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On marine deposits in the Indian, Southern, and Antarctic oceans

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thus entitled to assume that the quantity of snow is increasing in the interior.

But what is the reason why it does not increase?

As already mentioned, the snow-melting cannot be of any importance. The evaporation from the snow-surface cannot, in my opinion, be of much more importance, as it must be quite a trifle with such a low temperature of the air, and where most days a little snow falls. A factor of more importance is, I think, the snow-drifts occasioned by the wind, which very likely has a disposition to blow from the cold and high interior towards the lower and warmer coasts. In the middle of the continent the winds blow, however, in all possible directions, and thus even this factor is of no great importance. The principal factor in maintaining the level must, in my opinion, be the pressure which is produced within this immense layer of ice and snow. This pressure forces the ice downwards along the sloping sides of the mountains, through the valleys and towards the sea, into which it falls in form of ice-streams or glaciers, and is carried away in form of icebergs or is melted.

To a great many people it does not seem necessary that the ice must force its way to the coast in this manner, but I think that if we said that the interior of Greenland was filled or covered by an immense layer of pitch, nobody would doubt that this would find its way to the sea; yet, there is really in that respect no great difference between these two materials; by the immense pressure the ice is probably made even more viscid than melted pitch. But the pressure brings the ice to the sea not only in the form of ice, but also, and certainly in larger quantities, in the form of water. As is generally known, ice has the peculiarity that by pressure it can be transformed into water. At a certain depth we must therefore expect to see the ice thus transformed.

ON MARINE DEPOSITS IN THE INDIAN, SOUTHERN, AND ANTARCTIC OCEANS.

(*With a Map*).

BY JOHN MURRAY, LL.D., PH. D., etc.,
of the *Challenger* Expedition.

IN an article published in this Journal for November 1887 I gave some account of our knowledge of the deeper regions of the Indian Ocean, with special reference to the investigations carried on by Captain J. P. Maclear in H.M.S. *Flying Fish* during 1887.

Since that time extensive additions to our knowledge of the bathymetry and physical conditions of this ocean have been made by Captain Pelham Aldrich in H.M.S. *Egeria*, and by Captain A. Carpenter in H.M.S. *Investigator*. Through Captain Wharton, the Hydrographer of the Admiralty, I have received details of these investigations, and also the most excellent and valuable series of deposits collected with care by Captain Aldrich. These samples of the marine deposits have been submitted to a careful examination. In addition to those obtained by H.M.S. *Egeria*, I have recently examined a very large collection of deposits from the eastern coasts of Africa, made on board the ships belonging to the Telegraph Construction and Maintenance Company, while engaged in laying cables along that coast. Captain Carpenter of H.M.S. *Investigator* has also sent me numerous samples from the Bay of Bengal. These observations have filled up so many gaps in our knowledge of the deposits of these regions that, in the accompanying map, I have been tempted to indicate graphically their extent and distribution.

In the *Egeria* Captain Aldrich made a very extensive series of deep-sea soundings from Christmas Island to the Mauritius, then southward to nearly the 40th parallel of south latitude, and then eastward to the coast of Australia. It is a little remarkable that this splendid series of soundings has caused us to alter the contour lines of depth to only a small extent: the area over 3000 fathoms has been considerably increased, the 2000-fathom line has been shifted in some places, but, on the whole, there is little alteration to be made on the bathymetrical map which I published in 1887.[1] This circumstance gives us reason for believing that our knowledge of the contours of the great oceans is slowly approximating to the truth.

In order to give the reader some idea of the data from which the accompanying map has been constructed, a red mark has been placed at each position where there have been actual and reliable observations as to the depth and nature of the deposits in all depths of 1000 fathoms and deeper: a cross signifies that enough of the deposit has been obtained for chemical and microscopical examination. There were a very large number of observations and a large collection of deposits in depths of less than 1000 fathoms; these have usually been close to continental coasts and around oceanic islands, but no attempt has been made on the map to indicate their position by red marks.

The map represents the Indian Ocean and those portions of the Southern and Antarctic Oceans included between the meridians of 20° and 150° east, and is estimated to contain 27,600,000 square miles, 905,900 belonging to the Antarctic, and 9,372,600 to the Southern Ocean. In this area there are 415 reliable soundings of 1000 fathoms and deeper; two-fifths of this number are north of the equator. If we divide the region into an eastern and western part by the 70th meridian of east longitude, then three-fifths of the soundings are found in the western, and two-fifths in the eastern part; the greater number of soundings thus lie in the NW. of the Indian Ocean. By dividing the whole region into squares of 10 degrees each, there are 98 of such squares, 16 of which are north, and 82 south of the equator. Soundings have been taken in 56 of the squares, thus leaving 42 squares in which no information as to depth is at hand; these lie mainly south of the equator, only two being found on its north side. Of the 56 squares in which soundings are known, 22 lie along the coasts, leaving 34 remote from the continental shores. As stated above, there are 415 soundings of 1000 fathoms and deeper; of these 134 are from 1000 to 1500 fathoms (inclusive), 109 of

[1] *Scottish Geographical Magazine*, vol. iii. p. 560.

which are situated in 17 of the 22 shore squares, 25 in 12 of the 34 squares remote from land. 114 soundings have a depth of from 1500 fathoms to and including 2000 fathoms, distributed over 35 squares; of these 60 are situated in the squares near shore, leaving 54 in 22 of the remoter squares. There are 116 soundings ranging from 2000 fathoms to and including 2500 fathoms; 20 of these soundings are found in squares near shore, and 96 in those remote from shore. There are 51 soundings over 2500 fathoms (9 of which are over 3000 fathoms); 8 of these are in squares close to shore, 43 in those situated towards the central regions of the ocean. It thus appears that beyond the 1000-fathom line there is a gradual deepening from the shore, extending southwards and eastwards, the deeper soundings being found in the eastern portion of the region under consideration. The deepest part is, indeed, situated between the equator and the 40th parallel of south latitude. South of this the ocean gradually shallows towards the Antarctic Continent.

The contour lines having been drawn from a careful consideration of all the available data as to the depth, the following are the estimated areas between the various zones of depth:—

From 0 to 100	fathoms	= 1,449,800	square miles.
„ 100 to 500	„	= 1,151,700	„
„ 500 to 1000	„	= 967,900	„
„ 1000 to 2000	„	= 8,122,100	„
„ 2000 to 3000	„	= 15,858,700	„
Over 3000	„	= 49,800	„
		27,600,000	square miles.

It will thus be seen that the zone between 2000 and 3000 fathoms occupies a much larger portion of the whole area than any of the others, and it is estimated that the mean depth of the whole region is about 2300 fathoms.

I have estimated the area of the land draining into the Indian Ocean at 6,813,600 square miles, and the total amount of rain falling on this land annually at 4379 cubic miles.[1] That portion of this water which returns to the sea by rivers comes chiefly from the continent of Asia, and the detritus which is thus borne to the ocean makes up a very large part of the deposits now forming in the Bay of Bengal and Arabian Sea. A large amount of detrital matter is also borne to the region from the Antarctic continent by the ice which is shed from the land, and floats northwards in the form of large flat-topped icebergs. This detrital matter can be traced in the deposits nearly to the 40th parallel of south latitude. The deposits near the coasts of Africa, Australia, and the East Indian Islands are also largely modified by land detritus, but towards the central parts of the ocean it is difficult to trace the ordinary river detritus in the deposits that are there in process of formation.

The temperature of the water over the bottom in the deeper parts of this ocean is very uniform, and subject to little or no variation. Temperatures of 34°·2 and 33°·7 Fahr. have been observed in the Arabian

[1] *Scottish Geographical Magazine*, vol. iii. p. 75.

Sea and Bay of Bengal at the bottom, and these differ little, if at all, from those recorded by the *Challenger* in 50° south latitude; it is evident, then, that the deep cold water of the Arabian Sea and Bay of Bengal has flowed north along the bottom from the Southern and Antarctic Oceans.

The temperature of the surface waters varies greatly in different parts of these oceans, or at the same localities at different times of the year. In the tropical regions (north of 20° S.) there is usually a high and rather uniform temperature. In all the coral-reef regions this is from 70° to 81° Fahr., and the range throughout the year is often only 7° or 8° Fahr. Off the Cape of Good Hope and off Cape Guardafui the range is sometimes 20° to 30° Fahr. at different seasons or in different states of the wind—the cold deep water being brought to the surface in the latter locality when the wind is off shore.[1] In the Antarctic regions, again, the surface waters have a nearly uniform low temperature at all times. It is probable, from the observations of the *Challenger*, that the dense and warm tropical water which passes southwards along the eastern coasts of Africa into the great Southern Ocean, sinks, on reaching a latitude of about 50° south, to the bottom, and is slowly drawn northwards as a cold current to supply the place of southerly surface currents and evaporation in the tropics, and also southwards to supply the place of the relatively light and cold water that flows north as a surface current from the Antarctic.

These variations in the temperature of the surface waters determine to a large extent the nature of the deposits forming at the bottom, for these are largely composed of the dead shells and skeletons of organisms living in the water at and near the surface, and the species and abundance of these vary according to the temperature and other surface conditions. Diatoms are especially characteristic of the cold surface waters of the Antarctic and Southern Oceans and their siliceous frustules make up a large part of the deposits in these regions. Of pelagic Foraminifera which secrete carbonate of lime for their shells, there are only one or two species in Antarctic waters, whereas there are eighteen or nineteen species of these Rhizopods in the warm surface waters of the tropics. The carbonate of lime which is so abundant in the majority of oceanic deposits, is chiefly derived from the shells of these Foraminifera, together with Coccoliths, Rhabdoliths, and Pteropod and Heteropod shells.

In 113 soundings over 1000 fathoms in depth, the amount of carbonate of lime present in the deposit varies from a trace to 92·34 per cent. 48 of these contain from 0 to 20 per cent.; 11, from 20 to 40 per cent.; 11, from 40 to 60 per cent.; 14, from 60 to 80 per cent.; and 14 have over 80 per cent. Of those containing 0 to 20 per cent., 19 are situated in squares near shore, and have an average depth of 1480 fathoms; 29 are remote from shore, and have an average depth of 2540 fathoms; the latter are red clays or Radiolarian oozes, and the former are terrigenous deposits, largely made up of *débris* from the continents. When remote from land, those with a higher percentage of carbonate of lime have a less depth than those with a lower percentage, in the same latitude.

[1] See *Scottish Geographical Magazine*, vol. iii. p. 560, November 1887.

By reference to the accompanying map, the distribution of the various kinds of deposits throughout the region under consideration will be found to be graphically represented. It is of course understood that for a large part of the area we have no actual observations as to the nature of the deposits, so that the map is largely hypothetical, yet not any more hypothetical than maps showing zones of depth. The observation-spots are, however, all placed on the charts for all soundings of 1000 fathoms and deeper, so that the reader is made aware of the data from which the map has been constructed. Besides the actual examination of the samples procured in the soundings, a knowledge of the depth, the surface conditions, and the nearness or remoteness from land all give, when carefully studied, valuable indications as to the probable limits of the various kinds of deposits in different directions. It is believed that when maps of this kind are constructed for the whole ocean, they will be of the greatest service to all future investigators, for then surveyors will be able at once to point out errors, and in this way our knowledge of these deep-sea deposits and the conditions of deep-sea life will become more and more definite and accurate with each additional observation.

Assuming that the areas marked out by the various colours are approximately correct, then the extent of the areas occupied by the several varieties of deposits will be as follows:—

Oceanic Deposits.	Globigerina ooze,	11,503,000	sq. m.
	Diatom ooze,	5,265,200	„
	Radiolarian ooze,	1,129,400	„
	Red clay,	4,646,000	„
Terrigenous Deposits.	Blue mud,	4,339,400	„
	Coral muds and sands,	387,300	„
	Green sands,	329,200	„
		27,600,000	sq. m.

It is proposed now to make a few remarks on each of these varieties of deposits with the view of indicating their composition and pointing out how each kind merges into the other in adjacent regions.

Globigerina Ooze.—This term has now become quite familiar from the many references to this kind of deposit in popular works on Physical Geography and Geology. It is applied generally to the whitish or rose-coloured mud or ooze, collected in great depths, when this is largely composed of minute calcareous shells. All the shells in such a deposit do not belong to the genus *Globigerina*, but the majority of them usually do, so that the name is at once appropriate and distinctive; pelagic species of *Pulvinulina*, *Sphæroidina*, *Candeina*, and *Pullenia* are especially abundant in many tropical deposits. If, however, we limit our attention to the eight or nine species of pelagic *Globigerina*, and regard these from the point of view of numbers of individuals belonging to these species, then it appears to me that these greatly outnumber any other genus of organisms on the face of the earth. It does not seem possible to make an exception in favour of the minuter Microzoa, whether on land or in the ocean. The Rhizopods referred to this genus are found everywhere in the surface and sub-surface waters of the open ocean from the Equator to the Poles; their remains form the larger part of the marine deposits now in process of formation, and probably make up a larger part of geological formations than any other group of organisms. The species and individuals are most abundant and largest in the warm and salter waters of the tropical regions; they diminish in all these respects towards the Poles, where they are represented by one or two dwarfed species. Thus in examining a marine deposit, it is possible to tell approximately the latitude in which it was collected by the species of *Globigerina* that are present.

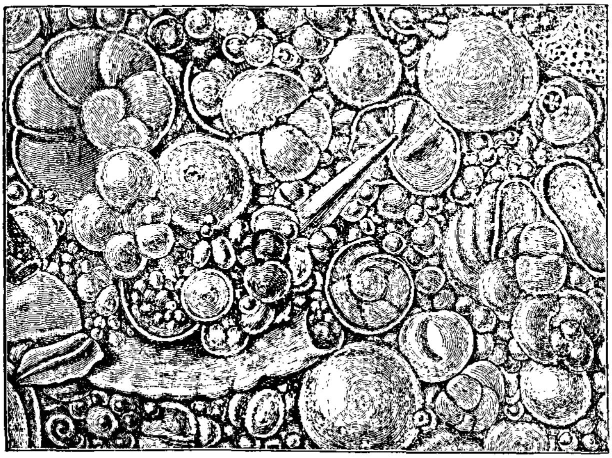

FIG. 1.—Globigerina Ooze, from 1900 fathoms, $\frac{25}{2}$. (From *Ency. Brit.*, 9th ed.)

A Globigerina ooze contains from 30 to over 80 per cent. of carbonate of lime, principally made up of some of the following species of pelagic Foraminifera:—

Orbulina universa, d'Orb.
Globigerina sacculifera, Br.
„ *æquilateralis*, Br.
„ *conglobata*, Br.
„ *dubia*, Egger.
„ *rubra*, d'Orb.
„ *bulloides*, d'Orb.
„ *inflata*, d'Orb.
„ *digitata*, Br.
„ *cretacea*, d'Orb. (?).

Sphæroidina dehiscens, P. & J.
Pullenia obliquiloculata, P. & J.
Hastigerina pelagica, (d'Orb.)
Pulvinulina menardii, (d'Orb.)
„ *tumida*, Br.
„ *canariensis*, (d'Orb.)
„ *micheliniana*, (d'Orb.)
„ *crassa*, (d'Orb.)
Candeina nitida, d'Orb.

In addition to these shells there are usually a few shells of bottom-living species of Foraminifera, such as Biloculinas, Uvigerinas, Truncatulinas, Textularias, and Rotalias, but these rarely make up over two or three per cent. of the whole deposit. Then, again, there may be fragments of Echinoderms, Ostracode shells, otoliths of fish, Coccoliths and Rhabdoliths, but these collectively make up only a relatively small proportion of the carbonate of lime present in the deposit. The residue left on removal of the carbonate of lime from a typical Globigerina ooze consists of Diatoms, Radiolarians, Sponge spicules, fine amorphous clayey matter, a few small mineral particles, usually not exceeding 0·1 mm. in diameter, generally consisting of fragments of pumice, of felspars, magnetite, augite, hornblende, and volcanic lapilli. This residue is usually reddish or brown from the presence of ferric oxides of iron and peroxide of manganese.

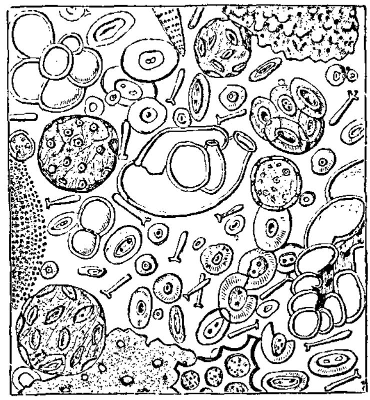

Fig. 2.—The finer particles of a Globigerina ooze, showing Coccoliths, Coccospheres, and Rhabdoliths, $\frac{540}{1}$. (From *Ency. Brit.*, 9th ed.)

All the various elements which go to make up a typical Globigerina ooze are subject to variations in amount with change of position and of conditions, such as variations of surface conditions, of depth, of proximity to land, or to great rivers and to volcanic eruptions either under water or on land. There is thus a gradual transition from a Globigerina ooze into all the other kinds of deposits. It is to be remembered, then, that there is no sharp line separating the one kind of marine deposit from another, as one might be led to suspect from an examination of the accompanying map. Indeed it is often very difficult to say whether a deposit under examination should be called a Globigerina ooze, a Pteropod ooze, a red clay, a Radiolarian ooze, a Diatom ooze, a blue or green mud, or coral mud, so gradually do these deposits merge the one into the other, although the difference between all these is well marked in typical samples.

Pteropod Ooze.—Everywhere in the surface waters of the warmer regions of the ocean there are innumerable pelagic Molluscs, such as Pteropods, Heteropods, and Gasteropods. These have shells much larger than the pelagic Foraminifera, but exceedingly thin and delicate. The dead shells of these creatures are sometimes found in immense numbers in some marine deposits. It is, however, a remarkable fact that they are wholly absent in all the deposits from very deep water, although we know them to be abundant in the surface waters of those very regions. In a typical red clay, Globigerina ooze, or Radiolarian ooze not a trace of these shells is to be found. No typical Pteropod ooze has as yet been found in the Indian Ocean. Had depths of 800, 1000, or 1200 fathoms, however, been met with in the tropical regions far from land, there is little doubt that these shells would have made up a considerable part of the deposit, which would consequently have been entitled to the name of Pteropod ooze. These shells are found in great numbers in the lesser depths near coral islands and in some of the near-shore deposits along the continents, but in these situations they are mixed up with a large quantity of *débris* from the land and from coral reefs. The Pteropod shells are believed to be removed from all the deeper deposits through the solvent action of sea-water on their relatively large but thin and delicate shells, which present a larger surface to its action than the more compact and thicker, though smaller, Foraminiferous shells. A Pteropod ooze contains from 70 to 90 per cent. of carbonate of lime, and has many more remains of bottom-living organisms than a Globigerina ooze, such as fragments of Echinoderms, Alcyonarians, Corals, Ostracodes, Foraminifera, fish remains, and Mollusc shells.

CORAL MUDS AND SANDS.—As a coral island or reef is approached from the open ocean, the water slowly shallows, and with the shallowing and approach to the reefs the character of the deposit alters. Pteropod and Heteropod shells appear in the deposits, so that the Globigerina ooze passes into what might be called a Pteropod ooze were it not for the admixture of remains of reef-forming organisms. These latter gradually increase in abundance as the reef is approached, till they predominate and more or less completely mask the remains of pelagic organisms; the deposit then becomes, near the reefs, a coral mud or sand, composed of fragments of calcareous Algæ, Corals, Molluscs, large Foraminifera, and other organisms. The proportion of carbonate of lime in these deposits sometimes reaches over 90 per cent.

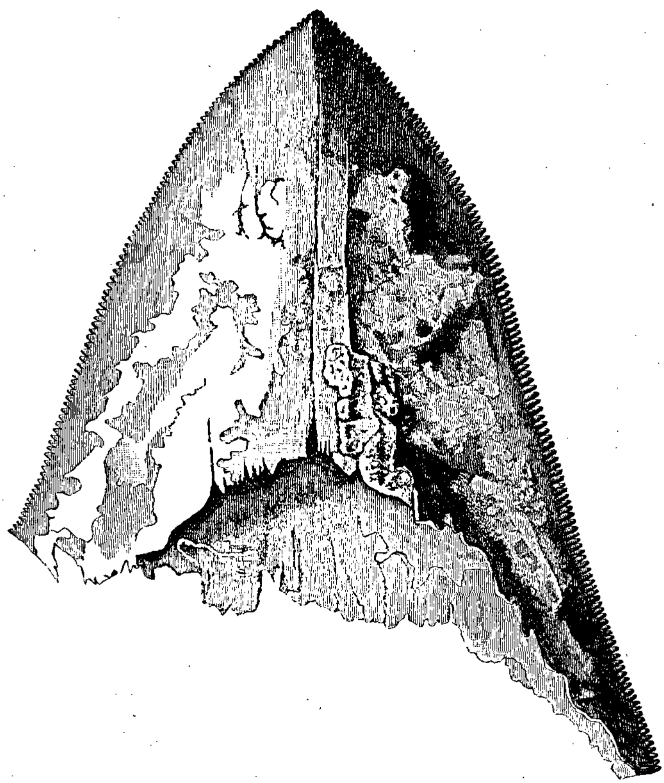

FIG. 3.—Tooth of *Carcharodon megalodon*, from 2385 fathoms.

RED CLAY.—Just as the proportion of lime in a Globigerina ooze increases, and the remains of calcareous organisms consequently become more abundant, as the depth becomes less in the open ocean or near coral islands, so, on the other hand, does the proportion of lime-secreting

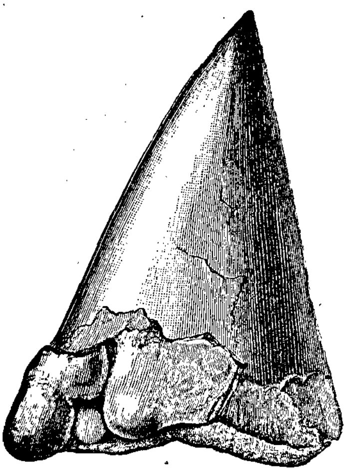

FIG. 4.—Tooth of *Oxyrhina trigonodon*, from 2350 fathoms.

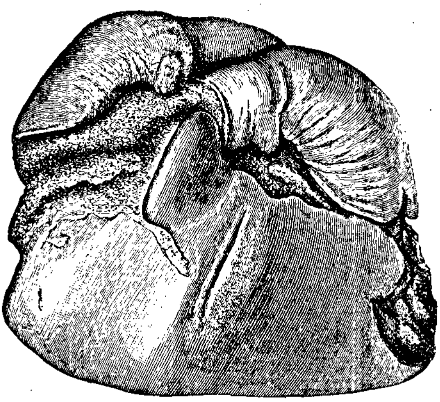

FIG. 5.—Ear-bone of *Ziphius Cavirostris*, from 2335 fathoms.

organisms become less with increasing depth, and the Globigerina ooze passes finally, in regions remote from land, into a red clay or a Radiolarian ooze. The red clay is almost identical in composition with the residue (after removal of the calcareous organisms) of a Globigerina ooze from the same region. Mineral particles are usually very minute; those with a diameter greater than 0·05 mm. do not as a rule make up more than one or two per cent. of the whole deposit. The great bulk of the deposit is exceedingly fine clayey matter, the mineral particles in which do not reach the dimensions above stated. The colour of this clay is red or brown, from the presence of the higher oxides of iron and manganese. In this deposit there is often merely a trace of carbonate of lime, and if microscopic examination shows any calcareous shells, it does not reveal more than one or two broken fragments of Foraminifera. In depths over 3000 fathoms this is usually the case, but in lesser depths what has been called red clay sometimes contains 20 or 30 per cent. of carbonate of lime, consisting of the shells of pelagic Foraminifera and Coccoliths. In some of the red clays of the Pacific Ocean there was a very large quantity of manganese peroxide, in the form of nodules and depositions around sharks' teeth and ear-bones of whales, as well as disseminated in fine grains through the deposit, giving it a dark brown colour. In the same deposits were

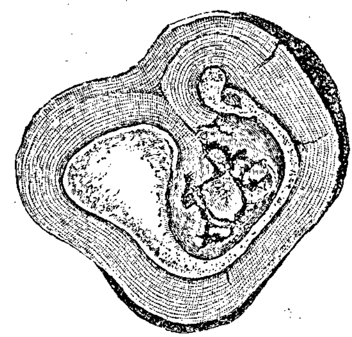

FIG. 6.—Section of a Manganese Nodule, showing ear-bone of *Mesoplodon* in the centre, from 2600 fathoms.

many crystals of philipsite, formed *in situ*, together with palagonite and cosmic spherules. Captain Aldrich has discovered a similar area in the centre of the Indian Ocean, about latitude 20° south, and between the meridians of 70° and 90° east longitude, where the deposits are almost

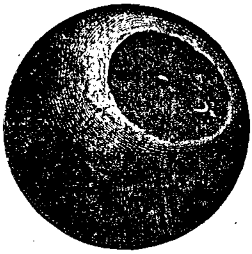

FIG. 7.—Black cosmic Spherule, with metallic nucleus, from 2375 fathoms, $\frac{60}{1}$.

FIG. 8.—Black cosmic Spherule, with metallic nucleus, from 3150 fathoms, $\frac{60}{1}$.

identical with many of those from similar depths in the Pacific. There are indications that volcanic disturbances have taken place at the bottom in these regions, but at a remote period rather than recently.

RADIOLARIAN OOZE.—Some samples of Globigerina ooze contain very few remains of Radiolarians; it is in some exceptional cases difficult to find a trace of them, but usually they are present. In some regions of the Pacific and Indian Oceans they make up a considerable part of the deposit; in these localities the Globigerina ooze passes with increasing depth into a Radiolarian ooze rather than into a red clay. It is at times difficult to say whether a deposit should be called a red clay or a Radiolarian ooze, for there is no difference between these two kinds of deposits except what is due to the greater or less abundance of the Radiolarian spicules and skeletons. When 25 per cent. of the deposit is estimated to consist of these siliceous remains, it is named a Radiolarian ooze; with a less percentage it is called a red clay. A Radiolarian ooze generally contains not more than a trace of carbonate of lime, but it may have 15 to 20 per cent. of carbonate of lime, and this is always due chiefly to the presence of fragments of pelagic Foraminifera. This deposit is found in the greatest depths far from land, and is well represented in the eastern part of the tropical Indian Ocean. It is still more largely developed in the Pacific Ocean, but a typical Radiolarian ooze has not yet been met with in the North and South Atlantic Oceans. Radiolarians appear to be more abundant in those parts of the ocean where there is a relatively low salinity, and are especially

Fig. 9.—Spherule of Bronzite, from 3500 fathoms, $\frac{25}{1}$.

numerous in the Pacific. However, they are always present in the waters of the open ocean, and it is difficult to account for

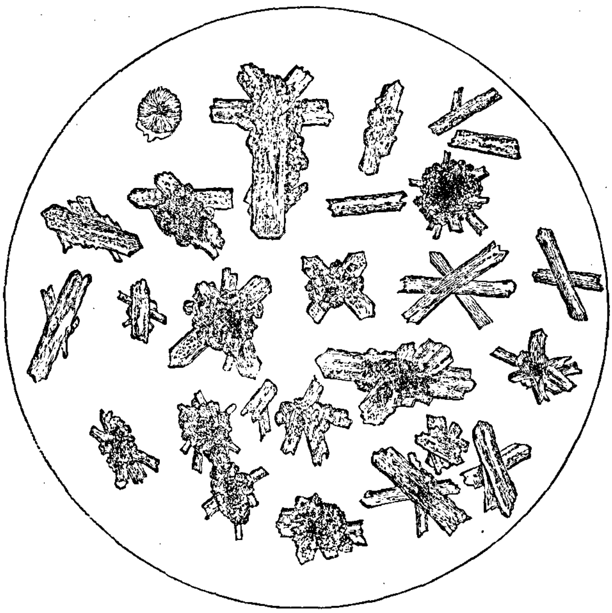

FIG. 10.—Crystals of Philipsite, from the deep water of the Pacific. (From *Ency. Brit.*, 9th ed.)

their complete or almost complete absence from many marine deposits, unless it be admitted that their siliceous remains are re-dissolved by the waters of the ocean. We can from an examination of the skeletons in the deposits see that this process has been going on, just as we observe the gradual breaking up and disappearance of the Globigerina shells in all the greater depths of the ocean. It is not then easy to determine whether the abundance of Radiolarians in some deposits, and their absence in others, is to be attributed to the greater activity of solution in some regions than in others, or to their greater or less abundance in the surface waters of the respective areas; both these circumstances must be taken into consideration in any discussion of the subject.

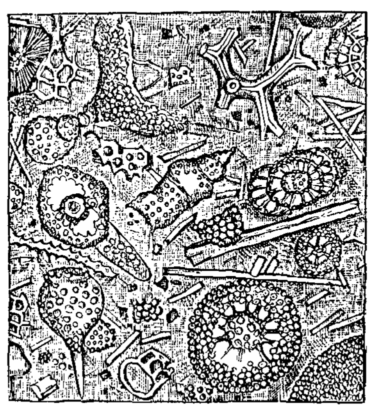

FIG. 11.—Radiolarian ooze, from 4475 fathoms in Central Pacific, $\frac{100}{1}$. (From *Ency. Brit.*, 9th ed.)

DIATOM OOZE.—In passing from the tropical regions of the Indian Ocean to the Southern Ocean and Antarctic, a gradual change is noticed in the character of the organisms captured in the surface waters by means of the tow-nets. The shelled Pteropods and Heteropods disappear, as well as many of the larger species of Globigerinidæ. Tropical species of Radiolarians give place to those which are characteristic of high and colder latitudes, and Diatoms become so numerous that the nets are often filled with a slimy mass composed almost entirely of those siliceous Algæ. A corresponding change takes place in the character of the deposits in process of formation over the floor of the ocean. The Globigerina ooze is made up of fewer species and smaller shells of pelagic Foraminifera as the Antarctic is approached, while the percentage of Diatom frustules in the deposits increases till the Globigerina ooze passes insensibly into a Diatom ooze, which in a typical example is pure white when dry, and resembles meal or flour. From the observations that have been already made, we have good grounds for believing that this Diatom deposit surrounds the Antarctic in the form of a broad band. It contains from ten to thirty per cent. of calcareous organisms, and, as the deposit is wholly within the region of floating ice, it contains in some places much land *débris*. This is especially the case close to the Antarctic continent, where the *débris* from the land predominates, and a blue mud characteristic of continental shores replaces the Diatom ooze.

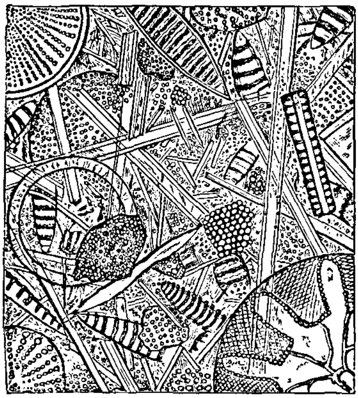

FIG. 12.—Diatom ooze, from 1900 fathoms in the Antarctic Ocean, $\frac{200}{1}$. (From *Ency. Brit.*, 9th ed.)

BLUE MUD.—In approaching any continental shore or volcanic island from the open ocean, the nature of the deposits changes in a similar manner owing to the admixture of *débris* from the land. The distance from land to which this detritus affects the deposits to any appreciable extent varies greatly. In the Antarctic its influence is widespread owing to the presence of floating ice. In the Bay of Bengal and Arabian Sea, terrigenous matters from the Indus and Ganges are also spread out over a wide extent of the ocean's floor, and this is always the case where large rivers enter the sea. The colour of the clayey matter of typical oceanic deposits is, as we have seen, usually red or brown, but where land influences prevail it is generally bluish; the immediate surface-layer is generally soft and reddish, coloured where the deposit is in contact with the water, but blue, stiff, and tenacious beneath the surface, where a reduction of the higher oxides takes place in consequence of the decomposition of animal matter that is going on in the deeper layers. All these blue muds appear to contain much more organic matter than the more remote oceanic deposits. The percentage of lime in a blue mud varies and is due to the presence of shells belonging to a great variety of organisms. Pelagic Foraminifera are sometimes present in considerable numbers, but are often wholly absent. There are many indications that blue muds accumulate more rapidly than any of the other deep-sea deposits. The mineral particles vary greatly both as to their nature and size, and often make up 60 to 80 per cent. of the whole deposit. Quartz, which is rare or absent in truly oceanic regions, is abundant along continental shores, together with fragments of minerals derived from ancient geological formations.

GREEN MUDS AND SANDS.—The fine silt or mud washed into the ocean by great rivers is principally concerned, from its large quantities, in the relatively rapid formation of the blue muds above mentioned; but along high and bold coasts, where no extensive rivers enter the sea, the deposits apparently accumulate much more slowly, and consequently assume a different aspect. The pelagic conditions approach much more closely to the shore, hence the deposits are largely made up of pelagic organisms. Owing to the slower accumulation, the mineral particles from the adjacent continents have been more exposed to the action of the sea, and have undergone much alteration. It is in such situations, as off the south and east coasts of Africa and off the coasts of Australia, that extensive deposits are now in process of formation, which much resemble the green sands of the Cretaceous period. Along all these coasts there is a greenish amorphous matter in the deposits which appears to be organic, as it burns on being heated on platinum foil, leaving a residue of carbon and red oxide of iron. A large proportion of the calcareous shells are filled with glauconitic matter, which remains as a perfect cast on removal of the lime by weak acids. Some of these casts are pale, and others dark green-coloured, the latter giving all the characteristic optical and chemical reactions of true glauconite. In our present seas there are extensive deposits of glauconite now being laid down along high and bold continental shores, removed from the embouchures of large rivers. It is, on the other hand, exceedingly rare to find traces of glauconite in any of the muds where there is an abundant deposit from rivers. This presence or absence of glauconite and glauconitic casts of the calcareous organisms, is, together with the condition and nature of the mineral particles, the chief distinction between what we have called *Green* and *Blue* muds.

VOLCANIC MUDS AND SANDS differ from Green Muds and Sands found along continental shores in the character of the mineral particles and in the absence of glauconite, the former being all derived from the decomposition of volcanic rocks. The Foraminiferous shells found off the Crozets and off the New Hebrides in the Pacific, are sometimes filled with pale yellow or reddish casts, which in some respects resemble glauconite, but it is very doubtful if any true glauconite is now forming about oceanic volcanic islands or in the deep sea removed from continental shores. It is not easy to be satisfied that the minerals in decomposition in a deposit determine the formation of glauconite in any particular locality, but the distribution here pointed out appears to show an association of this nature.

The foregoing sketch of the marine deposits of the Indian, Southern, and Antarctic Oceans may now be further illustrated by giving a detailed description of a typical sample of each variety from these regions. This will give to those interested in the subject some idea of the methods employed and the labour bestowed on the examination of the available material. In the case of a simple sounding only a few ounces of the deposit are procured, and the other observations at the same spot are usually few in number. In the case of the *Challenger* observations, however, there is usually a much more extensive series of observations at each of the observing stations, so that a rather complete idea may be formed of the conditions of the deep sea in these localities. With the view of illustrating this, a complete description is given of one of the *Challenger* dredging stations in the Southern Ocean. It appears to me that this will give a good idea of the recent advances in oceanographical research, and in our knowledge of the depths of the sea.

H.M.S. *Egeria*. Sounding No. xv. October 30, 1887. Lat. 20° 0′ S., long. 67° 33′ E. 1612 fathoms.

GLOBIGERINA OOZE, fawn colour, homogeneous, coherent when dry.

CARBONATE OF CALCIUM (86·85 per cent.), chiefly pelagic Foraminifera, with Coccoliths and Rhabdoliths, Ostracode valves, Echini spines, otoliths of fish.

RESIDUE (13·15 per cent.), ferric red colour.

Siliceous Organisms (2·00 per cent.), Radiolaria, Sponge spicules, a few Diatoms and casts of Foraminifera.

Minerals (7·00 per cent.), mean diameter 0·1 mm., angular; entirely made up of volcanic *débris*, obsidian, and other glassy fragments, magnetite, augite, hornblende, felspars, manganese, a few altered particles.

Fine Washings (4·15 per cent.), amorphous matter, fine mineral particles, fragments of siliceous organisms.

Remarks.—This is a typical *Globigerina ooze* from the tropics. The species of Foraminifera show this very clearly, all the shells of the pelagic species found in the tow-nets at the surface being specially abundant. These tropical species are absent in the deposit from the *Challenger* Station 157 in latitude 53° south, described further on.

The mineral particles are larger and more numerous than in most Globigerina oozes. This is owing to the presence in this region of many splinters of pumice, which I believe to have been derived from pumice floating on the surface of the ocean; these are rubbed and knocked together by the action of the waves, and thus produce a large number of minute fragments which fall to the bottom. After the eruption of Krakatoa very large fields of floating pumice were found all over the Indian Ocean for many months. The following is a list of the Foraminifera found in the deposit, those marked with a cross being pelagic species, which may be compared with the pelagic species similarly marked from the station in latitude 53° south, where there is a Diatom ooze:[1] —

Biloculina depressa, d'Orb.
,, *depressa*, var. *murrhyna*, Schw.
Miliolina venusta, Karr.
Rhizammina algæformis, Br.
Rhabdammina sp.
Reophax difflugiformis, Br.
,, *guttifera*, Br.
,, *membranacea*, Br.
,, sp.
Haplophragmium latidorsatum, Bornem., young.
Thurammina papillata, Br.
Trochammina lituiformis, Br.
Ammodiscus gordialis, J. & P.
Verneuilina pygmæa, (Egger.)
Gaudryina pupoides, var. *chilostoma*, Rss.
Lagena seminuda, Br.
,, *seminiformis*, Schw.
,, *lagenoides*, var. *tenuistriata*, Br.
,, *acuta*, (Rss.)
,, *globosa*, (Montag.)
,, *desmophora*, Ry. Jones.
,, *alveolata*, Br.
Nodosaria communis, d'Orb.
,, *calomorpha*, Rss.
Cristellaria gibba, d'Orb.
Polymorphina longicollis, Br.
,, *angusta*, Egger.
× *Orbulina universa*, d'Orb.
× *Globigerina rubra*, d'Orb.
× ,, *bulloides*, d'Orb. (?)
× ,, *digitata*, Br.
× ,, *conglobata*, Br.
× ,, *æquilateralis*, Br.
× ,, *sacculifera*, Br.
× ,, *dubia*, Egger.
× ,, *inflata* (? var.)
× *Sphæroidina dehiscens*, P. & J.
× *Pullenia obliquiloculata*, P. & J.
,, *quinqueloba*, Rss.
× *Candeina nitida*, d'Orb.
× *Hastigerina pelagica*, (d'Orb.)
Truncatulina akneriana, (d'Orb.)
,, *ungeriana*, d'Orb.
,, *wuellerstorfi*, (Schw.)
,, *tenera*, Br.
× *Pulvinulina tumida*, Br.
× ,, *menardii*, (d'Orb.)
,, *pauperata*, P. & J.
× ,, *canariensis*, (d'Orb.)
× ,, *micheliniana*, (d'Orb.)
,, *exigua*, Br.
Rotalia orbicularis, d'Orb.
Nonionina umbilicatula, Montag.
,, *pompilioides*, (F. & M.)

H.M.S. *Flying Fish*. Sounding No. XXVIII. January 21, 1887.
Lat. 9° 54′ S., long. 97° 42′ E. 3025 fathoms.

RADIOLARIAN OOZE, light brown, homogeneous, slightly coherent when dry. No effervescence was detected on treating the deposit with dilute hydrochloric acid, and no calcareous organisms were observed on microscopic examination, except a few small fragments of teeth of fish.

Siliceous Organisms (60·00 per cent.), chiefly Radiolaria, with Sponge spicules, many Diatoms, and a few arenaceous Foraminifera.

Minerals (10·00 per cent.), mean diameter 0·1 mm., a few particles much larger, and one or two rounded fragments of pumice measuring 2 mm. in diameter, all of volcanic origin and angular, consisting chiefly of scoriaceous and glassy fragments, lapilli, felspar, magnetite, augite, olivine, hornblende, a few flakes of mica, one or two

[1] In these lists the pelagic species are marked with a cross; the other species are usually represented by only a few specimens. These Foraminifera have been picked out, mounted, and labelled by Mr. Frederick Pearcey, who accompanied the *Challenger* Expedition as Naturalist's assistant.

grains of manganese, some yellow, pale green, brown, and red particles of palagonite.

Fine Washings (30·00 per cent.), amorphous matter, fine mineral particles and fragments of siliceous organisms.

Remarks.—The mineral particles are chiefly minute fragments of pumice with fresh fracture, showing that they had only, in all probability, recently fallen to the bottom. The following arenaceous Foraminifera were observed:—*Hyperammina elongata*, *Aschemonella catenata*, *Haplophragmium latidorsatum*, *Ammodiscus charoides*, *Trochammina pauciloculata*. Among the Radiolaria the Nassellaria are by far the most abundant; this is in marked contrast to the Radiolaria in 53° south latitude, where the Spumellaria predominate.

H.M.S. *Investigator*. Bay of Bengal. Lat. 17° 34′ N., long. 87° 59′ E. 1300 fathoms.

BLUE MUD, bluish grey and very coherent when dry, fine-grained, earthy, homogeneous, lustrous streak.

CARBONATE OF CALCIUM (2·94 per cent.), a few pelagic Foraminifera.

RESIDUE (97·06 per cent.), bluish grey.

Siliceous Organisms (3·00 per cent.), a few Radiolaria, Diatoms, and arenaceous Foraminifera.

Minerals (30·00 per cent.), mean diameter 0·05 mm., angular and rounded; felspar, a few grains of quartz, magnetite, olivine, hornblende, zircon, mica, grains of manganese.

Fine Washings (64·06 per cent.), large quantity of amorphous matter, minute mineral particles, and fragments of siliceous organisms.

Remarks.—The fine washings in this deposit are mostly made up of an immense number of minute mineral particles, of angular and rounded form, of the same nature as those mentioned under the heading "Minerals." Their average size is less than 0·02 mm. in diameter. In the washings of the dredge were many small concretions of the deposit held together by depositions of peroxide of manganese. Shells of the following Foraminifera (none of them in any abundance) were also observed in the deposit, in addition to fragments of Gasteropods, Lamellibranchs, Pteropods (one or two), Cephalopod beaks, otoliths of fish, Ostracode valves, Isopods in tubes.

× *Orbulina universa*, d'Orb.
× *Globigerina sacculifera*, Br.
× „ *dubia*, Egger.
× „ *æquilateralis*, Br.
× „ *inflata*, var.
× *Sphæroidina dehiscens*, P. & J.
„ *bulloides*, d'Orb.
× *Pulvinulina menardii*, (d'Orb.)
Pulvinulina pauperata, P. &. J.
Rhabdammina abyssorum, Sars.
„ *linearis*, Br.
„ *discreta*, Br.
Hyperammina ramosa, Br.
„ *subnodosa*, Br.
Reophax nodulosa, Br.
„ sp.

Marsipella elongata, Norm.
Haplophragmium latidorsatum (Bornem.)
„ *globigeriniforme*, (P. & J.)
„ *anceps*, Br.
„ *rotulatum*, Br.
„ *turbinatum*, Br.
„ *agglutinans*, (d'Orb.)
Ammodiscus tenuis, Br.
Hormosina globulifera, Br.
Hormosina monile, Br.
„ *ovicula*, Br.
Cyclammina pusilla, Br.
„ *cancellata*, Br.
Trochammina trullissata, Br.
Webbina clavata, J. & P.
Bathysiphon filiformis, Sars.
Clavulina communis, d'Orb.
Biloculina ringens, (Lamk.)
„ *depressa*, d'Orb.
Bulimina contraria, (Rss.)
Cristellaria reniformis, d'Orb.

H.M.S. *Egeria*. Sounding No. xx. Nov. 12, 1887. Lat. 23° 14′ 45″ S., long. 56° 18′ 15″ E. 2466 fathoms.

RED CLAY, dark brown colour, homogeneous, coherent when dry, plastic.

CARBONATE OF CALCIUM (12·22 per cent.), chiefly shells of pelagic Foraminifera, with small teeth of fish and Echini spines.

RESIDUE (87·78 per cent.), dark chocolate colour.

Siliceous Organisms (1·00 per cent.), two or three Radiolaria and a few fragments of Sponge spicules.

Minerals (5·00 per cent.), mean diameter 0·1 mm., entirely volcanic, mostly fragments of rock (lapilli), magnetite, felspars, olivine, augite, hornblende, palagonite, manganese grains, glassy fragments, many minute particles of the hardened deposit.

Fine Washings (81·78 per cent.), amorphous matter, fine mineral particles and a few fragments of siliceous organisms.

Remarks.—The carbonate of lime is principally due to the presence of fragments of pelagic Foraminifera, which are marked with a cross in the following list of Foraminifera observed :—

Biloculina depressa, d'Orb.
Miliolina venusta, (Karr.)
Hyperammina algæformis, Br.
Ammodiscus charoides, (J. & P.)
Virgulina schreibersiana, Czjzek.
Cassidulina subglobosa, Br.
Lagena crenata, P. & J.
„ *stelligera*, Br.
„ *gracilis*, Will.
„ *apiculata*, Rss.
„ *lævigata*, (Rss.)
„ *lagenoides*, var. *tenuistriata*, Br.
„ *acuta*, (Rss.)
Lagena sulcata, W. & J.
× *Globigerina dubia*, Egger.
× „ *inflata*, d'Orb.
× „ *sacculifera*, Br.
× „ *conglobata*, Br.
Pullenia quinqueloba, Rss.
Truncatulina pygmæa, Hantk.
„ *wuellerstorfi*, (Schw.)
× *Pulvinulina tumida*, Br.
× „ *menardii*, (d'Orb.)
× „ *micheliniana*, (d'Orb.)
× „ *crassa*, (d'Orb.)
Nonionina pompilioides, (F. & M.)

H.M.S. *Egeria*. Sounding No. XII. October 25, 1887. Lat. 21° 07′ S., long. 77° 49′ E. 2564 fathoms.

RED CLAY—dark chocolate colour, homogeneous, coherent when dry.

There was no trace of Carbonate of Calcium.

Siliceous Organisms (3·00 per cent.), a few Radiolaria and Diatoms.

Minerals (15·00 per cent.), mean diameter 0·15 mm., almost entirely volcanic, chiefly pumice *débris*, many manganese grains, philipsite, magnetite, hornblende, felspar, augite, many glassy fragments.

Fine Washings (82·00 per cent.), amorphous matter, fine mineral particles, oxides of iron and manganese.

Remarks.—The mineral particles were almost all minute fragments of pumice, with fresh fractures, and were larger and more numerous than in most typical red clays. Manganese peroxide appears to have been very abundant in this locality.

H.M.S. *Challenger*. Station 142. December 18, 1873. Lat. 35° 4′ S., long. 18° 37′ E. 150 fathoms.

GREEN SAND, with white spots, fine-grained, pulverulent and slightly coherent when dry.

CARBONATE OF CALCIUM (67·75 per cent.), chiefly pelagic Foraminifera (40 per cent.), with bottom-living Foraminifera (10 per cent.) and otoliths, teeth, fragments of bones of fish, *Serpula* tubes, Gasteropods, Lamellibranchs, Pteropods, Ostracodes, Echinoderm fragments, Polyzoa, Coccoliths (17 per cent.).

RESIDUE (32·25 per cent.), green and arenaceous.

Siliceous Organisms (7·00 per cent.), Sponge spicules, grey and green casts of Foraminifera, Diatoms, arenaceous Foraminifera.

Minerals (20·00 per cent.), mean diameter 0·3 mm., angular and rounded; quartz, glauconite, felspar, hornblende.

Fine Washings (5·25 per cent.), amorphous matter, fine mineral particles and fragments of siliceous organisms.

Remarks.—There were a very large number of invertebrate animals of all kinds in the dredgings at this station. Fifty-five new species, some of them belonging to new genera, are described in the *Challenger* Reports. There was much green-coloured matter in the deposit; some portions resembled vegetable tissue, and when heated on platinum-foil burned like an organic substance, becoming black, then red.

Glauconite is exceptionally well represented in this deposit on the Agulhas Bank. The grains are about one millimètre in diameter, and are isolated or agglommerated into nodules; they are always rounded, often mammillated, are hard and dark green, black or brown in colour; their surface is sometimes shining. The internal casts of the Foraminifera and other calcareous organisms are sometimes dirty white or pale green, and sometimes dark green, in every way like the larger mammillated glauconite particles, which latter often show rudely the form of the calcareous organisms. It seems undoubted that a large number of the characteristic glauconite grains have had their origin from the internal pale-coloured casts of the Foraminifera. In the dredgings were many glauconitic concretions containing phosphate of lime, and in most respects resembling concretions from the green sand.

The shells of several species of Pteropods belonging to *Cleodora* and *Spirialis,* together with the following Foraminifera were found in the deposit:—

Biloculina sphæra, d'Orb.
,, *ringens*, (Lamk.)
Miliolina seminulum, (Linn.)
,, *circularis*, (Bornem.)
,, *venusta*, (Karr.)
,, *agglutinans*, (d'Orb.)
Psammosphæra fusca, Schulze.
Rhabdammina abyssorum, Sars.
Hyperammina friabilis, Br.
Marsipella cylindrica, Br.
Rhizammina algæformis, Br.
Reophax dentaliniformis, Br.
,, *fusiformis*, (Will.)
Haplophragmium agglutinans, (d'Orb.)
,, *turbinatum*, Br.
Textularia aspera, Br.
,, *sagittula*, Defr.
Bulimina aculeata, d'Orb.
,, *marginata*, d'Orb.
,, *inflata*, Seg.
,, *pyrula*, d'Orb.
,, *punctata*, d'Orb.
Cassidulina lævigata, d'Orb.
Polymorphina myristiformis, W ll.
Lagena alveolata, var. *substricta*, Br.
,, *sulcata*, (W. & J.)
,, *sulcata*, var. *interrupta*, Will.
,, *marginata*, (W. & B.)
Nodosaria (*Glandulina*) *lævigata*, d'Orb.
,, ,, *æqualis*, Rss.
,, *radicula*, (Linn.)
,, *consolbrina*, var. *emaciata*, Rss.
,, *scalaris*, (Batsch.)
,, *perversa*, Schw.
Cristellaria obtusata, var. *subalata*, Br.
Cristellaria rotulata, (Lamk.)
Vaginulina linearis, (Montag.)
Marginulina costata, Batsch.
Uvigerina schwageri, Br.
,, *tenuistriata*, Rss.
,, *angulosa*, Will.
Sagrina striata, Schw.
× *Orbulina universa*, d'Orb.
× *Globigerina bulloides*, d'Orb.
× ,, *bulloides*, var. *triloba*, Rss.
× ,, *sacculifera*, Br.
× ,, *æquilateralis*, Br.
× ,, *conglobata*, Br.
× ,, *dubia*, Egger.
× ,, *inflata*, d'Orb.
× ,, *rubra*, d'Orb.
× *Sphæroidina dehiscens*, P. & J.
,, *bulloides*, D'Orb.
× *Pullenia obliquiloculata*, P. & J.
Anomalina ariminensis, (d'Orb.)
,, *coronata*, P. & J.
Truncatulina lobatula, (W. & J.)
,, *refulgens*, (Montf.)
,, *haidingeri*, d'Orb.
Rotalia sp.
,, *orbicularis*, d'Orb.
× *Pulvinulina menardii*, (d'Orb.)
× ,, *canariensis*, (d'Orb.)
× ,, *micheliniana*, (d'Orb.)
,, *oblonga*, (Will.)
,, *umbonata*, Rss.
,, *elegans*, (d'Orb.)
Operculina ammonoides, (Gron.)
Nonionina sp.
Polystomella macella, (F. & M.)

H.M.S. *Challenger*. STATION 151. February 7, 1874. Lat. 52° 59′ 30″ S., long. 73° 33′ 30″ E. 75 fathoms.

VOLCANIC MUD—greenish black.

CARBONATE OF CALCIUM (2·58 per cent.), *Serpula* tubes, Gasteropods, Lamellibranchs, Ostracodes, Echinoderm fragments, and Polyzoa (1·58 per cent.), pelagic and bottom-living Foraminifera (1·00 per cent.).

RESIDUE (97·42 per cent.).

Siliceous Organisms (10·00 per cent.), Radiolaria, Sponge spicules, and Diatoms.

Minerals (70·00 per cent.), mean diameter 0·6 mm., angular and rounded; fragments of brown and red glass, often enclosing microliths of olivine, felspar (plagioclase), augite, magnetite.

Fine Washings (17·42 per cent.), small quantity of amorphous matter, many fine mineral particles, flocculent organic matter, fragments of Sponge spicules and of Diatoms.

Remarks.—The Diatoms in this deposit were especially abundant for a shore deposit, but in the tow-nets at the surface they were also very abundant. In the dredging at this depth, off Heard Island, there was a very large number of animals belonging to all the Invertebrate groups; over forty new species of animals, some of them belonging to new genera, are described in the *Challenger* Reports from this Station.

FULL DESCRIPTION OF A *CHALLENGER* DREDGING STATION.

STATION 157. (Sounding 261.) South-West of Australia.

March 3, 1874; lat. 53° 5′ S., long. 108° 35′ E.
Temperature of air at noon, 38°·3. Mean for the day, 36°·9.

	At surface.	At 50 faths.	At 100 faths.	At bottom.
Temperature of Water,	37°·2	36°·6	32°·8	32°·2?
Density at 60° Fahr.,	1·02509	1·02507	1·02537	1·02561

Depth, 1950 fathoms; deposit, Diatom ooze.

At 6.30 A.M. shortened and furled sails and proceeded under steam to trawl and sound. At 8 A.M. put over trawl, and at 9 A.M. sounded in 1950 fathoms. A small quantity of Diatom ooze came up in the sounding tube. The distance from Cape Otway at noon was 1721 miles. The amount of current during the past three days was 55 miles, direction N. 19° E. Several temperatures were taken down to 500 fathoms. Samples of water were taken from depths of 50 and 100 fathoms. The carbonic acid was determined in the bottom water, and amounted to 44·3 mgrm. per litre. The tow-nets, which were dragged at the surface of the sea and a few fathoms beneath, came up nearly filled with a slimy mass consisting almost entirely of Diatoms; besides the Diatoms there were many Radiolarians, a few Copepods, Cypridinidæ, Hyperidæ, Pteropods, and pelagic Foraminifera. At 2 P.M. commenced heaving in trawl; it came up at 4 P.M. with a large quantity of the Diatom ooze, many large and small stones, and numerous animals. This was one of the most successful hauls of the expedition. A few of the usual sea-birds were observed during the day. Wind fell to a calm during the afternoon. There was a brilliant sunset, and at 11·45 P.M. a fine aurora australis, stretching in four concentric arcs over the SE. to W. horizon.

Detailed Description of the Deposit.

The Diatom ooze which came up in the trawl was of a yellowish, straw, or cream colour when wet. The intestines of many of the Holothurians and Annelids were seen to be filled with this ooze through the transparent bodies of the animals. Some portions of this deposit were somewhat coherent and adhered in laminated fragments when first taken from the trawl, being apparently the deeper layers of the deposit, but the larger portion of the deposit was of an oozy or watery consistence. It effervesced with weak acids. This ooze tended to sort itself very quickly when placed in water, the extremely fine particles remaining suspended in the water, while the larger mineral particles, Foraminifera, and larger Radiolarians, fell to the bottom layers of the bottles in which the ooze was preserved. In consequence of this there is a great difference in the quantity of carbonate of lime in samples taken from the same bottle; some samples giving 5 or 6 per cent., while other samples give about 25 per cent. Carefully selected samples, which do not seem to have undergone any sorting, give about 18 per cent. The large quantity of the deposit brought up in the trawl allows of a very much more detailed description being given than at any of the other stations where a Diatom ooze was met with. Nearly the whole of the deposit was carefully sifted, but a considerable quantity was brought home in the condition in which it was taken from the bag of the trawl.

When this ooze is dried it is nearly pure white, or has a very delicate cream colour. It is very light, soft to the touch, coherent under pressure, takes the impress of the fingers, and soils them in the same way as flour. It resembles closely the purest examples of diatomite of fresh-water origin. The following is a description of an average sample of the deposit:—

Carbonate of Calcium (18·19 per cent.) consists chiefly of *Globigerina bulloides* and *Globigerina dutertrei*, a few *Globigerina inflata* and *Pulvinulina micheliniana*; a few bottom-living Foraminifera, spines of Echini, fragments of Polyzoa, Ostracodes, otoliths of fish, and rarely beaks of Cephalopods with small fragments of Gasteropod and Lamellibranch shells.

Residue (81·81 per cent.), white, consists of—

Siliceous Organisms (50·00 per cent.), Diatoms principally, many Radiolarians, some Sponge spicules and arenaceous Foraminifera.

Minerals (3·00 per cent.), mean diameter 0·07 mm., angular; quartz, felspar, hornblende, a few magnetic particles, glassy fragments, and small fragments of palagonite.

Fine Washings (28·81 per cent.).—Composed essentially of the frustules of Diatoms and their fragments, a small quantity of argillaceous matter and very minute mineral particles.

In the following analysis of an average sample of the deposit the silica soluble in hydrochloric acid (HCl) must be considered as almost exclusively coming from the Diatoms and other siliceous organisms. The carbonate of lime comes principally from the Foraminifera present in the deposit. The insoluble part, which is given *en bloc*, proves only the presence of silicates.

In treating the siliceous remains in a water-bath with hydrochloric acid for more than twelve hours, we succeeded in obtaining only 3·00 per cent. of silica in solution. The numbers given here by Professor Brazier indicate that the siliceous residue after the attack with HCl has been treated with caustic potash.

Analysis of a Dried Specimen of Diatom ooze (Brazier).

Loss on ignition after washing and drying at 230° Fahr.,			= 5·30
Portion soluble in hydrochloric acid = 85·28.	=	Alumina,	= 0·55
		Ferric oxide,	= 0·39
		Calcium phosphate,	= 0·41
		Manganese oxide,	= trace
		Calcium sulphate,	= 0·29
		Calcium carbonate,	= 19·29
		Magnesium carbonate,	= 1·13
		Silica,	= 67·92
Portion insoluble in hydrochloric acid = 4·72.	=	Consisting of alumina and ferric oxide with silica,	= 4·72
			100·00

Rock Fragments from the Trawl.

The largest fragment of rock measures about 50 × 40 × 40 cm., and weighs more than 20 kilogrammes. It is a grey gneiss, fine-grained, and the fracture takes place parallel to the micaceous layers. Some layers are specially composed of mica, while others are more felspathic and granitic, the grains being about 2 or 3 mm. in diameter. The quartz appears to be the dominant element in the rock. The mica is biotite, sometimes presenting a slightly greenish tint. With the microscope the felspathic element is at once seen to be orthoclase and frequently microcline. There were several smaller pieces of rock of the same species as this larger fragment, one being 7 × 6 × 6 cm. Some of them, however, were more micaceous. Two of the fragments had distinct glacial markings. One fragment of basaltic volcanic rock is about 6 × 4 × 2 cm., and has sharp angles; it is hard, compact, and composed of plagioclase, augite (rather rare), magnetite, with the base transformed into a yellowish green matter.

There were more than thirty fragments of pumice with a diameter of from 1 to 3 cm., a few of them being much decomposed. Some are white in the fracture, others are red or black, and in the latter case are iridescent. The less scoriaceous specimens are rounded, the more porous are somewhat angular owing to the large size of the vacuoles. One large piece of pumice appears to be stratified, decomposition having been less rapid in the harder layers.

There seems little doubt that the fragments of gneiss above referred to have been transported from Antarctic land by floating ice. The largest fragment and some of the smaller ones were only partially imbedded in the deposit, the depth to which they were imbedded being marked by a sharp line. The portions above the surface of the deposit had a slight coating of the black oxide of manganese, and had Foraminifera (*Hyperammina vagans*, Brady), Actiniæ, Annelids, and Polyzoa growing on them. Some fragments of Hexactinellid spicules had a rather thick coating of manganese peroxide.

The Diatomaceæ. (Castracane, Bot. Chall. Exp., vol. ii. pt. iv.)

Considerable differences are recognisable between the general appearance of Diatom preparations made from surface gatherings as contrasted with those procured from the ooze forming the bottom in this locality. By far the most abundant species at the surface was the peculiar, very elongated, flexuous *Thalassiothrix longissima*, var. *antarctica*, Cleve and Grunow (=*Synedra thalassiothrix*, Cl. *in parte*), representatives of which have already been recorded as forming large floating masses in the Arctic Ocean.[1] In the Antarctic its frustules were found arranged in little bundles—from ten to twelve together—fastened together loosely at one end, but separate at the other, the whole being loosely twisted into a spindle. In preparations isolated frustules of it occur but rarely; often two are found closely apposed, but not uncommonly three, four, or even more are so placed. It is, perhaps, with *Chætoceros janischianum*, Cstr., the most characteristic species found on the surface.

The Chætocerotidæ and Rhizosoleniæ are found abundantly in the surface waters, but they are only represented by the terminal calyptræ of the latter in the bottom ooze. Most of the delicately curved though often large forms of *Corethron* and the singular cylindrical *Dactyliosolen* have only been found in surface gatherings, whilst the remarkable *Trachysphenia australis*, Petit, var. *antarctica* (Schwarz) [= *Fragilaria antarctica*, Cstr.], which abounds in the ooze, is much less common in the surface gatherings. Frustules of *Coscinodisci* and *Actinocycli* are also much less numerous at the surface than upon the bottom, but no species which is present in the superficial waters is absent from the ooze.

The contents of the alimentary canals of several of the Echinoderms and Annelids were examined with the view of ascertaining whether or not a predilection was exhibited by the animals for any particular species of Diatoms; it was found, however, that they made use of the ooze as a whole, in all probability taking in the uppermost layers containing specimens recently precipitated from the surface, which may still have contained traces of organic matter. The tubes of the Annelids and the tests of the Foraminifera, *Reophax nodulosa* and *Bathysiphon filiformis*, contained many of the large *Coscinodisci*.

The frustules, which Count Castracane has indicated as "*Fragilaria ? an Terebraria ?* sp.,"[2] may be regarded as the southern representative of *Fragilaria oceanica*, Cl., from the Arctic Ocean, with which it shows in the general arrangement and character of the frustules a considerable amount of agreement. Among the Diatoms observed at this Station the following have been also recorded in the Arctic zone:—[3]

[1] *Bihang til K. Svensk. Vetensk. Akad. Handl.* Bd. i., No. 13, Stockholm, 1873.

[2] Bot. Chall. Exp., part iv. p. 47, pl. xxv. fig. 1.

[3] I am obliged to Mr. John Rattray for preparing and naming the list of Diatoms.

Rhizosolenia setigera, Brightw.
„ *styliformis*, Brightw.
Chætoceros decipiens, Cl.
Coscinodiscus decrescens, var. *polaris*, Grun.
Coscinodiscus decrescens, var. *repleta*, Grun.
„ *subtilis*, var. *glacialis*, Grun.

Among the more peculiarly Antarctic species found at this Station may be noted the following:—

Navicula subtilis (Greg) [=*Pinnularia criophila*, Cstr.]
Trachysphenia australis, Petit, var. *antarctica* (Schwarz.) [=*Fragilaria antarctica*, Cstr.]
Rhizosolenia inermis, Cstr.
Dactyliosolen antarcticus, Cstr.
Chætoceros remotum, Cl. et Grun. [= *Chætoceros janischianum*, Cstr.]
Chætoceros remotum, Cl. et Grun., broad var.
Chætoceros boreale, Bail., var. *brightwellii*, Cl. [=*C. criophilum*, Cstr.]
Synedra lanceolata, Cstr.
Diatoma rhombicum, O'Me., var. *oceanica*, nov.
Corethron criophilum, Cstr., et var.
„ *murrayanum*, Cstr.
„ *hispidum*, Cstr.
Coscinodiscus lunæ [=*Coscinodiscus cycloteres*, Cstr.]
Actinocyclus oliveranus, O'Me.

The following is a list of the principal species that have been observed:—

(*A.*) *From the Surface-Net Gatherings.*

Navicula subtilis (Greg.) [=*Pinnularia criophila*, Cstr.].
Pleurosigma antarcticum (fide Grun.).
Amphiprora antarctica (fide Grun.).
Thalassiothrix longissima, var. *antarctica*, Cl. et Grun. [=*Synedra thalassiothrix*, Cl., in parte].
Trachysphenia australis, Petit, var. *antarctica* (Schwarz) = *Fragilaria antarctica*, Cstr., *Fragilaria* (?) an *Terebraria* (?) sp., Cstr.
Rhizosolenia inermis, Cstr.
„ *setigera*, Btw.
„ *styliformis*, Btw.
Dactyliosolen antarcticus, Cstr.
Chætoceros decipiens, Cl.
„ *remotum*, Cl. et Grun., broad var.
„ *remotum*, var. *robusta*, nov.
„ *remotum*, var. *biaurta*, nov.
Chætoceros boreale, Bail., var. *brightwellii*, Cl.
„ *atlanticum*, Cl.
„ *atlanticum*, var. *attenuata*, Cl. et Grun.
„ *antarcticum*, Grun.
„ *dispar*, Cstr.
„ *sigmoidea*, n. sp.
Corethron hispidum, Cstr.
„ *murrayanum*, Cstr.
„ *criophilum*, Cstr. et var.
Hemiaulus antarcticus, Ehrenb. [=*Eucampia balaustium*, Cstr.].
Actinocyclus oliveranus, O'Me., et forma minor.
Coscinodiscus lunæ, Ehrenb.
„ *excentricus*, Ehrenb.
„ *lineatus*, Ehrenb.
„ *lentiginosus*, Janisch.
„ *tumidus*, Janisch.

(*B.*) *From the Ooze obtained in the Trawl.*

Navicula subtilis, Greg.
Thalassiothrix longissima, var. *antarctica*, Cl. et Grun.
Synedra lanceolata, Cstr.
„ *nitzschioides*, Grun.
„ *filiformis*, Grun.

Thalassionema nitzschiodes, Grun., var. *lanceolata*, Grun.
Trachysphenia australis, Petit, var. *antarctica*, Schwarz.
Diatoma rhombicum, O'Me.
Nitzschia constricta, var. *antarctica*, nov.
Rhizosolenia styliformis, Brightw.
„ *furcata*, n. sp.
Corethron criophilum, Cstr.
Hemiaulus antarcticus, Ehrenb. = *Eucampia balaustium*, Cstr., *Eucampia balaustium*, var. *minor*, Cstr.
Asteromphalus hookerii (Ehrenb.) Ralfs.
„ forma *buchii*, Ehrenb.
„ forma *humboldtii*, Ehrenb.
„ forma *cuvierii*, Ehrenb.
„ forma *denarius*, Janisch.
„ *darwinii*, Ehrenb.
Hyalodiscus radiatus, O'Me., var. *arctica*, Grun.
Actinocyclus oliveranus,[1] O'Me.
Coscinodiscus margaritaceus, Cstr.
„ *lunæ*, Ehrenb.
„ *excentricus*, Ehrenb.
„ *atlanticus*, Cstr.
„ *atlanticus*, var., Cstr.
„ *lineatus*, Ehrenb.
Coscinodiscus lentiginosus, Janisch.
„ *lentiginosus*, var. *maculata*, Grun.
„ *africanus*, var. *wallichianus*, Grun.
„ *subtilis*, Ehrenb.
„ *subtilis*, var. *glacialis*, Grun.
„ *tumidus*, Janisch.
„ *tumidus*, var. *fasciculata*, nov.
„ *radiatus*, Ehrenb.
„ *decrescens*, var. *polaris*, Grun.
„ *decrescens*, var. *repleta*, Grun.
„ *fasciculatus*, A. S.
„ *griseus*, var. *gallopagensis*, Grun. (?)[2]
„ *curvatulus*, *maculata*, nov.
„ *tuberculatus*, Grev., var. *excentrica*, nov.
„ *tuberculatus*, var. *antarctica*, nov.
„ *elegans*, Grev.
„ *robustus*, Grev.
„ *robustus*, var. *minor*.
„ *antarcticus*, Cstr. (nov. Grun.)
„ *denarius*, A. S.
„ *marginatus*, Ehrenb.

Analysis of Diatomaceæ from the Deposit (Sipöcz).

The following analysis is, properly speaking, one of that portion of this deposit comprised under the headings "*Siliceous organisms*" and "*fine washings*." The substance sent for analysis had been treated with dilute hydrochloric acid (HCl) to remove the calcareous organisms, and consisted as nearly as possible of siliceous organisms, chiefly Diatoms, but mixed up with these were a few Radiolaria and Sponge spicules. The mechanical separation was not, however, complete, as is shown by the figures below.

The analysis agrees well with the description, for besides siliceous organisms, a small quantity of argillaceous matter and mineral particles

[1] The detached outer rims of this elegant species occur frequently in preparations.

[2] A few specimens occur in the ooze, which, though not absolutely identical with this form as figured by van Heurck (*Synop. d. Diat. d. Belg.*), are yet more closely allied to it than to any other.

is indicated. Considering the low percentage of all the bases it may be concluded that almost all the silica exists in the form of siliceous organisms.

I. 0·5618 grm. Diatomaceæ, dried at 120° C., gave 0·0330 grm. loss on ignition, then treated with fluorhydric and sulphuric acids gave 0·5092 grm. silica (SiO_2), 0·00112 grm. barium oxide (BaO), 0·0056 grm. potassium chloride (KCl) and sodium chloride (NaCl), which gave 0·0044 grm. potassio-bichloride of platinum (K_2PtCl_6) = 0·00134 grm. potassium chloride (KCl) consequently = 0·00085 grm. potassium oxide (K_2O), and 0·00426 grm. sodium chloride (NaCl) consequently = 0·00225 grm. sodium oxide (Na_2O).

II. 0·6487 grm. Diatomaceæ, dried at 120° C., gave 0·0379 grm. loss on ignition, and then treated with fluorhydric and sulphuric acids gave 0·5870 grm. silica (SiO_2), 0·0013 grm. barium oxide (BaO), 0·0057 grm. iron peroxide (Fe_2O_3), 0·0089 grm. alumina (Al_2O_3), 0·0022 grm. lime (CaO), and 0·0055 grm. pyrophosphate of magnesia ($P_2O_7Mg_2$) = 0·00198 grm. magnesia (MgO), and traces of phosphoric acid (P_2O_5).

	I.	II.	Mean.
Silica (SiO_2),	90·63	90·49	90·56
Iron peroxide (Fe_2O_3),	...	0·88	0·88
Alumina (Al_2O_3),	...	1·31	1·31
Lime (CaO),	...	0·33	0·33
Baryta (BaO),	0·20	0·20	0·20
Magnesia (MgO),	...	0·30	0·30
Potash (K_2O),	0·15	...	0·15
Soda (Na_2O),	0·40	...	0·40
Phosphoric acid (P_2O_5),	trace	trace	trace
Loss on ignition (H_2O),	5·87	5·84	5·85
	97·25	99·35	99·98

The Foraminifera. (Brady, Zool. Chall. Exp., vol. ix. pt. xxii.)

The carbonate of lime in the deposit consists chiefly of the shells of pelagic Foraminifera which have fallen to the bottom from the surface, especially the dwarfed forms like *Globigerina dutertrei*, many of the specimens of which scarcely differ from the Arctic *Globigerina pachyderma* in size and contour, and *Globigerina inflata*; although in the following list the bottom-living species, with carbonate of lime shells, are more numerous than the pelagic species, yet the number of individuals are relatively very few in number, the list having been compiled from the examination of a very large quantity of the deposit. While the shells of the pelagic forms are very small when compared with those found in tropical areas, the Miliolidæ, Astrorhizidæ, Lituolidæ, and other bottom-living forms are, on the other hand, represented by very large and beautiful forms. Some specimens of *Miliolina* were one-eighth of an inch in diameter; specimens of *Reophax* and *Rhabdammina* are over one inch in length. Among the arenaceous species there are many interesting illustrations of the mode in which these Rhizopods select and arrange the various particles in the deposit to form their tests. *Astrorhiza crassatina* here forms its test almost exclusively of the spherical Radiolarian *Cromyosphæra antarctica; Storthosphæra* selects the finest mineral particles, with an occasional larger particle of quartz or palagonite; one form selects only the shells of the pelagic Foraminifera, and another only the smallest Diatomaceæ; *Reophax nodulosa* and *Bathysiphon filiformis* make use of many large *Coscinodisci*, arranging them flatways over the surface, and *Rhabdammina abyssorum* forms its tube of the larger angular fragments of quartz, felspar, magnetite, and other mineral particles. The following 37 genera and 67 species have been observed in the deposit:—

Biloculina depressa, d'Orb.
„ *irregularis*, d'Orb.
„ *ringens* (Lamk.).
„ *sphæra*, d'Orb.
Miliolina oblonga (Montag.).
„ *venusta* (Karr.).
„ *seminulum* (Linn.).
„ *circularis* (Bornem.).
„ *fichteliana* (d'Orb.).
Keramosphæra murrayi, Br.
Astrorhiza crassatina, Br.
Storthosphæra sp. (?).
Pelosina rotundata, Br.
Hyperammina vagans, Br.
Rhabdammina abyssorum, Sars.
„ *discreta*, var. *silicea*, Br.
Rhizammina algæformis, Br.
„ sp.
Saganella (?) sp.
„ (?) sp.
Reophax pilulifera, Br.
„ *nodulosa*, Br.
„ *scorpiurus*, Montf.
„ *adunca*, Br.
Bathysiphon filiformis, Sars.
Haplophragmium latidorsatum, Bornem.
Placopsilina vesicularis, Br.
Thurammina papillata, Br.
„ *compressa*, Br.
„ *albicans*, Br.
Hormosina ovicula, Br.
Ammodiscus charoides, (J. and P.).
Trochammina pauciloculata, Br.
Webbina clavata, J. and P.
Cyclammina cancellata, Br.
Verneuilina pygmæa, Egger.
Gaudryina pupoides, d'Orb.
Clavulina communis, d'Orb.
Pleurostomella brevis, Schwg.
Cassidulina subglobosa, Br.
„ *crassa*, d'Orb.
Lagena alveolata, Br.
„ *lævis* (Montag).
„ *lævigata* (Rss.).
„ *globosa* (Montag).
Nodosaria communis, d'Orb.
Cristellaria convergens, Bornem.
„ *crepidula* (F. and M.).
„ *dilute-striata*, Gümb.
Polymorphina angusta, Egger.
„ *thouini*, d'Orb.
Uvigerina pygmæa, d'Orb.
× *Globigerina bulloides*, d'Orb.
× „ *inflata*, d'Orb.
× „ *dutertrei*, d'Orb.
× „ *pachyderma* (Ehrenb.).
Pullenia sphæroides (d'Orb.).
Spirillina decorata, Br.
Truncatulina ungeriana (d'Orb.).
„ *lobatula*, (W. and J.)
„ *pygmæa*, Hantk.
Anomalina grosserugosa (Gümb.).
Pulvinulina patagonica (d'Orb.).
× „ *crassa* (d'Orb.).
× „ *micheliniana* (d'Orb.).
„ *exigua*, Br.
Rotalia soldanii, d'Orb.
Nonionina pompilioides (F. and M.).

Radiolaria. (Haeckel, Zool. Chall. Exp., vol. xviii. pt. xl.)

(*A.*) *From the surface-net gatherings.*

In striking contrast to the wealth of forms in the deep-sea deposit at this station is the uniformity of the Radiolarian surface fauna. This doubtless arises from the fact that the tow-nets were only dragged through a relatively small distance of the surface waters, whereas the deposit at the bottom represents the accumulation of forms which have fallen from the surface during an immense period of time. The absence of some species of Acantharia and Phæodaria in the deposit, when compared with their relative abundance in the surface-net gathering, is to be accounted for by the structure and composition of the skeletons, which are more readily dissolved after the death of the animal. Certain species of Acantharia and Phæodaria are the more abundant here, and these are very rich in individuals. Of the Acantharia the most abundant are *Acanthonia claparedei*, *Acanthostaurus purpurascens* and *Amphilonche lanceolata*; of the Phæodaria, *Challengeron pearceyi*, *Challengeron swirei*, *Challengeron balfouri* and *Challengeron richardsii*.

List of Species from Surface Nets.

I.—Spumellaria.

a. Sphæroidea.

Styptosphæra spongiacea, Hkl.
Acanthosphæra antarctica, Hkl.
Cromyomma perspicuum, Hkl.
Rhizosphæra trigonacantha, Hkl.
" *antarctica*, n. sp.

b. Discoidea.

Porodiscus flustrella, Hkl.
Stylodictya multispina, Hkl.
Euchitonia muelleri, Hkl.
Stylotrochus challengeri, n. sp.

II.—Acantharia.

Acanthonia claparedei, Hkl.
Acanthostaurus purpurascens, Hkl.
Amphilonche lanceolata, Hkl.
Porocapsa coronodon, Hkl.

III. Nassellaria.

Dictyospyris tetrastoma, Ehrenb.
Cyrtocalpis ovulum, Hkl.
Cornutella clathrata, Ehrenb.

IV. Phæodaria.

Dictyocha stapedia, Hkl.
Distephanus speculum, Hkl.
Autodendrum antarcticum, n. sp.
Auloscena penicillus, Hkl.
Challengeron pearceyi, Hkl.
" *swirei*, Hkl.
" *balfouri*, Hkl.
" *richardsii*, Hkl.

(*B.*) *From the ooze obtained in the trawl.*

The sediment which remains after removing the Diatoms and Foraminifera and larger mineral particles is almost pure Radiolarian ooze of a very peculiar composition. It is distinguished from all other forms of Radiolarian ooze by the fact that it is mainly composed of a few species of Sphæroidea which make up about nine-tenths of the whole mass. By far the commonest of these Spumellaria is *Cromyosphæra antarctica*, which is probably genetically related with the very similar form, *Cromyomma perspicuum*, occurring on the surface at the same station.[1] The characteristic and abundant deep-sea form *Cromyosphæra antarctica* is distinguished from the superficial *Cromyomma*, chiefly by the greater stoutness

[1] See Report on the Radiolaria, pt. i. pp. 85, 262; the figure there referred to, pl. xxx. fig. 8, represents the latter, not the former.

of the bars of its skeleton and the lack of spines on its surface. The diameter of the sphere, which consists of four concentric lattice-shells, varies between 0·15 mm. and 0·3 mm., being usually about 0·2 mm. The two inner (medullary) shells are connected with the two outer (cortical) shells by triangular bars, which have a slight spiral twist. The whole structure is very similar to that which Haeckel has figured[1] in the case of the cosmopolitan *Rhizosphæra trigonacantha*, but it is distinguished from this by the lack of external radial spines and the peculiar structure of the cortical shell, which consists of two strong clearly separated lattice-plates united by numerous radial bars; these latter are often connected together so that the cortical shell becomes spongy, whence this variety might be known as *Spongodictyum antarcticum.* Furthermore, *Cromyosphæra antarctica* appears to be connected by transitional forms with several other species in the accompanying list, as, for example, with *Spongoplegma antarcticum.*

Of the other Spumellaria the Discoidea are the most abundant, particularly the spongy forms (Spongodiscida, *e.g.*, *Spongodiscus*, *Spongotrochus*, *Stylotrochus*). Particularly noteworthy is a new genus, *Spongopyle,* not described in the Report; it is a Spongodiscid with a marginal osculum like that of the Porodiscid *Ommatodiscus,* which also occurs at this Station.

In contrast to the large number of Sphæroidea and Discoidea the Prunoidea and Larcoidea are present only as isolated specimens.

Very few species of Nassellaria are present, but among them the Botryodea, which are generally rare, are rather abundant, especially *Botryocello borealis* and *Botryopyle cribrosa.*

The most common Cyrtoidea are a few cosmopolitan forms, for example, *Cornutella clathrata, Cornutella cannulata,* and *Lithomitra lineata.*

The Acantharia are only represented in the deposit from Station 157 by a single rare species, *Pantopelta icosaspis.*

The Phæodaria are represented in this deposit by a few remarkable forms, such as *Sagenoscena penicillata, Aulosphæra bisternaria, Cannosphæra antarctica* and *Conchasma hippurites;* all these, however, are rare.

List of Species from the Deposit.[2]

I. Spumellaria.

a. Sphæroidea.

Cenosphæra solida, Hkl.
„ *papillata*, Hkl.
„ *antiqua*, Hkl.
„ *antarctica*, n. sp.
Carposphæra nobilis, Ehrenbrg.
Thecosphæra diplococcus, Hkl.
Cromyosphæra antarctica, Hkl.
Styptosphæra spongiacea, Hkl.
Spongoplegma antarcticum, Hkl.
Spongodictyon antarcticum, n. sp.
Amphisphæra neptunus, Hkl.
Stauracontium antarcticum, Hkl.
Hexaconium thexaconium, Hkl.
„ *antarcticum*, Hkl.
Acanthosphæra antarctica, Hkl.
Sphæropyle weissenbornii, Dreyer.
Prunopyle antarctica, Dreyer.
Cladococcus antarcticus, Hkl.
„ *dendrites*, Hkl.
Haliomma antarcticum, Hkl.
Actinomma pachycapsa, Hkl.

[1] Monogr. d. Radiol., 1862, Taf. xxv. figs. 1-7.
[2] I am obliged to Dr. F. Dreyer for preparing this list of Radiolarians.

Pityomma piniferum, Hkl.
Cromyomma perspicum, Hkl.
Rhizosphæra trigonacantha, Hkl.
„ *antarctica*, n. sp.

b. Prunoidea.

Cromyocarpus quadrifarius, Hkl.
Cromyatractus tetraphractus, Hkl.
Spongurus cylindricus, Hkl.
Spongocore cincta, Hkl.

c. Discoidea.

Porodiscus flustrella, Hkl.
„ *heterocyclus*, Hkl.
„ *spiralis*, (Ehrenb.)
Ommatodiscus stöhrii, Hkl.
„ *lævigatus*, Stöhr.
Stylodictya multispina, Hkl.
Rhopalastrum irregulare, Hkl.
Euchitonia muelleri, Hkl.
Spongodiscus resurgens, Ehrenb.
„ *spiralis*, Hkl.
Spongopyle osculosa, Dreyer.
Spongopyle setosa, Dreyer.
Stylotrochus antarcticus, n. sp.,
„ *challengeri*, n. sp.
Spongotrochus murrayi, n. sp.
„ *wyvillei*, n. sp.
„ *moseleyi*, n. sp.
„ *willemoesii*, n. sp.
„ *scutella*, Hkl.
„ *antarcticus*, Dreyer.

d. Larcoidea.

Stypolarcus spongiosus, Hkl.
Larcospira oliva, Hkl.

II. Acantharia.

Pantopelta icosaspis, Hkl.

III. Nassellaria.

a. Plectoidea.

Hexaplagia antarctica, Hkl.

b. Spyroidea.

Tripospyris eucolpos, Hkl.
Dictyospyris tetrastoma, Ehrenb.
„ *enneastoma*, Hkl.

c. Botryodea.

Androspyris aptenodytes, Hkl.
Botryocella borealis (Erhenb.)
Botryopyle cribrosa (Ehrenb.)
Botryocyrtis quinaria, Ehrenb.
Botryocampe inflata, Ehrenb.

d. Cyrtoidea.

Cyrtocalpis ovulum, Hkl.
Cornutella clathrata, Ehrenb.
„ *annulata*, Ehrenb.
Cornutanna orthoconus, Hkl.
Halicapsa hystrix, Hkl.
Dictyocephalus antarcticus, n. sp.
Dicolocapsa megacephala, Hkl.
Dictyophimus antarcticus n. sp.
Thercorys plutonis, n. sp.
Lithostrobus bicornis, n. sp.
Theocalyptra cornuta (Ehrenb.)
Lithostrobus cornutella, Bütschli.
Lithomitra lineata (Ehrenb.)
Eucyrtidium chrysalidium, Hkl.

IV. Phæodaria.

Aulactinium actinosphærium, Hkl.
Sagenoscena penicillata, Hkl.
Aulosphæra bisternaria, Hkl.
Aulastrum dichoceros, Hkl.
Aulodictyum hydrodictyum, Hkl.
Cannosphæra antarctica, Hkl.
Challengeria naresii, Hkl.
„ *trifida*, Hkl.
Conchasma hippurites, n. sp.

The Animals obtained in the Trawl.

In addition to the Protozoa, the following is a list of the living animals obtained in the trawl, most of which may be regarded as having been captured at or near the bottom of the ocean. Some of the species are represented by six or eight specimens, and of the remainder one to four specimens were obtained, so that altogether nearly one hundred and fifty individuals belonging to these higher orders were procured by the trawl on this occasion. When we remember that the trawl was only dragged over the bottom for a very short distance, and that the length of the beam was only 12 feet, we can form some idea of the abundance of life existing in this region at a depth of two and a half miles. It will be observed that nearly all these animals are new to science, those with n. sp. after them being described for the first time in the *Challenger* Reports; many of the species were again found in other localities. The study of this station alone shows what large contributions the *Challenger* Expedition has made to our knowledge of the conditions of the deep sea, the geographical and bathymetrical distribution of life, and the general physics of the globe.[1]

Hexactinellida (Schulze, Zool. vol. xxi. pt. 53).
Balanella pipetta, n. g., n. sp.
Holascus polejaevii, n. g., n. sp.

Monaxonida (Ridley and Dendy, Zool. vol. xx. pt. 50).
Cladorhiza moruliformis, n. sp.

Pennatulida (Kölliker, Zool. vol. i. pt. 2).
Umbellula carpenteri, n. sp.

Actiniaria (Hertwig, Zool. vol. vi. pt. 16).
Cereus spinosus, n. sp.
Corallimorphus objectus, n. g., n. sp.

Madreporaria (Moseley, Zool. vol. ii. pt. 7).
Bathyactis symmetrica, n. g., n. sp.
Leptopenus discus, n. g., n. sp.

Hydroida.
Stephanoscyphus simplex, Allman, MS.

Medusæ (Haeckel, Zool. vol. iv. pt. 12).
Atolla wyvillei, n. sp.

Asteroidea (Sladen, Zool. vol. xxx. pt. 51).
Hymenaster latebrosus, n. sp.
Lonchotaster forcipifer, n. sp.
Hyphalaster planus, n. g., n. sp.

Ophiuroidea (Lyman, Zool. vol. v. pt. 14).
Ophiacantha cosmica, n. sp.
Ophiocten amitinum, n. sp.
Ophiocymbium cavernosum, n. g., n. sp.
Ophioglypha fraterna, n. sp.
„ *lienosa*, n. sp.
„ *loveni*, n. sp.

Echinoidea (Agassiz, Zool. vol. iii. pt. 9).
Pourtalesia carinata, n. sp.
„ *ceratopyga*, n. sp.
Spatangocystis challengeri, n. sp.
Genicopatagus affinis, n. sp.

Holothurioidea (Théel, Zool. vol. iv. pt. 13; vol. xiv. pt. 39).
Benthodytes sordida, n. sp. (13).
Elpidia ambigua, n. sp. (13).
„ *purpurea*, n. sp. (13).
Peniagone horrifer, n. sp. (13)
Oneirophanta mutabilis, n. sp. (13).
Psychropotes longicauda, n. sp. (13).
Psychropotes longicauda, var. *monstrosa*, n. (13).
Psychropotes longicauda, var. *fuscopurpurea*, n. (13).
Scotoplanes globosa, n. sp. (13).
„ *robusta*, n. sp. (13).
Pseudostichopus villosus, n. sp. (39).

Entozoa (Linstow, Zool. vol. xxiii. pt. 71).
Prothelmins profundissima, n. g., n. sp.

Gephyrea (Selenka, Zool. vol. xiii. pt. 36).
Phascolion lutense, n. sp.

Annelida (M'Intosh, Zool. vol. xii. pt. 34).
Lætmonice producta, Grube, var. *wyvillei*, n.
Lætmonice producta, var. *benthaliana*, n.
Maldanella antarctica, n. sp.
Nothria armandi, n. sp. (fragment).
Pista abyssicola, n. sp. (fragment).

[1] In carrying on the work referred to in this paper, I have of course been greatly assisted by the various contributors to the *Challenger* Reports, especially by my colleague, Professor Renard, and by my assistants in the *Challenger* office, Mr. Chumley, Mr. Pearcey, Mr. Ross, and Mr. Dawson.

Praxilla abyssorum, n. sp.
Trophonia wyvillei, n. sp.

Ostracoda (Brady, Zool. vol. i. pt. 3).
? *Bairdia bosquetiana*, Brady.
Macrocypris similis, n. sp.
Cythere dasyderma, n. sp.
„ *dictyon*, n. sp.
Krithe producta, n. sp.
Cytheropteron mucronalatum, n. sp.

Cirripedia (Hoek, Zool. vol. viii. pt. 25).
Scalpellum improvisum, n. sp.

Isopoda (Beddard, Zool. vol. xvii. pt. 48).
Eurycope spinosa, n. sp.

Schizopoda (Sars, Zool. vol. xiii. pt. 37).
Boreomysis scyphops, Sars.
Gnathophausia gigas (Suhm).

Macrura (Zool. vol. xxiv. pt. 52).
Hymenodora mollicutus, n. sp.

Pycnogonida (Hoek, Zool. vol. iii. pt. 10).
Phoxichilidium pilosum, n. sp.

Lamellibranchiata (Smith, Zool. vol. xiii. pt. 35).
Lima (*Limatula*), n. sp. One valve only with the umbo broken away; hardly sufficient to describe.
Leda, n. sp. Probably a young shell.
Lyonsiella papyracea, n. sp.
Neæra meridionalis, n. sp. (fragment).
Silenia sarsii, n. sp.
? *Kellia*, sp. Two valves with damaged apices, making it impossible to determine with certainty its generic position.
—— ? Two very minute shells (mere fry) beyond identification either generically or specifically.

Gasteropoda (Watson, Zool. vol. xv. pt. 42).
Dentalium leptoskeles, n. sp.
Pleurotoma (*Surcula*) *lepta*, n. sp.

Cephalopoda (Hoyle, Zool. vol. xvi. pt. 44).
Eledone rotunda, n. sp.

Polyzoa (Busk, Zool. vol. x. pt. 30; vol. xviii. pt. 50).
Bugula bicornis, n. sp.
Caberea darwinii, Busk (?).
Cellepora bicornis, n. sp.
Idmonea marionensis, Busk (?).
Onchopora sinclairii, Busk.
Salicornaria magnifica, n. sp.

Tunicata (Herdman, Zool. vol. vi. pt. 17).
Abyssascidia vasculosa, n. sp.
Styela sericata, n. sp.

Fishes (Günther, Zool. vol. xxii. pt. 57).
Bathylagus antarcticus, n. g., n. sp.
Macrurus armatus, Hector.
„ *filicauda*, n. sp.
Scopelus antarcticus, n. sp.

PROCEEDINGS OF THE ROYAL SCOTTISH GEOGRAPHICAL SOCIETY.

A SPECIAL MEETING of the Society was held on the 1st of July in the Hall of the Merchant Company, Edinburgh, to hear the paper from Dr. Fridtjof Nansen which we publish this month. Dr. Nansen was very cordially received. Professor James Geikie, Vice-President of the Society, was in the chair. Dr. John Murray moved, and Dr. Alexander Buchan seconded, the vote of thanks to Dr. Nansen for his interesting and valuable address.

On the following evening, Dr. Nansen was entertained at Dinner by the Royal Society Club. Dr. Murray presided.