling horses with their legs straight and stiff and carried right forward, with the toes turned up and the tips of the toes only resting on the stirrup irons. The vaqueiros, however, ride much in the usual English fashion.

"Sheep are used as beasts of burden in a small way in Feira St. Anna. I saw three or four laden with small barrels of water slung across their backs. They were driven by children, who were thus taking water from the well outside the town round to the various houses. The sheep seemed perfectly trained, and went along at a smart pace. Sheep are used as beasts of burden in Ladak to transport goods over the mountains of Little Thibet, and carry from 20 to 30 lbs.[1]; but their use for this purpose is very uncommon.

"In the crowd we met with a German farmer, who was a friend of my companion, and he invited us to pass the night at his house, his farm lying on the road to St. Amaro, by which we were to travel. We had our mules brought up to the inn door, and there gave

[1] The Middle Kingdom, Williams, vol. i. p. 204.

them a feed of maize to make sure that they got it. We saddled them ourselves in front of the inn, and after much ceremonious shaking of hands with the host and many polite speeches, rode off.

"On the road we passed several herds of cattle, which were being driven towards Bahia. In one of these some of the cattle were very wild. There were three vaqueiros in charge of it, a man and two lads of from sixteen to eighteen years of age. There was thick bush on either side of the road, and every now and then the cattle broke away into this. The use of the rough lurcher-like dogs which follow the vaqueiros now appeared. In the thick scrub the vaqueiro could do nothing without his dog. The cattle are out of sight in an instant, and go off dashing full pace through the bushes. The dogs are after them at their heels at once, and drive them to the vaqueiros, who dash off into the thick of the bushes in pursuit, bending right forward in the saddle, and stooping till their heads are beside their horses' necks, to avoid the branches.

"One cow came full charge down the road behind me, and I had only just time to back my mule into the bush out of the way. One of the lads was after her. He seized her tail just as he was opposite to me, held on for about 20 yards, and then, digging in his spurs and shooting forwards, turned her over with a thud. She was up, however, again, and off into the bush in an instant, and he after her with the dog in full pursuit, and I saw him disappear under the branch of a tree with his body laid right back on his horse's rump to avoid it.

"We passed about sunset through a village, where there is a hospital, a very substantial building, erected by the vicar, who for many years diligently collected subscriptions for that purpose. The church was lighted up and the people were going to vespers. One of the villagers was pointed out to me by the German farmer as being the hereditary owner of a large estate worth several thousand pounds, and a number of slaves. He was quite black and dressed in tatters, looked like a slave himself, and was driving cows along the road. He could neither read nor write.

"Our host was an emigrant from the Hartz district. He had been out in Brazil about fourteen years, and had a farm of several hundred acres, most of which was grass land; the grass growing where sugar had once been planted. He bought cattle and sheep at Feira St. Anna, kept them some time on his farm, and then killed them and sold the meat in St. Amaro and the district. He also grew a large patch of sugar cane, which was ground at a large mill close by, he receiving half the sugar produced as his share. He had bought one slave: all foreigners, except English, being allowed to possess slaves in Brazil. The slave was married to a girl, who was principal servant in the house and whom the farmer had assisted to buy her freedom. Frau Wilkens, his wife, who had no children, described the girl as most trustworthy, honest, and deeply attached. Her small child, a chubby little negro, was a great pet in the house. The greater part of the work on the farm was done by slaves hired from the owners of neighbouring plantations. There

was a row of about thirty very small wooden houses or huts on a neighbouring hill, where the slaves belonging to the owner of the sugar mill lived.

"Cassava or Mandioca (*Jatropha manihot*), a Euphorbiaceous plant, allied to our Common Spurge, was also grown on the estate, and there was a small manufactory of farinha; it is an indigenous South American plant, though now widely spread in the tropics, and was cultivated in Brazil by the original inhabitants, before they were molested by Europeans. The plant is not unlike the Castor-oil plant in appearance, and is planted in rows slightly banked up; the tubers are long and spindle-shaped. The preparation of them was conducted in a small hut, a large fly-wheel being turned by a negro, and driving, by means of a band, at a rapid rate, a small grinding wheel provided with iron cutting teeth. The cassava root, which had been peeled and washed by a negress, was reduced to a coarse meal by means of the grinding wheel; the meal was then put into a wooden trough, and a board was tightly pressed upon it by means of a lever, heavily weighted with stones. The cassava was thus left in the press for twelve hours, in order that the poisonous juice which it contains should be expressed. The mass was then taken out and dried on a smooth stone surface, beneath which a wood fire was burning. The resulting chalky-white meal, when sifted, yields samples of three degrees of fineness; the finest, a white flour-like powder, is tapioca, *i.e.*, true, original tapioca, an imitation of which, made from potato starch, is commonly sold in England; the intermediate sample is used in starching clothes and cooking; and the coarsest substance, which is coarser than oatmeal, and consists of irregularly-shaped dried chips of the roots, is called farinha, and is, as before described, commonly eaten with gravy at dinner, taking the place of bread, and forming a staple article of food.

"Our host was well to do; he had thriven better than any of the emigrants who came out with him, and, having no family to provide for, talked of going home soon. An old German was staying in the house, an idler, whose real occupation was gardening, his father having been imperial gardener, as he informed us with great pride; he also did a little trade in the way of peddling books. He had landed, more than twenty years before, at Rio, and had reached Bahia on foot. He was now travelling from estate to estate, and staying at each as long as he could, under pretence of doing up the garden, but although he had been two months at the farm, the few square yards of garden were as yet untouched. He had been too lazy to learn Portuguese, and understood very little. He seemed, however, a favourite at the farm, and was well taken care of, tea being made as a special luxury for him, and he had many stories to tell, and quaint sayings, and had amusingly strong Prussian sympathies.

"The farmer guided us to a large tract of primitive forest close by, which was extremely difficult to penetrate. Here I caught, with a butterfly net, a curious Bat (*Saccopteryx canina*), which has remarkable glandular pouches on the under sides of the wings, at the elbow-joints; these pouches are well developed only in the males, rudimentary in the

females, and secrete a red coloured strongly smelling substance, supposed to act as a sexual attraction. The bat was resting on a bare tree-trunk, asleep, the dense forest growth overhead making this exposed situation quite dark enough for it.

"On our way back to the farm, we watched some ants carrying off bits of cassava leaves to their holes. One cannot go a walk anywhere in the neighbourhood of Bahia without seeing these Leaf-cutting Ants (*Œcodoma*) at work. Their habits have been described by many observers, and recently by Mr. Belt[1] at great length. A new Hymenopterous insect (*Pepsis collaris,* Kirby)[2] was obtained during the excursion.

"The further road to St. Amaro lay through sugar estates all the way. I left St. Amaro early next morning by steamer, and reached Bahia at 10 A.M."

During the stay at Bahia the steam pinnace was engaged several days dredging in the bay. In some places the deposit was a white quartz sand, containing fragments of felspar, mica, magnetite, hornblende, and other minerals, and also fragments of Echinoderms, Polyzoa, *Serpulæ*, and other organisms. In other places it was a dark mud, containing, along with fine argillaceous matter, all the above mentioned minerals and organisms. The dredgings were very successful, animals belonging to all the principal invertebrate groups being taken. Astrophytons and Ophiurids were especially abundant.

[1] Thos. Belt, The Naturalist in Nicaragua, p. 71 *et seqq.*, London, John Murray, 1874.
[2] *Ann. and Mag. Nat. Hist.*, ser. 5, vol. xiii. p. 408, 1884.