immediate vicinity of the volcano, rapidly falling off in size at a comparatively short distance from the Sunda Straits.

The longer waves, with the original period of two hours, are traced by automatic and eye observations to have proceeded mainly in a westerly direction from Krakatão, being noticeable at Ceylon, all over the western part of the Indian Ocean, the south coasts of Africa and South America, the west coast of Australia, and possibly—though the evidence is not free from doubt—as far as the west coast of France and the entrance to the English Channel. In other directions, such as the China Sea, the Pacific, and the Gulf of Mexico, they do not seem to have been felt, the supposed indications not being compatible in any way with the times and distances.

As a general result, it may be said that the mean depths deduced by the formula $V = \sqrt{gh}$, from the best data for the speed of the waves, corresponded fairly with that given by the soundings, but in nearly every case the formula gave a smaller depth than the soundings. This and other circumstances lead us to conclude, not so much that the formula is incorrect, but that, with so few, and in some cases such badly placed, automatic gauges, and from such complex oscillations as seem to have occurred in many of those discussed in this section, it is scarcely possible to arrive at anything but a very rough approximation to the mean depths. The shelving of the bottom near land, which in many cases is not well determined, and the possible existence of ridges in mid-ocean, constitute obstacles to a determination of mean depth, which is all the passage of such waves can indicate. In so far, however, as they yield an approximate check of this kind on soundings, their observation ought to be encouraged by the establishment of more automatic gauges in suitable spots.

One very peculiar feature of the Krakatão long waves is that, while their original period when leaving Krakatão was two hours, they became subdivided (possibly by an interpolated series caused by reflection from the coast of Java) into waves of half this period; and, by the time they reached the North Atlantic, into waves of about one-quarter of this period. Their consecutive oscillations could thus only be identified with those of the original oscillations by doubling or quadrupling the observed periods.

Although at great distances from Krakatão the height of the largest long wave was, as might be expected, only a few inches; at such comparatively remote places through the more open route to the west as Ceylon and Mauritius, the higher and shorter waves made their presence felt to heights of several feet, and created considerable astonishment as well as damage in these localities.

Like the air and sound waves, the occurrence of seismic waves on such a scale and over such a wide area appears to have been quite unprecedented; and their discussion, like that of the former, will in the present case probably yield results of considerable value to hydrography as well as other branches of science.

(*To be continued.*)

FOUNDATIONS OF CORAL REEFS.

THE following extract from a letter from Captain Aldrich, R.N., H.M. surveying-ship *Egeria*, now employed in the Pacific Ocean, is interesting from several points of view.

". . . . The following morning at daylight (July 10) we picked up 268 fathoms (volcanic rock) some considerable distance southward of the Pelorus Reef. This, again, will involve a further search. Twelves miles to the northward the depth was 444, and two subsequent soundings at five-mile intervals gave 713 (ooze) and 888 (ooze). From here the soundings continued to grow shoaler, until in lat. 22° 51′ S., long. 176° 26′ W., we sounded in 335 fathoms (cinder), being close to the assigned position of the Pelorus Reef. The water deepened again to 719 (cinder), when we hove to for the night. On July 11 we continued about this position, the shoalest sounding being 246. On the 12th we continued the search, and by following up at quarter-mile intervals struck 95 fathoms late in the afternoon. Prepared a beacon, and the following day (July 13), after excellent star observations, sounded and shoaled as yesterday, and when the men were standing by to slip the beacon, discoloured water was reported from the mast-head; it was almost immediately seen from the deck, and by 9 a.m. the beacon was dropped in 24 fathoms, with a stretch of light-greenish water extending in a northerly and southerly direction for about half a mile. The whalers were lowered, and remained all day in this green water.

"Meantime more discoloured water was reported from aloft, and I sent Mr. Kiddle up with his glasses, and he verified the report; so, leaving the boats on the Pelorus, I went with the ship, and, after going two miles, I made out the small streak from the poop. It had remained as steady as possible, and had every appearance of being a very small shoal. The ship was taken to within 100 yards of it, and the dingy lowered to get a sounding on it; no bottom, however, could be got, so the ship was put in the middle of it and a sounding of 150 (no bottom) obtained. A bucket of this water was drawn and a bottle of it preserved, but I do not see anything in it to account for the light greenish colour, and it may be that the colouring matter may not lie actually on the surface; the fact remains, that this small patch was sighted at very nearly three miles distance from aloft, and that even when within 100 yards of it I believed it to be shoal-water, and that a sounding of 150 (no bottom) was actually obtained in the middle of it. On our return to the Pelorus, I was not, therefore, much astonished when I found that no very shoal water had been got by the boats. The ship was anchored in 14 fathoms, not far from the beacon, and the wire machines put into the whalers, and a search on bearings from the standard compass and mast-head angles carried on during the afternoon and on the next day, July 14. Nothing less than 14, however, was got, and I am under the impression that nothing less is to be met with, as the bottoms are loose ashes and cinder; so that, as in the case of the Graham Shoal, there may have been a shoal quite recently which does not exist now. I think that had there been anything dangerous about it we should have seen it, as anchoring in 14 fathoms mid-ocean caused many inquiring eyes to be cast around. . . . .

"Another curious thing about the greenish water is that I went over it all in the ship; and the line between it and the dark water was most distinct. Moreover, the shoalest sounding of 14 fathoms was not found in the light water, but in the dark water alongside it. There was no sign of coral among the bottoms brought up. . . . My attention was pretty well occupied at this time, and it did not occur to me to do more than have a bucket of the water drawn from the green colour to preserve, which has been done. Afterwards, I much regretted that I did not get specimens from different depths, as certainly this is a most curious instance of, in one case, picking up a shoal from the existence of some colouring matter, not coral; and, in the other, of being almost positive that a shoal existed where an actual sounding proved it not to do so. I can quite excuse a man reporting a shoal under such circumstances, and it may be that a good many of the reported dangers have come on the charts in this way. . ."

The position of the Pelorus Reef referred to is in lat. 23° S., long. 176° 25′ W., about forty miles south of Pylstaart Island, which is volcanic. The reef was originally reported in 1861 by H.M.S. *Pelorus*, Commodore Seymour (now Lord Alcester), the ship passing within one-third of a mile of it, when breakers were distinctly seen.

Lord Alcester assures me that there was no doubt of the breakers, otherwise it might be thought that the deceptive appearance that misled Captain Aldrich, also misled the officers of the *Pelorus*.

It thus appears probable that, as in some other cases (of which the Graham Island in the Mediterranean is perhaps best known), the cinders and ashes which formed, and still form, the summit of the volcanic mound originally thrown up, are being by wave-action gradually swept away, and will continue to be so removed until the top of the bank is reduced below the limit of such action, or, as in the case of the Graham Shoal, the solid rock is laid bare.

If so, it is another case of the preparation of a suitable foundation for coral builders by a process directly the reverse of that of building up by marine organisms on mounds that have failed to reach the surface, suggested by Mr. John Murray to be the principal method.

It remains for those who have made submarine eruptions their study to say whether a mound raised in the sea is covered with loose matter in a sufficient percentage of cases to justify this mode of coral-foundation-making being given an important place amongst others.

In the latest known cases of islands so formed, viz. Steers and Calmeyer Islands, thrown up near Krakatão in 1883, and Falcon Island, which appeared in 1885 in the Tonga Group, the surface structure was loose. The two former very shortly disappeared below the level of the sea. What is happening to the latter is not known, as it is seldom sighted; but from its volume and height (290 feet) the process of reduction, even if no compact nucleus exists above water, must be slow.

The deceptive appearance of the masses of minute organisms which floated in the vicinity of the bank is no doubt an abundant source of false reports. These clouds of matter are commoner in inclosed and calmer waters, like the Red Sea, than in open oceans, where they are so much more liable to be dispersed by the waves before they can accumulate to any size. The assistance they afforded in this instance to the searchers is remarkable, and so far as I know unique, as they are generally found in deep water. W. J. L. WHARTON.

RECENT VISIT OF NATURALISTS TO THE GALAPAGOS.

CAPTAIN J. M. DOW has placed at my disposal the subjoined short account of a visit recently paid to the Galapagos Group by the United States steamer *Albatross*, which will, I am sure, be of much interest to naturalists. P. L. SCLATER.

U.S. Commission of Fish and Fisheries, Steamer "Albatross," Acapulco, Mexico, April 24, 1888.

CAPTAIN J. M. DOW, *Panama*.

MY DEAR SIR,—Thinking that you might like to know something of the results of our trip to the Galapagos, I take this opportunity of writing.

Leaving Panama on the morning of March 30, we made during that day six hauls of the trawl in depths from 7 to 51 fathoms. These gave us fine results, including many species with which you are doubtless familiar. The fishes included species of *Upeneis*, *Arius*, *Polynemus*, *Aphronitia*, *Serranus*, *Selene*, *Prionotus*, *Hæmulon*, *Synodus*, *Tetrodon*, *Ophidium*, *Sciæna*, *Micropogon*, *Lophius*. We were delighted to see *Thalasophryne* and two allied species. The number of shells, Crustacea, &c., was almost innumerable. The care of so much material kept us very busy. The next day we sounded off Cape Mala, and found the depth to be 1927 fathoms. No more dredging was done until we neared the Galapagos on April 3, when we made a haul in 1379 fathoms, where the amount of material obtained was small, although it included some very good things. At the islands we made visits to eight of the principal ones. Most of our days were spent on shore, beginning early in the morning, and oftentimes bird-skinning and other work was prolonged far into the night. The islands presented a very inhospitable look along the shores, with the black lava cropping about everywhere; but in two of them (Chatham Island and Charles Island) the interior was extremely fertile and pleasant. Collecting was always difficult; but, with the co-operation of officers and men, we obtained a great quantity of material. We naturally looked to the birds first, on account of Darwin's previous work there. We have over 250 good bird-skins, besides several hundred specimens in alcohol, and a few skeletons. Of the fifty-seven species before reported from there, we obtained examples of fifty or more, and we have, in addition, several which are apparently new to science. We hope, with our material, to settle some of the curious problems of these islands.

We secured specimens of all the reptiles which have been before found there, and also hope that we have two or three new lizards. The tortoises excited great interest, and it would please you to see the many large ones which are now crawling about our decks. We expect now that we shall be able to raise them in the States.

Fishing was good at all of our anchorages, and we all had sport in catching fishes over the ship's side. We got between thirty and forty species in all, including a large brown "grouper," which is there caught and salted for the Ecuador market.

One night, while running from one island to another, we stopped and drifted for a while, and put the electric light over the side. Besides many small things, large sharks came around in great numbers. More than twenty were seen at once, and I know that the sight would have pleased you. We all regretted that you were not with us. Notwithstanding the necessity for rapid work, good-fellowship always prevailed as usual. I hope that some time you may take a trip with me on the *Albatross*, and see how we do it.

Hoping that this will not prove too long an account for you,

I remain,
Yours very sincerely,
LESLIE A. LEE.

THE BRITISH ASSOCIATION.

SECTION A—MATHEMATICAL AND PHYSICAL SCIENCE.

A Simple Hypothesis for Electro-magnetic Induction of Incomplete Circuits; with Consequent Equations of Electric Motion in Fixed Homogeneous or Heterogeneous Solid Matter, by Sir William Thomson.

(1) To avoid mathematical formulas till needed for calculation consider three cases of liquid[1] motion which for brevity I call Primary, Secondary, Tertiary, defined as follows:—Half the velocity in the Secondary agrees numerically and directionally with the magnitude and axis of the molecular spin at the corresponding point of the Primary; or (short, but complete, statement) *the half velocity in the Secondary is the spin in the Primary, and* (*similarly*) *half the velocity in the Tertiary is the spin in the Secondary.*

(2) In the Secondary and Tertiary the motion is essentially without change of density, and in each of them we naturally, therefore, take an incompressible fluid as the substance. The motion in the Primary we arbitrarily restrict by taking its fluid also as incompressible.

(3) Helmholtz first solved the problem—Given the spin in any case of liquid motion, to find the motion. His solution consists in finding the potentials of three ideal distributions of gravitational matter having densities respectively equal to $1/4\pi$ of the rectangular components of the given spin; and, regarding

[1] I use "liquid" for brevity to signify incompressible fluid.