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eye has never penetrated. Friendly, very friendly are the Japanese with whom, in his day's work, the foreign resident mingles—pleasant, very pleasant is their intercourse. But there is no real intimacy, no heart to heart converse, no chumming together. In his Japanese friend's house the foreigner is an honoured guest. The deep springs of Japanese family life are hid from his view. Slight indications there may be occasionally that, though all is smiling, all is not smooth. Now and again social earthquakes occur in which a wife possibly is divorced for a mere caprice, but this is rare in the better ranks of society. To the stranger the good-humoured affability of a Japanese may often seem to be the outcome of a frank and confiding nature. But for keeping his own counsel there is not his superior on earth. Rarely does the countenance display the inner feeling of the soul. It is inscrutable. If not expressionless in repose, it is smiling. Then, his very politeness may compel him to hide a disagreeable truth, or at the utmost to express it in very indirect language. His native tongue, with its elaborate impersonal forms of address, and even of command, reflects the whole social sentiments of the people. It abounds in double negatives, in honorifics to the person addressed, in deprecatory phrases concerning self or self's belongings. To behave so as not to grieve others, to keep personal cares in the background, and to sympathise with others in their joys, are rules of conduct that find many curious illustrations and are sometimes strangely misunderstood by the foreigner. But there might be no end to such reflections. In a broad sense, the Japanese are like ourselves, very human. They are probably more callous to suffering and less susceptible to pain, and are not so overweighted with the responsibilities of life. But after a prolonged residence in the country, when the novelty has faded, and only a few characteristics retain their pristine freshness, the impression remains on the mind that to the Japanese, as to ourselves, life is grave. Their history abounds in tragic tales of heroism. The tragic still is, and, let us hope, the heroic too.

DEEP-SEA DEPOSITS.¹

DURING the voyage of the *Challenger* the special charge of the samples of mud and ooze obtained from the sea-bottom was intrusted to Mr. John Murray, and one of the reports which Sir Wyville Thomson presented to the Royal Society during the cruise contains the first-fruits of his study of these specimens. During the sixteen years that have passed since that report was penned the subject has been gradually evolved from small beginnings, and its latest development is to be seen in the volume before us, which is second in interest to none of the long series containing the results of that memorable voyage. To give as

¹ *Report on the Scientific Results of the Voyage of H.M.S. "Challenger," during the years 1873-76. Deep-Sea Deposits.* By John Murray, LL.D. and Rev. A. F. Renard, LL.D. London, 1891.

accurate an idea of its contents as is possible within the limits of a few pages is the object of the present article.

The volume opens with a brief historical sketch of the progress of our knowledge of oceanography in general, and of the materials composing the sea-bottom in particular; and this is followed by a chapter describing the sounding machines, dredges, and other apparatus employed in collecting samples of deep-sea deposits, as well as of the routine method of examination and description which was found on the whole to be most suitable. First, the ooze or mud was examined microscopically both in the wet and dry conditions, special attention being paid to its physical properties; not the least important of these being colour, which often discriminates immediately between organic and inorganic deposits. This preliminary investigation was followed up by a more searching inquiry under the microscope, the deposit being first separated into portions containing particles of similar dimensions and specific gravity by a process of repeated decantation. In a certain number of typical cases the whole of the organisms present in the sample were isolated and their species determined.

The next process was the determination of the percentage of carbonate of lime, which was accomplished by decomposition of the deposit by hydrochloric acid in a carbonic acid apparatus in the usual way. By the previous inspection with the microscope the percentage composition of this carbonate of lime, as regards (1) Pelagic Foraminifera, (2) Bottom Foraminifera, (3) other organisms, was estimated. The insoluble residue was next examined, first as a whole and then after fractional decantations conducted upon a regular system. Three different classes of substances were separated by this process, which are termed respectively (1) Siliceous Organisms, (2) Minerals, (3) Fine Washings. Samples of each of these were mounted for examination under the microscope.

The second chapter is occupied almost entirely by a tabular statement of the results of this treatment as applied to the deep-sea deposits collected by the *Challenger*. These tables occupy more than 100 pages, and contain the bare facts upon which the greater part of our knowledge of these matters is based. It is impossible to exaggerate their importance, for they are, as a matter of fact, the only full analyses of a series of such deposits that have ever been published.

Chapter III. treats of "Recent Marine Formations, and the Different Types of Deep-Sea Deposits; their Composition, Geographical and Bathymetrical Distribution," and it is necessary to state that, in the compilation of this and succeeding sections of the work in which Messrs. Murray and Renard summarise the results of their labours, their conclusions are based not merely upon the *Challenger* collections. They have had the inestimable advantage of examining the specimens gathered together by practically all the deep-sea expeditions which have hitherto been despatched, and hence their generalisations rest upon a very wide basis indeed. The nature of the sea-bed as shown by every available sounding was marked down upon a map prepared on Lambert's equal-area¹

¹ For particulars regarding this projection see this *Magazine*, vol. ii. p. 549, 1886.

projection, the boundaries of the different kinds of deposit were marked out, and then the area occupied by each was obtained by means of the planimeter.

Deep-sea deposits admit of a two-fold classification; from the point of view of their relative geographical and bathymetrical position they may be arranged in three groups: (1) Deep-Sea, (2) Shallow-Water, (3) Littoral; whilst with regard to their composition as well as geographical and bathymetrical range they may be divided into two categories: (1) Pelagic, (2) Terrigenous. These facts are indicated in the following table, which also gives the names proposed for the different kinds of deposits:—

MARINE DEPOSITS.

1. DEEP-SEA DEPOSITS, beyond 100 fathoms.	<div>Red Clay Radiolarian Ooze Diatom Ooze Globigerina Ooze Pteropod Ooze Blue Mud Red Mud Green Mud Volcanic Mud Coral Mud</div>	1. PELAGIC DEPOSITS, formed in deep water removed from land.	
2. SHALLOW-WATER DEPOSITS, between low-water mark and 100 fathoms.	Sands, gravels, muds, etc.	2. TERRIGENOUS DEPOSITS, formed in deep and shallow water close to land-masses.	
3. LITTORAL DEPOSITS, between high- and low-water marks.	Sands, gravels, muds, etc.		

The RED CLAY occupies the greater depths of the oceans remote from land, covering over 51 million square miles, or more than one-fourth of the total area of the globe, and is probably the most characteristic of the deep-sea deposits: it is soft, plastic, and greasy to the touch, and presents, in fact, all the physical and chemical peculiarities of clays. Its basis appears to be hydrated silicate of alumina, and the view is adopted in the work that it has arisen from the decomposition of pumice and other volcanic materials spread over the floor of the ocean by aerial or submarine eruptions. Its most remarkable peculiarity is its almost total lack of carbonate of lime.

The RADIOLARIAN OOZE, like the Red Clay, is found only in the greatest depths of the ocean; it consists, in fact, of a basis of Red Clay, with a considerable but varying proportion of Radiolarian skeletons mixed with it, so that no precise line of distinction can be drawn between the two species of deposit. The material brought up from the deepest sounding made by the *Challenger*, which took place between Papua and Japan, was a very typical example of this kind of ooze. It contained 80 per cent. of siliceous organisms and but little clay: 338 species of Radiolaria have been described from it. Hitherto no deposit of this kind has been met with in the Atlantic Ocean, and in the opinion of Messrs. Murray and Renard it is unlikely that it will be found there.

The DIATOM OOZE, characterised by containing a considerable quantity of the frustules of diatoms, was found by the *Challenger* at only

five stations, all situated in the Antarctic region; it has since been discovered by the *Tuscarora* in the North Pacific, near the Kurile Islands. The purest specimens when dry are white and flour-like, resembling the Diatomite of fresh-water origin, though there are usually mineral particles present in sufficient quantity to give it a gritty feeling when passed through the fingers. This deposit appears to cover an area of some 10 million square miles in a zone of varying width surrounding the South Polar regions, and an undefined area in the North Pacific.

The GLOBIGERINA OOZE was probably the first of all the deep-sea oozes to be made known to the scientific world, for it appears that specimens of it were obtained by Lieut. Berryman of the U.S. Navy, and described by Ehrenberg and Bailey so long ago as 1853. It is defined as containing over 30 per cent. of carbonate of lime, principally made up of the dead shells of pelagic Foraminifera. It may be white, rose-red, or yellowish in colour, according to the nature of its inorganic constituents; when dry it is generally pulverulent. The carbonate of lime may be as much as 96·8 per cent. of the deposit, but on the average it is 64·47 per cent., the amount diminishing as the depth increases. The residue of the deposit, after the calcareous matter has been removed by acids, "consists of matters similar to those met with in a Red Clay, and having the same origin." Globigerina Ooze occupies all the medium depths of the ocean at a distance from land, especially where there are warm surface currents, its extension towards the north being only in the track of the Gulf Stream.

The PTEROPOD OOZE differs from the last-named deposit only in the larger proportion which it contains of shells of mollusca, such as Pteropods and Heteropods. It is found in its most characteristic form on the central ridges of the Atlantic, at depths not exceeding 1400 fathoms. The deposits laid down on the slopes of the continents at similar depths also contain considerable quantities of these Molluscan shells, but the distinctive features of the deposit are masked by the quantity of mineral particles which reach it from the shore.

We may now turn to the Terrigenous deposits, or those of which the materials are derived from the land. The formations laid down between the tide-marks, and in depths less than 100 fathoms, are not here considered; the remainder occupy an area of over 18 million square miles. These deposits are known as "muds," in contradistinction to the pelagic group, which have received the name of "oozes."

The BLUE MUD is by far the most widely distributed, occupying about 14 million square miles. When fresh it is of a blue or slate colour, with a reddish upper layer in contact with the water. The blue colour is due to the presence of organic matter which reduces the iron oxides present to the ferrous state, the red to ferric oxide produced by superficial oxidation. The mineral particles are derived, generally speaking, from the nearest land, and vary greatly in size according to their distance from the shore. Quartz particles are specially abundant.

The RED MUDS are found along the coast of Brazil, and owe their peculiar colour to the quantity of ochreous matter carried into the sea by

the Amazons and Orinoco, the amount of putrescible organic matter present being insufficient to reduce them to the state of blue mud. Similar deposits are reported to occur in the Yellow Sea, near the mouth of the Yang-tse-Kiang.

The GREEN MUDS and sands owe their special character to the mineral known as glauconite, which is formed *in situ* in the water, and deposited in the interior of shells. It occurs along bold rocky shores where but few rivers open into the sea.

The VOLCANIC and CORAL MUDS, as their names indicate, are found surrounding the oceanic islands of their respective categories, and consist of the detritus obtained from them.

The distribution of these deposits over the surface of the sea-bottom is exhibited in a map, in the preparation of which not merely the *Challenger* collections but also those of other expeditions have been utilised, in the manner indicated above.

The following table shows the estimated area occupied by each deposit, along with the percentage of carbonate of lime it contains, and the mean depth at which it is found.

	Mean Depth in Fathoms.	Mean percentage of Ca CO ₃ .	Area in Square Miles.
Red Clay,	2730	6.70	51,500,000
Radiolarian Ooze,	2894	4.01	2,290,400
Diatom Ooze,	1477	22.96	10,880,000
Globigerina Ooze,	1996	64.53	49,520,000
Pteropod Ooze,	1044	79.26	400,000
Coral Mud,	740 }	86.41	2,556,800
Coral Sand,	176 }		
Blue Mud, etc.,	1016	19.20	16,050,000

The obvious diminution of the amount of calcareous matter in the pelagic deposits as the depth increases is one of the most important facts elicited by the expedition.

The next section of the Report treats of the "Materials of Organic Origin in Deep-Sea Deposits," and we are informed in the preface that it is mainly the work of Dr. Murray. After some remarks on the relations of the marine fauna and flora in general, we meet with a statement of the chemical reactions which are believed to go on between the dead organic materials and the sea-water. This is so concisely expressed, and the subject is one of such importance, that we cannot do better than quote the passage referring to it *in extenso*.

"The analyses of sea-water inform us that earthy and alkaline sulphates make up a very large part of the total sea-water salts. When these are exposed to the action of carbon, or of organic matter, which, of course, contains carbon, the sulphates are reduced, and sulphides formed; the carbon unites with the oxygen, formerly combined with the metal and metalloid, to form carbonic acid. Thus for every molecule of sulphate decomposed in this way, one molecule of sulphide and two molecules of carbonic acid are formed. As, practically, all the carbon of

marine organisms must thus ultimately be resolved into carbonic acid, the quantity of that acid produced in this way must be enormous, and cannot but exert a great solvent action not only on the dead calcareous structures, but also on the minerals in the muds on the floor of the ocean. Were these reactions to end at this stage, the bottom of the sea would soon become so poisoned by sulphides as to be unfit to support either animal or vegetable life. As soon, however, as the sulphides are produced, the carbonic acid, which is formed at the same time, decomposes the sulphides, forming earthy and alkaline carbonates, sulphuretted hydrogen being given off; the latter passing into the circumambient water is oxidised into sulphuric acid, which in turn decomposes the carbonate of lime dissolved in the sea-water or existing in the form of calcareous shells, sulphate of lime being finally formed. The nitrogenous or albuminoid matters present in animal tissues and fluids break up ultimately, by a series of complex reactions, into ammonia and nitrogen; the former is either liberated, or, combining with the carbonic acid, passes into solution as carbonate of ammonia, or becomes oxidised into nitrates. Further, the sulphur and phosphorus are given off in combination with hydrogen, becoming finally oxidised into sulphuric and phosphoric acids, which, decomposing the alkaline and earthy carbonates present in sea-water, give rise to sulphates and phosphates.

Murray and Irvine have shown by direct analyses that ammoniacal salts, formed as indicated by the above reactions, are everywhere present in the ocean, due to the decomposition of albuminoid matter, ammonia being always one of the products."

In spite of the opinion which has been expressed to the contrary, putrefaction appears to go on even at the greatest depths.

The different kinds of organisms are then discussed in some detail. The curious Cocoliths and Rhabdospheres are regarded as of vegetable origin; in the case of the Foraminifera only about a score of species are mentioned as belonging to the surface; yet so numerous are they individually as to make up 90 per cent. of the bottom deposit over which they live. The shells of crustacea are almost entirely absent from the deep sea, nothing having been found of the higher forms except the tips of the claws of crabs. Very remarkable, considering the shoals of fish that inhabit the ocean, is the scarcity of their remains; with the exception of otoliths and teeth, fish bones were dredged up on only three or four occasions. The sharks' teeth from the Red Clay of the Pacific, some of which belong to species now extinct, have already been often described, as also the ear-bones of whales, which occur along with them.

Of the organisms with siliceous skeletons the most important are Diatoms, Radiolarians, and Sponge-spicules, each of which is separately considered. With regard to the general questions of the relations of silica to marine life, the two most important matters advanced are, first, the suggestion that silica in suspension may be available for the use of animals as well as silica in solution, and, second, that siliceous skeletons are to some extent soluble in sea-water, which accounts for the absence of Diatom frustules and Radiolarian skeletons from places where we should otherwise expect to find them.

Chapter V. treats of the "Mineral Substances in Deep-Sea Deposits," which fall into three categories: (1) those derived from the crust of the earth; (2) those derived from extra-terrestrial space; and (3) those formed

in situ on the sea-bottom. Of the first class drifted pumice is the most widespread, and its importance as the origin of the greater part of the Red Clay has been already alluded to. The second group contains those minute globular magnetic bodies commonly known as "cosmic spherules." Their physical and chemical characters are fully described and the reasons discussed for attributing to them a meteoric origin. Though extremely minute in quantity, they are of great interest from their bearing on astronomical science.

The third group, comprising the minerals formed at the bottom of the sea, is the subject of a special chapter. Of these the most important are the manganese nodules and the glauconite casts. With regard to the former, the view is defended that they are concretions round nuclei of various kinds, the manganese being derived chiefly "from the decomposition of the more basic volcanic rocks and minerals with which the nodules are" associated. The glauconitic grains appear to be formed in the interior of calcareous shells, whilst the larger and more irregular ones are believed to have grown upon a nucleus which was originally so produced.

An account is also given of the minute crystals of the mineral Phillipsite, found in the deepest parts of the oceans, and apparently due to the decomposition of volcanic rocks.

The body of the Report is followed by three appendices, the first of which explains the signs used in an extensive series of maps and charts illustrating the soundings made during the cruise; the second is an elaborate analysis of the manganese nodules, with special reference to the occurrence in them of the rarer elements, by Dr. John Gibson; whilst the third contains a large number of different analyses by Professor Brazier, the late Professor Dittmar, Dr. Sipöcz, and other chemists.

In addition to the maps and charts, the monograph is illustrated by twenty-nine plates, which for beauty of execution are not surpassed by any that have appeared in earlier volumes of these Reports. It is impossible to give them higher praise than this.

In concluding this brief summary it may be pointed out that the volume before us contains the first attempt which has yet been made to deal on broad lines with the vast subject of submarine geology. Of the importance of such a work to the whole scientific world it is scarcely needful to speak. It forms a rich storehouse of facts which cannot be neglected by those who study either the history of the earth in the past, and the changes which are taking place in it at present, or the general biological problems involved in the relation of marine animals to their environment.

WILLIAM E. HOYLE.