IV. *On the Composition of Sea-water in the different parts of the Ocean.* By Georg Forchhammer, *Professor at the University, and Director of the Polytechnic Institution at Copenhagen. Communicated by the President.*

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In the year 1843 a friend of mine, Mr. Ennis of Falmouth, sent me some bottles of sea-water from the Mediterranean, which I subjected to a chemical examination, a work which induced me to collect what other chemists had determined about the constitution of the water of the great Ocean. This labour convinced me that our knowledge of the composition of sea-water was very deficient, and that we knew very little about the differences in composition which occur in different parts of the sea.

I entered into this labour more as a geologist than as a chemist, wishing principally to find facts which could serve as a basis for the explanation of those effects that have taken place at the formation of those voluminous beds which once were deposited at the bottom of the ocean. I thought that it was absolutely necessary to know with precision the composition of the water of the present ocean, in order to form an opinion about the action of that ocean from which the mountain limestone, the oolite and the chalk with its flint have been deposited, in the same way as it has been of the most material influence upon science to know the chemical actions of the present volcanos, in order to determine the causes which have acted in forming the older plutonic and many of the metamorphic rocks. Thus I determined to undertake a series of investigations upon the composition of the water of the ocean, and of its large inlets and bays, and ever since that time I have assiduously collected and analyzed water from the different parts of the sea. It is evident that it was impossible to collect this material in a short time, and without the assistance of many friends of science, and I most gratefully acknowledge how much I am indebted to many distinguished officers of the Danish and British Navy, as well as to many private men, who were all willing to undertake the trouble carefully to collect samples of sea-water from different parts of the ocean, both from the surface and from different depths. I shall afterwards, when giving the particular analyses, find an opportunity to mention the name of each of those to whom I am indebted for my material.

While I was thus occupied for a space of about twenty years, another series of experiments closely allied to my work was commenced in England, and has partly been published under the able and scientific superintendence of Rear-Admiral FitzRoy. This most important series of observations regards the specific gravity of sea-water from the most different parts of the globe; it comprehends a much more numerous series than my observations, but I trust that it will not make my work superfluous, but that both these investigations will supplement each other. By the kindness of Admiral FitzRoy I am able to compare the instruments which are used by the British Navy with my chemical analyses, and thus to obtain a comparison between both series.

I have at different times found an opportunity to publish several parts of my observations, and in 1859 I collected what had been done up to that time in an academical treatise in the Danish language*. Since that time I have obtained numerous samples of sea-water, principally from places which my previous examination had not reached. In this new form, and greatly augmented by new facts, I permit myself to lay it before the illustrious scientific society of a nation to whose navigators I owe so great a part of the material for my inquiries. This part contains an enumeration of the elements which hitherto have been ascertained to exist in the water of the ocean, and an explanation of the methods used to show their presence and to determine their quantity. It contains a determination as complete as possible of the distribution of the saline substances at the surface of the different parts of the sea, and in the different depths at the same place.

On the Elements which occur in the Water of the Ocean.

The elements which occur in greatest quantity in sea-water have been long known, and chlorine, sulphuric acid, soda, magnesia, and lime have for more than a century past been considered as its essential parts. In our century iodine, bromine, potash, silica, phosphoric acid, and iron have been discovered in sea-water, and the latest inquiries, my own included, have brought the number of elements occurring in sea-water up to twenty-seven.

Next to direct analyses of sea-water, the analysis of sea-weeds, and of animals living in the sea, offers us precious means of determining those elements which occur in so small a quantity in sea-water, that it hitherto has been impossible to ascertain their presence in the water by chemical tests. It is now well known that the organic beings collect substances which are necessary for their existence, and thus offer the means to the chemist of ascertaining that these substances were present in the medium in which the organisms lived, and from which they collected their food. As to the plants of the sea, the whole fucoid tribe derive the substances of which they consist from the surrounding sea-water and from the air with which they are in contact, but not from the soil on the bottom of the sea, since that part of them which generally is called their root is no root at all, and is not qualified to extract food from the soil and stones to which it adheres. Even those marine plants which do not belong to the fucoid tribe, as, for instance, the *Zostera marina*, and which have a real root, that may extract food from the soil, will most probably extract the great quantity of mineral elements which they contain mostly from the surrounding sea-water. As to the animals that live in the sea, they derive their substance either from the sea-water itself, or from plants that are

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* Om Söevandets bestanddele og deras Fordeling: Havet. af G. Forchhammer, Professor ved Kjobenhavns Universitet.

nourished by sea-water, or from other animals that live upon sea-weeds, thus deriving their whole mineral substance either directly or indirectly from the sea. I have availed myself of the means which the organisms of the sea furnish, to determine a great number of elements that thus must exist in solution in sea-water.

As to this great number of elements contained in the sea-water, we might ask one question, which is of great importance for the history of the earth, viz. how all these elements got into the sea, whether they were in the original sea, or subsequently got into the sea, where they are now slowly accumulating. When we consider that the sea constantly loses a great quantity of pure water by evaporation, and that a large part of this water falls on the land, dissolves a number of substances from it, and carries them at last into the sea, where they constantly would increase in quantity if it were not for its organisms which deprive it again of them, we may well suppose that these two effects, of which the one acts to increase, and the other to diminish the quantity of mineral substances in sea-water, are pretty equal, and leave the sea unchanged. I will, however, not dwell upon these mutual chemical decompositions and combinations, which, partly depending upon organic life, partly upon inorganic mechanical and chemical forces, play such a great part in the changes of the earth, but I hope at some future time to find leisure to publish my investigations in this branch of the history of the earth.

The elements which hitherto have been found in sea-water are,—

1. *Oxygen.*—Besides that oxygen which is a constituent part of water, and other compounds that occur in the sea, such as the sulphates, phosphates, carbonates, and silicates, it occurs in a free uncombined state, absorbed by the water itself. It plays a very material part in the small but constant changes which take place in the sea-water, and whose general effects are that the organic substances dissolved in it are changed into carbonic acid and water. This effect takes place principally near the surface, and decreases with increasing depth; and water from the deeper parts of the sea is able to destroy the colour of a greater quantity of the hypermanganate of potash than that from the surface, which again shows that there is more organic matter undestroyed in the deep sea.

2. *Hydrogen.*—Besides the hydrogen which belongs to the composition of water, it occurs in the organic substances and in the ammonia which are dissolved in sea-water.

3. *Chlorine.*—Next to the elements of water chlorine is the element which occurs in greatest quantity in sea-water, and has from the earliest times been recognized as such.

4. *Bromine* has been long known as an essential part of the sea, easily recognized in the residue from the evaporation of sea-water after the crystallization of the greater part of the chloride of sodium.

5. *Iodine.*—This substance is well known to have been the first element in sea-water discovered not directly, but by the analysis of the ashes of fucoidal plants, which by organic power had collected and concentrated it from sea-water.

6. *Fluorine.*—DANA long ago showed that fluorine occurs in the lime of corals, where

its presence may be ascertained with great facility. To prove directly its existence in sea-water, I evaporated 100 lbs. of it taken in the Sound near Copenhagen, and when it was so much condensed that the salt began to crystallize, I precipitated the whole by an excess of ammonia, washed the precipitate, and dissolved in muriatic acid. It was now again precipitated by ammonia, and the precipitate boiled with a solution of muriate of ammonia. The washed precipitate weighed now 3·104 English grains, and was divided into two parts, of which one was heated in a small platinum crucible with sulphuric acid. The vapours etched glass. The other part was distilled in a bent glass tube with sulphuric acid, and the vapour condensed in a solution of ammonia. The vapours etched the glass tube, and when the ammoniacal liquor was evaporated and the salt dissolved, silica remained. With much greater facility the fluorine was shown in the stony matter deposited at the bottom of the boilers of the Transatlantic steamers, of which I owe samples to the late Dr. G. Wilson of Edinburgh, who likewise discovered fluorine in sea-water.

7. *Sulphur.*—This element occurs in considerable quantity in sea-water combined with oxygen as sulphuric acid, forming salts with baryta, strontia, lime, and magnesia. In pure sea-water, or in such sea-water as only contains a very small quantity of organic matter, no decomposition of the sulphates takes place, and I have kept sea-water for many years in well-corked bottles without the least alteration. Near the shores and at the mouth of great rivers, where considerable quantities of organic matter are washed into the sea, it is easily decomposed, particularly if it is kept in bottles. This decomposition shows itself always by the production of sulphuretted hydrogen. Water from the polar regions is very subject to decomposition, probably on account of a greater quantity of organic matter than in water from lower latitudes. It is, however, very difficult to assign all the different causes which may produce decomposition of sea-water. All the water which was brought by the Swedish Spitzbergen Expedition in bottles from the polar sea was decomposed, and emitted sulphuretted hydrogen when the bottles were opened, while all the water brought from the same sea by the same Expedition in tubes of glass, hermetically closed by melting, was undecomposed. Hypermanganate of potash is the best test for the sulphuretted hydrogen of such water, its colour is instantaneously destroyed by the water, and sulphuric acid is formed again. The quantity of sulphuretted hydrogen formed in such water differs greatly, and depends, at least partly, upon the quantity of organic matter contained in it. Water from the Mediterranean is very subject to this kind of decomposition; but the greatest quantity of sulphuretted hydrogen which I have met with in any sample was found in water which I owe to Admiral Washington, and which had been taken by Captain Prevost of the 'Satellite', under 35° 46′ S. lat. and 52° 57′ W. long., off the east coast of South America, and not very far from the mouth of the Rio de la Plata; 3000 grains of this water destroyed the colour of 455 drops of a solution of hypermanganate of potash, of which the same quantity of ordinary sea-water only bleaches four to six drops*.

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* This test has only a relative value in comparing different kinds of water, the quantity of oxygen required for complete oxidation being proportional to the quantity of hypermanganate destroyed.

In this kind of decomposition, where sulphuretted hydrogen is formed, the organic matter is changed into carbonic acid and water, while the oxygen which this change requires is taken from the sulphates, and the sulphuret thus formed takes its oxygen again from the hypermanganate. Thus the result of the series of decompositions is the revival of the same sulphate with which it began, and the formation of carbonic acid and water from the organic matter which was present. In the second case, where the hypermanganate directly oxidizes the organic matter, the same quantity of oxygen must be used, and the same products are obtained. In both cases the oxygen is ultimately derived from the hypermanganate. This reasoning supposes that no oxygen from the atmosphere is absorbed, and no sulphuretted hydrogen has escaped during the operations. The absorption of oxygen is prevented by the cork of the bottle, but when it is opened some sulphuretted hydrogen certainly will escape, and we may conclude that in the cases where sulphuretted hydrogen is formed, there has been a little more organic matter than the hypermanganate indicates.

This fermentation of the sea-water occasions of course a loss of sulphuric acid, and makes the analysis in some degree inaccurate. The greatest loss of sulphuric acid which I have observed was in the case of the water from the 'Satellite' above mentioned, where the proportion to chlorine was found to be 9·13:100, while the mean proportion is 11·94:100, thus about one-seventh of the sulphuric acid was decomposed. It is very probable that this great quantity of organic matter is owing to the water of the Rio de la Plata, because the water contained only 17·721 chlorine, while the mean number for that region is 19·376, which seems to prove a considerable admixture of river-water. I may here also mention a curious instance where no decomposition had taken place, although the circumstances seemed to be very favourable for it. The sample had been taken by the late Sir JAMES ROSS in 1841, at 77° 32′ S. lat., in the neighbourhood of the great ice-barrier, and it was marked "Sea-water containing animalculæ." It was very muddy when I opened the bottle, but had not the least smell of sulphuretted hydrogen. Tested without being filtered, 1000 grains bleached 180 drops of the hypermanganate; when filtered the same quantity bleached 39 drops. It contained thus a great quantity of organic matter. The quantity of chlorine was 15·748, which proves that it was much diluted, probably by the melted ice from the barrier; the proportion of sulphuric acid to chlorine was 11·65 : 100, which approaches pretty near to the normal proportion. It had been about twenty years in the bottle when I analyzed it, and the cork was sound. It is difficult to conceive why this water had not suffered any decomposition.

8. *Phosphorus.*—This element, in combination with oxygen, is a never failing part of sea-water, which remains as phosphate of lime when the water is evaporated to dryness and the salts remaining dissolved in boiling water. The small quantity of insoluble matter which remains consists of phosphate of lime, sulphates of baryta and of strontia, fluoride of calcium, carbonate of lime, and silica. When this mixed substance is heated with muriatic acid, filtered, and tested with molybdate of ammonia, phosphoric acid will

always be found; or when the insoluble remainder from evaporation is heated in a glass tube with potassium, it will, when breathed upon, emit the smell of phosphuretted hydrogen.

9. *Nitrogen* occurs in sea-water combined with hydrogen as ammonia, and its presence may be shown by mixing sea-water with a solution of baryta, and distilling the mixture in a glass retort. In the distilled portion ammonia may be shown by adding some drops of nitrate of protoxide of mercury, which will form grey clouds, or by muriatic acid and chloride of platinum, which, when carefully evaporated, will leave the well-known yellow salt insoluble in alcohol. It can hardly be doubted that this ammonia is partly formed by the living animals of the sea, which exhale ammonia, and partly by the putrefaction of their dead bodies. We might ask why we find so small a quantity of ammonia, the causes for its formation being so general; but it is well known that plants will absorb it, and that the circulation of nitrogen in the sea is between sea-water, plants, and animals, as it is on the dry land between soil, plants, and animals.

10. *Carbon* occurs always in the water of the sea, partly as free carbonic acid, partly, but in very small quantities, as carbonate of lime, partly in combination with oxygen, hydrogen, and nitrogen as organic matter, derived from the destruction of the numerous organic beings that live in the sea. It is by the oxidation of these substances that the sulphates of sea-water are decomposed, and that the hypermanganate of potash is bleached when boiled with sea-water; and it is owing to these substances that all sea-water disoxidizes the peroxide of iron either to protoxide or to sulphuret, and that all ferruginous clay or sand deposited in deep sea has a dark colour.

11. *Silicium.*—Silica is found in the insoluble remainder from the evaporation of sea-water when the salts are dissolved in water. It can be separated from the phosphates and fluorides by dissolving in weak muriatic acid, when it remains undissolved along with small quantities of sulphate of baryta and strontia. In this state it is easily recognized by the blowpipe. In the Sponges it is collected in great quantity; and when the large cyathiform sponge from Singapore is calcined, it leaves a skeleton which retains the original form and size of the sponge, and consists almost entirely of silica, the large pores of it being lined with oxide of iron, which evidently has belonged to some part of the animal itself. It is found also in other animals of the sea, and it occurs in the ashes of sea-weeds of the fucoid family, though it is not yet ascertained whether it belongs to the fucus itself, or to the infusoria which usually cover its surface.

12. *Boron.*—I have long tried to find boracic acid in sea-water, but for a long time all my endeavours were vain. Notwithstanding I felt convinced that it must be there, since both boracic acid and borates are not very rare, and a great part of its salts with lime and magnesia are more or less soluble in water. Thus I thought that water from the land must have carried boracic acid into the sea, where it still must be accumulating, since we do not know any combination by which it could be separated again from the water. An additional proof of the correctness of this idea I found in the occurrence of Stassfurthite (mostly consisting of borate of magnesia), together with all

other salts that occur in sea-water, in the beds of rock-salt at Stassfurth in Germany. The lower part of this bed of rock-salt, which by a boring was not penetrated through at a depth of 800 feet, consists of pure chloride of sodium. Upon this rest the other salts of sea-water, consisting of magnesia, lime, and potash combined with muriatic and sulphuric acids in numerous combinations, among which we also find the Stassfurthite (borate of magnesia with chloride of magnesium). Boracite, a similar combination of boracic acid, occurs at Luneburg and at Segeberg, associated with gypsum and chloride of sodium, which latter at Luneburg forms a spring of saturated brine, and at Segeberg occurs in separate crystals imbedded in the gypsum.

I thought I might be able to form a borate insoluble in water, and with such characteristic properties that it might be possible to determine the boracic acid in it. It is well known that Heintz, by melting chloride of magnesium, chloride of sodium, magnesia, and boracic acid, obtained octohedral crystals, which were boracite, and another set of crystals, of hemiprismatic form, which also contained boracic acid and magnesia. The crystals were microscopic, but could easily be recognized by their different form of crystallization. To make myself acquainted with these different artificial combinations, I melted borax, common salt, and sulphate of magnesia in a crucible, allowed it to cool slowly, and dissolved it in water. There remained a heavy crystalline powder, which under the microscope proved to consist of six-sided hemiprismatic prisms, containing both magnesia and boracic acid. I could not discover any octohedral crystal, and no boracite seemed to have been formed. In another experiment I fused common salt, magnesia, and borax; after solution I obtained the same hemiprismatic crystals, but no octohedrons; and felt now convinced that I hardly should obtain boracite by fusing salt of sea-water, but that I might obtain the hemiprismatic borate if sea-water contained boracic acid.

The experiment was made in the following way:—I evaporated 6 lbs. of sea-water taken from the Sound near Copenhagen, transferred the salt into a perfectly clean platinum crucible, which was placed upon magnesia in a common Hessian crucible, exposed it to a white heat, and cooled slowly. After solution of the salt, the powder remaining was placed under the microscope, where it was found to consist almost entirely of hemiprismatic crystals which frequently formed twins, and by their whole exterior showed themselves to be essentially different from the hemiprismatic borate. Many of them were corroded at the sides and ends, as if they had partly been dissolved. I supposed them to be gypsum, which of course must be formed by the evaporation of sea-water; and although the gypsum by melting would be changed into anhydrite, they afterwards, during washing with water, would again form a hydrate. I thought even several times to have seen square prisms (anhydrite?) change into the hemiprismatic form under my observation in the microscope, and get oblique cracks like one cleavage of gypsum. The powder was again washed with hot water, and the solution was found to contain both sulphuric acid and lime. When the wash-water contained only traces of sulphuric acid, the powder, greatly diminished in quantity, was again observed under the microscope, and showed very few half-dissolved prisms of gypsum, but numerous very small octohedrons, which had been hidden by the gypsum. Besides these octohedrons, some hemiprismatic crystals were found, precisely similar to those which I formerly had obtained when forming a borate of magnesia. The powder contained, further, some prisms which were striated parallel to the axis, and had a face perpendicular to this axis; they resembled precisely the crystals which I several years ago described as artificial apatite, and which were obtained by fusing calcined bones with chloride of sodium; and they were in fact apatite, formed of the phosphoric acid, fluorine, chlorine, and lime of the sea-water. Of the powder in question, which essentially consisted of octohedrons, I dissolved 7·184 grains in nitric acid, which left 0·160 grain of a reddish powder consisting mostly of oxide of iron, but showing also under the microscope hemiprismatic crystals like the borate of magnesia. The nitric solution gave with ammonia a precipitate which weighed 0·633, and contained phosphoric acid. At last the remaining solution gave with phosphate of soda and an excess of ammonia 16·667 ignited phosphate of magnesia=6·074 pure magnesia. The sum of all these substances thus determined was 6·867, so that only a quantity amounting to 0·317 grain which was wanting could be boracic acid.

It was thus clear that the octohedrons analyzed could not be boracite, and there could hardly be any doubt but that the substance was essentially pure magnesia, mixed with small quantities of oxide of iron, phosphate of lime, and other substances which were still to be determined. Pure magnesia occurs among the Vesuvian minerals crystallized in regular octohedrons, and has obtained the name of Periclase. In this case the periclase was formed by the decomposition of the hydrate of chloride of magnesium contained in the salt of sea-water, and decomposed in the melting heat. As a further proof of its nature as pure magnesia, it may be mentioned that, when boiled with a solution of sal-ammoniac, it was dissolved with a strong smell of ammonia. The solution contained magnesia, and nothing else besides salts of ammonia could be discovered.

When the octohedral crystals were removed by boiling with a solution of sal-ammoniac, the remaining powder contained only hemiprismatic prisms of the supposed borate of magnesia, crystals of apatite, and very acute six-sided pyramids, which in their form had some similarity to crystals of sapphire, and a considerable quantity of amorphous red oxide of iron, probably mixed with silica. A portion of this powder was moistened with sulphuric acid, and during twenty-four hours left to spontaneous evaporation. I could now observe crystals of sulphate of magnesia and needles of sulphate of lime. The substance, nearly dry, was mixed with diluted alcohol, which, when inflamed, showed the green margin of the flame characteristic of boracic acid, and gave a brown colour to curcuma paper, although the solution was acid. It is thus proved that this salt contained boracic acid, which in this case could only be derived from sea-water. When this powder was boiled with muriatic acid, apatite, borate of magnesia, and silicate of peroxide of iron were dissolved, and a very small quantity of the six-sided pyramids remained, which resisted the action of acids, but were made soluble by fusing with carbonate of soda. When the soda was washed away, the remaining substance dissolved in muriatic acid, and it could now be proved that *alumina* was present. The quantity of these six-sided pyramids obtained from 6 lbs. of sea-water was, however, so small, that no experiments could be made to ascertain whether it contained other substances besides alumina.

I have been somewhat more explicit in relating my experiments to ascertain the existence of boracic acid and alumina in sea-water, partly because I found it very difficult to find unequivocal proofs of their presence, and partly because it interested me highly to find how useful the microscope may be in inorganic analysis, when used in combination with chemical tests.

When I had convinced myself that boracic acid occurred in sea-water, it appeared to me in the highest degree probable that the organisms of the sea would collect it, and that it might be found in their ashes. I was so fortunate as to begin my experiments with a plant that contained it in a rather large quantity, viz. the *Zostera marina.* The plant was collected in the month of December, at the sea-shore near Copenhagen, dried, and burnt. The ashes were washed with water, and the solution, which contained mostly chloride of potassium and sulphate of potash, contained also a small quantity of boracic acid, probably combined with soda. The insoluble part of the ashes was moistened with sulphuric acid until it had a sour taste, evaporated in a moderate heat to dryness, and washed with water. When this solution was mixed with strong alcohol and filtered, it burned with a green flame, and gave to curcuma paper a brown, and to litmus paper a red colour. To separate the boracic acid from the other substances I chose superheated steam, a method to which I was led by a consideration of the way in which boracic acid reaches the lagoons of Tuscany. It is well known that this acid comes with steam from the interior of the earth, and is condensed when escaping from the fumaroles. An experiment in which I mixed dry borax with sulphuric acid, and exposed it to the action of superheated steam at 300° to 400° Centigrade, volatilized not only boracic acid in form of a solution, but gave even the well-known scales of its hydrate. The experiment with the distillation of the ashes of *Zostera marina* with sulphuric acid and superheated steam succeeded completely. The water contained boracic acid, which by a slow evaporation was obtained in crystalline scales; and another portion of it was converted into borax, which was obtained in its regular form. Even *Fucus vesiculosus* contains the same acid, but in a much smaller quantity.

13. *Silver.*—MALAGUTI first showed that silver occurs in the organisms of the sea; I have subsequently proved it to exist in a coral, a *Pocillopora*, and several chemists have since tried to prove that silver is precipitated by the galvanic current between the copper coating of a vessel and sea-water. If the last determination is confirmed, the existence of silver in sea-water is proved by direct experiment. From the *Pocillopora alcicornis* I have separated it in the following manner:—I dissolved the coral in muriatic acid, precipitated the solution by hydrosulphate of ammonia, and dissolved the precipitate, which consisted of sulphurets, of phosphate of lime, and fluoride of calcium, in

very weak cold muriatic acid, which left the sulphurets of silver, lead, and copper probably mixed with those of cobalt and nickel. These sulphurets were separated from the solution, evaporated to dryness with a little nitric acid, to which were added a few drops of muriatic acid, and dissolved in water, which leaves sulphate of lead and chloride of silver undissolved. When the filter which contained the latter substances is burnt, the silver is reduced to metal; a solution of pure soda will dissolve the sulphate of lead and leave the silver, which, when dissolved in nitric acid, can be tested with muriatic acid. I obtained from *Pocillopora alcicornis* about $\frac{1}{3,000,000}$, or from a solid cubic foot of the coral about half a grain of silver.

14. *Copper* has not been discovered in sea-water itself, but occurs so frequently in the lime-salts of the animals of the sea, and in the ashes of the sea-weeds, that it can be discovered with great facility by its well-known tests. In the *Pocillopora* I found about six times more copper than silver, in the coral *Heteropora abrotanoides* about $\frac{1}{350,000}$ copper, and in the yellowish-green substance which remained after the filtration of the muddy sea-water which Sir James Ross had taken in 77° 33′ S. lat., it could be shown with great facility. Also the ash of *Fucus vesiculosus* contained copper.

15. *Lead* occurs, like copper, in the shells of the animals of the sea and in the ashes of sea-weeds, but in greater quantity. In the *Pocillopora alcicornis* there was found about eight times as much lead as silver, and in *Heteropora abrotanoides* about $\frac{1}{50,000}$ of the coral. It occurs likewise in *Fucus vesiculosus*.

16. *Zinc*.—It has not been shown directly in sea-water, nor could I find it in the lime-salts of shells and corals, but it occurs in considerable quantities in the ashes of sea-weeds; 400 grains of the ashes of *Zostera marina* contained 0·139 oxide of zinc$=\frac{1}{3000}$. It occurs also in the ashes of *Fucus vesiculosus*.

17. *Cobalt*.—I have discovered this metal in the ashes of *Zostera marina*, and in the fossil sponges of the chalk, but not in the large cyathiform sponge of the present sea from Singapore.

18. *Nickel*.—We have no such delicate test for nickel as the blowpipe is for cobalt, but I have several times observed the well-known brown colour of the solution on precipitating the sulphurets of the ashes of sea-weed by hydrosulphate of ammonia, and I think we are fairly entitled to suppose that these two metals occur together in sea-water as they occur in company in the mineral kingdom.

19. *Iron* can be discovered directly in sea-water by evaporating it to dryness and dissolving the salts again in water, when it remains insoluble and combined with silica. It remains mixed with all the other combinations that are insoluble or difficultly soluble in water, but in the solution of these residues in muriatic acid can easily be indicated by the common prussiate of potash. It occurs in great quantity in the ashes of sea-weeds and the lime-salts of sea animals.

20. *Manganese* can be determined directly in sea-water, accompanying the oxide of iron separated from a rather large quantity of sea-water, by the application of the well-known test for manganese before the blowpipe with carbonate of soda and nitrate

of soda or potash. In some sea-weeds it occurs in considerable quantity, particularly in the ashes of *Zostera marina* when it is in full growth. This ash contains about 4 per cent. of it, enough, when muriatic acid is poured upon the ash, to cause an effervescence of chlorine. Manganese is found in a much smaller quantity in the animals of the sea.

21. *Aluminium.*—I have often tried to find alumina in sea-water which had been filtered, but always without result, until at last, in my experiments to find boracic acid, I found alumina also, as is mentioned under boron. Aluminium must thus be enumerated as one of the elements that occur in the water of the sea. It occurs in greater quantity than most metals, iron, and perhaps manganese, excepted.

22. *Magnesium.*—This element occurs, as is well known, in large quantity in sea-water, in about the same quantity as sulphuric acid, and only sodium and chlorine are found in greater quantity. Sea-weeds contain it likewise in considerable quantity, and it is a constant companion of the carbonate of lime which the shell-fishes and corals deposit. In *Serpula filigrana* it amounts to 13·49 per cent. carbonate of magnesia. Its average quantity is, however, only 1 per cent.

23. *Calcium.*—Lime occurs in sea-water in a small quantity combined with carbonic acid, and dissolved in an excess of it; in a greater quantity combined with phosphoric acid, and as fluoride of calcium; but the greatest quantity is combined with sulphuric acid. Among all the bases which river-water carries into the sea, lime is the most frequent; and it is only owing to the organic beings of the sea, and principally to its lower animals, that so small a quantity remains, lime being constantly separated by the organo-chemical action of these animals.

24. *Strontium.*—I have discovered this element in the sea-water, and also in the deposit of the boilers of the Transatlantic steamers. It occurs likewise in the ashes of the fucoid plants, and specially in the *Fucus vesiculosus.* I shall here explain how I have convinced myself that this plant contains both strontia and baryta. When the ash was successively extracted, first with water, and then with muriatic acid, a rather considerable quantity of insoluble substances remained, which was fused with carbonate of soda, and again extracted by water containing some pure soda to dissolve the silica, while the sulphuric acid from the sulphate of strontia and baryta had combined with the soda of the carbonate. To remove the lime from the remainder, I dissolved it in muriatic acid which contained a little sulphuric acid. What remained undissolved was again fused with carbonate of soda and extracted with water. The remaining carbonates were now dissolved in muriatic acid, and afterwards precipitated by a solution of sulphate of lime. The mixed sulphates of strontia and baryta were separated by fluosilicic acid, and the salt of strontia dissolved in alcohol, which then burned with the beautiful red colour of strontia.

25. *Baryta* occurs both in sea-weeds and in sea-animals, but the ashes of sea-weeds contain more of it than the corals and shells. It can even be determined directly in sea-water, and in the deposits of the boilers of the Transatlantic steamers.

26. *Sodium.*—It is well known that sodium in combination with chlorine forms the most important salt in sea-water; next to chlorine, oxygen, and hydrogen, sodium is the most abundant element in sea-water.

27. *Potassium* is the alkaline element which, next to sodium, occurs most frequently in sea-water, and it may easily be shown in the sea-water itself.

On the Quantitative Analysis of Sea-water.

It is evident that an analysis which should determine the quantity of every one of the substances now enumerated would be a very laborious task, and that the number of analyses required to ascertain the composition of sea-water in different parts of the ocean would be a work exceeding the power of a single observer. Besides this there is another difficulty, which makes a series of such analyses quite impossible; 100 lbs. of sea-water would be the least quantity that could be used, but such a quantity could but with difficulty be procured, and could not be kept unaltered by evaporation and fermentation. Fortunately such analyses are not required, and of the numerous elements discovered in sea-water, only a few occur in such a quantity that their quantitative determination can be of any consequence. It is besides a result of my analyses of sea-water, that the differences which occur in water from different parts of the ocean essentially regard the proportion between all salts and water, the strength of sea-water, or, to use another expression, its *salinity*, and not the proportion of the different elements of the salts *invicem*; in other words, the difference in the proportion between chlorine and water may be very variable, but the proportion between chlorine and sulphuric acid, or lime or magnesia will be found almost invariable. The substances which, in respect of quantity, play the principal part in the constitution of sea-water, are chlorine, sulphuric acid, soda, potash, lime, and magnesia; those which occur in less, but still determinable quantity are silica, phosphoric acid, carbonic acid, and oxide of iron. All the numerous other elements occur in so small a proportion, that they have no influence whatever on the analytical determination of the salinity of sea-water, though, on account of the immense quantity of sea-water, they are by no means indifferent, when we consider the chemical changes of the surface of the earth which the ocean has occasioned, or is still producing.

In my complete quantitative analyses I have always determined the quantity of chlorine, sulphuric acid, magnesia, lime, and potash. The sodium or soda is calculated under the supposition that there were no other metalloids or acids than chlorine or sulphuric acid, and no other bases or oxides of metals than lime, magnesia, potash, and soda; it was supposed, besides, that the sea-water was neutral. These suppositions are not quite correct: of metalloids we find, besides chlorine, bromine, iodine, and fluorine; of acids we find, besides sulphuric acid, also carbonic, boracic, silicic, and phosphoric acids; and of bases we find, besides those that have been enumerated, a great number; but all these substances occur in very small quantities, and may be neglected. I have, however, in most cases determined the quantity of insoluble remainder left when sea-water is evaporated to dryness, dissolved in water, and washed until all sulphate of lime is removed. This remainder contains silica, phosphate of lime, carbonate of lime, sulphate of baryta and strontia, oxide of iron, and probably borate of magnesia or lime, and is in my memorandum of the analysis mentioned under one head, with the designation *Silica, &c.* In those cases where this small remainder was not determined, it was calculated proportionally to the quantity of chlorine. Thus, for instance, water taken in 44° 33′ N. lat. and 42° 54′ W. long. contained, in 1000 parts, chlorine 18·842, and *silica, &c.* 0·069. In water taken in 47° 50′ N. lat. and 33° 50′ W. long., the quantity of chlorine was found to be 19·740, and silica is, according to the former proportion, calculated as 0·072. In this case the silica, &c. was $\frac{1}{273}$ of the quantity of the chlorine, and in general it is less than $\frac{1}{200}$; thus the possible error is utterly unimportant.

I rejected a method often used, which consists in evaporating sea-water to dryness, because it is inaccurate, and the result depends partly upon trifling circumstances. If evaporated by steam of 100° C. there will remain a very notable quantity of water, which quantity can only be ascertained with great difficulty. If it is dried at a higher temperature, muriatic acid from the chloride of magnesium will be driven out together with the water. I preferred thus, as I have already mentioned, to determine the quantity of the five above-named substances, to ascertain under one head all the small quantities of the different substances that remain insoluble in water, such as silica, phosphate of lime, &c., and to calculate the soda. At first I tried to separate the quantity of all the different substances in one portion of sea-water, but soon found that this method was neither so exact nor so easy as that which I shall now explain.

1. Of one portion of 1000 grains, I separated the chlorine by nitrate of oxide of silver after I had poured a few drops of nitric acid into the water. In those cases where the water had fermented, I allowed it to stand in an open glass jar, in a warm place, until all smell of sulphuretted hydrogen had disappeared. To try how exact a result this method could give, I took a larger portion of sea-water, and weighed three different portions, each of 3000 grains, and precipitated the chlorine. The result was—

	Chloride of silver.
	145·451
	145·544
	145·642
Mean . .	145·541

The greatest difference is

−0·090=0·022 chlorine.

+0·083=0·020 chlorine.

These small differences are probably due to the small irregularities occasioned by the evaporation of very small quantities of water during weighing. The dried chloride of silver was as much as possible removed from the filter, melted in a porcelain crucible, weighed, and calculated as pure chloride of silver. The filter was burnt in a platinum crucible, by which the small quantity of chloride of silver was reduced to metallic silver, from which the chlorine which had been combined with it was calculated. This supposition is correct if the quantity of chloride of silver adhering to the filter is very small.

2. The determination of the *sulphuric acid* was likewise made with 1000 grains of sea-water, which, after addition of some few drops of nitric acid, was precipitated with nitrate of baryta. To try the exactness of the method three portions of sea-water were weighed, each of 3000 grains. The result was—

	Sulphate of baryta.
	12·417
	12·316
	12·250
Mean . . .	12·328

The greatest difference was

−0·078=0·027 sulphuric acid.
+0·089=0·030 sulphuric acid.

3. To determine *lime* and *magnesia* 2000 grains (in the latter experiments only 1000 grains) were weighed, and mixed with so much of a solution of sal-ammoniac that pure ammonia did not produce any precipitate, then ammonia was added until the liquid had a strong smell thereof. It was now precipitated with a solution of the common phosphate of soda and ammonia, and filtered when the precipitate had collected into a granular powder. The precipitate thus obtained consists of tribasic phosphate of lime, and tribasic phosphate of magnesia and ammonia, which was washed with a weak solution of ammonia. All the filtered solution and the wash-water was evaporated in a steam-bath to dryness, and afterwards digested in a tolerably strong solution of pure ammonia, by which means there is further obtained a small quantity of the phosphates. The dry phosphates of lime and magnesia are heated, and if they are not completely white, they are moistened with a few drops of nitric acid, and again heated and afterwards weighed. The mass was now dissolved in muriatic acid mixed with alcohol until the whole contained 60 per cent. (volume) thereof, mixed with a few drops of sulphuric acid, and allowed to stand for twelve hours, when the sulphate of lime is collected on a filter, heated and weighed. It contains, besides the sulphate of lime, silica, oxide of iron, phosphate of alumina, and sulphate of baryta and strontia, from which substances the sulphate of lime is separated by boiling it with a solution containing 10 per cent. of chloride of sodium, which dissolves the sulphate of lime and leaves the other combinations undissolved. The remainder is washed, heated, and its weight deducted from that of the sulphate of lime. To try how exact the determination of the lime was, I have taken three times 3000 grains of the same water, separated the lime, and obtained the following results:—

	Sulphate of lime.
	2·761
	2·753
	2·684
Mean . . .	2·733

The greatest differences are—

$-0·049=0·020$ lime.
$+0·028=0·012$ lime.

To find the quantity of magnesia contained in the weighed mixture of the phosphates of magnesia and lime, the lime, whose quantity has been determined, must, by calculation, be converted into tribasic phosphate of lime, and deducted from the whole quantity of phosphates; the other small quantities of different salts, which had been precipitated with the sulphate of lime, must likewise be deducted; the remainder is bibasic phosphate of magnesia, from which the pure magnesia is calculated. The sea-water tried in this way gave, after deduction of lime, silica, &c., the following result:—

	Pure magnesia.
	3·913
	3·970
	3·942
Mean . . .	3·942

The differences from the mean are—

$-0·029$
$+0·028$

4. The determination of potash or potassium in sea-water was tried by different methods, but gave no satisfactory results, so that I must consider the quantity of potash in the analyses as far less exact than any of the other substances whose quantity has been determined in sea-water. Happily there is so small a quantity of potash in sea-water, that any error in the determination of that substance has only an insensible influence on the whole result. For a number of the analyses I have used the following method. The weighed sea-water was evaporated to dryness, the dry mass again dissolved in water, and the undissolved residue washed with warm water until all sulphate of lime is dissolved, and the wash-water does not contain any sulphuric acid. The remaining powder consists of the different after-named salts and oxides insoluble in water; it is generally weighed and noted under one head.

To this solution I add so much carbonate of lime that the sulphuric acid finds lime enough to combine with, and as much muriatic acid as would dissolve the lime of the carbonate. The quantity of carbonate of lime is determined in the following way. The equivalent of sulphate of baryta being 1456, and that of carbonate of lime being 625, there will be an excess of lime if I take carbonate of lime in such a quantity that its weight is one-half of the quantity of sulphate of baryta, obtained from an equal quantity of the same sea-water in a previous experiment for the determination of sulphuric acid. All is now evaporated to dryness and dissolved in alcohol of 60 per cent., which leaves the sulphate of lime and dissolves all the chlorides; so that the solution is quite free from sulphuric acid. It is now a third time evaporated with a sufficient quantity of chloride of platinum. Alcohol of 60 per cent. leaves the chloride of platinum and potassium, which might be weighed, and the quantity of chloride of potassium calculated from it; but as it is most difficult in a laboratory where there is constantly work going on to avoid the absorption of the vapours of ammonia by evaporating liquors, I prefer heating the double chloride to a dull red heat, and assisting the decomposition of the chloride of platinum by throwing small pieces of carbonate of ammonia in the crucible. When all the chloride of platinum is decomposed, the crucible is weighed, the chloride of potassium is extracted by alcohol of 60 per cent., and the remainder weighed again. This method has the advantage, that even if a small quantity of gypsum should have accompanied the double chloride, it will have no influence upon the determination of the chloride of potassium. When I do not want to determine the insoluble remainder, I evaporate the sea-water with a sufficient quantity of chloride of calcium, and thus leave out one evaporation and solution.

In the few cases where I have tried to determine the different substances which in this chapter I have called silica, &c., I have used the following method. The filter upon which the remainder is collected and washed is burnt in a platinum crucible, evaporated with some drops of muriatic acid, and dissolved in water. What remains is silica, often coloured by a little oxide of iron, and mixed with a small quantity of sulphates of baryta and strontia. It is evaporated with fluoric acid and a drop of sulphuric acid to get rid of the silica. What remains after evaporation and heating is sulphate of baryta, of strontia, and oxide of iron. The solution in muriatic acid is precipitated by ammonia, and the precipitate is noted as phosphate of lime, but contains besides a little fluoride of calcium. The remaining liquid contains a little lime, which I precipitate with oxalate of ammonia, and suppose to have been in the sea-water as carbonate of lime dissolved by carbonic acid. In the water of the great ocean there occurs only a very small quantity of carbonate of lime, but near the shores, in the bays and inlets, and principally in the mouth of the great rivers, its quantity increases with the quantity of fresh water from the land. If the sulphates of the sea-water are decomposed to sulphurets, there is always precipitated a larger quantity of carbonate of lime, but that is the result of the decomposition, and its carbonic acid is owing to the organic substances which are oxidized by the oxygen of the sulphates.

I have never tried to ascertain the nature and quantity of the gases which occur in sea-water, because the collection of sea-water for that purpose would require quite different precautions from those which were necessary for the water intended for the analysis of its solid contents.

It might seem that the relative quantity of salt might be inexact, because water might have evaporated through the cork during the long time which often elapsed between the time when it was taken up from the sea, and the time when it was analyzed. It is, however, easy to see whether the quantity of water in the bottle has diminished, or whether the cork has been corroded; in both cases the sample has been rejected, but I must remark that these cases have been rare. In the last three or four years all the samples which have been taken according to my direction have been marked on the neck of the bottle with a file, on that place to which the water reached when the bottle was filled.

As to the calculation of the combinations of the different substances that have been found by the analysis, I have chosen the following method:—

The whole quantity of lime was supposed to be united with sulphuric acid.

What remained of sulphuric acid after the saturation of lime, was supposed to be combined with magnesia.

What remained of magnesia after the saturation of sulphuric acid, was supposed as magnesium to enter into combination with chlorine, and form chloride of magnesium.

The potash was supposed to form chloride of potassium.

That portion of chlorine which was not combined with magnesium or potassium, was supposed to form a neutral combination with sodium.

Lastly, that small quantity of different substances, "silica, &c.," was added, and the sum of all these combinations thus calculated forms the number which in the Tables is called "All Salts." It is hardly necessary to remark, that it is quite indifferent how we suppose the acids and bases to be combined in sea-water, the sum must always be the same, provided the salts are neutral, and all the acids (chlorine included) are determined, as well as all the bases, with the exception of soda.

On the Distribution of the Salts in the different parts of the Sea.

The next question to be considered refers to the proportion between all the salts together and the water; or to express it in one word, I may allow myself to call it the *salinity* of the sea-water, and in connexion with this salinity or strength, the proportion of the different solid constituent parts among themselves. On comparing the older chemical analyses of sea-water, we should be led to suppose that the water in the different seas had, besides its salinity, its own peculiar character expressed by the different proportions of its most prevalent acids and bases, but the following researches will show that this difference is very trifling in the ocean, and has a more decided character only near the shores, in the bays of the sea, and at the mouth of great rivers, wherever the influence of the land is prevailing.

In the Tables which are annexed to this paper I have always calculated the single substances and the whole quantity of salt for 1000 parts of sea-water, but besides this I have calculated the proportion between the different substances determined, referred to chlorine =100, and of all the salts likewise referred to chlorine. This last number is found if we divide the sum of all the salts found in 1000 parts of any sea-water by the quantity of chlorine found in it, and I call it the *coefficient* of that sample of sea-water. The following remarks, and the Tables which belong to them, will show that there is a very small difference in the coefficient of the different parts of the ocean, but that the differences become striking in the neighbourhood of the shores.

A. *On the salinity of the surface of the different parts of the ocean and its inlets.*

In the Tables annexed to this paper I have divided the sea into seventeen regions. My reason for doing so was that by this method I was able to avoid the prevailing influence which those parts of the ocean which are best known, and from which I have most observations, would exert upon the calculations of the mean number for the whole ocean.

First Region. *The Atlantic Ocean between the Equator and* 30° *N. lat.*—The mean of fourteen complete analyses is 36·169 per 1000 salt; the maximum is 37·908 per 1000, the minimum 34·283. The maximum lies in 24° 13′ N. lat. and 23° 11′ W. long., about 5° W. from the coast of Africa, where no rivers of any size carry water from the land, and where the influence of the dry and hot winds of the Sahara is prevailing. The maximum for the region is also the maximum of surface-water for the whole Atlantic; it is equal to the mean salinity of the Mediterranean, and only the maximum of that sea off the Libyan desert and that of the Red Sea are higher. The minimum is from 4° 10′ S. lat. and 5° 36′ W. long. close to the coast of Africa, where the large masses of fresh water which the great rivers of that region pour into the ocean exercise their influence. Its coefficient is 1·810.

Second Region. *The Atlantic Ocean between* 30° *N. lat. and a line from the north point of Scotland to the north point of Newfoundland.*—The mean of twenty-four complete analyses is 35·946 salt, the maximum 36·927, and the minimum 33·854. The maximum is in 38° 18′ N. lat. and 43° 14′ W. long. in the middle of the Atlantic; the minimum occurs in 43° 26′ N. lat. and 44° 19′ W. long., and is evidently owing to the enormous quantity of fresh water which the St. Lawrence, through its southern mouth, pours into the Atlantic. This region is under the influence of the Gulf-stream, and the corresponding South Atlantic region has only a mean salinity of 35·038. Its coefficient is 1·812.

Third Region. *The northern part of the Atlantic, between the northern boundary of the second region, and a line from the south-west cape of Iceland to Sandwich Bay in Labrador.*—The mean salinity deduced from twelve complete analyses is 35·391, its maximum 36·480, its minimum 34·831. The maximum falls in 55° 45′ N. lat. and 20° 30′ W. long., just on the boundary of Region 2, the minimum in 60° 25′ N. lat. and 3° 15′ W. long., near the large northerly opening of the North Sea. This region owes evidently its high salinity to the large northern direct branch of the Gulf-stream. Its coefficient is 1·808.

Fourth Region. *This region comprehends the East Greenland current, which flows along the east coast of Greenland towards the south and west, turns towards the north, when it reaches the south promontory of Greenland, runs along the west coast of that large land into Davis Straits, where it disappears in the polar current from Baffin's Bay.*

—I owe most of the samples from this current to Colonel SCHAFFNER, who took them on his expedition to Iceland and Greenland connected with the Northern Transatlantic Telegraph. The quantities being too small to allow a complete analysis, I have only determined the quantities of chlorine and sulphuric acid. I have, however, analyzed three other samples of water from this current taken by Captain GRAM, who during many years commanded one of the Danish Government's Greenland ships; and from these three complete analyses I have deduced the coefficient 1·813, instead of 1·812, which is the mean coefficient of the whole ocean. Thus I have calculated the mean salinity of the East Greenland current to be 35·278 *, while it is in the third region 35·391, and in the sea between Norway and Spitzbergen 35·347. These observations about the salinity of the current, connected with some other observations which will be afterwards discussed, make it highly probable that the East Greenland current is the returning Gulf-stream. At all events it is no polar current, which will easily be seen in comparing it with the Baffin's Bay current with a salinity 33·281, or the water to the north of Spitzbergen with 33·623, or the Patagonian polar current, which runs along the west coast of South America, and has 33·966. Nor is it probable that it comes from the north shores of Siberia, where such a great number of powerful rivers bring a vast quantity of fresh water into the sea. Its salinity is so great that it even exceeds that of the South Atlantic Region, between 30° S. lat. and the line between the Cape of Good Hope and Cape Horn, whose salinity is only 35·038.

Fifth Region, A. *The Baffin's Bay and Davis Straits Region.*—The mean of eight complete analyses is 33·281, the maximum 34·414, the minimum 32·304. This region shows the very interesting fact that its salinity increases on passing from latitude 64° toward the North, being in 64° 32·926, in 67° 33·187, somewhat further to the North 33·446, and in latitude 69° 33·598. This peculiarity is owing to the powerful current from the Parry Islands, which through different sounds passes into Baffin's Bay, where it is mixed with the great quantity of fresh water that comes into the sea from the West Greenland glaciers. Had this fact been known before the sounds that connect the Parry Archipelago with Baffin's Bay were discovered, it might have proved the existence of these sounds, because bays and inlets show quite the reverse; the further we get into them the less saline the water becomes.

Fifth Region, B. *The Polar Sea between the North Cape in Norway and Spitzbergen.*—I have eleven samples of water taken on the Swedish Spitzbergen Expedition by Professors NORDENSKJÖLD and BLOMSTRAND, of which I have rejected one taken in one of the bays of Spitzbergen, and another belonging to the sea to the north of Spitzbergen. None of these analyses were complete, and I have only determined the quantity of chlorine and of sulphuric acid; and even the latter could in several instances not be determined, since the water had fermented. The mean quantity of chlorine in the nine remaining samples was 19·507; and if we take the mean coefficient of the four North

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* If we take the general coefficient of the ocean, 1·812, the salinity of the East Greenland current would be 35·258, which of course makes no material difference.

Atlantic regions (the East Greenland current included), 1·810, 1·812, 1·808, 1·813, it will be 1·811; and if we use this coefficient, the mean salinity of that part of the sea will be 35·327, or if we take the mean coefficient of the whole ocean, 1·812, it will be 35·347. The maximum was in 76° 15′ N. lat. and 13° 15′ E. long., with 20·019 chlorine =36·254 salt; the minimum in 70° 30′ N. lat. and 19° 5′ E. long., with 18·993 chlorine =34·396, near the coast of Norway, which evidently has had influence upon the result*.

Fifth Region, C. *The Polar Sea to the North of Spitzbergen.*—I have only one observation, of which I owe the sample to Professor Blomstrand. It is from 80° N. lat. and 12° E. long., containing 18·517 chlorine, which gives, with a coefficient of 1·812, a salinity of 33·623.

Sixth Region. *The German Ocean or the North Sea.*—The mean of six complete analyses is 32·823 per 1000 salt, the maximum is 35·041, the minimum 30·530 per 1000 salt, the maximum is from the mouth of the channel near the Gallopper, and the minimum is from Heligoland, where the water of the Elbe has a considerable influence. The mean coefficient is 1·816, which also shows the influence of the land.

Seventh Region. *The Kattegat and the Sound.*—The quantity of salt in the water of this region is very variable; a northerly current and wind brings water which is richer in salt than that brought by a southerly wind and current. The mean of six complete analyses and 141 observations, in which only the chlorine was determined, gives 16·230 per 1000 salt, the maximum 23·243, and the minimum 10·869. It must further be remarked that the proportion of chlorine and lime, which in the whole ocean are in mean number 100 : 2·96, in this region are 100 : 3·29, which again must be considered as depending upon the influence of the land. The mean coefficient is 1·814.

Eighth Region. *The Baltic.*—The mean numbers are deduced from complete analyses of samples of sea-water taken on board the Frigate 'Bellona,' on a voyage from Copenhagen to St. Petersburg, combined with a complete analysis of water from Svartklubben to the north of Stockholm. Its salinity varies very much in the different localities, and is of course less in the eastern than in the western portions of the Baltic; it varies also in the same place according to wind and current. I found the mean for this region 4·931 per 1000 salt, the maximum 7·481 in the channel between Bornholm and Sweden, the minimum in the merchant harbour of Kronstadt =0·610 per 1000 salt. The mean proportion of chlorine and lime is 100 : 3·64, in the Bay of Finland it is 100 : 7·49. The mean coefficient is 1·835, in the merchant harbour of Kronstadt it is 2·230. The influence of the land is here expressed in these different numbers.

Ninth Region. *The Mediterranean.*—All my observations lie between the Straits of Gibraltar and the Greek Archipelago. It is a general belief that the water of the Mediterranean contains more salt than the water of the ocean in general, and this opinion depends partly upon some analyses, partly upon the observation that at the Straits of Gibraltar there is a constant upper-current, which runs into the Mediterranean,

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* That this sea is a branch of the Gulf-stream was acknowledged long ago.

and an under-current which carries its waters into the Atlantic. This opinion of the superior salinity of the Mediterranean has been completely confirmed by eleven complete analyses of water taken between the Straits of Gibraltar and the Greek Archipelago. The mean salinity of this region is 37·936, while the whole ocean contains 34·388 per 1000 salt. Its coefficient is 1·815. Its maximum (39·257) falls between the Island of Candia and the African shore off the Libyan desert, as the maximum of the Atlantic is off the Sahara, but the mean of the Mediterranean is a little higher than the maximum of the Atlantic; the whole Mediterranean is under the influence of Africa, and its hot and dry winds. The minimum for the Mediterranean is at the Straits of Gibraltar with 36·301; the mean salinity of the northern Atlantic Ocean between 30° and 40° N. lat., but more towards the west, is 36·332 (deduced from eight complete analyses); the surface-water from the Straits of Gibraltar is thus corresponding to that from the Atlantic of the same latitude. When entering the Straits the quantity of salt increases rather rapidly, and is at a short distance from them, at 4° 2′ W. long., 37·014; between the Balearic Islands and the Spanish coast it is 38·058, and a little further on 38·321, between the Island of Sardinia and Naples 38·654. Somewhat nearer to the coast of Malta it decreases to 38·541, and further on towards Greece it decreases again to 38·013, and would probably decrease more in the direction of the Bosphorus, but I have no observations from that part of the Mediterranean. From Malta to the coast of Africa it increases to the maximum of 39·257.

There is another opinion generally reported, that the water of the Mediterranean contains a greater proportion of magnesia than the water of the ocean. This is, however, not the case; the mean proportion between chlorine and magnesia is for the Mediterranean 100 : 10·90, and for the ocean 100 : 11·07; nor is there any remarkable difference in the proportions of the other main substances. The proportion between chlorine and sulphuric acid is for the ocean 100 : 11·89, and for the Mediterranean 100 : 11·82; for lime it is in the ocean 100 : 2·96, and in the Mediterranean 100 : 3·08.

Tenth Region, A. *The Black Sea and the Sea of Assov.*—Like the Baltic, the Black Sea contains sea-water of but little strength, and the mean deduced from three observations, of which one is from myself, the two others by M. Göbel, is 15·894, maximum =18·146, minimum =11·880. In my own analysis of water from the Black Sea, fifty English miles from the Bosphorus, I found the proportion of chlorine 100, to sulphuric acid 11·71, to lime 4·22, to magnesia 12·64, and thus a considerable increase in the lime and magnesia.

Tenth Region, B. *The Caspian Sea.*—This sea being by many geologists considered to have been in former times in connexion with the Black Sea, it might be of some interest to compare its water with that of the Black Sea. I have, however, not had opportunity of making an analysis of it myself, but have calculated other analyses according to my method. Of these five analyses four are by M. Mahner, and published by M. Baer in his 'Caspian Studies' (Caspische Studien). As might be expected, the quantity of saline matter shows great differences, between 56·814 per 1000 in the Bay of Karassu or

Kaidaik, and 6·236 per 1000. The proportion between chlorine, sulphuric acid, lime, and magnesia, is

100 : 44·91 : 9·34 : 21·48.

It is quite evident that the Caspian Sea, if it ever had any connexion with the Black Sea, must have changed its character entirely since that time, and this change might either be occasioned by the different salts which the rivers brought into the lake, and which accumulated there by evaporation of the water, or it might be caused by the deposition of different salts in the basin of the Caspian Sea itself. If we now compare the abnormal proportions in the Caspian Sea,

Chlorine 100, Sulphuric acid 44·91, Lime 9·34, Magnesia 21·48,

with the normal proportions in the ocean,

Chlorine 100, Sulphuric acid 11·89, Lime 2·96, Magnesia 11·07,

we find that the excess of lime and magnesia will nearly neutralize the excess of sulphuric acid, and leave only a small quantity of sulphuric acid (3·72), which may be neutralized by alkalies. Thus rivers which brought sulphate of lime and of magnesia into the Caspian Sea, might in the lapse of 100 and 1000 years certainly change the composition of its water in the direction which it now has. Its mean coefficient is 2·434.

Eleventh Region. *The Atlantic Ocean between the Equator and* 30° *S. lat.*—The mean quantity of salts in this region, deduced from seven observations, is 36·553, the maximum 37·155, the minimum 35·930. The relative quantity of chlorine, sulphuric acid, lime, and magnesia is 100 : 12·03 : 2·91 : 10·96. The water of this region is richer in salt than the corresponding region in the North Atlantic Sea. Its coefficient is 1·814.

Twelfth Region. *The Atlantic Ocean between* 30° *S. lat. and a line from Cape Horn to the Cape of Good Hope.*—Mean salinity 35·038, maximum 35·907, minimum 34·151; the maximum not far from the Cape of Good Hope, the minimum not far from the Falkland Islands. Its salinity is less than the corresponding region in the North Atlantic (Region 2), which is 35·932, even less than the third and fourth regions (the East Greenland current), whose salinity is 35·278. This seems partly to depend upon the Gulf-stream, which causes a considerable evaporation in the northern part of the Atlantic, partly upon the River Plata in the South Atlantic, which carries an enormous quantity of fresh water into the southern sea. I have analyzed four samples of sea-water taken under the influence of that large river. One, taken by Captain PREVOST in 35° 46′ S. lat. and 52° 57′ W. long., almost at the mouth of the Plata, contained so much organic matter that a great part of its sulphuric acid was decomposed, so that the original quantity of salt could not be ascertained, but the quantity of chlorine, which, as far as we know, is not affected by the fermentation of the water, was only 17·721, which, multiplied by 1·808, the coefficient of this region, gives a quantity of salts =32·040; the other three samples, taken between 40° 30′ and 50° 31′ S. lat., and 40° 50′ and 52° 15′ W. long., are all far below the mean salinity of this region. It deserves to be remarked, that all the samples from the western part of this region have a less quantity of sulphuric acid than the normal, and the samples from the eastern part of the region nearer to the African coast have a proportion of sulphuric acid which is considerably greater than the normal quantity. Does this depend upon the more prevailing volcanic character of the west coast of Africa compared to the east coast of America?

Thirteenth Region. *The sea between Africa and the East Indian Islands.*—The mean of this region is 33·868, but it is deduced from observations that have given very different results. The maximum (35·802) is from 31·54 S. lat., 72° 37′ E. long., about midway between the Cape of Good Hope and Australia. Now in the North Atlantic Ocean even the mean salinity between 30° and 55° N. lat. is 35·932, thus greater than the maximum in this region, though this maximum is from near 32° S. lat. The fact is striking. The minimum (25·879) is from a place high up in the Bay of Bengal, and of course highly influenced by the vast quantity of water from the Ganges. It lies, however, about 300 English miles from the mouth of the Ganges; and another specimen from N. lat. 17° 20′, and about sixty miles nearer the mouth of the Ganges, has 32·365 per 1000 salt, so that it seems as if some other cause has also been operating to weaken the sea-water at the minimum place.

Fourteenth Region. *The sea between the south-east coast of Asia, the East Indian Islands, and the Aleutic Islands.*—The mean quantity of salt, deduced from seven complete analyses, is 33·506, the maximum from a place to the south-east of Japan, in 38° 31′ N. lat., is only 34·234, less than the maximum of the German Ocean between 50° 60′ N. lat., and surrounded by land (35·041). The minimum (32·370) between the larger East Indian Islands depends evidently upon the influence of the surrounding land. The mean proportion of chlorine, suphuric acid, lime, magnesia, is 100:11·76 : 3·05:10·99, very nearly normal. The mean coefficient is 1·815.

Fifteenth Region. *The sea between the Aleutic Islands and the Society Islands, between 38° N. lat. and 32° S. lat.*—The mean quantity of salt is only 35·219, which is very near the mean of the East Greenland current (35·278), and very much below the mean of the Atlantic between 30° S. and 30° N. lat., which is 36·321. Its maximum is 36·061 near Borabora, about 16° S. lat., while the maximum of the corresponding tropical part of the Atlantic is 37·908; its minimum, under 38° 26′ N. lat., very far from any land, is 34·157. The mean proportion of chlorine, sulphuric acid, lime, and magnesia is 100:11·67:2·93:11·06. The mean coefficient is 1·806.

Sixteenth Region. *The Patagonian cold-water current.*—Mean 33·966 per 1000, maximum 34·152, minimum 33·788. The minimum is in the southernmost part of this current, and the maximum under 35° 22′ S. lat. The mean proportion of chlorine, sulphuric acid, lime, and magnesia is 100:11·78:2·88:11·04. The mean coefficient is 1·806.

Seventeenth Region. *The South Polar Sea.*—I have only three analyses, all on samples taken by the late Sir James Ross. One was from 77° 32′ S. lat., 188° 21′ E. long., close to the great ice-barrier. The water was full of animalculæ, but, notwithstanding, had not fermented. The quantity of salt which it contained was 28·565 per 1000. The next sample was from 74° 15′ S. lat., 167° E. long.; the water was muddy, probably from animalculæ and diatomaceæ. The place was not far from Victoria Land, at some distance from Coulman Island. It contained only 15·598 salt. The third, from 65° 57′ S. lat., 164° 37′ E. long., had the surprising quantity of salt 37·513 per 1000. The mean of these three observations is 27·225 per 1000; but this mean number is of very little consequence, being derived from numbers differing so greatly. It is, however, very surprising that water from the neighbourhood of the supposed Antarctic continent should have a salinity higher than any one found in the south equatorial regions of the Atlantic, and only be exceeded by a single one in the North Atlantic regions. I am sure that no material fault exists in the analysis, and this curious fact must thus remain unexplained until repeated observations in that region shall procure us further information. Should the observation be proved to be correct, it would render the existence of a "Gulf-stream" in the Antarctic zone very probable. There is still another peculiarity in these observations which deserves attention, viz. the great proportion of sulphuric acid to chlorine. In the water in the neighbourhood of Coulman's Island it is 12·47 : 100, and in that from 65° 57′ S. lat. 12·55 : 100, while in the whole ocean it is as 11·89 : 100. This might depend upon the very pronounced volcanic character of the Antarctic continent. There is still one question to be discussed with respect to the Antarctic Sea, how it is to enter into the mean numbers of the whole ocean. The observation from the neighbourhood of Coulman's Island must be rejected, because it is too near the land, and we have no corresponding observations from the open Antarctic Ocean. Its high coefficient (1·861) shows the great influence of the neighbouring land. The observation from 65° 57′ S. lat. must also be rejected as doubtful; there remains only the observation from the neighbourhood of the great ice-barrier, and I have taken that for the mean of the Antarctic region.

General Results of the preceding investigation.

If we except the North Sea, the Kattegat, Sound, and Baltic, the Mediterranean and Black Sea, the Caribbean Sea and the Red Sea, which have all the characters of bays of the great ocean, the mean numbers are the following:—

Sea-water.	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Coefficient.
1000	18·999	2·258	0·556	2·096	34·404	1·812
	100	11·88	2·93	11·03		
Equivalents	429	45	16	82		

Thus it is evident that sea-water in its totality is as little a chemical compound as the atmospheric air; that it is composed of solutions of different chemical compounds; that it is neutral, because it everywhere in the atmosphere finds carbonic acid to neutralize its bases, and everywhere on its bottom and shores finds carbonate of lime to neutralize any prevailing strong acid; that, lastly, the great stability of its composition depends upon its enormous mass and its constant motion, which occasions that any local variation is evanescent compared to the whole quantity of salt.

If we take the mean numbers for the five regions of the Atlantic between the southernmost point of Greenland and that of South America, we find the mean quantity of salt for the whole Atlantic 35·833, while the sea between Africa and the East Indies has only 33·850, the sea between the East Indies and the Aleutic Islands 33·569, and the South Sea, between the Aleutic Islands and the Society Islands, 35·219 per 1000 salt. The Atlantic is thus that part of the ocean which contains the greatest proportion of salt, which result is rather surprising if we consider the vast quantity of fresh water which the rivers of Africa, America, and Europe pour into it: of Africa four-fifths are drained into the Atlantic either directly or through the Mediterranean; it is most probably nine-tenths of America which is drained into the Atlantic, since the Cordilleras run close to the western shore of the continent; and of Europe, also, about nine-tenths of the surface sends its superfluous water to the Atlantic. This greater quantity of fresh water from the land, and the greater quantity of salts in the corresponding sea, seem to contradict each other, but can be explained by a higher temperature, and, as the result of this higher temperature, a greater evaporation.

Some of the large bays of the ocean have in the tropical or subtropical zone a greater mean than the Atlantic: such are the Mediterranean, with 37·936 per 1000 salt (mean of eleven observations); the Caribbean Sea, with 36·104 per 1000 (one observation); the Red Sea, 43·067 per 1000 (mean of two but little differing observations), which is the greatest salinity of the sea I know of.

In approaching the shores the sea-water becomes less rich in salts, a fact which finds its explanation in the more or less great quantity of fresh water which runs into the sea. On such shores where only small rivers flow out, the effect produced is but very trifling, as, for instance, on the western shores of South America. The effect of large rivers in diluting the sea-water is much greater than is generally supposed; thus the effect of the La Plata river, whose mouth lies in about 35° of S. latitude, was still observable in a sample of sea-water taken at 50° 31′ S. lat., at a distance of 15° of latitude, or 900 English miles from the mouth of the river; at about the same distance, the water of the North-Atlantic Sea suffered a considerable depression in salinity, probably owing to the water of the St. Lawrence. This influence is of a double kind, partly in diluting the sea-water, partly in mixing it up with organic substances that will occasion its decomposition by putrefaction.

The polar currents contain less salt than the equatorial. I have determined the quantity and nature of the salts in two very well-defined polar currents,—the West-Greenland polar current, with 33·176 per 1000 salt, and the Antarctic polar or Patagonian current, on the west side of South America, which contains 33·966. It is highly interesting to observe that the East Greenland current, which according to its geographical relations might be considered as a polar current, which in fact has been considered in that way, has a very high mean quantity of salt, viz. 35·278 per 1000, while the sea to the north of Spitzbergen, according to one analysis, contains 33·623 per 1000 salt. I think I shall afterwards, from other phenomena also, prove that the East

Greenland current is a returning branch of the Gulf-stream; but I may here remark that the great quantity of salt which it contains almost by itself proves the more equatorial nature of this current.

As to the chemical substances which constitute the salts of the sea-water, it must be remarked that the polar current of West Greenland contains a larger quantity of sulphuric acid than any other region, with the exception of the south polar region and the East Greenland current.

The proportion between chlorine and sulphuric acid is—

For the West Greenland current. . .	100 : 12·27
For the East Greenland current . . .	100 : 12·34
Near Coulman's Island, Victoria Land .	100 : 12·47
From 65° 57′ S. lat.	100 : 12·55
The mean proportion for the ocean is .	100 : 11·89

This excess of sulphuric acid in the Antarctic Sea might be explained by the decided volcanic character of its islands and shores; even for the East Greenland current, the neighbourhood of Iceland and its volcanos might account for the excess of sulphuric acid; but the West Greenland polar current is under no such influence, and the surface-water of the Mediterranean, where so many volcanos exist, has 11·82 sulphuric acid, which is even a little below the mean proportion, 11·89. Only the water from the depth of the Mediterranean has an increased proportion of sulphuric acid, viz. 12·07. Thus it appears improbable that the excess of sulphuric acid in these polar regions should be owing only to volcanic action. It might depend upon the want of fucoidal plants. I have formerly, in a paper printed in the Report of the British Association for 1844, shown that the fucus tribe has a great attraction for sulphuric acid, and that the sulphuric acid, by the putrefaction of the plant, is reduced to soluble sulphurets and to sulphuretted hydrogen, which with the oxide of iron, which is partly dissolved, partly suspended in water, will form sulphuret of iron. Thus the sulphur will disappear from sea-water, and a great quantity of sea-weeds will diminish the quantity of sulphuric acid in the sea-water. Now it is well known that the polar regions have few or no sea-weeds, and Sir James Ross, when returning from the Antarctic polar region, remarks expressly that he observed the first sea-weed very far from the southernmost port of his voyage. An unusually small quantity of sulphuric acid seems to exist in the first of my regions, that part of the Atlantic which lies between the Equator and 30° N. lat., its relative quantity being 11·75. Does that depend upon the Sargassum Sea?

The greatest proportion of lime in the ocean occurs in its second region, the middle part of the northern Atlantic, where its proportion is 3·07, the mean proportion being 2·96; the least quantity of lime is found in the West Greenland polar current, with a proportion of 2·77; and next to that in the Patagonian polar current, with a proportion of 2·88. Wherever in other regions the influence of land is prevailing, the lime is likewise prevailing. In the Baltic I found its proportion 3·59, in the Kattegat 3·29, in that part of the German Ocean which lies close to the Kattegat 3·15, and in the whole German Ocean 2·87. In a sample from the Black Sea which I analyzed I found it 4·22.

B. *On the difference of the contents of Sea-water at the surface and in different depths.*

It would be natural to suppose that the quantity of salts in sea-water would increase with the depth, as it seems quite reasonable that the specific gravity of sea-water would cause such an arrangement. But this difference in specific gravity relative to the increase in the quantity of salts is counteracted by the decreasing temperature from the surface to the bottom. We have parts of the sea where the quantity of solid salts increases with the depth; in other parts it decreases with the increasing depth; in other places hardly any difference can be found between surface and depth; and, lastly, I have found one instance where water of a certain depth contained more salt than both that aboveand below. These differences are to a great extent dependent upon currents both on the surface and in different depths. The phenomenon of double currents at the Straits of Gibraltar has been long known, and in close connexion with these double currents the saline contents of the water of the Mediterranean increase in quantity with the depth. There is, however, one exception in the Mediterranean, under interesting circumstances, which I shall afterwards discuss more at length. I have made eleven complete analyses of the surface-water of the Mediterranean, and calculated another quoted in VIOLETTE et ARCHAMBAULT, 'Dictionnaire des analyses chimiques,' vol. i. p. 358, without a more exact reference to the place where it was taken. Of my own analyses, one must be rejected on account of the great quantity of sulphuretted hydrogen that had been formed, and of course caused a loss of sulphuric acid; but it causes also a loss of lime, because the formation of sulphuretted hydrogen is contemporaneous with the formation of carbonic acid, which will precipitate the lime when deprived of its sulphuric acid. The mean number of the remaining analyses of surface-water is 20·889 per 1000 for the chlorine, and 37·936 for all salts. The mean number for chlorine of eight analyses of water taken from a depth of between 300 to 600 feet is 21·138. In each case the deep water was richer in chlorine than that from the surface, except in one instance, where the chlorine of the surface-water was 21·718, and all salts, calculated from a complete analysis, were 39·257 per 1000, while the chlorine of water taken from a depth of 522 feet was 21·521 per 1000. This curious exception occurred between Candia and the African coast, where the dry and hot winds from the neighbouring Libyan desert evidently cause a strong evaporation and a considerable elevation of temperature, which counteract each other as to specific gravity. The difference between the upper and lower current in the Straits of Gibraltar is, in the surface-water, chlorine 20·160 per 1000, all salts 36·391, and in the depth of 540 feet, chlorine 20·330.

The cause why the surface-current is Atlantic water flowing into the Mediterranean, and the under-current Mediterranean water flowing into the Atlantic, has long since been assigned to depend upon the comparatively small quantity of water that flows from the land into the Mediterranean, and the hot and dry African winds that cause more water to evaporate than the rivers bring into the sea. My analyses have not given me any reason to alter anything in our views of the cause of this difference, nor do I regard the single instance of water that is more rich in salts at the surface than in the depth as more than a local exception.

As to the difference between surface and deep water for other substances, I shall only remark that the deep water of the Mediterranean contains a remarkable excess of sulphuric acid. The proportion between chlorine and sulphuric acid is

For the whole ocean . . .	100 : 11·89
Mediterranean surface . . .	100 : 11·82
Mediterranean depth . . .	100 : 12·07

Already in the Straits of Gibraltar the difference has the same character. The proportion is

For the surface	100 : 11·42
For the deep water	100 : 11·93

In some places, however, in the Mediterranean the surface-water is richer in sulphuric acid than water from the depth; thus, for instance, the sea between Sardinia and Naples had a proportion of 12·55 sulphuric acid in surface-water.

In the Baltic we have the same phenomenon; the water from the depth contains likewise more salt than that from the surface, but the direction of the currents is the reverse. The upper-current goes generally (not always) out of the Baltic, and the under-current goes, as it would appear, always into the Baltic. The cause of this great difference between the Baltic and the Mediterranean is evident; the Baltic receives the excess of atmospheric water from a great part of Europe. The greater part of Sweden, the greater part of European Russia, and a great part of North Germany send their water into the Baltic, and the evaporation is comparatively small. Thus the excess must find its way through the Sound and the Belts. With the assistance of Captain PROSILIUS, who in the year 1846 commanded the vessel at the station of Elsinore, the surface-current was observed on 134 days, from the 27th of April to the 11th of September; of which on 24 days it ran from the north, on 86 days from the south, and on 24 days there was no surface-current at all. The quantity of chlorine was determined for every sample by titration, and from that the quantity of salt deduced by multiplication with the determined coefficient 1·812. The mean quantity of salt for the current from the North was 15·994 per 1000; that for the current from the South 11·801; that for the period when there was no current at all was 13·342. Once a week a sample was taken from the bottom, by sending a reversed bottle down to the bottom, turning it there, and after having allowed it to stand some time, taking it slowly up. The mean of nineteen observations was 19·002 per 1000 salt, which, according to the manner in which the samples were taken, is rather under than above the real mean, and proves clearly that it is water from the Kattegat which runs at the bottom of the Sound. But we have also direct observations of the same fact. Some years ago a steamer was, close to Elsinore, struck by another steamer, and sunk a very short time after the collision.

When afterwards, in quiet sea, without current, a diver went down to save the passengers' goods, he found a violent current from the North. To the same class of phenomena belongs also the observation that large deep-going vessels not unfrequently go on in the Sound against surface-current, where smaller vessels do not succeed.

This under-current of Elsinore reaches often, and perhaps always, the harbour of Copenhagen, which I ascertained by a series of observations for which the laying of gas- and water-pipes offered me a good opportunity. To carry these pipes under the harbour, from Copenhagen to Christianshaven, on the Island Amager, a tunnel was projected through a solid hard limestone of the chalk formation, which lies under Copenhagen, its harbour, and its neighbourhood. When the tunnel was completed, it was found that the sea-water slowly filtered through the limestone, and fell down in drops from the roof of the tunnel. Comparative analyses would show how the water of the bottom of the harbour differed from that of the surface, and I might at the same time clear up another rather important question. It is generally known that the question of the formation of the dolomites, or the double carbonates of lime and magnesia, has excited a great interest, and many theories have been proposed about their formation. I myself have shown that a solution of carbonate of lime in carbonic acid water, when poured into sea-water, precipitates both carbonate of lime and carbonate of magnesia, but that the quantity of magnesia increases with the increased temperature in which the decomposition takes place. Neutral carbonate of lime thrown into sea-water would however, even at the boiling-point, not precipitate any carbonate of magnesia. It might, however, be a question of time, and it might be possible that such a decomposition would take place if sea-water during a long time was in close connexion with solid carbonate of lime. This would be the case if sea-water slowly filtered through 30 feet of solid limestone, which it does in the tunnel. We cannot, of course, expect to obtain any result by comparative analyses of the limestone; any change in the composition of this great mass of limestone would be so small that no result could be drawn from it, but we might analyze the sea-water filtered through the stone, and determine very small changes in its composition. Thus a series of comparative analyses of the sea-water from the surface of the harbour, of that from the bottom of it, and of the water filtered through the limestone into the tunnel, would show, first, whether the under-current from Elsinore reaches the harbour of Copenhagen; and secondly, whether the limestone roof of the tunnel acts upon the salts of magnesia in the sea-water which filters through it.

The experiments were made in the following way: once a week, from the 3rd of March to the 25th of April, 1852, one sample was taken of sea-water from the surface of the harbour over the tunnel, another sample from the bottom of the harbour at the same place, and a third sample was collected from the filtering water in the tunnel. The mean of these analyses gave,

For the surface	15·845 per 1000 salt
For the bottom of the harbour .	17·546 ,,
For the tunnel	18·315 ,,

which seems to prove that the under-current from Elsinore, at least at that season, reached Copenhagen. The difference between the water from the bottom of the harbour and the tunnel might either be occasioned by the slowness with which the water filters through the limestone of 30 feet thickness, so that it was water from another period which at last reaches the tunnel, or it may be explained by the way in which the samples from the bottom were taken, by sending an open bottle reversed down to the bottom, where it was turned and allowed to stand some time, to let the heavier water from the bottom dislodge the lighter water which had entered the bottle. The mean relative quantity of lime and magnesia was—

For the surface . . 1 lime to 4·062 magnesia.
For the bottom . . 1 lime to 4·153 magnesia.
For the tunnel . . 1 lime to 3·485 magnesia.

The proportion between lime and magnesia is therefore pretty much the same in the water from the surface and the bottom of the harbour, but in the water from the tunnel the relative proportion of the lime is increased. This may depend either upon a diminution of the magnesia, or upon an increase of the lime, or upon a combination of both effects; but if these changes took place only according to equivalents, it would prove that there had been formed dolomitic combination by the filtration of the magnesia salts of sea-water through the carbonate of lime in the limestone. To ascertain this point, I have compared the lime and magnesia with a third substance in sea-water, for which I chose chlorine. This mean proportion was—

For the surface . . 100 chlorine : 2·82 lime : 11·07 magnesia.
For the bottom . . 100 chlorine : 2·62 lime : 10·96 magnesia.
For the tunnel . . 100 chlorine : 3·11 lime : 11·08 magnesia.

It follows from these comparisons that the absolute quantity of lime had increased in the water of the tunnel, but that the absolute quantity of the magnesia in the same filtered water had not decreased, but was as nearly the same as an analysis could show. Thus the increase of the lime depended upon the solution of some carbonate of lime from the limestone. It was further found that water from the tunnel, when evaporated to dryness and dissolved, left more carbonate of lime than surface-water. The cause of this solution of the carbonate of lime was evidently to be sought in a bed of black mud which covers the bottom of the harbour, and is slowly converted into carbonic acid by the atmospheric oxygen absorbed by the sea-water. The sea-water impregnated with carbonic acid had dissolved some of the limestone through which it filtered.

Here might also be the place to mention and explain a rather curious phenomenon which is observed all along our coasts of the Sound and the Baltic, at least as far as Kiel. When the ice in spring begins to thaw, it disappears quite suddenly, and all the fishermen along the shore assure you unanimously that it sinks. I have examined a great number of these men, and have not found a single one who did not confirm the sudden disappearance of the ice in spring, and who did not consider it to be quite certain that the ice in spring sinks. I could, however, not find a single one of them who had *in spring* fished the ice up in his nets, while they very often in autumn and the beginning of the winter find it at the bottom, and see it rise to the surface*. It was evident that the sudden disappearance of the ice in spring was the fact which they had observed, and that the sinking of the ice was the popular explanation of the fact.

The natural philosopher will not allow ice to sink in sea-water, and it seems necessary to find another explanation. In order to give that I must first mention another peculiarity with the under-current of Elsinore. I observed on the 2nd of March, 1850, the temperature of the under-current with a maximum thermometer to be +2·6 C. (36°·8 F.) at the depth of 108 feet, while the temperature at the surface was +1·6 C. (34°·9 F.). Early in the next spring a friend of mine repeated the observation, and found likewise the higher temperature in the under-current, the difference being about 2° C. A third observation made in summer gave no difference. To explain this, I must observe that the water of the Kattegat, at least in its depth, is a branch of that great part of the Gulf-stream that passes along the western shores of Norway, and that the under-current at Elsinore necessarily must be less affected by the cold which reigns over the Baltic in winter time. Thus the under-current has in spring a higher temperature than the water of the surface, and at the same time contains a greater quantity of salt. Suppose, now, that the ice towards spring has begun to thaw and has become porous, as is generally the case, the warmer and more saline water will come in contact with it from below, and will melt it, partly on account of its temperature above freezing-point, partly on account of the greater quantity of salt which it contains. Thus without any apparent greater changes on the surface the ice will melt quickly and almost imperceptibly, and disappear. This effect of the under-current will be increased by the peculiarity of sea-water, that its point of greatest density lies below the freezing-point of pure water, and a constant series of small vertical currents will be formed where the warmer water rises, and that which is refrigerated by the contact with the ice sinks, which motion always will increase the melting of the surface-ice.

Besides at Elsinore and at Copenhagen, it has been observed at Kiel, near Stockholm, and in the Bay of Finland, that the deeper water is more saline than that of the surface. At Svartklubben, near Stockholm, water from the surface contained 3·256 chlorine =5·919 salt, and from a depth of 720 feet 3·912 chlorine =7·182 salt (coefficient 1·836); in the Bay of Finland, between the islands Nervoe and Sukjeld, the surface-water contained 3·552 per 1000 salt, while in a depth of 180 feet it contained 4·921.

It was only for the two larger salt-water basins of Europe, the Mediterranean and

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* This formation of the bottom ice is very frequently observed on our shores. There is a fishing bank a little to the north of Elsinore, where the fishermen often in the beginning of the winter find themselves suddenly surrounded by ice, which they see rise through the water, containing numerous pieces of Fucus inclosed in its mass. The same fact has also been observed not far from Copenhagen, and off Nyborg in the Great Belt. It seems, in fact, a phenomenon peculiar to such places where a strong current runs over a place that is not very deep.

the Baltic, that I was able to determine the quantity of salt near the surface and in the depth, but it is very probable that similar differences also may occur in other large inlets of the ocean. I want, however, direct observations in sufficient number, and shall here only mention an observation from the Caribbean Sea, where surface-water contained 19·936 chlorine, and water from a depth of 1170 feet contained 19·823 per 1000 chlorine. This difference in which the deeper water is less saline may be another instance of the effect of hot winds, like the water from the Mediterranean between Africa and the Island of Candia.

Going on now to the main section of the ocean, we will begin with the Atlantic, about which we have the best information, and which seems to show the most interesting facts. I will state the results of my investigations in moving from Baffin's Bay towards the south. In Baffin's Bay itself the water of the surface contains the same quantity of salt as that of the depth, but as soon as we pass the southernmost point of Greenland, the water of the surface contains more salt than that from the depth. This difference increases in going towards the Equator, and is indeed very considerable near that line. About the Equator, and a little to the south of it, many irregularities appear, as, for instance, in one case where the strongest water was found between two weaker portions above and below. In other cases the quantity of salt decreased with the depth, and in some instances it increased with it. I shall now state the observations themselves. Dr. Rink sent me water from the surface in Baffin's Bay to the west of Disco Island, which contained 33·594 per 1000 salt, and at the same place from a depth of 420 feet, which contained 33·607. The difference is so small that it signifies nothing. At the southernmost point of Greenland a small difference is observed, viz. in 59° 45′ N. lat. and 39° 4′ W. long., where surface-water contains 35·067, and that from a depth of 270 feet 34·963; but in about the same latitude and about 13° further towards W., at 59° 42′ N. lat. and 51° 20′ long., the proportion was reversed, the surface-water contained 34·876 per 1000 salt, while that from the depth contained 34·975 per 1000. From the sea between Iceland and Greenland (in which it appears that a returning branch of the Gulf-stream, the East Greenland current, runs towards the S.W.) I have obtained eight specimens from a depth between 1200–1800 feet. Unfortunately no specimens of water from the surface were taken at the same time, but we have a sufficient number of other surface observations, and thus we may compare the mean numbers, which are 35·356 for the surface, and 35·057 for a depth between 1200–1800 feet. In comparing the single observations of the deep water, we find that it contains the greatest quantity of salt in the eastern part at 35° 1′ W. long., with 35·179 per 1000 salt, decreasing regularly towards the westernmost part of this region in 55° 40′ W. long., with a quantity of salt =34·858 per 1000. Specimens taken by Captain Gram in 59° 50′ N. lat. and 7° 52′ W. long., contained for surface-water 35·576 per 1000, and for water from 270 feet depth 35·462.

I have two other comparative analyses of water from the East Greenland current, of which I owe the specimens to Colonel Schaffner. The analyses were not made com-

plete, but only chlorine and sulphuric acid were determined, which gives at 64° 30′ N. lat. and 26° 24′ W. long.,
for the surface,
19·616 chlorine, which with a coefficient 1·812 is =35·544 salt;
for a depth of 1020 feet,
19·504 chlorine, which with a coefficient 1·812 is =35·341 salt.

The next analysis of water from 62° 47′ N. lat. and 37° 31′·5 W. long., gave
for the surface,
19·491 chlorine =35·318 per 1000 salt;
for a depth of 1200 feet,
19·466 chlorine =35·272 per 1000 salt.

Further to the S.W., near the bank of Newfoundland, specimens taken by Captain von Dockum gave,
for the surface,
36·360 per 1000 salt;
for a depth of 240 feet,
36·598 per 1000 salt,

which is an increasing quantity of salt for the deep water, and coincides with other observations which show that this curious decreasing of the quantity of salt, with the increasing depth, belongs only to the deep part of the Atlantic far from the shores. On the European side of that ocean three samples, taken by Captain Schulz at 47° 15′ N. lat. and 9° 30′ W. long., gave the following quantities of salt:—
from the surface,
35·922 per 1000;
from a depth of 390 feet,
35·925 per 1000;
from a depth of 510 feet,
36·033 per 1000;
thus showing a trifling increase of salt with the depth.

The most complete set of experiments showing this influence of the shores, I have made on twelve samples taken by the 'Porcupine' in 1862, which I owe to the obliging kindness of Rear-Admiral FitzRoy. The samples are taken between 50° 56′ and 55° 22′ N. lat., and 12° 6′ and 15° 59′ W. long., about four degrees to eight degrees of longitude to the west of Ireland, and five of them were from the surface, while seven were from deep water, between 1200 and 10,500 feet.

The mean of the five surface observations is—

Chlorine.	Sulphuric acid.	Lime.	Potash.	Magnesia.	All salts.
19·662	2·342	0·566	0·367	2·205	35·613.

The mean of the seven observations from the deep sea is—

Chlorine.	Sulphuric acid.	Lime.	Potash.	Magnesia.	All salts.
19·677	2·357	0·583	0·363	2·193	35·687

Chlorine =100, the proportions are—

	Chlorine.	Sulphuric acid.	Lime.	Potash.	Magnesia.	All salts.
For surface . . .	100	11·91	2·88	1·87	11·21	181·1
For deep water. .	100	11·98	2·96	1·84	11·14	181·4

The difference is very trifling, and the quantities of salts increase in a very slight degree with the depth.

I owe all the other samples from the North Atlantic Ocean which have been used for my analyses, of which I am now going to give the results, to the late Sir James Ross, through the assistance of the most honourable and learned President of the Royal Society, General Sabine, who always is most willing to assist scientific labours with his powerful influence and his prudent advice, and to whose intercession I am indebted for several of the most interesting results I have obtained in this investigation.

At 18° 16′ N. lat. and 29° 56′ W. long.,
from the surface,
20·429 chlorine =36·833 per 1000 salt (coefficient deduced from five complete analyses of water from Sir J. Ross=1·803);
from 3600 feet,
19·666 chlorine =35·448 per 1000 salt.

At 16° 27′ N. lat. and 29° W. long.,
from the surface,
20·186 chlorine =36·395 per 1000 salt (coefficient 1·803);
from 900 feet,
20·029 chlorine =36·112 per 1000 salt (coefficient 1·803);
from 2700 feet,
19·602 chlorine =35·342 per 1000 salt (coefficient 1·803).

At 15° 38′ N. lat. and 28° 10′ W. long.
from the surface,
20·081 chlorine =36·206 per 1000 salt (coefficient 1·803);
from 3360 feet,
19·744 chlorine =35·598 per 1000 salt (coefficient 1·803).

At 14° 18′ N. lat. and 27° 15′ W. long., surface observation wanting;
from 900 feet,
19·934 chlorine =35·941 per 1000 salt (coefficient 1·803);
from 2700 feet,
19·580 chlorine =35·303 per 1000 salt (coefficient 1·803);
from 3600 feet,
19·705 chlorine =35·528 per 1000 salt (coefficient 1·803).

At 12° 36′ N. lat. and 25° 35′ W. long.,
from the surface,
20·114 chlorine =36·195 per 1000 salt (direct observation);
from 11,100 feet,
19·517 chlorine =35·170 per 1000 salt (direct observation).

At 11° 43′ N. lat. and 25° 6′ W. long.,
from the surface,
20·035 chlorine =36·123 per 1000 salt;
from 3600 feet,
19·855 chlorine =35·799 per 1000 salt;
from 4500 feet,
19·723 chlorine =35·561 per 1000 salt.

At 1° 10′ N. lat. and 25° 54′ W. long.,
from the surface,
19·757 chlorine =35·622 per 1000 salt;
from 1800 feet,
19·715 chlorine =35·546 per 1000 salt;
from 3600 feet,
19·548 chlorine =35·245 per 1000 salt.

For the South Atlantic Ocean, the relation between the salts of the upper and lower parts of the sea is variable and difficult to explain. In 0° 15′ S. lat. and 25° 54′ W. long. the quantity of salts found in different depths was as follows:—
from the surface, wanting;
from 900 feet,
19·763 chlorine =35·820 (coefficient 1·814);
from 1800 feet,
19·991 chlorine =36·264 (coefficient 1·814);
from 4500 feet,
19·786 chlorine =35·892 (coefficient 1·814);
from 5400 feet,
20·007 chlorine =36·293 (coefficient 1·814).

Most deviating is a series of observations from 22° 37′ S. lat. and 34° 57′ W. long.:—
from the surface,
20·397 chlorine =37·000 (coefficient 1·814);
from 900 feet,
20·323 chlorine =36·866 (coefficient 1·814);
from 1800 feet,
23·189 chlorine =42·165 (coefficient 1·814);
from 2700 feet,
20·331 chlorine =36·880 (coefficient 1·814);
from 3600 feet,
20·405 chlorine =37·015 (coefficient 1·814).

Already in the water from different depths immediately on the south side of the Equator there is a curious variation; at 1800 feet it is about one-half per 1000 richer in salt than at 900 feet, and in 4500 feet the quantity of salt has diminished as much as it had increased before. At 5400 feet it has a greater quantity of salt than any of the upper specimens has shown. In the series from 22° 37′ S. lat. the surface has a high number, higher than any corresponding sample from the North Atlantic, it sinks a little at 900 feet, but rises at 1800 feet to a quantity of salt which does not occur in any other place in the whole Atlantic, not even the maximum of the Mediterranean, and we know only the Red Sea which exceeds it; it is as if the water of the Red Sea were transported to this submarine current. I thought there might be a fault in the determination of the chlorine, and repeated it; but the difference was very insignificant, being in the one case 23·187, in the other 23·191, the mean being 23·189. I thought that by some accident some salt might have come into the instrument by which the water was taken, and I made a complete analysis of the water, but the different substances which were determined showed but slight differences from the normal proportions, viz.—

	Chlorine.	Sulphuric acid.	Lime.	Potash.	Magnesia.
22° 37′ S. lat., 1800 feet . .	100	11·59	2·77	2·14	11·29
South Atlantic.	100	12·03	2·91	——	10·96

It might perhaps be owing to an evaporation in the bottle, but then the bottle was full, and cork and sealing-wax were sound, while about one-seventh of its whole contents must have been evaporated to explain the difference. If there is any mistake in this curious observation, it must probably have been caused by a negligence which left the instrument for taking the water from the deeper part of the sea partly filled with sea-water, exposed to evaporation in tropical heat, and sent it down without being cleaned. I should hardly think that such a fault could have been committed, and we must hope that new experiments will confirm the fact. The series of observations from 0° 15′ S. lat. belong in fact to the same kind, by the alternation of stronger and weaker sea-water in different depths; but the curious and surprising fact in the observation from 22° 37′ S. lat. is, that in the whole Atlantic Ocean we do not know a single place where water with that quantity of salt occurs. The next specimen, from 22° 37′ S. lat. and a depth of 2700 feet, is very nearly the same as that from 900 feet, and that from 5400 feet very near that from the surface of the same place.

It appears thus that the water of the North Atlantic Ocean, between the southernmost part of Greenland and the equator, decreases in salinity with the depth, but that this curious fact is observed only in the middle bed of the Atlantic, and disappears when we approach the shores on both sides of the ocean. As to the cause of this rather surprising state, I am still of the same opinion which I expressed when I first observed it, that it depends upon a polar under-current. The hypothesis has been published, that it depended upon fresh-water springs at the bottom of the ocean, and such an opinion might have some chance as long as we only had few observations; but now we have such a number of observations spread over a vast extent of the ocean, that it appears to be quite impossible to explain it by springs of fresh water, which of course must be more frequent and more powerful near the land, from which they have their origin. Observation, however, shows the reverse; near the shores the water is either uniform throughout its whole depth, or the quantity of salt increases with the depth.

The next question is whether we can find a similar distribution in the other parts of the ocean. As to the southern portion of the Atlantic, there occurs such a confused distribution of the quantity of salt in the different depths at the same place, that we are not able as yet to draw any conclusions from it, but must wait for more copious observations.

As to the other parts of the ocean, I have only very few observations from the sea between Africa and the Aleutic Islands; but these few observations do not show any regularity, or at all events seem more to incline to an increase of the quantity of salt with the increasing depth. The geographical distribution between land and sea is, however, quite different in this large part of the ocean. While a strong polar current from Baffin's Bay pours its cold and less saline waters into the North Atlantic Sea, the large mass of Asia prevents any north polar current from reaching the south Asiatic sea, into which the numerous great rivers of Asia send vast quantities of warm fresh water.

As to the south polar currents, we know very little about their influence upon the salinity of the southern ocean; but in Sir James Ross's 'Voyage' (vol. ii. p. 133) there is an observation upon the different specific gravity in different depths, which indicates a state of things similar to that in the North Atlantic Ocean. His observations are these:—"At 39° 16′ S. lat., 177° 2′ W. long., the specific gravity of the surface-water 1·0274, at 150 fathoms 1·0272, and at 450 fathoms 1·0268, all tried at the temperature of 60° F., and showing that the water beneath was specifically lighter than that of the surface when brought to the same temperature; our almost daily experiments confirmed these results"*.

The principal currents of the Atlantic, the Equatorial current, the Gulf-stream, and the East Greenland current.

These three currents are in fact only the same; they begin, as is well known, in the Bay of Benin, under the Equator, and the main current runs straight to the west over the Atlantic to Cape Roque, on the east coast of South America. I certainly shall not try to lessen the weight of the arguments which assign the cause of this equatorial current to the rotatory motion of the earth, but I will only give some remarks as to other influences that act to the same effect.

If we compare the quantity of salt which is found in sea-water in the region between

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[*] To compare these observations of specific gravity with the quantity of salt in different depths, which I have mentioned in the former part of this paper, I shall here refer to some experiments which I have made to obtain a ratio by which I could compute the quantity of salts in the sea-water from the specific gravity, and *vice versâ*. I have compared, in thirteen specimens of sea-water, the specific gravity with the quantity of chlorine which the water contained, between 13°·75 C. (56°·75 F.) and 18°·8 C. (65°·8 F.). It was found that a unit in the fourth decimal place of the specific gravity of sea-water, measured by the hydrometer, is equal to $\frac{71}{1,000,000}$ of chlorine, the minimum being 66, the maximum 76. To find what quantity of salt corresponds to the specific gravity of the surface-water, as determined by Sir James Ross to be 1·0274, we must multiply 274 by 71, which gives 19·454 chlorine in the sea-water, and that number being multiplied by the general coefficient 1·812, gives 35·251 per 1000 salt for the water from the surface. According to the same computation the sea-water from 150 fathoms contained 34·993 per 1000 salt, and that from 450 fathoms 34·478 per 1000 salt.

5° N. lat. and 5° S. lat. with those between 5° and 20° to the North and of 5° to 30° to the South, we find the interesting fact that the water flowing in the vicinity of the Equator contains less salt than that which flows both to the north and to the south of it. For the equatorial region (5° S. to 5° N.) the mean of six observations is 35·575 per 1000; or if we leave out a sample from Sir JAMES ROSS, from 150 fathoms' depth (that from the surface is wanting), it is 35·520. From 5° to 20° N. the mean of eight analyses is 36·279, and from 5° to 30° S. the mean of six analyses is 36·631 per 1000. This difference is still more striking on comparing the salinity of the equatorial region with that of the northern Atlantic region (second region), whose mean is 35·932 per 1000 salt. It deserves further attention, that the maximum of the equatorial region is below the mean of its neighbours both to the south and to the north. It appears to me that this curious fact can be explained only by the vast quantity of fresh water which the Niger, the Ogaway, and a number of other West African rivers carry in this region into the sea, which all gets into the equatorial current, and moves to the westward. It is evident that this warm water must increase its relative quantity of salt by evaporation during its motion across the Atlantic, and a comparison of the analyses of the single samples of the water from the equatorial current shows that this effect really takes place. The easternmost sample contains the minimum, with 34·238 per 1000, and the two westernmost samples contain the greatest quantity of salt, with 36·084. Thus the equatorial current appears as a continuation of the large West African rivers of the equatorial zone, which dilute the sea-water of the equatorial region with about 8 per cent. of fresh water, and thus counteract the great evaporation. While the equatorial current continues its course along the north-east coast of South America, it receives and carries with it the waters of the Paranahyba, the Araguai, the Amazon river, the Essequibo, the Orinoco, and numerous smaller rivers of the north coast of South America; but though I have no observations from this part of the current*, the fact is shown by three observations from the sea in the neighbourhood of the Danish islands of St. Croix

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* [When my remarks on the equatorial current between Cape Roque and the West Indian islands were written, I was not aware of the very interesting observations which General SABINE made in 1822, on the influence of the water of the Amazon river on that of the Equatorial current. I shall now insert them here, their bearing being in the same way as my deficient observations.

In 5° 8′ N. lat. and 50° 28′ W. long. a distinct line of separation was observed between the pure blue water of the ocean and the discoloured water mixed with that from the Amazon river, the mouth of which was about 300 miles distant. The blue water had a specific gravity of 1·0262, which according to my calculation (p. 37) is =33·672 per 1000 salt, while the water on the other side of the line of separation was 1·0204=26·345 per 1000 salt; further on, under the influence of the river, it was 1·0185=23·800 per 1000 salt. But the river water kept on the surface and in a depth of 126 feet, the specific gravity was 1·0262(=33·672 per 1000 salt).

In 7° 1′ N. lat. and 52° 38′·5 W. long. the specific gravity was 1·0248=31·905 per 1000 salt, and in 120 feet depth again 1·0262 specific gravity.

In 7° 5′ N. lat. and 53° 30′ W. long. it was 1·0253=32·549 per 1000 salt.

In the Gulf of Paria, off the mouth of the Orinoco, the specific gravity was 1·0204=26·345 per 1000 salt, and in crossing one of the branches of the river itself the specific gravity was found to be only 1·0064=8·234 per 1000 salt. See 'An Account of Experiments to determine the Figure of the Earth, by EDWARD SABINE. London, 1825.'—G. F., April, 1865.]

and St. Thomas, whose mean salinity is 35·7 per 1000; while two degrees more to the north the mean of two observations is 36·7, which seems to be the normal salinity of the West Indian Sea. In the Caribbean Sea, where the Magdalene river gives a new quantity of fresh water, the sea contains on the surface, according to one observation, 36·104 per 1000 salt. I have unfortunately no observation from the Mexican Gulf, nor from the beginning of the Gulf-stream, where it leaves the Mexican Gulf, but to the north of the Bermudas it contains only 35·883 per 1000 salt, about the same quantity which the equatorial current contains between 20° and 30° W. longitude. From that place the salt of the Gulf-stream increases constantly during its course towards the north-east, viz. 36·105 per 1000, 36·283 per 1000. In 43° 26′ N. lat. and 44° 19′ W. long., about 16° of longitude to the east of the southern mouth of the St. Lawrence, between Nova Scotia and Newfoundland, it sinks suddenly to 33·854 per 1000, and rises from thence slowly in its course towards the east to 34·102 and 35·597, until, midway between Newfoundland and the south-western cape of Great Britain, it has risen to 35·896 per 1000, a quantity of salt which diminishes very little in the whole North Atlantic Ocean between Scotland and Iceland. During this whole long course, from the Bay of Benin to Spitzbergen, this remarkable current shows a constant oscillation between the diluting influence of the large rivers and the evaporation occasioned by the high temperature of the current.

Now we shall try to trace its further progress. I have always thought that the East Greenland current was of polar origin, and that it carried the waters from the large opening between Spitzbergen and the northernmost coast of Greenland into Davis's Straits, where it turns and mixes its waters with the polar current that comes from the North American polar sea through Lancaster Sound, and the numerous other sounds that connect Baffin's Bay with the American polar sea, but I never had an opportunity of making comparative analyses of the water from that but seldom visited part of the ocean. Colonel SCHAFFNER had the kindness on his voyage between the eastern part of Iceland and the south part of Greenland to take a number of samples, which I have analyzed, and the result of which will be found in my fourth region, the East Greenland current. The mean of twelve observations of water, taken for the greatest part by Colonel SCHAFFNER (three by Captain GRAM), is 35·278 per 1000 salt, where one analysis of water taken in the ice-pack is left out, being no fair sample of sea-water from that region. In comparing this mean number with that of the North Atlantic Ocean (35·391), there will hardly be found any difference in the quantity of salt the two contain; while there is a great difference between these and the real polar current of Baffin's Bay, which is 33·281 per 1000, or of the Patagonian polar current (33·966). I think we may infer from this fact, that the East Greenland current is a returning branch of the Gulf-stream, and that the east coast of Greenland proportionally gives very few icebergs and very little glacial water to the sea. For comparison's sake I shall mention here that the sea about midway between Norway and Spitzbergen contains 35·222 per 1000. I found the water taken on the south side of that island to contain 35·416 per 1000, while that on the north side of Spitzbergen contained 33·623 per 1000. The last-mentioned sample seems to be real polar water, while all the water that flows between Norway, Spitzbergen, Iceland, and the east coast of Greenland partakes of the nature of the Gulf-stream.

Besides the reasons just mentioned for considering the East Greenland current to be a returning branch of the Gulf-stream, reasons which are deduced from the quantity of salt which the water contains, there are other reasons which lead to the same result. It is well known that the Gulf-stream brings tropical fruits from America to the coast of Norway, and it has once brought a river-vessel loaded with mahogany to the coast of the Faroe Islands. It is likewise known that similar fruits to those which are found on the Norwegian shores are carried by the sea to the coast of Iceland, and principally to its north and east coasts, where they only could get if the Gulf-stream turns between Spitzbergen and Iceland, and thus runs between Iceland and Greenland towards the south-west. It would be difficult to explain how a polar current could bring tropical fruit to the north coast of Iceland.

On the west coast of Greenland the south-easterly wind brings in winter a mild temperature, and this fact is so generally known in the Danish colonies of Greenland, that many of the colonists are convinced that there are volcanos in the interior of that snow-clad land. The temperature which this current, that in winter and spring is full of drifting ice (not icebergs), communicates, can of course not be above freezing-point, but that temperature is mild, when the general temperature in winter is 8°, 10°, or 12° R. below the freezing-point. All these facts together leave hardly any doubt in my mind that it is the Gulf-stream which runs along the east coast of Greenland, and at last in Davis's Straits mixes its waters with the polar current from Baffin's Bay. In its course towards the south it meets the main part of the Gulf-stream at Newfoundland, where it partly mixes with it to begin its circulation anew, partly dives under it, and runs as a ground stream as far as the Equator. In a similar way the southern branch of the Gulf-stream, which goes parallel to the western shores of South Europe and North Africa, joins the equatorial current at its beginning in the Bay of Benin, and begins also its circulation anew.

Chemical Decomposition in Sea-water.

If we consider the almost uniform composition of sea-water in the different parts of the ocean, such as they are represented by comparing the salts with the quantity of chlorine as unity, and thus avoiding the influence of the different quantities of water in which they are dissolved, we might be inclined to suppose the salts of sea-water to be in chemical combination with each other, and to form a compound salt with definite proportions. This is however not the case, and sea-water is not more a chemical compound than the atmospheric air, and the steadiness of the quantity of the different substances depends partly upon the enormous mass of the water of the ocean, compared to which all changes disappear, partly upon the constant motion which current and wind occasion. In the bays and those parts of the sea which only have narrow sounds that connect them with the main ocean, where therefore the general motion of the sea cannot have that influence it has in the open ocean, we observe differences which show the influence of the land upon the constituent parts of the sea-water. This want of chemical combination between different salts will become more evident when, instead of comparing their different quantities, we compare the relative number of their equivalents. The mean quantity of the different substances in the whole ocean, as deduced from the mean of regions I., II., III., IV., V., XI., XII., XIII., XIV., XV., XVI., XVII., is in 1000 parts of sea-water,—

Chlorine.	Sulphuric acid.	Lime.	Potash.	Magnesia.	All salts.	Coefficient.
18·999	2·258	0·556	0·367*	11·03	34·404	1·811

Chlorine =100.

Sulphuric acid.	Lime.	Potash.	Magnesia.	All salts.
11·88	2·93	1·87*	11·03	181·1

Proportion of Equivalents.

Chlorine.	Sulphuric acid.	Lime.	Potash.	Magnesia.
429	45	16	6	82.

There is one question which deserves a closer examination, viz. how the salts that now constitute the water of the sea came into it? Is it the land that forms the sea, or is it the sea that makes the land? Are the salts that now are found in sea-water washed out of the land by the atmospheric water? Has the sea existed from the beginning of the earth? and has it slowly but continually given its elements to form the land?

To try to give an answer to these most important questions, let us suppose that any river, for instance the Rhine, had its outlet into a valley with no communication with the sea, it would be filled with water until its surface was so great, that the annual evaporation was equal to the quantity of water which the river carried into it; then there would be a physical equilibrium but no chemical, because all the water that was carried into the lake would contain different mineral substances, which the rain-water had dissolved from the country which the river drains, while the loss by evaporation would be pure water. The quantity of saline substances in the lake would constantly go on increasing until chemical changes would occasion the precipitation of different salts. By comparing the chemical constitution of the water of the Rhine, we might form an idea of the different elements contained in the water of this lake. We should find that among the bases the lime was prevailing, and next to it the magnesia, next to it the soda, the iron, the manganese, the alumina, and potash. Of acids the carbonic would be prevailing, and next to it the sulphuric, the muriatic (chlorine), and the silicic. Now all these substances are found in sea-water, but the proportions are quite different.

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* The potash which I have mentioned here represents in fact not the mean of all the observations in the great ocean, but only the mean of a number of determinations for the northern part of the Atlantic, my older observations on the quantity of potash in the other parts of the ocean being not exact enough. This quantity of potash differs most probably very little from the real mean.

The ocean is in fact such a lake, into which all the rivers carry what they have dissolved from the land, and from which pure water evaporates; and whatever we think about the constitution of the primitive ocean, this effect of the rivers, which has lasted for thousands of years, must have had an influence upon the sea. Why do we not observe a greater influence of the rivers? Why does not lime, the prevailing base of river-water, occur in a greater proportion in the water of the ocean? In all river-water the number of equivalents of sulphuric acid is much smaller than that of lime, and yet we find in sea-water about three equivalents sulphuric acid to one of lime. There must thus be in sea-water a constantly acting cause that deprives it again of the lime which the rivers furnish, and we find it in the shell fishes, the corals, the bryozoa, and all the other animals which deposit carbonate of lime. From the proportion between sulphuric acid and lime in river-water and in sea-water, it is evident that these animals are able not only to deprive the water of its carbonate of lime, of which sea-water contains very little, but that they also must decompose the sulphate of lime, a decomposition which probably depends upon the carbonate of ammonia which is formed by the vital process of these animals. I have shown that a salt of ammonia occurs in sea-water, certainly in small quantities, which however does not signify much, since the ammonia is constantly absorbed by the sea-weeds. Thus it is a chemical action of small animals which constantly deprives the sea of its excess of lime.

Next to the lime we must consider the silica, which is a constant constituent of river-water, and the immense quantity of diatomaceæ, of infusoria, and sponges will account for the small quantity of it at any given time in sea-water. I shall name next the sulphuric acid. All the shells of shell fishes, all the carbonate of lime in the corals and bryozoa contain some sulphate of lime, about one per cent. or less, but all the sea-weeds attract a great quantity of sulphates, which by the putrefaction of the plants are changed into sulphurets; and the sulphurets give again their sulphur to the iron, both that which is dissolved in sea-water, and that which in the form of oxide, combined with clay and other earths, is mechanically suspended in the water of the sea, principally near the shores. Thus the sulphur is made insoluble and disappears from the brine. The magnesia enters in a small quantity into the shells and corals, but only a small quantity is thus abstracted from sea-water, and at last the soda and muriatic acid or chlorine form, as far as we know, by the pure chemical or organico-chemical action that takes place in the sea, no insoluble compound. Thus the quantity of the different elements in sea-water is not proportional to the quantity of elements which river-water pours into the sea, but inversely proportional to the facility with which the elements in sea-water are made insoluble by general chemical or organo-chemical actions in the sea; and we may well infer that the chemical composition of the water of the ocean in a great part is owing to the influence which general and organo-chemical decomposition has upon it, whatever may have been the composition of the primitive ocean. I shall, however, not dwell any longer on this side of the question, which deserves a much more detailed representation than I can give it here.

There is a more special decomposition of sea-water, which takes place exceptionally, but these exceptions are very frequent. They depend upon the organic beings that live in the sea, die, and decay in the sea, and are finally dissolved. Of these substances that have their origin from organic beings, I have already named ammonia; but there are other substances of organic origin, probably of a more complicated nature, which I have observed in the following way. If we pour one or two drops of a solution of hypermanganate of potash into fresh sea-water, which has no smell of sulphuretted hydrogen, we shall after a short time observe a change in the colour of the liquid, but it is hardly more than the first drop that is decomposed so soon after it has been mixed with sea-water. The next decomposition goes slower, and is only finished after the liquid has been boiled for some time. Now if we pour hypermanganate of potash into a very diluted solution of ammonia, it will be completely decomposed by warming the mixture to a slight degree. I suppose that the first action upon the hypermanganate depends upon the ammonia in sea-water, and the next, which is slower and requires boiling and a longer time of action, depends probably upon the other products of spontaneous decomposition of organic matter. Coinciding with these observations is the experience that sea-water taken near the surface decomposes a smaller quantity of hypermanganate than that which is taken from the depth. If it was ammonia that produced the decomposition, there is no reason why there should be less of it near the surface than in deep water, since it being combined with a strong acid (either sulphuric or muriatic) neither could be volatilized nor oxidized. If it was organic matter, it would be oxidized near the surface, on account of the absorbed oxygen of the atmosphere.

When this organic matter increases in sea-water near the shores, or at the mouth of rivers, it will cause a real putrefaction, and attack the sulphates, converting them into sulphurets, which again are decomposed by the carbonic acid formed from the organic substances at the expense of the oxygen of the sulphuric acid. This sulphuretted hydrogen gets free, the carbonic acid will precipitate lime, and a loss of sulphuric acid by fermentation will always occasion a loss of lime in sea-water. Putrefaction seldom decomposes more than a small quantity of the sulphuric acid present in sea-water, and even where it seems to have been very powerful, not one-third part of the sulphuric acid has been destroyed. While thus a portion of the sulphates always remains undecomposed, there also seems always to remain a portion of the organic matter unoxidized. The sulphuretted hydrogen acts instantaneously upon hypermanganates, but when all smell of sulphuretted hydrogen has disappeared, there still remains some substance in putrefied sea-water which bleaches the hypermanganates when the water is boiled. It may be one of the lower oxides of sulphur, or it may be that the organic substance was not fully oxidized.

There is still one general effect of the organic substances dissolved in sea-water, that all iron is reduced from peroxide to protoxide, all mud from the deeper parts of the sea is dark coloured, either grey, bluish, or green. All Sir JAMES ROSS's deep soundings brought blue or green mud or sand to the surface.

In the following Tables the sulphuric acid, lime, magnesia, and potash are given both in parts per 1000 sea-water, and referred to chlorine as 100. The latter numbers are distinguished by being enclosed in parentheses.

First Region.—From the Equator to 30° N. lat.

	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts together.	Coefficient.
1. Sir James Ross, June 11, 1843. N. lat. 1° 10′, W. long. 25° 54′	19·757	2·303 (11·66)	0·584 (2·96)	2·333 (11·81)	35·737	1·801
2. Captain Irminger, September 9, 1847. Tocorady Bay, Guinea, 1 mile from the land	19·584	2·315 (11·66)	0·765 (3·85)	2·179 (10·99)	35·803	1·803
3. Captain Irminger, September 7, 1847. N. lat. 4° 10′, W. long. 5° 36′	19·014	2·224 (11·64)	0·660 (3·47)	2·163 (11·37)	24·283	1·803
4. Sir James Ross, July 6, 1843. N. lat. 6° 43′, W. long. 27° 4′	20·070	......	......	......	36·327	......
5. Valkyrie, February 3, 1848. N. lat. 10°, W. long. 24° 19½′	19·766	2·415 (12·22)	0·568 (2·87)	2·117 (10·71)	35·941	1·818
6. Sir James Ross, July 11, 1843. N. lat. 11° 43′, W. long. 25° 6′	20·035	......	......	......	36·263	......
7. Sir James Ross, July 22, 1843. N. lat. 12° 36′, W. long. 25° 33′	20·114	2·343 (11·39)	0·619 (3·08)	2·315 (11·21)	36·195	1·800
8. Sir James Ross, July 25, 1843. N. lat. 15° 38′, W. long. 27° 15′	20·081	......	......	......	36·347	......
9. Sir James Ross, July 26, 1843. N. lat. 16° 57′, W. long. 29°	20·186	......	......	......	36·537	......
10. Sir James Ross, July 27, 1843. N. lat. 18° 6′, W. long. 29° 56′	20·429	......	......	......	36·976	......
11. Ornen, October 19, 1846. N. lat. 19° 20′, W. long. 65° 28′	19·818	2·376 (11·99)	0·567 (2·86)	2·123 (10·76)	35·775	1·805
12. Valkyrie, January 28, 1848. N. lat. 24° 13′, W. long. 23° 11′	20·898	2·446 (11·70)	0·595 (2·85)	2·280 (10·91)	37·908	1·814
13. Captain von Dockum, July 17, 1845. Between the Islands St. Croix and St. Thomas	19·650	2·309 (11·75)	0·567 (2·89)	2·236 (11·36)	35·732	1·819
14. Captain von Dockum, July 18, 1845. Likewise between the two islands	17·798	2·304 (11·64)	0·426 (2·15)	2·195 (11·69)	35·769	1·807
15. Ornen, October 23, 1846. N. lat. 22° 43′, W. long. 65° 12′	20·320	2·423 (11·92)	0·602 (2·96)	2·208 (10·87)	36·784	1·810
16. Captain von Dockum, July 29, 1845. N. lat. 22° 30′, W. long. 69° 10′	20·145	2·344 (11·64)	0·554 (2·75)	2·164 (10·74)	36·508	1·812
17. Captain Irminger, March 17, 1849. N. lat. 25° 4′, W. long. 65° 40′	20·302	2·450 (12·07)	0·620 (3·05)	2·302 (11·34)	36·736	1·809
18. Captain von Dockum, July 30, 1845. N. lat. 23° 26′, W. long. 64° 8′	20·291	2·207 (10·88)	0·606 (2·99)	2·251 (11·09)	36·352	1·792
19. Ornen, October 28, 1846. N. lat. 29° 27′, W. long. 60° 1′	20·389	2·418 (11·86)	0·600 (2·94)	2·217 (10·87)	36·838	1·807
Mean	20·034	2·348 (11·75)	0·595 (2·98)	2·220 (11·11)	36·253	1·810
Maximum	20·898	2·450 (12·22)	0·765 (3·85)	2·333 (11·81)	37·908	1·819
Minimum	19·014	2·207 (10·88)	0·426 (2·15)	2·117 (10·71)	34·283	1·792

Second Region.—The Atlantic between 30° N. lat. and a line from the northernmost point of Scotland to the north point of Newfoundland.

	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts together.	Coefficient.
1. Captain von Dockum, August 3, 1843. N. lat. 31° 51', W. long. 67° 23'	20·159	2·449 (12·15)	0·607 (3·01)	2·460 (12·20)	36·480	1·810
2. Captain von Dockum, August 3, 1843. N. lat. 32° 52', W. long. 68°. To the west of the Bermudas	20·064	2·489 (12·15)	0·566 (2·82)	2·062 (10·28)	36·635	1·826
3. Captain Schulz, September 28, 1860. Straits of Gibraltar	20·160	2·302 (11·42)	0·610 (3·03)	2·134 (10·59)	36·391	1·805
4. Ornen, November 5, 1846. N. lat. 36° 13', W. long. 55° 7'	20·080	2·398 (11·94)	0·600 (2·98)	2·250 (11·20)	36·304	1·808
5. Captain von Dockum, August 6, 1843. N. lat. 36° 52', W. long. 66° 38'. North from Bermudas in the Gulf-stream	19·890	2·336 (11·74)	0·595 (2·99)	2·299 (11·66)	35·883	1·804
6. Ornen, November 7, 1846. N. lat. 37° 5', W. long. 48° 24'	20·103	2·518 (12·52)	0·643 (3·15)	2·177 (10·83)	36·643	1·823
7. Captain von Dockum, August 7, 1843. N. lat. 37° 24', W. long. 61° 8'	19·943	2·374 (11·90)	0·595 (2·98)	2·284 (11·45)	36·105	1·810
8. Ornen, November 9, 1846. N. lat. 38° 18', W. long. 43° 2'	20·247	2·557 (12·63)	0·689 (3·40)	2·260 (11·16)	36·928	1·824
9. Captain von Dockum, August 13, 1843. N. lat. 39° 39', W. long. 55° 16'	20·063	2·432 (12·12)	0·588 (2·93)	2·208 (11·01)	36·283	1·808
10. Captain von Dockum, August 13, 1843. N. lat. 40° 21', W. long. 54° 15'	20·098	2·425 (12·07)	0·606 (3·02)	2·391 (11·90)	36·360	1·809
11. Ornen, November 11, 1846. N. lat. 40° 53', W. long. 36° 23'. S.W. from the Newfoundland Bank	20·062	2·427 (12·10)	0·718 (3·58)	3·123 (10·58)	36·389	1·814
12. Captain von Dockum, August 17, 1843. N. lat. 43° 26', W. long. 44° 19'	18·685	2·208 (11·82)	0·534 (2·86)	2·081 (11·14)	33·854	1·812
13. Captain von Dockum, August 18, 1843. N. lat. 44° 33', W. long. 42° 34'. E. from the Newfoundland Bank	18·842	2·236 (11·87)	0·560 (2·97)	2·079 (11·03)	34·102	1·810
14. Ornen, November 13, 1846. N. lat. 44° 39', W. long. 30° 20'	19·890	2·376 (11·95)	0·650 (3·27)	2·154 (10·83)	36·032	1·812
15. Ornen, November 15, 1846. N. lat. 46° 22', W. long. 22° 55'	19·857	2·400 (12·09)	0·582 (2·93)	2·185 (11·01)	36·010	1·813
16. Ornen. N. lat. 47° 10', W. long. 18° 45'	19·892	2·400 (12·09)	0·586 (2·94)	2·175 (10·94)	36·090	1·814
17. Ornen. N. lat. 47° 17', W. long. 14° 24'	19·722	2·441 (12·38)	0·590 (2·99)	2·166 (10·98)	35·872	1·819
18. Captain von Dockum. N. lat. 47° 17½', W. long. 19° 9'	19·656	2·346 (11·94)	0·580 (2·95)	2·170 (11·04)	35·625	1·812
19. Captain von Dockum. N. lat. 47° 18', W. long. 21° 6½'	19·915	2·413 (12·12)	0·587 (2·95)	2·172 (10·91)	36·119	1·814
20. Captain von Dockum. N. lat. 47° 40', W. long. 32° 7'	19·860	2·327 (11·72)	0·583 (2·94)	2·265 (11·40)	35·896	1·808
21. Captain Schulz. N. lat. 47° 45', W. long. 9° 30'	19·664	2·556 (13·01)	0·589 (2·99)	2·273 (11·57)	35·922	1·823
22. Captain von Dockum. N. lat. 47° 50', W. long. 33° 50'	19·749	2·320 (11·75)	0·601 (3·04)	2·183 (11·06)	35·597	1·803
23. Ornen. N. lat. 48° 10', W. long. 9° 35'	19·882	2·393 (12·03)	0·726 (3·65)	2·077 (10·45)	36·093	1·815
24. Captain von Dockum. N. lat. 50° 3', W. long. 11° 6'	19·691	2·336 (11·86)	0·572 (2·90)	2·208 (11·21)	35·570	1·806
25. Porcupine, mean of 5 analyses of surface-water taken between 51° 9' and 55° 32' N. lat., and 12° 11' and 13° 59' W. long.	19·662	2·342	0·566	2·205	35·613	1·811
Mean	19·828	2·389 (12·05)	0·607 (3·07)	2·201 (11·10)	35·932	1·812
Maximum	20·247	2·557 (13·01)	0·726 (3·65)	2·460 (12·20)	36·927	1·826
Minimum	18·685	2·208 (11·08)	0·534 (2·82)	2·062 (10·28)	33·854	1·791

Third Region.—The northern part of the Atlantic, between the northern boundary of the second region, and a line from the south-west point of Iceland to Sandwich Bay, Labrador.

	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Coefficient.
1. Lieutenant Skibsted, 1844. W. long. 3° 15′, N. lat. 60° 25′	19·287	2·254 (11·68)	0·488 (2·51)	2·136 (11·07)	34·831	1·806
2. Captain Paludan, May 8, 1845. W. long. 5° 19′, N. lat. 60° 9½′	19·485	2·289 (11·75)	0·568 (2·92)	2·146 (11·01)	35·223	1·808
3. Captain Gram, May 5, 1845. W. long. 7° 52′, N. lat. 59° 50′	19·671	2·342 (11·91)	0·592 (3·01)	2·210 (11·23)	35·576	1·809
4. Captain Gram, 1845. W. long. 7° 20′, N. lat. 60° 20′	19·619	2·296 (11·70)	0·587 (2·99)	1·820 (9·28)	35·387	1·814
5. Captain Gram, May 7, 1845. W. long. 14° 7′, N. lat. 60° 9′.....................	19·620	2·306 (11·75)	0·581 (2·96)	2·189 (11·16)	35·493	1·809
6. Captain Gram, 1845. W. long. 16° 32′, N. lat. 61°	19·558	2·285 (11·68)	0·581 (2·97)	2·330 (11·91)	35·281	1·804
7. Taken by an Unknown. W. long. 20½°, N. lat. 55¾°........................	20·185	2·336 (11·59)	0·699 (3·31)	2·241 (11·10)	36·480	1·807
8. Captain Gram, May 10, 1845. W. long. 20° 30′, N. lat. 59° 58′..................	19·560	2·294 (11·73)	0·584 (2·99)	2·214 (11·32)	35·291	1·804
9. Captain Paludan, May 10, 1845. W. long. 23° 3′, N. lat. 62° 15′	19·466	2·343 (12·04)	0·576 (2·96)	2·117 (10·88)	35·348	1·816
10. Captain Gram, May 15, 1845. W. long. 26° 23′, N. lat. 59° 50′..................	19·545	2·330 (11·92)	0·583 (2·98)	2·190 (11·20)	35·397	1·811
11. Captain Gram. W. long. 26° 37′, N. lat. 60° 30′	19·579	2·277 (11·63)	0·570 (2·91)	2·196 (11·22)	35·399	1·808
12. Captain Gram, September 1, 1845. W. long. 36°, N. lat. 58° 58′	19·386	2·365 (12·20)	0·578 (2·98)	2·135 (11·01)	34·990	1·805
Mean	19·581	2·310 (11·80)	0·528 (2·97)	2·160 (11·03)	35·391	1·808
Maximum	20·185	2·385 (12·50)	0·669 (3·31)	2·330 (11·98)	36·480	1·811
Minimum	19·287	2·254 (11·59)	0·488 (2·51)	1·820 (9·28)	34·831	1·804

Fourth Region.—The East Greenland Current.

	Chlorine.	Sulphuric acid.	Sulphuric acid. Chlorine =100.	All salts. Coefficient 1·813.
1. Colonel Schaffner, September 2, 1860. Faxefjord, Iceland. W. long. 24° 1′ 30″, N. lat. 64° 16′ 11′	19·517	2·360	12·09	35·385
2. Colonel Schaffner, September 3, 1860. W. long. 26° 24′, N. lat. 64° 30′	19·616	2·420	12·34	35·563
3. Colonel Schaffner, September 6, 1860. W. long. 27° 8′, N. lat. 64° 15′	19·579	2·382	12·17	35·495
4. Colonel Schaffner, September 8, 1860. W. long. 29° 36′, N. lat. 63° 25′	19·518	2·293	11·75	35·386
5. Colonel Schaffner, September 9, 1860. W. long. 27° 34′ 35″, N. lat. 63° 34′ 30″	19·545	2·300	11·77	35·435
6. Colonel Schaffner, September 9, 1860. W. long. 33° 22′ 45″, N. lat. 63° 24′	19·442	2·341	12·04	35·248
7. Colonel Schaffner, September 10, 1860. W. long. 37° 31′ 30″, N. lat. 62° 47′	19·491	2·291	11·75	35·337
8. Colonel Schaffner, September 11, 1860. W. long. 38° 18′, N. lat. 62° 16′ 34″	19·469	2·309	11·86	35·297
9. Colonel Schaffner, September 13, 1860. In ice pack. W. long. 41° 45′, N. lat. 60° 48′ 40″*	16·831	1·995	11·85	30·515
10. Colonel Schaffner, September 14, 1860. W. long. 40° 56′, N. lat. 59° 49′	19·136	2·252	11·75	34·694
11. Captain Gram, May 18, 1845. W. long. 33° 32′, N. lat. 60° 23′*	19·512	2·385	12·22	35·390
12. Captain Gram, May 20, 1845. W. long. 39° 4′, N. lat. 59° 26′*	19·306	2·310	11·97	35·067
13. Captain Gram, May 22, 1845. W. long. 46° 1′, N. lat. 57° 57′*	19·365	2·305	11·90	35·038
Mean	19·458	2·329	11·97	35·278
Maximum	19·616	2·420	12·34	35·563
Minimum	19·136	2·252	11·75	34·694

* This observation in the pack is not used for determining the means. Observations 11, 12, 13 are complete analyses with a coefficient 1·814, 1·816, and 1·809; mean 1·813. This mean coefficient is used for calculating the quantity of all salts in Colonel SCHAFFNER's samples, where there was not enough for complete analysis.

Fifth Region.—Davis Straits and Baffin's Bay.

	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Coefficient.
1. Captain Gram, May 26, 1845. N. lat. 60° 32′, W. long. 53° 11′	19·010	2·283 (12·01)	0·550 (2·89)	2·115 (11·13)	34·414	1·810
2. Captain Gram, June 2, 1845. N. lat. 62° 8′, close to the island ved Frederickshaab	18·317	2·161 (11·80)	0·551 (3·01)	2·036 (11·12)	33·109	1·808
3. Captain Gram, June 12, 1845. Close to the Killiksut Islands near Nanarsuit (about N. lat. 60°)............................	18·386	2·144 (11·66)	0·546 (2·97)	2·018 (10·98)	33·190	1·806
4. Dr. Kaiser, September 5, 1845. N. lat. 64° 41′, Davis Straits.....................	18·251	2·131 (11·68)	0·455 (2·49)	2·140 (11·73)	32·926	1·804
5. Dr. Kaiser, September 4, 1845. N. lat. 66° 58′, about 30 English sea-miles from Greenland	17·818	2·187 (12·27)	0·496 (2·78)	2·005 (11·25)	32·304	1·813
6. Dr. Kaiser, August 30, 1845. N. lat. 68° 43′, W. long. 52° 45′, harbour of Egedesminde	18·325	2·238 (12·21)	0·495 (2·70)	2·080 (11·35)	33·187	1·811
7. Dr. Kaiser, September 3, 1845. 8 sea-miles from Godhavn, Disco (about N. lat. 69° 50′)	18·401	2·255 (12·25)	0·455 (2·47)	2·008 (10·91)	33·446	1·818
8. Dr. Rink, July 5, 1849. N. lat. 69° 45′, 24 English sea-miles W. from Disco	18·524	2·268 (12·24)	0·530 (2·86)	2·109 (11·39)	33·595	1·814
Mean	18·379	2·208 (12·01)	0·510 (2·77)	2·064 (11·23)	32·281	1·811
Maximum	19·010	12·27	3·01	11·73	34·414	1·818
Minimum	17·818	11·66	2·47	10·91	32·304	1·804

Sixth Region.—The North Sea.

	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Coefficient.
1. 1844. Between the Orkneys and Stavanger, in Norway	18·772	2·312 (12·31)	0·488 (2·59)	2·128 (11·33)	34·302	1·827
2. 1844. S.W. of Egernsund, Norway......................	18·278	2·223 (12·14)	0·455 (2·49)	2·192 (11·98)	33·294	1·822
3. Captain von Dockum, September 16, 1845. In the Hooft in the deep channel near the Galloppers	19·282	2·351 (12·19)	0·560 (2·90)	2·166 (11·23)	35·041	1·817
4. Captain von Dockum, September 18, 1845. About forty-five English sea-miles W. from the lighthouse of Hanstholm..................	17·127	2·079 (12·09)	0·548 (3·19)	1·929 (11·26)	31·095	1·815
5. Captain von Dockum, September 18, 1845. Skagerack, between Hirtshals and the Skau.	18·131	2·141 (11·81)	0·565 (3·12)	2·037 (11·23)	32·674	1·802
6. Back, S. Heligoland. Analysis from Erdmann's Journal, Bd. 34, p. 185	16·830	2·008 (11·93)	0·485 (2·88)	1·866 (11·09)	30·530	1·814
Mean	18·070	2·185 (12·09)	0·517 (2·86)	2·053 (11·25)	32·823	1·816
Maximum	19·295	2·351 (12·31)	0·565 (3·19)	2·192 (11·98)	35·041	1·827
Minimum	17·127	2·008 (11·77)	0·455 (2·49)	1·866 (11·09)	30·530	1·808

Seventh Region.—The Kattegat and the Sound.

	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Coefficient.
1845, April. North of Kullen. Current from the South	6·227	0·776 (12·46)	0·195 (3·13)	0·712 (11·43)	11·341	1·821
1845, April. North of the island of Anhalt. Current from the South	8·429	1·028 (12·09)	0·257 (3·02)	......	......	......
1845, June. North of Kullen. Current from the North	9·376	1·178 (12·57)	0·393 (4·19)	0·986 (10·51)	17·254	1·840
1845, June. North of Anhalt. Current from the North	9·632	1·099 (11·41)	0·298 (3·10)	1·059 (10·99)	17·355	1·802
1844. Captain Skibsted. Kattegat	10·077	1·208 (11·54)	0·319 (2·78)	1·253 (11·31)	19·940	1·801
Elsinore. Mean of 134 observations between April 17 and September 11, 1846	12·827	......	......	......	23·243	......
1846, October 4. Copenhagen. Current from the South	5·966	0·750 (12·57)	0·196 (3·28)	0·620 (10·39)	10·869	1·822
Copenhagen. Mean of 7 observations between March 3 and April 21, 1852	8·742	......	......	......	15·841	......
Sandefjord, on the south-east coast of Norway. Analyzed by Professor Strecker	7·740	0·875 (11·30)	0·266 (3·44)	0·818 (10·59)	13·996	1·808
Mean	8·780	0·998 (11·94)	0·275 (3·29)	0·908 (10·86)	16·230	1·814
Maximum	12·827	1·278 (12·57)	0·393 (4·19)	1·253 (11·43)	23·243	1·840
Minimum	5·966	0·750 (11·30)	0·195 (2·78)	0·620 (10·39)	10·869	1·801

Eighth Region.—The Baltic.

	Chlorine.	Sulphuric acid.	Lime.	Potash.	Magnesia.	All salts.	Coefficient.
1. Bellona. N. lat. 58° 27′, E. long. 20°	3·863	0·489 (12·65)	0·136 (3·52)	0·066 (1·71)	0·447 (11·57)	7·061	1·828
2. Bellona. Between Hammershuus, on the Island of Bornholm, and Sandhammer in Sweden	4·079	0·514 (12·60)	0·126 (3·09)	0·094 (1·99)	0·436 (10·69)	7·481	1·834
3. Bellona. Between Oland and Gothland...	3·991	0·527 (13·19)	0·137 (3·43)	0·075 (1·88)	0·480 (12·03)	7·319	1·834
4. Bellona. Entrance of the Bay of Finnland	3·833	0·472 (12·33)	0·145 (3·78)	0·068 (1·77)	0·508 (13·25)	6·933	1·809
5. Bellona. Bay of Finnland, between Hogland and Tysters	2·596	0·346 (13·31)	0·092 (3·54)	0·044 (1·69)	0·299 (11·52)	4·763	1·835
6. Bellona. Bay of Finnland, between Nervoe and Seskjeld	1·931	0·239 (12·38)	0·076 (3·91)	0·047 (2·43)	0·226 (11·70)	3·552	1·839
7. Bellona. Bay of Finnland, W. from Kronstadt	0·331	0·040 (11·95)	0·019 (5·81)	0·023 (0·69)	0·046 (13·90)	0·738	2·230
8. Bellona. Bay of Finnland. Merchant-harbour of Kronstadt	0·294	0·044 (14·97)	0·022 (7·49)	0·006 (0·21)	0·046 (15·65)	0·610	2·075
9. Svartklubben, to the North of Stockholm...	3·265	0·407 (12·50)	0·132 (4·05)	0·056 (1·72)	0·403 (12·38)	5·919	1·836
Mean	2·687 (100·00)	0·342 (12·73)	0·098 (3·64)	0·053 (1·97)	0·321 (11·94)	4·931	1·835
Maximum	4·079 (100·00)	0·527 (14·97)	0·145 (7·49)	0·094 (2·43)	0·508 (15·65)	7·481	2·230
Minimum	0·294 (100·00)	0·040 (11·95)	0·019 (3·09)	0·006 (0·21)	0·046 (10·69)	0·610	1·809

Ninth Region.—The Mediterranean.

	Chlorine.	Sulphuric acid.	Lime.	Potash.	Magnesia.	All salts.	Coefficient.
1. Heimdal, Captain Schulz, Sept. 28, 1860. Straits of Gibraltar	20·160	2·302 (11·42)	0·610 (3·03)	0·415 (2·06)	2·134 (10·59)	36·391	1·805
2. Heimdal, Captain Schulz, Sept. 29, 1860. N. lat. 36° 9′, W. long. 4° 2′	20·235	2·583 (12·8)	0·613 (3·03)	0·345 (1·70)	2·305 (11·39)	37·014	1·829
3. Heimdal, Captain Schulz, Oct. 8, 1860. N. lat. 40° 28′, E. long. 1° 48′. Between the Balearic island and the Spanish coast	21·085	2·444 (11·59)	0·641 (3·04)	0·474 (2·25)	2·402 (11·39)	38·058	1·805
4. Heimdal, Captain Schulz, Oct. 10, 1860. N. lat. 41° 12′, E. long. 2° 23′	21·056	2·542 (12·07)	0·635 (3·02)	0·336 (1·60)	2·356 (11·19)	38·321	1·819
5. Heimdal, Captain Schulz, Oct. 12, 1860. N. lat. 42° 25′, E. long. 6° 0′. Between Barcelona and Corsica	21·217	2·458 (11·59)	0·629 (2·96)	0·428 (2·03)	2·379 (11·21)	38·290	1·805
6. Heimdal, Captain Schulz, Oct. 20, 1860. N. lat. 40° 25′, E. long. 11° 43′. Between Sardinia and Naples	21·139	2·652 (12·55)	0·660 (3·12)	0·492 (2·33)	2·322 (10·98)	38·654	1·828
7. Mr. Ennis, 1837. Malta	20·497	2·471 (12·06)	0·640 (3·12)	0·174	2·074 (10·12)	37·177	1·814
8. Heimdal, Captain Schulz, Nov. 13, 1860. N. lat. 36° 10′, E. long. 16° 10′. To the East of Malta	21·297	2·514 (11·8)	0·686 (3·22)	0·417 (1·96)	2·403 (11·28)	38·541	1·809
9. Heimdal, Captain Schulz, Oct. 23, 1860. N. lat. 37° 20′, E. long. 16° 32′. Between Malta and Greece	21·180	2·390 (11·29) Sulphuretted hydrogen.	0·597 (2·82)	0·304 (1·41)	2·392 (11·29)	38·013	1·795
10. Heimdal, Captain Schulz, Oct. 28, 1860. N. lat. 33° 34′, E. long. 24° 34′. Between Candia and the coast of Africa	21·718	2·517 (11·60)	0·677 (3·12)	0·392 (1·80)	2·447 (11·27)	39·257	1·808
11. The Mediterranean; exact place unknown. Calculated after an analysis in Violette and Archambault's 'Analyses chimiques'	20·900 Brom. 432 21·332	2·433 (11·64)	0·621 (2·97)	0·32	2·223 (10·64)	37·655	......
Mean	20·889	2·470 (11·82)	0·642 (3·08)	0·372 (1·78)	2·277 (10·90)	37·936	1·815
Maximum	21·718	2·652 (12·59)	0·622 (3·22)	0·492 (2·33)	2·447 (11·39)	39·257	1·829
Minimum	20·160	2·302 (11·42)	0·597 (2·82)	0·174	2·074 (10·12)	36·391	1·805

Remarks.—No. 9 is not taken in the calculation of the mean coefficient, on account of the decomposition of the sulphuric acid, which always lowers the coefficient; the small quantity of lime in No. 9 depends probably upon the same decomposition, the sulphate of lime being changed into sulphuret of calcium, which again, by carbonic acid and water, is decomposed into sulphuretted hydrogen and carbonate of lime, which is precipitated.

Tenth Region, A.—The Black Sea and the Sea of Assou.

	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Coefficient.
1. Water from the Black Sea, 50 English miles from the Bosphorus. F.	9·963 (100·00)	1·167 (11·71)	0·420 (4·22)	1·259 (12·64)	18·146	1·821
2. Water from the Black Sea. Gobel	9·869 (100·00)	1·032 (10·46)	0·182 (1·84)	1·126 (11·41)	17·666	1·790
3. Water from the Sea of Assou. Gobel ...	6·569 (100·00)	0·674 (10·26)	0·128 (1·95)	0·672 (10·23)	11·880	1·808
Mean	8·800 (100·00)	0·958 (10·89)	0·243 (2·76)	1·019 (11·58)	15·897	1·806
Maximum	9·963 (100·00)	1·167 (11·71)	0·420 (4·22)	1·259 (12·64)	18·146	1·821
Minimum...............	6·569 (100·00)	0·674 (10·26)	0·128 (1·84)	0·672 (10·23)	11·880	1·790

B.—From the Caspian Sea.

	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Coefficient.
1.	2·731 (100·00)	1·106 (40·50)	0·268 (9·81)	0·700 (25·63)	6·236	2·283
2. Baer. From Tuik Karaga. Analysis by Mehner, Baer (Caspische Studien)	5·741 (100·00)	2·316 (40·34)	0·373 (6·50)	1·240 (21·60)	14·000	2·439
3. Baer. Bay of Kaidak or Karassi. Analysis by Mehner, Baer (Caspische Studien)	23·976 (100·00)	10·112 (42·11)	1·432 (5·91)	4·657 (19·42)	56·814	2·370
4. Baer. Bay of Mertuyi Kultak. Analysis by Mehner, Baer (Caspische Studien)......	12·504 (100·00)	5·613 (44·89)	1·733 (13·86)	2·096 (16·76)	31·000	2·480
5. Baer. Bay of Krasnowood. Analysis by Mehner, Baer (Caspische Studien)	6·182 (100·00)	3·494 (56·52)	0·760 (12·29)	1·471 (23·80)	16·410	2·654
Mean	10·227	4·528 (44·27)	0·913 (8·93)	2·033 (19·88)	24·892	2·434
Maximum	23·976	10·112 (56·52)	1·733 (13·86)	4·657 (25·63)	56·814	2·654
Minimum	2·731	1·106 (40·34)	0·268 (5·91)	0·700 (16·76)	6·236	2·283

Eleventh Region.—The Atlantic, between the Equator and 30° S. latitude.

	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Coefficient.
1. Valkyrie, February 11, 1848. S. lat. 3° 19', W. long. 25° 34'	20·003	2·312 (11·56)	0·596 (2·98)	2·235 (11·17)	36·084	1·804
2. Valkyrie, February 16, 1848. S. lat. 17° 9', W. long. 33° 29'	20·491	2·465 (12·03)	0·598 (2·92)	2·218 (10·82)	37·155	1·813
3. Sir James Ross. S. lat. 22° 37', W. long. 34° 57'...................	20·397	......	......	......	37·001	1·814
4. Dr. Fischer, 1846. S. lat. 23°' 5', W. long. 37° 15'	20·115	2·428 (12·07)	0·580 (2·88)	2·233 (11·10)	36·442	1·812
5. Dr. Fischer, 1846. S. lat. 28° 15', W. long. 38° 26'...................	19·831	2·393 (12·07)	0·596 (3·01)	2·254 (11·37)	35·930	1·812
6. Captain Prevost, February 4, 1857. S. lat. 29° 14', W. long. 47° 37'...................	20·049	2·379 (11·87)	0·563 (2·81)	2·253 (11·24)	36·261	1·809
7. Valkyrie, March 15, 1848. S. lat. 29° 13½', W. long. 38° 26'	20·166	2·537 (12·58)	0·585 (2·90)	2·022 (10·03)	36·997	1·835
Mean	20·150	2·419 (12·03)	0·586 (2·91)	2·203 (10·96)	36·553	1·814
Maximum	20·491	2·537 (12·58)	0·598 (3·01)	2·254 (11·37)	37·155	1·835
Minimum	19·831	2·312 (11·56)	0·563 (2·81)	2·022 (10·03)	35·930	1·804

Twelfth Region.—The Atlantic between S. lat. 30° and the southernmost points of America and Africa.

	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Coefficient.
Dr. Fischer, 1846. S. lat. 30° 45', W. long. 42° 30'	19·809	2·329 (11·76)	0·583 (2·94)	2·234 (11·28)	35·807	1·808
Dr. Fischer, 1846. S. lat. 40° 30', W. long. 40° 50'	19·237	2·253 (11·71)	0·582 (3·03)	2·156 (11·21)	34·774	1·808
Dr. Fischer, 1846. S. lat. 45° 20', W. long. 48° 40'	19·154	2·194 (11·45)	0·557 (2·91)	2·135 (11·15)	34·526	1·803
Dr. Fischer, 1846. S. lat. 50° 31', W. long. 52° 15'	18·909	2·245 (11·87)	0·518 (2·74)	2·190 (11·58)	34·151	1·806
Fregat Valkyrie, 1848. S. lat. 36° 11½', W. long. 6° 39'	19·431	2·451 (12·61)	0·541 (2·78)	2·091 (10·76)	35·065	1·805
Fregat Valkyrie, 1848. S. lat. 37° 11½', E. long. 12° 25½'...............	19·713	2·404 (12·19)	0·553 (2·81)	2·156 (11·04)	35·907	1·821
Mean	19·376	2·313 (11·94)	0·556 (2·87)	2·160 (11·15)	35·038	1·809
Maximum	19·809	2·451 (12·61)	0·583 (3·03)	2·234 (11·58)	35·907	1·821
Minimum	18·909	2·194 (11·45)	0·518 (2·74)	2·091 (10·76)	34·151	1·803
Captain Prevost*. S. lat. 35° 46', W. long. 52° 57'	17·721	1·615 (9·10) Sulphuretted hydrogen.	0·448 (2·49)	1·899 (10·72)	34·489	1·946

* This sample has been left out in the calculation of the mean numbers because the quantity of sulphuric acid was greatly diminished by putrefaction.

Thirteenth Region.—The sea between Africa and the East Indian Islands.

	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Coefficient.
1. Galathea, September 24, 1845. S. lat. 31° 54′, E. long. 72° 27′	19·753	2·361 (11·98)	0·600 (3·04)	2·207 (11·17)	35·802	1·812
2. Galathea, October 1, 1845. S. lat. 14° 14′, E. long. 83° 38′	19·498	2·341 (12·01)	0·569 (2·92)	2·105 (10·80)	35·381	1·814
3. Galathea, October 6, 1845. N. lat. 0° 19′, E. long. 84° 51′	19·381	2·334 (12·04)	0·591 (3·05)	2·005 (10·35)	35·169	1·815
4. Galathea, October 28, 1845. N. lat. 17° 20′, E. long. 88° 12′	14·289	1·724 (12·06)	0·446 (3·12)	1·699 (11·89)	25·879	1·818
5. Galathea, December 31, 1845. N. lat. 18° 17′, E. long. 90° 13′	17·838	2·131 (11·94)	0·543 (3·04)	1·944 (10·90)	32·365	1·814
6. Galathea. Nancovri on the Nicobar Islands	18·246	2·156 (11·81)	0·547 (3·00)	1·997 (10·94)	33·036	1·817
7. Galathea, May 13, 1846. S. lat. 4° 54′, E. long. 107° 15′, Sea of Java	17·970	2·132 (11·88)	0·547 (3·07)	1·979 (11·01)	32·766	1·823
8. Valkyrie, April 14, 1848. S. lat. 38° 52′, E. long. 30° 31′	19·413	2·470 (12·72)	0·543 (2·80)	2·134 (10·99)	35·583	1·833
9. Valkyrie, April 19, 1848. S. lat. 36° 59′, E. long. 47° 23′	19·710	2·349 (11·92)	0·572 (2·90)	2·193 (11·13)	35·701	1·816
10. Valkyrie, April 26, 1848. S. lat. 35° 2′, E. long. 62° 52′	19·548	2·380 (12·17)	0·588 (3·01)	2·101 (10·75)	35·415	1·817
11. Valkyrie, May 14, 1848. S. lat. 1° 56′, E. long. 81° 5′	19·626	2·330 (11·87)	0·567 (2·89)	2·207 (11·24)	35·512	1·809
12. Valkyrie, May 21, 1848. N. lat. 12° 3′, E. long. 80° 8′	18·763	2·250 (11·99)	0·567 (3·02)	2·086 (11·12)	33·809	1·802
Mean	18·670	2·247 (12·04)	0·557 (2·98)	2·055 (11·01)	33·868	1·814
Maximum	19·753	2·470 (12·72)	0·600 (3·12)	2·207 (11·89)	35·802	1·833
Minimum	14·289	1·724 (11·81)	0·446 (2·80)	1·699 (10·35)	25·879	1·802

Fourteenth Region.—The sea between the S.E. shore of Asia, the East Indian and the Aleutic Islands.

	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Coefficient.
1. Galathea, May 18, 1846. The Chinese Sea. S. lat. 0° 33′, E. long. 107° 22′	17·757	2·104 (11·85)	0·516 (2·90)	1·958 (11·03)	32·370	1·823
2. Galathea. N. lat. 4° 30′, E. long. 107° 16′	18·486	2·258 (12·21)	0·572 (3·03)	2·067 (11·19)	33·680	1·822
3. Galathea. N. lat. 25° 40′, E. long. 120° 50′	17·923	2·160 (12·05)	0·533 (2·97)	1·961 (10·94)	32·533	1·815
4. Galathea. N. lat. 30° 56′, E. long. 127° 30′	18·564	2·209 (11·90)	0·552 (2·97)	2·022 (10·89)	33·580	1·809
5. Galathea. N. lat. 30° 56′, E. long. 139° 39′	18·847	2·257 (11·98)	0·575 (3·05)	2·089 (10·08)	34·153	1·812
6. Galathea. N. lat. 38° 31′, E. long. 148° 27′	18·873	2·247 (11·90)	0·613 (3·25)	2·046 (10·84)	34·234	1·814
7. Galathea. N. lat. 38° 35′, E. long. 148° 44′	18·788	2·213 (11·78)	0·580 (3·09)	2·048 (10·90)	33·990	1·809
Mean	18·462	2·207 (11·95)	0·563 (3·05)	2·027 (10·93)	33·506	1·815
Maximum	18·873	2·258 (12·05)	0·613 (3·25)	2·089 (11·19)	34·234	1·823
Minimum	17·757	2·104 (11·78)	0·516 (2·90)	1·958 (10·84)	32·370	1·809

Fifteenth Region.—The sea between the Aleutic Islands and the Society Islands.

	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Coefficient.
1. Galathea, September 11, 1846. N. lat. 38° 26′, E. long. 172° 11′	18·908	2·195 (11·61)	0·545 (2·88)	2·066 (10·93)	34·157	1·806
2. Galathea, September 17, 1846. N. lat. 38° 42′, W. long. 176° 53′	19·006	2·220 (11·68)	0·535 (2·82)	2·078 (10·93)	34·274	1·803
3. Galathea, September 21, 1846. N. lat. 37° 3′, W. long. 160° 5′	19·244	2·243 (11·65)	0·555 (2·88)	2·110 (10·69)	34·715	1·804
4. Galathea, September 24, 1846. N. lat. 32° 8′, W. long. 150° 17′	19·824	2·316 (11·68)	0·549 (2·83)	2·209 (11·14)	35·877	1·809
5. Galathea, October 5, 1846. Off Honolulu, Sandwich Islands	19·625	2·283 (11·63)	0·580 (2·95)	2·152 (10·96)	35·395	1·804
6. Galashea. Off Matuiti	19·943	2·326 (11·66)	0·610 (3·06)	2·224 (11·15)	36·051	1·808
7. Galathea. Off Borabora	19·917	2·347 (11·78)	0·623 (3·13)	2·252 (11·31)	36·061	1·805
Mean	19·495	2·276 (11·67)	0·571 (2·93)	2·156 (11·06)	35·219	1·807
Maximum	19·943	0·347 (11·78)	0·623 (3·13)	2·252 (11·31)	36·061	1·809
Minimum	18·908	2·195 (11·61)	0·535 (2·82)	2·066 (10·69)	34·157	1·803

Sixteenth Region.—The Patagonian current of cold Water.

	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Coefficient.
1. Dr. Fischer. S. lat. 57° 27′, W. long. 66° 57′	18·769	2·133 (11·37)	0·507 (2·70)	2·116 (11·27)	33·788	1·800
2. Dr. Fischer. S. lat. 52° 38′, W. long. 76° 20′	18·796	2·210 (11·76)	0·546 (2·91)	2·048 (10·90)	33·969	1·807
3. Dr. Fischer. S. lat. 47° 40′, W. long. 78° 25′	18·760	2·238 (11·89)	0·560 (2·98)	2·036 (10·85)	33·980	1·811
4. Dr. Fischer. S. lat. 38° 10′, W. long. 78° 14′	18·768	2·226 (11·86)	0·563 (3·00)	2·100 (11·19)	23·932	1·808
5. Dr. Fischer. S. lat. 33° 54′, W. long. 74° 23′	18·754	2·224 (11·86)	0·537 (2·86)	2·079 (11·09)	33·976	1·812
6. Captain Prevost. S. lat. 35° 22′, W. long. 73° 49′	18·976	2·257 (11·89)	0·531 (2·80)	2·076 (10·94)	34·152	1·800
Mean	18·804	2·215 (11·78)	0·541 (2·88)	2·076 (11·04)	33·966	1·806
Maximum	18·976	2·257 (11·93)	0·563 (3·00)	2·116 (11·27)	34·152	1·812
Minimum	18·754	2·133 (11·37)	0·507 (2·70)	2·036 (10·85)	33·788	1·800

Seventeenth Region.—The South Polar Region.

	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Coefficient.
1. Sir James Ross, January 30, 1841. S. lat. 77° 32′, E. long. 188° 21′. Near the ice barrier	15·748	1·834 (11·65)	0·498 (3·16)	1·731 (10·99)	28·565	1·814
2. Sir James Ross, February 25, 1841. S. lat. 74° 15′, E. long. 167° 0′. Near Caulmans Island	8·477	1·053 (12·42)	0·251 (2·96)	·887 (10·46)	15·776	1·861
3. Sir James Ross, March 6, 1841. S. lat. 65° 57′, E. long. 164° 34′	20·601	2·586 (12·55)	0·623 (3·02)	2·231 (10·83)	37·513	1·821
Mean *	14·942	1·824 (12·21)	4·57 (3·06)	1·616 (10·81)	27·285	1·826

* These mean numbers are uncertain, the number of observations being very limited, and so very different. I should think that the first observation will be a fair sample of South Polar water, and have preferred it to the mean of the three observations in the calculation of the means of the whole ocean.

Comparison of the Means of all the Regions of the Ocean (German Ocean, Kattegat, Baltic, Mediterranean, and Black Sea excepted).

	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Coefficient.
I. The Atlantic between the equator and N. lat. 30°	20·034	2·348 (11·75)	0·595 (2·98)	2·220 (11·11)	36·253	1·810
II. The Atlantic between N. lat. 30° and a line from the north point of Scotland to Newfoundland	19·828	2·389 (12·05)	0·607 (3·07)	2·201 (11·10)	35·932	1·812
III. The northernmost part of the Atlantic...	19·581	2·310 (11·80)	0·528 (2·97)	2·160 (11·03)	35·391	1·808
IV. The East Greenland Current	19·458	2·329 (11·97)	....	....	35·278	1·813
V. Davis Straits and Baffin's Bay	18·379	2·208 (12·01)	0·510 (2·77)	2·064 (11·23)	33·281	1·811
XI. The Atlantic between the equator and S. lat. 30°	20·150	2·419 (12·03)	0·586 (2·91)	2·203 (10·96)	36·553	1·814
XII. The Atlantic between S. lat. 30° and a line from Cape Horn to the Cape of Good Hope	19·376	2·313 (11·94)	0·556 (2·87)	2·160 (11·15)	35·038	1·809
XIII. The Ocean between Africa, Borneo, and Malacca	18·670	2·247 (12·04)	0·557 (2·98)	2·055 (11·01)	33·868	1·814
XIV. The Ocean between the S.E. coast of Asia, the East Indian, and the Aleutic Islands	18·462	2·207 (11·95)	0·563 (3·05)	2·027 (11·98)	33·506	1·815
XV. The Ocean between the Aleutic and the Society Islands	19·495	2·276 (11·67)	0·571 (2·93)	2·156 (11·06)	35·219	1·807
XVI. The Patagonian cold-water current ...	18·804	2·215 (11·78)	0·541 (2·88)	2·076 (11·04)	33·966	1·806
XVII. The South Polar Sea.....................	15·748	1·834 (11·65)	0·498 (3·16)	1·731 (10·99)	28·565	1·814
Mean	18·999	2·258	0·556	2·096	34·404	1·811
Mean proportion of the most important substances in sea-water, chlorine=100	....	11·88	2·93	11·03		
Equivalents..	429	45	16	82		

Comparison between the quantity of Salt in the water of the surface and the depth of the Sea, between Africa and the East Indies.

	Depth.	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Coefficient.
Valkyrie, May 14, 1848. S. lat. 1° 56′, E. long. 81° 5′.........	Surface	19·626	2·330 (11·87)	0·567 (2·89)	2·207 (11·25)	35·512	1·809
	215 feet	19·606	2·451 (12·50)	0·558 (2·85)	2·147 (10·75)	35·819	1·827
Valkyrie, April 28, 1848. S. lat. 35° 2′, E. long. 62° 52′	Surface	19·548	2·349 (12·02)	0·588 (3·01)	2·101 (10·75)	35·415	1·817
	300 feet	19·786	2·380 (1 203)	0·572 (2·89)	2·218 (11·21)	35·671	1·803

Comparison between the quantity of Salt in the water of the surface and the depth of the Sea, between the East Indian and Aleutic Islands.

	Depth.	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Coefficient.
Galathea, August 27, 1846. N. lat. 38° 31′, E. long. 148° 27′ ...	Surface	18·873	2·178 (11·54)	0·615 (3·26)	2·046 (10·84)	34·052	1·804
	300 feet	19·075	2·249 (11·79)	0·543 (2·85)	2·132 (11·18)	34·426	1·805
Galathea, May 23, 1846. N. lat. 4° 30′, E. long. 107° 16′ ...	Surface	18·846	2·258 (11·98)	0·572 (3·04)	2·067 (10·97)	34·132	1·811
	360 feet	18·885	2·195 (11·62)	0·567 (3·00)	2·147 (11·38)	34·033	1·802

Comparison between the quantity of Salt in Sea-water from different depths in the South Atlantic Ocean.

Samples taken by Sir James Ross.	Depth.	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Coefficient.
Sir James Ross, June 10, 1844. S. lat. 0° 15′, W. long. 25° 54′	900 feet	19·763	2·584 (13·07)	0·657 (3·32)	2·249 (11·38)	36·165	1·830
	1800 feet	19·991	2·456 (12·29)	0·566 (2·83)	2·191 (10·96)	36·358	1·819
	4500 feet	19·786	2·398 (12·12)	0·554 (2·80)	2·320 (11·73)	35·889	1·814
	5400 feet	20·007	2·418 (12·09)	0·574 (2·87)	2·187 (10·93)	36·313	1·815
Sir James Ross, June 2, 1843. S. lat. 14° 22′, W. long. 22° 35′	3600 feet	19·743	......	......	......	......	......
Sir James Ross, June 4, 1843. S. lat. 15° 23′, W. long. 23° 40′	2700 feet	19·346	......	......	......	......	......
Sir James Ross, June 8, 1843. S. lat. 21° 48′, W. long. 31° 24′	900 feet	19·604	......	......	......	......	......
Sir James Ross, June 9, 1843. S. lat. 22° 24′, W. long. 32° 53′	3600 feet	19·627	......	......	......	......	......
Sir James Ross, June 10, 1843. S. lat. 22° 37′, W. long. 34° 57′	Surface	20·397	......	......	......	......	......
	900 feet	20·323	......	......	......	......	......
	1800 feet	23·189	......	......	......	......	......
	2700 feet	20·331	......	......	......	......	......
	3600 feet	20·405	......	......	......	......	......
Valkyrie, March 15, 1848. S. lat. 29° 15′·5, W. long. 38° 26′ ...	Surface	20·166	2·537 (12·58)	0·585 (2·90)	2·022 (10·03)	36·997	1·835
	480 feet	19·736	2·448 (12·40)	0·573 (2·90)	2·023 (10·25)	36·227	1·835
Sir James Ross, March 28, 1843. S. lat. 43° 10′, Long. 14° 44′ φ	6300 feet	19·635	2·346 (11·95)	0·631 (3·21)	2·140 (10·90)	35·607	1·813
Sir James Ross, Dec. 21, 1840. S. lat. 57° 52′, Long. 170° 30′ φ ...	Surface	19·396	2·293 (11·82)	0·624 (3·22)	2·108 (10·87)	35·131	1·811
Sir James Ross, March 6, 1841. S. lat. 65° 57′, Long. 164° 37′ φ ...	Surface	20·600	2·586 (12·55)	0·623 (3·02)	2·231 (10·83)	37·513	1·821
Sir James Ross, January 25, 1841. S. lat. 74° 15′, Long. 167° 0′ φ	Surface	8·477	1·053 (1·242)	0·251 (2·96)	0·887 (10·46)	15·776	1·861

Comparison between the quantity of Salt in Sea-water from the surface and different depths in the North Atlantic Ocean.

Samples taken by Sir James Ross, Dr. Rink, Mr. Gram, Captain Schulz, and Admiral von Dockum.	Depth.	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Coefficient.
Dr. Rink, July 5, 1849. W. from Disco. N. lat. 69° 45'......	Surface	18·524	2·268 (12·24)	0·530 (2·86)	2·119 (11·39)	35·595	1·814
	420 feet	18·532	......	0·542 (2·92)	2·098 (11·32)	......	......
Merchant-Capt. Gram, May 20, 1845 W. long. 39° 4', N. lat. 59° 45' ...	Surface	19·306	2·310 (11·97)	0·575 (2·98)	2·119 (10·98)	35·067	1·816
	270 feet	19·364	2·337 (12·07)	0·579 (2·99)	2·186 (11·28)	34·963	1·806
Merchant-Capt. Gram, May 5, 1845. W. long. 7° 52', N. lat. 59° 50'	Surface	19·671	2·342 (11·91)	0·592 (3·01)	2·210 (11·23)	35·576	1·809
	270 feet	19·638	2·338 (11·91)	0·598 (3·05)	2·210 (11·25)	35·462	1·806
Between Iceland and Greenland. Mean	Surface	......	......	......	......	35·356	......
Ditto, Mean of eight samples from	1200 to 1800 feet	......	......	......	......	35·057	......
Captain Schulz, R.D.N., 1845. W. long. 9° 30', N. lat. 47° 45'......	Surface	19·644	2·556 (13·01)	0·589 (3·00)	2·273 (11·57)	35·925	1·829
	390 feet	19·640	2·595 (13·21)	0·623 (3·17)	2·357 (12·00)	35·925	1·829
	510 feet	19·699	2·594 (13·17)	0·628 (3·19)	2·296 (11·66)	36·033	1·829
Admiral von Dockum, Aug. 13, 1845. W. long. 54° 15', N. lat. 40° 21' ...	Surface	20·098	2·425 (12·07)	0·606 (3·02)	2·391 (11·90)	36·360	1·809
	210 to 270 feet	20·172	2·425 (12·02)	0·605 (3·00)	2·261 (11·21)	36·598	1·814
Captain Irminger, March 17, 1849. W. long. 64°, N. lat. 25° 40'.........	Surface	20·302	2·450 (12·07)	0·620 (3·05)	2·301 (11·33)	36·705	1·808
	2880 feet	20·222	2·380 (11·77)	0·581 (2·87)	2·274 (11·26)	36·485	1·804
Sir James Ross July 29, 1843. W. long. 32° 10', N. lat. 20° 54' ...	2700 feet	20·238	......	......	......	......	......
	3600 feet	19·703	......	......	......	......	......
Sir James Ross, July 27, 1843. W. long. 29° 56', N. lat. 18° 16' ...	Surface	20·429	......	......	......	......	......
	3600 feet	19·666	......	......	......	......	......
Sir James Ross, July 26, 1843. W. long. 29° 0', N. lat. 16° 57'......	Surface	20·186	......	......	......	......	......
	900 feet	20·029	......	......	......	......	......
	2700 feet	19·602	......	......	......	......	......
Sir James Ross, July 25, 1843. W. long. 28° 10', N. lat. 15° 38' ...	Surface	20·081	......	......	......	......	......
	6360 feet	19·747	......	......	......	......	......
Sir James Ross, July 24, 1843. W. long. 27° 15', N. lat. 14° 18' ...	900 feet	19·934	......	......	......	......	......
	2700 feet	19·580	......	......	......	......	......
	3600 feet	19·705	......	......	......	......	......
Sir James Ross, July 22, 1843. W. long. 25° 35', N. lat. 12° 36' ...	Surface	20·114	2·343 (11·65)	0·619 (3·08)	2·315 (11·51)	36·195	1·800
	1850 feet	19·517	2·271 (11·64)	0·598 (3·06)	2·128 (10·90)	35·170	1·802
Sir James Ross, July 11, 1843. W. long. 25° 6', N. lat. 11° 43'......	Surface	20·035	......	......	......	......	......
	3600 feet	19·855	......	......	......	......	......
	4500 feet	19·723	......	......	......	......	......
Sir James Ross, July 6, 1843. W. long. 27° 4', N. lat. 6° 55'	Surface	20·070	......	......	......	......	......
	900 feet	19·956	......	......	......	......	......
	3600 feet	19·885	......	......	......	......	......
Sir James Ross, 1843. W. long. 25° 54', N. lat. 1° 10'......	Surface	19·757	2·303 (11·66)	0·584 (2·96)	2·333 (11·81)	35·737	1·809
	1800 feet	19·715	2·265 (11·49)	0·547 (2·77)	2·253 (11·43)	35·520	1·802
	3600 feet	19·548	2·322 (11·88)	0·545 (2·79)	2·239 (11·45)	35·365	1·809

Comparison of water from the surface and the depth of the North Atlantic

	Depth.	Chlorine.	Sulphuric acid.	Lime.	Potash.
Porcupine. N. lat. 51° 1½′, W. long. 14° 21′ ... Sp. gr. 1·0270.	2370 feet	19·677	2·343 (11·91)	0·556 (2·83)	0·442 (2·24)
Porcupine, June 25, 1862. N. lat. 50° 56′, W. long. 12° 6′ ... Sp. gr. 1·0282.	6000 feet	19·776	2·376 (12·01)	0·610 (3·08)	0·381 (1·93)
Porcupine, June 27, 1862. N. lat. 51° 9′, W. long. 15° 59′ ... Sp. gr. 1·0280.	Surface	19·690	2·285 (11·60)	0·577 (2·93)	0·433 (2·20)
Porcupine, July 3, 1862. N. lat. 52° 9′, W. long. 15° 10′ ... Sp. gr. 1·0265.	Surface	19·706	2·381 (12·08)	0·570 (2·89)	0·367 (1·86)
Porcupine, July 3, 1862. N. lat. 52° 9′, W. long. 15° 10′ ... Sp. gr. 1·0280.	5100 feet	19·752	2·297 (11·73)	0·580 (2·94)	0·433 (2·19)
Porcupine, Aug. 29, 1862. N. lat. 51° 58′, W. long. 12° 47′ ... Sp. gr. 1·0280.	2400 feet	19·666	2·323 (11·81)	0·611 (3·11)	0·364 (1·85)
Porcupine, August 28, 1862. N. lat. 52° 40′, W. long. 15° 58′ ...	Surface	19·645	2·339 (11·91)	0·583 (29·7)	0·335 (1·71)
	10,500 feet	19·758	2·423 (12·26)	0·563 (2·90)	0·325 (1·64)
Porcupine. N. lat. 53° 1½′, W. long. 12° 55′ ... Sp. gr. 1·0280.	Surface	19·651	2·352 (11·97)	0·557 (2·83)	0·374 (1·90)
	1200 feet	19·424	2·405 (12·38)	0·559 (2·83)	0·351 (1·81)
Porcupine, August 16, 1862. N. lat. 55° 32′, W. long. 12° 11′ ... Sp. gr. 1·0255.	Surface	19·616	2·359 (11·99)	0·545 (2·78)	0·325 (1·65)
	9780 feet	19·686	2·330 (11·84)	0·599 (3·04)	0·323 (1·64)
Mean of surface observations	....	19·662	2·342 (11·91)	0·566 (2·88)	0·367 (1·87)
Mean of observations from the depth ...	....	19·677	2·357 (11·98)	0·583 (2·96)	0·374 (1·90)

Water from the Red Sea, and from different depths in the Baltic.

	Depth.	Chlorine.	Sulphuric acid.	Lime.	Potash.
Water from the Red Sea. Procured by Mr. Polack of Alexandria	....	23·730	2·889 (12·17)	0·689 (2·90)	0·387 (1·63)
From Wady Rarandel, upon the Sanai peninsula, taken by Mr. Neergaard ...	....	23·171	2·761 (11·92)		
Baltic. Water from Svartklubleen, taken by Messrs. Widegreen and Nyström	Surface	3·256	0·407 (12·50)	0·132 (4·05)	0·056 (1·71)
	108 feet	3·663			
	240 feet	3·881			
	300 feet	3·912			
	510 feet	3·969			
	600 feet	3·958	0·565 (14·27)	0·137 (3·46)	0·058 (1·47)
	720 feet	3·960			
	948 feet	3·977			

Sea between lat. N. 51° 1′½ and 55° 32′; and long. W. 12° 6′ and 15° 59′.

Magnesia.	Silica, &c.	Chloride of sodium.	Sulphate of magnesia.	Sulphate of lime.	Chloride of potassium.	Chloride of magnesium.	All salts.	Coefficient.
2·211 (11·24)	0·110	27·977	2·376	1·353	0·700	3·212	35·728	1·816
2·211 (11·18)	0·100	28·056	2·279	1·483	0·603	3·344	35·865	1·814
2·235 (11·35)	0·074	27·735	2·213	1·402	0·686	3·438	35·548	1·805
2·226 (11·30)	0·105	28·005	2·373	1·385	0·581	3·305	35·754	1·814
2·179 (11·03)	0·071	28·119	2·298	1·409	0·685	3·206	35·788	1·812
2·175 (11·06)	0·071	27·914	2·193	1·487	0·575	3·330	35·570	1·809
2·128 (10·83)	0·071	28·139	2·279	1·418	0·531	3·145	35·583	1·811
2·209 (11·18)	0·078	28·188	2·451	1·369	0·517	3·203	35·806	1·812
2·145 (10·92)	0·113	28·119	2·355	1·354	0·592	3·131	35·664	1·815
2·183 (11·24)	0·104	27·740	2·432	1·359	0·555	3·158	35·348	1·820
2·225 (11·34)	0·088	27·916	2·379	1·326	0·517	3·298	35·524	1·811
2·182 (11·08)	0·069	28·081	2·253	1·457	0·511	3·261	35·632	1·810
2·192 (11·15)	0·090	27·983	2·320	1·377	0·581	3·263	35·615	1·811
2·193 (11·14)	0·086	28·011	2·326	1·417	0·592	3·245	35·677	1·813

Water from the Red Sea, and from different depths in the Baltic.

Magnesia.	Silica, &c.	Chloride of sodium.	Sulphate of magnesia.	Sulphate of lime.	Chloride of potassium.	Chloride of magnesium.	All salts.	Coefficient.
2·685 (11·31)	0·136	33·871	2·882	1·676	0·612	3·971	43·148	1·818
0·403 (12·38)	0·027	4·474	0·329	0·322	0·089	0·678	5·919	1·818
0·441 (11·14)	0·072	5·810	0·632	0·333	0·092	0·526	7·465	1·886

Water from the Mediterranean.—Comparison between water from the surface and from different depths.

	Depth.	Chlorine.	Sulphuric acid.	Lime.	Potash.	Magnesia.	Silica, &c.	All salts.	Coefficient.
1. Straits of Gibraltar, procured by Mr. Ennis, Falmouth, 1837	Surface.	20·046	2·221 (11·08)	0·676 (3·37)	0·155 (0·77)	2·133 (10·64)	0·057	36·147	1·803
2. Straits of Gibraltar, taken by Captain Schulz, September 28, 1860	Surface.	20·160	2·302 (11·42)	0·610 (3·03)	0·415 (2·06)	2·134 (10·59)	0·073	36·391	1·805
3. Straits of Gibraltar, taken by Captain Schulz, September 28, 1860, from 540 feet depth	540 feet	20·330	2·425 (11·93)	....	....	....	....	....	....
4, 5*. A little on the Mediterranean side of the Straits, N. lat. 36° 9′, W. long. 4° 2′, September, 29, 1860	Surface.	20·235	2·583 (12·77)	0·613 (3·03)	0·345 (1·70)	2·305 (11·39)	0·093	37·014	1·829
	Depth *	21·119	2·493 (11·80)	....	....	....	....	....	....
6, 7*. Between the Balear island and the Spanish coast, N. lat. 40° 28′, E. long. 1° 48′, October 8, 1860	Surface.	21·085	2·444 (11·59)	0·641 (3·04)	0·474 (2·25)	2·402 (11·39)	0·083	38·058	1·805
	Depth *	21·207	2·746 (12·95)	0·664 (3·13)	0·354 (1·67)	2·317 (10·97)	0·138	38·946	1·836
8, 9*. Between the Balear island and the Spanish coast, N. lat. 41° 12′, E. long. 2° 23′, October 10, 1860	Surface.	21·056	2·542 (12·07)	0·635 (3·02)	0·336 (1·60)	2·356 (11·19)	0·087	38·321	1·820
	Depth *	21·211	2·513 (11·85)	....	....	....	....	....	....
10, 11. About midway between Corsica and Barcelona, N. lat. 42° 25′, E. long. 6° 0′, October 12, 1860	Surface.	21·217	2·458 (11·59)	0·629 (2·96)	0·428 (2·02)	2·379 (11·21)	0·075	38·290	1·805
	420 feet	21·304	2·500* (11·73)	....	....	....	....	....	....
12, 13. Between Sardinia and Naples, N. lat. 40° 25′, E. long. 11° 43′, October 20, 1860	Surface.	21·139	2·652 (12·55)	0·660 (3·12)	0·492 (2·33)	2·322 (10·98)	0·080	38·654	1·829
	300 feet	21·100	2·610 (12·37)	....	....	....	....	....	....
14. Malta, procured by Mr. Ennis, 1837	Surface.	20·497	2·471 (12·06)	0·640 (3·12)	0·174	2·074 (10·12)	0·080	37·177	1·814
15, 16. Somewhat to the east of Malta, N. lat. 36° 10′, E. long. 16° 10′, November 13, 1860	Surface.	21·297	2·514 (11·85)	0·686 (3·22)	0·417 (1·96)	2·403 (11·29)	0·118	38·541	1·810
	390 feet	21·311	2·515 (11·80)	....	....	....	....	....	....
17, 18. Between Malta and Greece, N. lat. 37° 20′, E. long. 16° 32′, October 23, 1860	Surface*.	21·180	2·390 (11·28)	0·597 (2·82)	0·304 (1·44)	2·392 (11·29)	0·029	38·013	1·795
	522 feet	21·290	2·510 (11·79)	....	....	....	....	....	....
19, 20. Between Candia and the coast of Africa, N. lat. 33° 34′, E. long. 24° 34′, October 28, 1860	Surface.	21·718	2·517 (11·59)	0·677 (3·12)	0·392 (1·80)	2·447 (11·27)	0·098	39·257	1·808
	522 feet	21·521	2·524 (11·73)	....	....	....	....	....	....
Mean of surface observations	....	20·845	2·470 (11·85)	0·647 (3·10)	....	2·296 (11·01)	....	37·785	1·813
Mean of observations of deep water	....	21·155	2·537 (11·99)	....		....	....	....	....
Mean of the surface of the ocean	....	18·999	2·258 (11·88)	0·556 (2·93)	....	2·096 (11·03)		34·404	1·811

* The depth in samples 5, 7, 9 is not exactly noticed, but it must have been between 300 and 540 feet.