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SOME RESULTS OF THE NORWEGIAN ARCTIC EXPEDITION, 1893–96.*

By FRIDTJOF NANSEN, D.Sc., D.C.L., LL.D.

It might seem desirable to lay before the readers of this Journal a full survey of the additions to our knowledge of the northern regions and their physical conditions acquired during the three years we spent there. But the material we brought home is so abundant, that a long time must elapse before it can be put into shape by the various specialists. It is obvious, then, that only after such preparation will it be possible to give any complete account of the results themselves and of their scope. An attempt to give some of these results now would undoubtedly be to run the risk of making many errors, of giving a false impression of what the expedition has contributed to science, and, in addition, the survey itself would be very imperfect. But the Royal Geographical Society may rightly expect to hear something of the results, and so I shall give what I can, though on the express understanding that this is only a provisional account, which has no pretension to be other than a vague outline of a few of the results and investigations which, at the moment, seem to be of importance. I will begin with that branch of science with which this Society is particularly concerned—geography.

When due regard is had to the manner in which this expedition was planned and carried out, it is not in the nature of things to expect that any great geographical discovery, as the term is popularly understood, would be the result. Our expedition was intended to be a sea-expedition pure and simple, which was to drift with the drift-ice and,

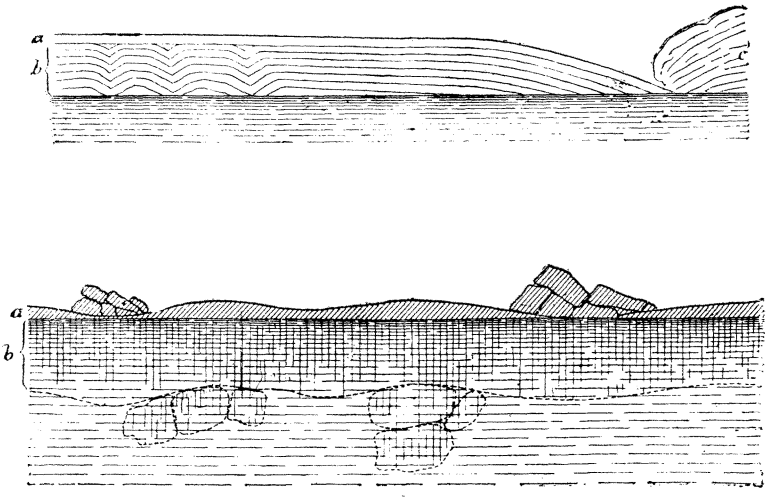
* Map, p. 588. For the illustrations which accompany this paper we are indebted to Messrs. Constable & Co., the publishers of Dr. Nansen's 'Farthest North.' The route-map, with certain modifications, has also been reproduced from the same work.

by preference, keep clear of all land. The discovery of new lands can therefore hardly be said to have been our object, and we were fortunate enough, I had almost said, not to discover any. I say fortunate, for the reason that such new lands might easily have prevented the successful issue of the expedition, as they would have stopped the drift of the ice. But negative results are also an outcome, and I think I may say that the expedition has contributed not a little to the increase of our knowledge of the distribution of land and sea in the regions nearest the north pole.

Before entering upon further reference to this, I will, however, first dwell shortly on some small changes in the configuration of the coasts along which we travelled. The first and foremost of these was the coast of Asia, where we made some discoveries of minor importance. In the Kara sea we discovered an island which, after its discoverer, was called Sverdrup's island. Along the coast of Asia we discovered several new islands and groups of islands. We landed on Kjelman's islands, discovered by Nordenskjöld, and made various observations of interest regarding their appearance and extent. North-east of these we found a group of islands we called Scott Hansen's islands; north-east of these, again, lie Clements Markham's islands; north of them are the Ringnaes islands; north-east are Mohn's islands; and east of some others, and nearer the coast, lie General von Tillo's islands. When we arrived at Taimyr island, which was visited by Nordenskjöld, we made a discovery of greater importance. We found that our way was barred by land-fast unbroken ice. As will be remembered, there are, according to Nordenskjöld's chart, on the north side of this island, due north of Cape Laptev, three or four islands only, and these he called Almquist's islands. We thought, therefore, that it must be an easy matter to find a way outside them; but, to our astonishment, we continually found new islands stretching further and further north, and when we at last reached the northern extremity of these, there was still no passage; the ice lay close in to the coasts. They appeared to be an extensive group of islands, and for a long time I was in doubt as to whether what we had on our east were a large continuous land or several islands of lesser extent, as wherever I turned the glass inwards I saw land. The weather, however was so thick that one could not see far, and I am inclined to think that they are a large group of islands lying at the northern end of Taimyr island.

I have called them after the man who showed us the way along the coast of Asia, the discoverer of the north-west passage; they bear the name of Nordenskjöld's islands. I am, however, inclined to believe that this group of islands had already been discovered, and that by the Russian Laptev, who travelled along the coast in sledges, but by whom they were taken for a continuous island, and that in reality they are the same as those marked on the older Russian charts as Taimyr island, which is separated from the mainland by a broad sound. The latitude

also seems to coincide with this, although the most northern islands in our group are situated a good way north of the Taimyr island of the Russian chart. I think, then, that the Taimyr island found by Nordenskjöld was in reality taken by Laptev to be the mainland, and that the Taimyr sound found by him is, in point of fact, a new discovery. It seems very reasonable to suppose that a sound as narrow and crooked as this one, which one cannot see right through, would not have been discovered by persons passing quickly by, especially when travelling in sledges. When we were there, I could not myself, even from the crow's-nest on the main mast of the *Fram*, clearly discern what it was, as it looked like a small closed-in fjord. It seems inconceivable to me



ICE STRATIFICATION.

that any one, even had he really discovered the sound, could have marked it on the chart as the broad strait we find between Taimyr Island and the mainland on the Russian charts.

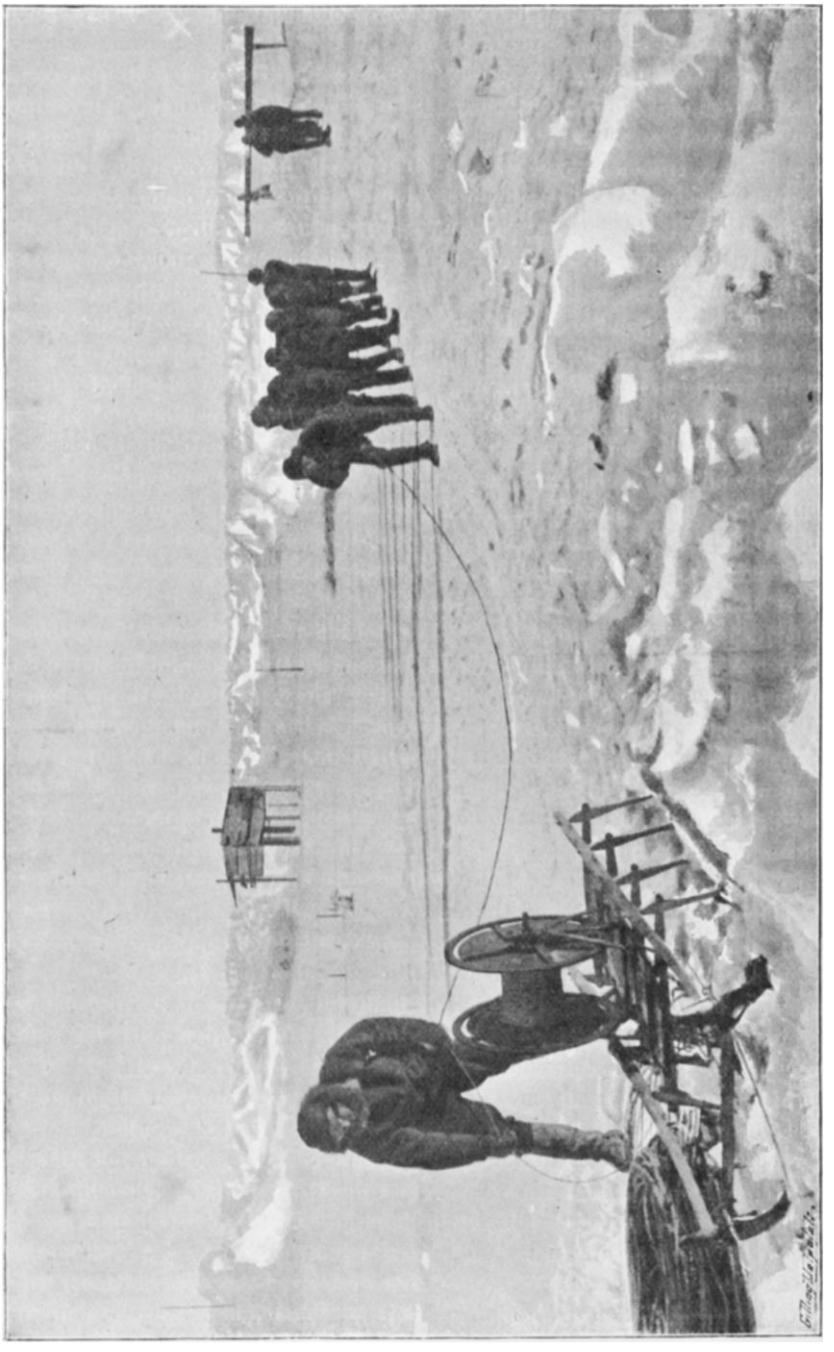
After being stopped at the north end of this group of islands, we were constrained to turn back again and make an attempt further south. We hoped for Nordenskjöld's Taimyr sound. There, however, progress seemed somewhat difficult, and we lay to for several days to investigate the sound further before daring to penetrate into it with the *Fram*. There too we made several discoveries, finding the land indented by fjords and sounds, and with many islands outside. At last on September 6 a gale broke up the ice, and we were able to get past Cape Laptev and into Taimyr bay. Great, however, was our astonishment to meet here, halfway in the bay according to the old charts, low sandy land stretching out like a broad tongue into the Taimyr sea. I called this tongue of land King Oscar's peninsula. In what manner it trends southwards we naturally could not determine for

more than a very short distance, and I have therefore tried to unite it as well as I could with what the earlier charts indicate as the coast about the mouth of the Taimyr river farther south, and which one may suppose to be fairly correctly placed.

On the east side of this tongue of land, as will be seen by the charts, a shallow bay runs into the land, which we called Toll's bay. A little further north we found a deep fjord, which penetrated inland as far as I could see, and which was probably the mouth of a good-sized river. The coast of the whole of the Chelyuskin peninsula northwards is very low, while inland we observed somewhat high mountain ridges, partly covered with snow, and on some I should almost be inclined to think there were small glaciers. Near Cape Chelyuskin itself there was a table-mountain (Mount Eivind Astrup) of medium height, which appeared to consist of some kind of sedimentary rock formation. On the west side of Cape Chelyuskin we found two small groups of islands —Fearnley's islands and Axel Heiberg's islands. Farther east there also seemed to be some small changes to be made in the trend of the coast-line. Thus the north-east corner of the Chelyuskin peninsula appeared to stretch somewhat farther north than it is usually marked; while the coast east of Thaddeus inlet, and the islands Peter and Paul, lay somewhat more to the south, as, according to our course, we should have sailed right over them without seeing them. I will not, however, dwell longer on these less important matters.

Without comparison, the most important geographical discovery made during our voyage was that concerning the polar basin itself. This had hitherto generally been considered to be a shallow sea,* in any part of which it might be expected to find land. This was pointed out at the meeting of the Royal Geographical Society during the discussion that took place before my departure. The reason of this assumption was the fact that, so far as the sea had been examined hitherto, it was everywhere shallow. In the sea south of Franz Josef Land and Spitsbergen, there was a depth of as much as 160 fathoms, while along the coast of Siberia not more than 40, at most 80, fathoms had been found. Then the expeditions which had penetrated northwards into this sea had always discovered new land. Thus the Austro-Hungarian *Tegethoff* expedition discovered Franz Josef Land during its drift, and the *Jeannette* expedition discovered Henrietta island, Jeannette island, and Benett island. In the plan of this expedition, I urged the possibility that a deeper channel might run across the unknown polar basin, uniting the Atlantic Ocean with the tract where the *Jeannette* had drifted; I drew attention to the fact that the sea stretching

* Not all authorities were of this opinion, however; twenty years ago had Sir Clements Markham maintained that there was deeper water to the north of Franz Josef Land, as will be mentioned later.



TAKING A SOUNDING OF 2058 FATHOMS.

northwards between Spitsbergen and Greenland was very deep—up to 2600 fathoms; and, at the same time, that the *Jeannette* seems to have found an increase in the depth northwards, or possibly only a narrow channel of water 80 fathoms deep, while on either side there were only 40 fathoms or less: and I then thought that these facts might possibly be connected with each other. I had, however, imagined the polar basin, taken as a whole, to be shallow. We found great depths, the sea in lat. 79° N., north of the New Siberian islands, suddenly becoming deeper and sinking to a depth of 1800 to 2000 fathoms, and this depth was preserved during the entire drift of the *Fram* north-west and west, as far as north of Spitsbergen. It is my opinion, thus, that not only does such a channel exist, as I had surmised, but that we must take it for granted that the polar basin, considered as a whole, is a deep sea which forms a continuation northwards and eastwards of the same depth as the northern part of the Atlantic Ocean. How far this deep sea extends to the east it is difficult to form any opinion; we know now that it goes as far as to the north of the New Siberian islands, but it is only reasonable to suppose that it extends still further east, since, in the case of the *Jeannette*, every time the drift set her northward or north-eastward, the depth of the sea was found to increase.

What, then, is it reasonable to suppose with regard to the distribution of land and sea in the yet unknown polar area? I think we may with safety say that little or no land can lie on this side of the pole, as it is not probable that such a deep sea should only be a narrow channel. It appears to me to be too continuous for this, and on this account alone I should be inclined to think that it extends a good way north of that part of the sea traversed by us. In addition to this, we saw no indication whatever of land in any direction. During our sledge-journey north of the *Fram's* route, the ice appeared to be drifting with great speed—even greater than that of the ice we found further south. There was a great deal of movement in the lanes, and at different times we were carried away in different directions with some rapidity—so rapidly, in fact, that it sometimes seemed as if we had been given up, helpless, to the violence of the wind and current. Masses of ice like these could hardly move with such great freedom in different directions if land of any extent were in the vicinity, as this would cause insurmountable obstacles to the drift. It ought also to be remembered that this was particularly the case every time the wind carried us in a northerly or north-westerly direction, but that, on the other hand, the drift seemed to be unusually sluggish every time we were set back towards the south-east.

A good indication as to how far tracts of land of any extent are to be assumed farther north or not, we shall certainly find in our meteorological observations; the course of the isotherms and the

DEEP-WATER TEMPERATURE, "UP WITH THE THERMOMETER."

distribution of the atmospherical pressure, the directions of the wind, etc., must tell us something of the matter. Unfortunately this great mass of material has not yet been investigated, so that I shall reserve all mention of it till some future date. I will only for the present remark that, from these data, hitherto I have not been able to find any indication of tracts of land north of us. There is, however, one thing which causes me to think that we are right in supposing the polar sea to be of greater extent north of our route, and that is the drift-ice itself. If the *Fram* had continued her drift in the ice instead of working herself out of it north of 83° N., there is no room for doubt but that she would have been drifted southwards in the vicinity of the east coast of Greenland. She would have come towards known waters with the drift-ice which is carried down by the east Greenland polar current, and which we know so well from Scoresby's description of it. It was the same drift-ice which we had struggled with for three years.

It is not, however, reasonable to suppose that the *Fram* would have drifted close under the east coast of Greenland; she would undoubtedly have had a broad belt of ice between her and the coast, and the ice composing this belt must, it goes without saying, proceed from a part of the polar sea which lay to the north of us during our drift, and this part may be of fairly great extent. If, for instance, we look at the relation between the polar sea itself and its masses of ice, and the east Greenland polar current and the continual transport of ice, it suggests a comparison between these relations and those which exist between a vast expanse of inland ice and its ejection through a narrow ice-valley, such, for instance, as we find in the ice-fjords of Greenland. In the inner polar basin, where the *Fram* drifted, the ice, as in the interior of the inland ice, was very slow in its movement. By degrees, however, as it approaches its outlet the movement augments, the ice streams off with greater and greater speed southwards, until it at last comes south, where it is broken up by waves and wind, and melts in the warm water. It is in the same manner that the offshoots of the inland ice stream out through the ice-valleys and the ice-fjords and down into the warmer strata of air, there to melt and finally emerge into the sea, where, broken off, they float away in the form of icebergs. A certain breadth of ice-belt in the polar current of the east coast of Greenland must consequently correspond to considerably broader and more extensive parts in the known or unknown polar sea. I think, consequently, that we may with certainty conclude that on this side of the pole there is an extensive ice-covered sea. There is, on the contrary, a possibility of the existence of land of some extent on the other side of the pole. It is hardly reasonable to suppose that the northern confines of the American arctic archipelago have yet been reached. We may expect to find islands, perhaps islands of some magnitude, north of the limit which has been reached. A closer

examination of these parts, we must hope, will be undertaken in a not distant future.

Before I conclude this short summary of the geographical results of the expedition, I must touch on a point which may be of some importance, and this is the character and extent of Franz Josef Land. The drift of the *Fram* has, as before mentioned, revealed to the north of Franz Josef Land a deep sea, and that this land can have no such extension northwards as has been surmised in several quarters. The discoveries made during Johansen's and my sledge-journey over the ice serve only the more to corroborate this statement. The discoveries we made here may not seem overwhelming to some people; for already twenty years ago the President of this Society, Clements Markham, said, "Franz Josef Land seems to be a part of the Spitsbergen group, rising out of the same shallow sea, with deeper water to the north."

This expression of opinion was then a somewhat isolated instance, and aroused contradiction rather than the reverse, at a time when it was customary to consider Franz Josef Land as the south coast of an extensive mass of land. I can now, after having myself explored part of this "deeper water to the north," give this opinion my full and entire concurrence. When I addressed this Society before my departure, I expressed it as my opinion that Franz Josef Land was not an eligible point of departure for an expedition to the pole if the object were to press forward overland, seeing that I regarded Franz Josef Land, as I then said, as merely "a group of islands." Our expedition seems also to corroborate this. Franz Josef Land not only proves now to be a group of islands, but a group of comparatively very small islands. How far they extend to the northward we cannot yet determine with precision, but, in any case, their extent in this direction cannot be of importance. Petermann's Land cannot be of any great size, for otherwise we must have seen it when we went southwards in the summer of 1895.

That Oscar's Land, also, is of no great extent I think I may conclude, from the fact that the ice on the north coast outside our winter quarters appeared to drift unhindered from the land towards the north every time a southerly gale sprang up. If there had been land of any extent in that direction—that is to say, where Oscar's Land should lie—it would assuredly have hindered the drift of this ice. Of the extent of the land in an easterly direction, it is difficult at present to form any opinion. When we came west from Hvidten Land—the first islands discovered by us—and perceived the chain of islands west and south of us, they stretched like an apparently continuous coast, here and there only divided by small sounds and fjords. The southernmost land that we saw was Wilczek Land, which, however, seemed to disappear in a south-easterly direction, and we saw no land farther east. On the

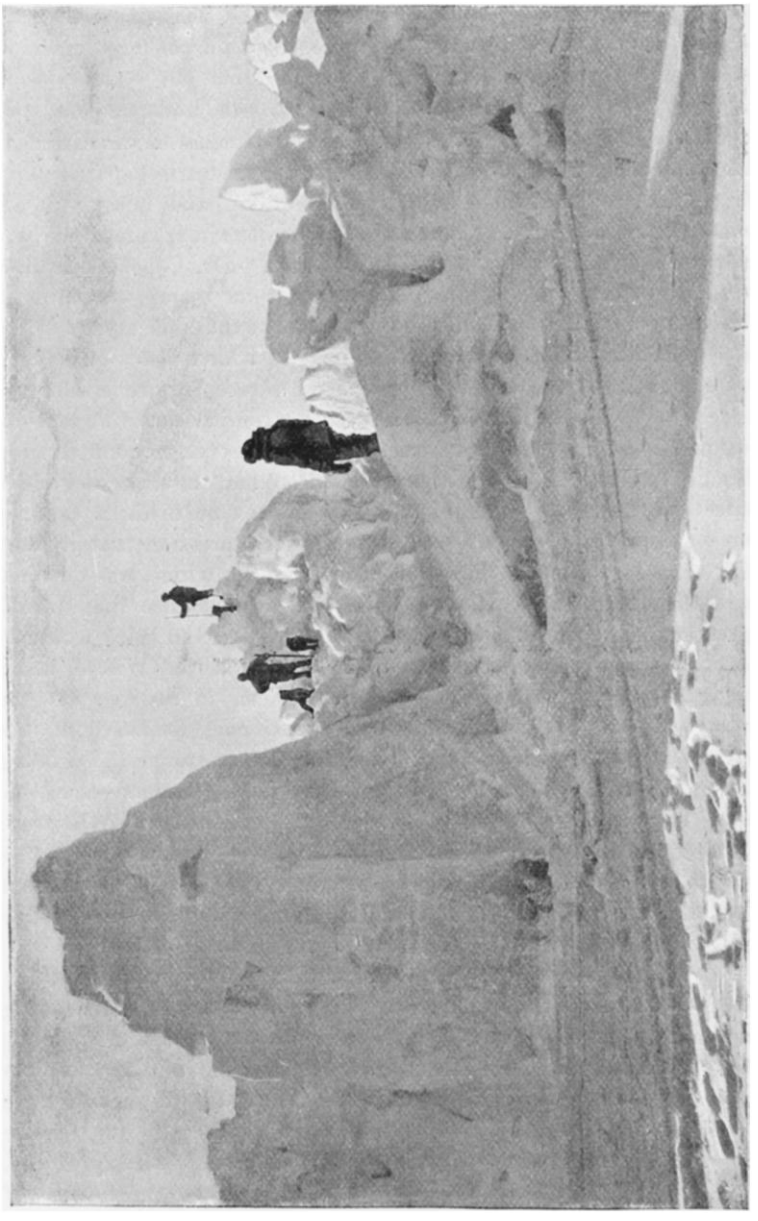
other hand, to judge by the sky, there were signs denoting a considerable quantity of open water. That there really are islands in that direction, however, seems possible, from the fact that when we were encamped, during June and July, in about lat. 85° 5′ N. and long. 63° to 64° E., where we lay for a month, waiting for the deep snow to melt in order that our progress southwards might be easier, we had, several times during the month, long periods of strong northerly wind, yet without its being able to drive us farther south, although the ice seemed to move tolerably unhindered in other directions. This might indicate that there was a wall of land to the south of us, running east and west, and stopping the drift of the ice.

I think it is probable that the group of islands composing Franz Josef Land extends very much farther west than we now know, since neither Jackson nor we saw the limits of the land westwards on the north side of Alexandra Land. In point of fact, we discovered new islands in the west as far as our range of vision admitted, and, to judge by the large open land-lane which ran in that direction, one might suppose that the land there was of considerable extent. On the south side of Alexandra Land, Leigh Smith, equally with Jackson, failed to find the western limits of the land. Set this beside the fact of the new land discovered by the Norwegian sealers on the east side of North-East Land, the so-called White island or New Iceland, which is probably the same as the mystical Gillies Land; it is then reasonable to suppose that between these lands there lies a continuous chain of islands, which in reality connect Franz Josef Land with Spitsbergen, and would be so closely continuous, that it would be difficult to say where the one group of islands ends and the other begins. On this point, too, Clements Markham's words, that "Franz Josef Land seems to be a part of the Spitsbergen group," hold good. The geological structure of Franz Josef Land seems also to indicate that this is actually the case, and it is my intention to touch on this directly. In these parts, which Johansen and I should have visited had we not fallen in with Jackson, the Jackson-Harmsworth expedition will no doubt have many interesting discoveries to make.

Before I leave the geography of Franz Josef Land, I have a few words to say relative to the map.

I will first mention a discrepancy between our experiences and Payer's map, a discrepancy which has been the subject of a good deal of discussion, and perhaps also of misunderstanding. It was, however, this discrepancy which brought us to think that the land we met with could not be the Franz Josef Land visited by Payer. It was our opinion, therefore, that our watches must be altogether wrong, and that we had come to a land much further west—either the west coast of Franz Josef Land, or more correctly Alexandra Land, or perhaps Gillies

Land, or some other new land situated between Franz Josef Land and Spitzbergen. Where Payer placed the north end of Dove glacier and



PRESSURE MOUND NEAR THE *FRAM*.

the entire north end of Wilczek Land, we found only sea, with the exception of the four islands which I named Hvidten Land. Of Payer's

Rawlinson's sound we saw nothing, nor the north end of Austria Sound, and his Wilczek Land becomes in reality a smallish island, the northern extremity of which lies about one degree further south than he placed it. I could hardly conceive such a mistake, seeing that the land lay comparatively near his route, and therefore could not for a moment suppose that his map was incorrect, but rather that our watches were wrong. It was only after we had met Jackson and compared our watches, that I discovered that such must nevertheless be the case.

I have thought much as to how this error can have arisen, particularly as Payer's map, on the whole, is so carefully drawn, and, in my opinion, satisfies all the demands which can be made on a map prepared by a man travelling so quickly through a country. Dr. Copeland is now engaged in working on Payer's great materials for a map, and through the kindness of the former I have been enabled to convince myself of the unusual reliability of this important material. I have also seen Payer's sketches, and have been able, through them, to recognize several of the lands seen and visited by us. I think that, by a comparison of Payer's observations with ours, some more exact idea of the northern configuration of this group of islands could be arrived at. When one looks at Payer's sketches and reads his description of his journey northwards towards Crown Prince Rudolf's Land, one receives the impression that it must be easy to make a mistake like that made by him, which was destined to be so fateful for us. It arose from the circumstance that during the greater part of the time he was there he had fog and thick weather, and he says himself that he was under the impression that Wilczek Land ceased a little way north of 81° N., just as it does in reality; but one clear day (April 7) he was, as has been mentioned, disabused of this error, and, as he himself writes, "When the sun scattered the driving mist, we saw the glittering ranges of its enormous glaciers—the Dove glaciers—shining down on us. Towards the north-east we could trace land trending to a cape lying in the grey distance—Cape Buda-Pest, as it was afterwards called. The prospect thus opened to us of a vast glacier-land, conflicted with the general impression we had formed of the resemblance between the newly discovered region and Spitsbergen."

What Payer really saw here were, I think, banks of mist on which the sun was shining, and which on such occasions can have a misleading resemblance to glaciers—a fact which we often had occasion to notice during our journey. These banks of mist extended northwards from Wilczek Land over Hvidten Land, and so onwards towards Prince Rudolf's Land. Perhaps, too, Payer did really see the top of the glacier on the largest of the islands of Hvidten Land—the upper one, which I called Eva island; then, too, he probably saw the nearest of these islands, and has marked it by the name of Freeden Insel.

I can understand all the more easily that such a mistake may arise, since I very nearly was guilty of the same thing myself, seeing that

when I came southwards through the sound discovered by Jackson—the British Channel—along the west coast of Hooker island, I thought all the while that we had a vast continuous glacier-land on our west. It was only when the mist lifted and it cleared on the evening of June 11, that we discovered the broad sound which lies between Northbrook island and Bruce island on one side, and Alexandra Land with Peterhead on the other. Had not this happened, and we had been constrained to make a map of these parts without receiving later information, I should have been guilty of exactly the same mistake as that of Payer farther north, and thus I do not reproach him in any way.

Between our observations and Jackson's map of the land observed by him there are but few discrepancies to be mentioned here. The most important, perhaps, is that the land which Jackson saw to the north, and which he supposed to be King Oscar's Land, is in reality some small islands lying west of our winter hut, some 40′ farther south; we saw them not far from us the whole winter. Jackson, however, expressly states on his map that it was the "approximate position, very misty, distance uncertain, and single bearings;" and when he saw my map he agreed that the land he had seen must be our three islands, for which reason I have not given them any name. The alteration in the position of this land makes it necessary, however, to move Queen Victoria sea, so-called by him, a little further south. This open water, which was fallen in with by him as well as by us, and which we had occasion to see being formed during the course of the winter, cannot, however, be regarded as any open sea; such a designation would easily lead to misconceptions, as this open water must rather be regarded as a land-lead, which, like all other land-leads, is formed and opened by a land-breeze, and is closed again by the wind blowing in shore. This discovery of open water on the north side of the islands one had to be prepared for, as exactly the same thing occurred with Payer twenty-two years ago, as he found a piece farther north on the north side of Karl Alexander Land and the west side of Crown Prince Rudolf's Land.

The other minor discrepancies which Jackson's map shows compared with our observations are of so little moment that I will not even name them. With regard to the giving of names on my map, I will only observe here that when I found out that the land on which we had lived during the winter was divided by a sound from Karl Alexander Land *

* It ought, perhaps, to be mentioned that we did not find the sound which, according to Payer's map, should separate Andrée island from Karl Alexander Land. On discussing this matter with Dr. Copeland, he told me that he could not find anything in Payer's material which indicated the existence of this sound. Payer's original sketch-map had no Andrée island or no such sound, and Copeland believed, therefore, that Andrée island and the sound were due to a mistake by the man who made Payer's map after his return from his journey.

By seeing Payer's sketches of Karl Alexander Land, I have been able to identify various promontories. I could especially easily recognize Cape Felder, which has a

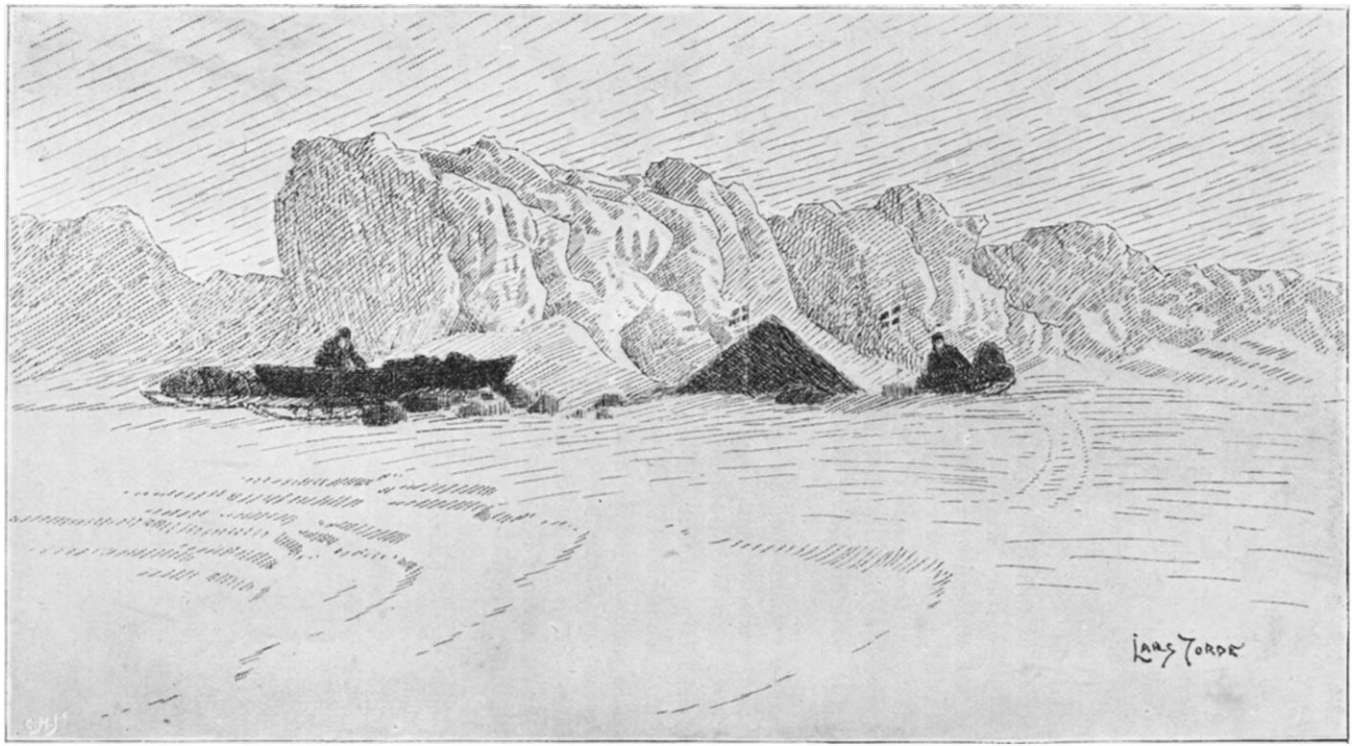
lying north of it, and so named by Payer, I asked Jackson if he had any objection to my calling this land Frederick Jackson's island, as a slight token of our gratitude for his unusual hospitality towards us, and to this he agreed. I have otherwise refrained from giving names to any of the countries which Jackson saw before we did.

The island situated between Jackson's island and Karl Alexander Land I have permitted myself to call after Leigh Smith, as a slight acknowledgment of his important instrumentality in the mapping and investigation of this interesting group of islands. It is, in a measure, a continuation of the work begun by Leigh Smith which the Jackson-Harmsworth expedition has undertaken, and they have already accomplished work deserving of great credit. Jackson's map of the part of the group of islands which he has surveyed gives the idea of great accuracy. Thus, when I compared our observations with his map, I found that for the place where our winter hut was situated, which lies near his northernmost point, there was only a difference of some few minutes. It is particularly unfortunate that, during the last two years, circumstances have prevented Jackson from travelling over a still greater part of this group of islands. In the coming year these difficulties will be surmounted, and we may expect an eminently satisfactory map of the whole extent of this interesting group of islands; one of the more important problems will then be solved yet remaining in the sea on this side of the pole.

In concluding my remarks on the geographical discoveries made by us on our expedition, it may, perhaps, be appropriate to add a few words on the geological character of the countries we visited. The geological investigations we were in a position to make during our voyage along the coast of Asia were necessarily of very small extent, as our visits on shore were of an accidental nature and of extremely short duration. At no place where we landed did we find stationary sediments which were not metamorphosed. As a rule the stationary rocks we met with consisted of crystalline schists and granites; amongst these may be mentioned a characteristic aplitic Muscovite granite from Cape Laptev. On the north-east corner of the Chelyuskin peninsula we observed a very finely grained helleflinta, in its appearance resembling quartzite.

Of more importance were the indications of an ice-period which I thought I found in several places on the north coast of Siberia. The undulating tundra of Yalmal, consisting of sand, clay, and small stones (boulders), had already reminded me of the North German plains, and suggested the idea of a vast ground moraine (till). It was full of

peculiar shape, and which Johansen and I visited on the night between August 16 and 17, 1895 (see 'Farthest North,' vol. ii. pp. 310-312). I describe it in my diary as "a curious high ridge, as sharp as a knife-blade." There is also a photograph from this place in my book, vol. ii., facing p. 730.



OUR NORTHERNMOST CAMP, 86° 13·6′ N. LAT., APRIL 8, 1895.

round depressions and lakes, which reminded one of the North German lakes, and those so often to be seen on extensive ground moraines. We, however, found no large erratic blocks on these tundras, and our investigations were of such a slight character, that I dare not, at present, form any certain opinion as to the glacial origin of this land. Farther north, indeed, I found unmistakable glacial marks. Thus, on the beach of one of the Kjellman islands, where we landed, I found a striated rock-surface of such a nature that it could not be explained in any other way than as proceeding from the scouring of glaciers. The drift-ice does indeed occasion scratches or striæ on the coasts, but this striation is necessarily somewhat superficial, and the scratches are extremely irregular in their direction. The striæ I found here, on the contrary, were decided and deep, and ran parallel to each other in a definite direction. That I only found striæ of this kind in that part of the beach which is laid dry at low tide, is easily explained by the fact that the surface of the rocks in these regions is so weathered by the prevailing climate that, as a rule, all striation disappears very rapidly, the mountains being fissured and shattered in all directions by the frost.

Wherever we landed up here, the country was covered in all directions with larger or smaller boulders, and these, no doubt, were in some places of the same kind as the stationary rocks. In other places, however, I often found large blocks differing completely from the rock which formed the ground on which they lay. The land on the west side of the Chelyuskin peninsula, at the head of Toll's bay, where I went reindeer-shooting one day (September 8, 1893), had a thoroughly typical till-like appearance. This was a very undulating clay plain, over which were strewn a multitude of large boulders of different rocks, and these could with difficulty be explained otherwise than as being material brought hither by an extensive ice-sheet. This land, too, was of striking resemblance to the plains we know, and which are generally admitted to be glacial ground moraines. The fact that I found an indication of stratification in several places where the clay had fallen away—as, for instance, along the shore and in some stream-beds—can hardly be regarded any longer as an argument against its moraine-like character, as we, for example, know of several incontestable cases of moraines in the south of Norway which have distinct stratification. Even in end moraines such a stratification is commonly found in Norway. It is only a proof that the moraine was formed under the sea.

It may be thought that the glacial traces we found might be owing to local glacier formations; but compare these with what Toll found almost simultaneously with us on the New Siberian islands and at Anabar, where he has pointed out the most interesting remains of an ice-period, and it must be conceded that the probability is that at any rate a considerable part of the north coast of Siberia must have been

buried under an ice-sheet like that which in its time covered the whole of Northern Europe, and the exemption from an ice-period, which it has been endeavoured to grant Siberia, no longer holds good. The entire configuration of the Siberian coast also appears to indicate that it has had an ice-period here, as outside it there lies a belt of rocks and islands such as very seldom occurs, except off glaciated coasts. Moreover, the coast itself, when we approached it, appeared to be much fringed everywhere with deep fjords, such as are seldom found in other than glaciated lands. I should imagine that the whole of the north-west coast is indented in a similar manner, and the impression given by the ordinary maps of a continuous even coast-line is therefore misleading.

The geological structure of Franz Josef Land is of a very peculiar nature. It appeared, wherever we visited it, to consist of basalts. In the northern parts of the islands these basalts and other plagioclase-pyroxene rocks reached the very shore, and I looked in vain for fossil-bearing strata. Further south, however, near Cape Flora and thereabouts, the basalt did not reach to the sea; but, as the Jackson expedition had already discovered, an immense formation of clay stretched from the shore up to an altitude of from 500 to 600 feet, and on this formation the basalt rested to a height of another 500 to 600 feet. I brought home with me a collection of specimens of basalt from the neighbourhood of Cape Flora, as well as from further north. These have been examined microscopically by Professor Brögger. There is a great difference in the basalt in different parts. While in some places it has a decided porphyritic structure, thereby differing from many typical basalts more resembling many melaphyres, to a very great extent the basaltic lavas have an amygdaloid structure. The cavities are filled with zeolites (especially analcime) and calcite; it was in other parts—at Cape McClintock, for example—very coarse-grained in quality, with diabase structure (doleritic structure), and appears to be closely connected with the diabases (dolerites) and basalts found in Spitsbergen, particularly on Stans Foreland and the Stor Fjord as intrusive sheets. The basic rocks of Franz Josef Land seem to have been formed in the Jurassic period, for the clay formation on which they rested at Cape Flora was undoubtedly Mesozoic (Russian Jura, Lamberti-zone), and above the basalt was found, as I shall mention presently, fossil plants belonging to the later Jura period.

It thus appears that Franz Josef Land is, taken altogether, of Mesozoic (Jurassic) formation. These numerous flat basaltic streams, which extend over all the islands at about the same height, seem to tell us that at one time it was a continuous mass of land, which in the course of ages, eroded by the various wasting forces, such as frost, moisture, snow, glaciers, and the sea, has become cut asunder, destroyed, and has partially disappeared under the surface of the sea, while only scattered islands and rocks now remain, separated from each other by sounds and

fjords. These basalts have, as I mentioned before, a striking resemblance to those formed in parts of Spitsbergen; like these, they contain very little olivine and iron ore, and it is probable that Franz Josef Land and Spitzbergen formed a continuous eruptive province, different in age and rocks from the great Tertiary eruptive province of North-Western Europe, Færoe islands, Iceland, Scotland, Ireland, and Greenland.

An interesting discovery was made while we were at Cape Flora, Jackson and the geologist of the English expedition, Dr. Koetlitz, finding one day, on a basalt mountain projecting from a glacier, numerous fossil plants. One day later Koetlitz and I went there together, and made a valuable collection of them. My comrade Johansen also found his way there one day on "ski," quite unwittingly, and also collected fossils, which he brought to me. These fossils have been examined, since our return, by Prof. Nathorst, and it proves that Jackson and Koelitz's find is a highly interesting one. Prof. Nathorst has, in a letter, given me some preliminary information on the character of these fossil plants, and he says that "in spite of their fragmentary character, the specimens of fossil plants brought home are of great interest, as we are enabled through them to get a glimpse, for the first time, into the plant-world which existed in the latter part of the Jura period in the tracts north of 80° N." The leaves of a certain pine, closely connected with the *Pinus Nordenskiöldi* of the Jura strata of Spitsbergen, East Siberia, and Japan, but probably belonging to a species differing from them, are most common. There are also leaves of another kind, the fragment of a cone,* and several seed-vessels, of which one reminds us of the *P. maakiana* from the Jura strata of Siberia and Spitsbergen. Nathorst, in addition, mentions several other conifers, which, however, I will not touch upon here. Interesting, he says, is the appearance of the genus *Feildenia*, as it has hitherto only been known in the polar regions. It was first found by Nordenskiöld, in 1869, in the Tertiary strata of Spitsbergen; afterwards by Feilden, in the Tertiary strata of Discovery bay, in Grinnell Land, during the English polar expedition of 1875–76. It has been found since by Nathorst in Spitsbergen, in the upper Jurassic strata.

The most beautiful in the whole collection are the leaves of a little *Ginkgo*, of which one is complete. This genus, with plum-like seed and with leaves which, unlike those of other conifers, have a real leaf-surface, is now found in Japan in a single species; but it appeared in earlier times in a multitude of forms, and was widely distributed. It was particularly luxuriant in East Siberia in the Jura period, and it is also known from Spitsbergen and Eastern Greenland (near Scoresby's sound), and many places in Europe, etc. The leaf

* Leigh Smith brought home a fossil cone from Franz Josef Land, which Carruthers decided to be that of a pine; but he supposed it to belong to the upper part of the Chalk system

represented here belongs to a new kind, which Nathorst has called *Ginkgo polaris*, and which is closely connected with Heer's *Ginkgo flabellata*.

There are also fossils of several other conifers, which, however, I will not enumerate here. "On the whole," says Nathorst of this Jura flora of Franz Josef Land, "it is, by reason of its wealth of conifers, its poverty of ferns, and its lack of sycads (or, at any rate, great rarity of them), of about the same general character as the upper Jura flora of Spitsbergen, although the species may differ; and it would seem that the flora does not testify to particularly favourable climatic conditions, although the difference between then and now is a vast one. The deposit presumably took place in the vicinity of a forest of conifers. As far as can be judged by the material, the flora must belong to the upper white Jura rather than to the more medium brown Jura."

I will conclude these remarks on the geological investigations with a few words on the present bottom-sediment of the polar basin. By examining with the microscope the samples which we secured by means of our soundings, it proved that they differ essentially from the samples taken from the north Atlantic Ocean, as they are wanting in the organic compounds or shells of marine animals which form such an important ingredient in the ground-mud of that ocean. On examination with acids, it was also shown that this mud is particularly deficient in carbonate of lime, and seems to be chiefly of mineral components. There has not yet been time to subject these samples to very careful examination, and I will, therefore, for the present refrain altogether from attempting any explanation of the characteristic composition of this mud. It appears that a deposit of sedimentary strata is now taking place in the polar basin which, however, may prove to be extremely deficient in fossils.

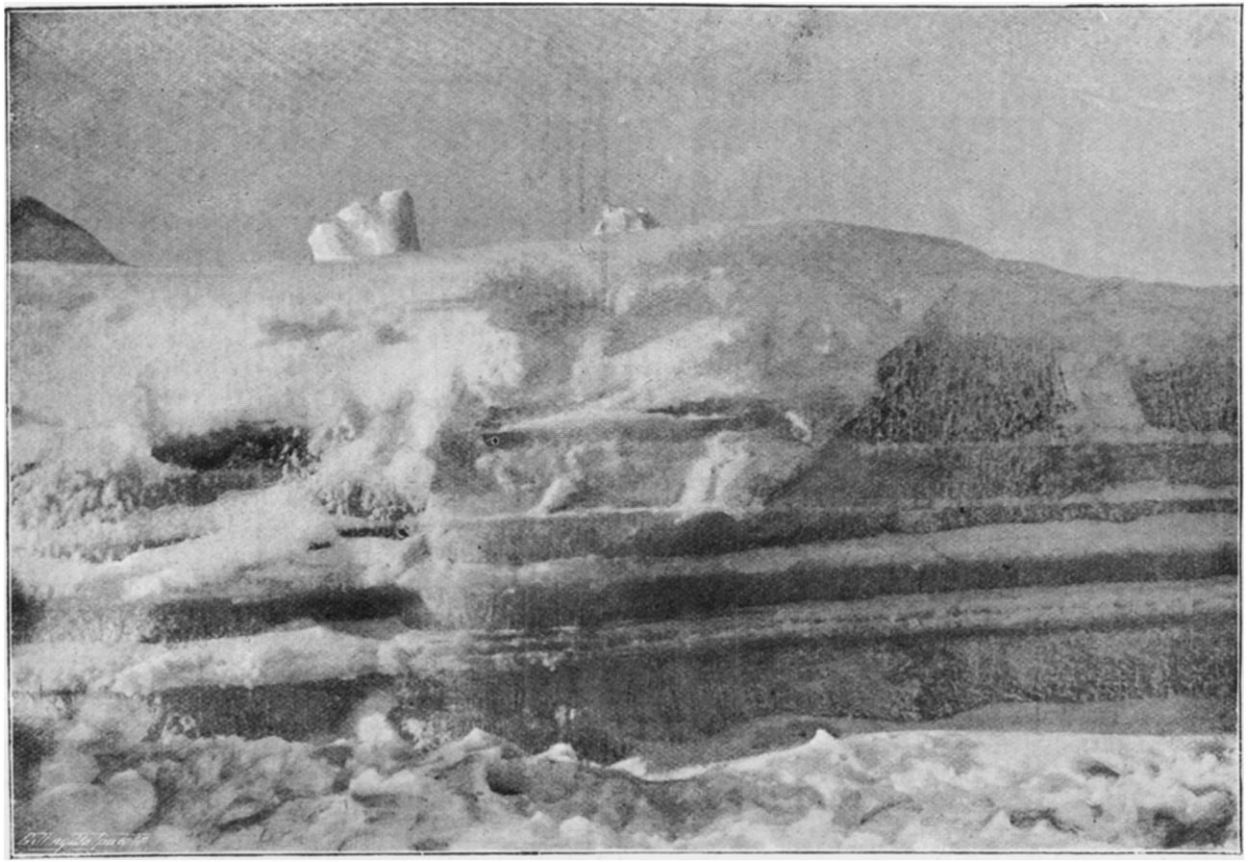
A very important result of the Norwegian Polar Expedition is the glimpse it has given us into the drift and transport of ice in the hitherto unknown polar sea. As I pointed out before my departure, the plan of the expedition was based on the assumption that a current or continual drift of ice must go right across the polar basin from the sea north of Siberia and Bering Straits, and over towards the sea between Spitsbergen and Greenland. It was with this ice that I intended to let the *Fram* drift. My assumption seemed to be at variance in several ways with the current ideas of the nature of the polar sea. Meanwhile the expedition was carried out in accordance with the plan; it has proved that the premises from which I started were more or less correct, and it has enabled us now to form a fairly complete picture of the manner in which the ice drifts ceaselessly across this basin.

Although, as I say, the assumption of such a drift was at variance with current opinion, something of the kind had already been suggested

in several quarters. I will again refer to the eminent President of the Society, Clements Markham, who, in 'The Report on the English Expedition of 1875–76,' said, twenty years ago, that the water emptied from the rivers of Asia and America into the polar basin "causes a current round the area from left to right, and also across from the eastern to the western hemisphere." As early as 1869 the Swedish naturalist, Professor Agardh, showed that the driftwood of Spitzbergen originated in Siberia. Among the others who made investigations before in the same direction, I must mention Professor Moha, who, when the articles from the *Jeannette* were found in 1884 on the south-west coast of Greenland, pointed out that they must have drifted straight across the polar basin north of Franz Josef Land and Spitzbergen, and down along the east coast of Greenland.

A thing which caused me most of all to place reliance on a drift of this kind being in constant movement across the polar basin, and to think that it might be turned to account for the purposes of an expedition on the plan that we have carried out, was first and foremost the Siberian driftwood which is constantly brought to the east coast of Greenland, and from the earthy matter to be found everywhere on the drift-ice which comes down along the east coast of Greenland. On microscopic investigation of this mud which I had collected, it proved that it could not well proceed from anywhere else but from Siberia. During our journey we again found, ourselves, the same proofs of the origin of the ice; I found earthy matter on the ice as far north as 86° N., and driftwood likewise. I remember one day far north, during Johansen's and my journey over the ice, our astonishment at seeing a large piece of timber projecting from the ice; it hailed perhaps from the interior of Siberia, and was on its way to the Eskimo of Greenland. The only thing we could do was to cut our initials on it, with the date and latitude, in the hope that it might take a greeting to some acquaintance away in Greenland. We often found similar driftwood in the neighbourhood of the *Fram*. Sverdrup once found a half-rotten piece of timber which was firmly frozen into the ice—this was in April, 1896. When, about a month later, he came across the log again, he was astonished to find that it had been broken off and dragged some distance away. The bears had, no doubt, been amusing themselves by exercising their strength.

But what causes the drift of this ice over this sea? It is first of all the winds. The prevailing winds blow from the Siberian sea towards the north Atlantic Ocean, and they do, in course of time, carry the ice over in that direction. But the winds are, as we know, very irregular forces with which to deal, and in consequence of this the drift is not particularly regular either. Sometimes there are stoppages, sometimes a return drift, sometimes even a drift sideways; but, on the whole, it proved that every time the wind carried us in the right direction—



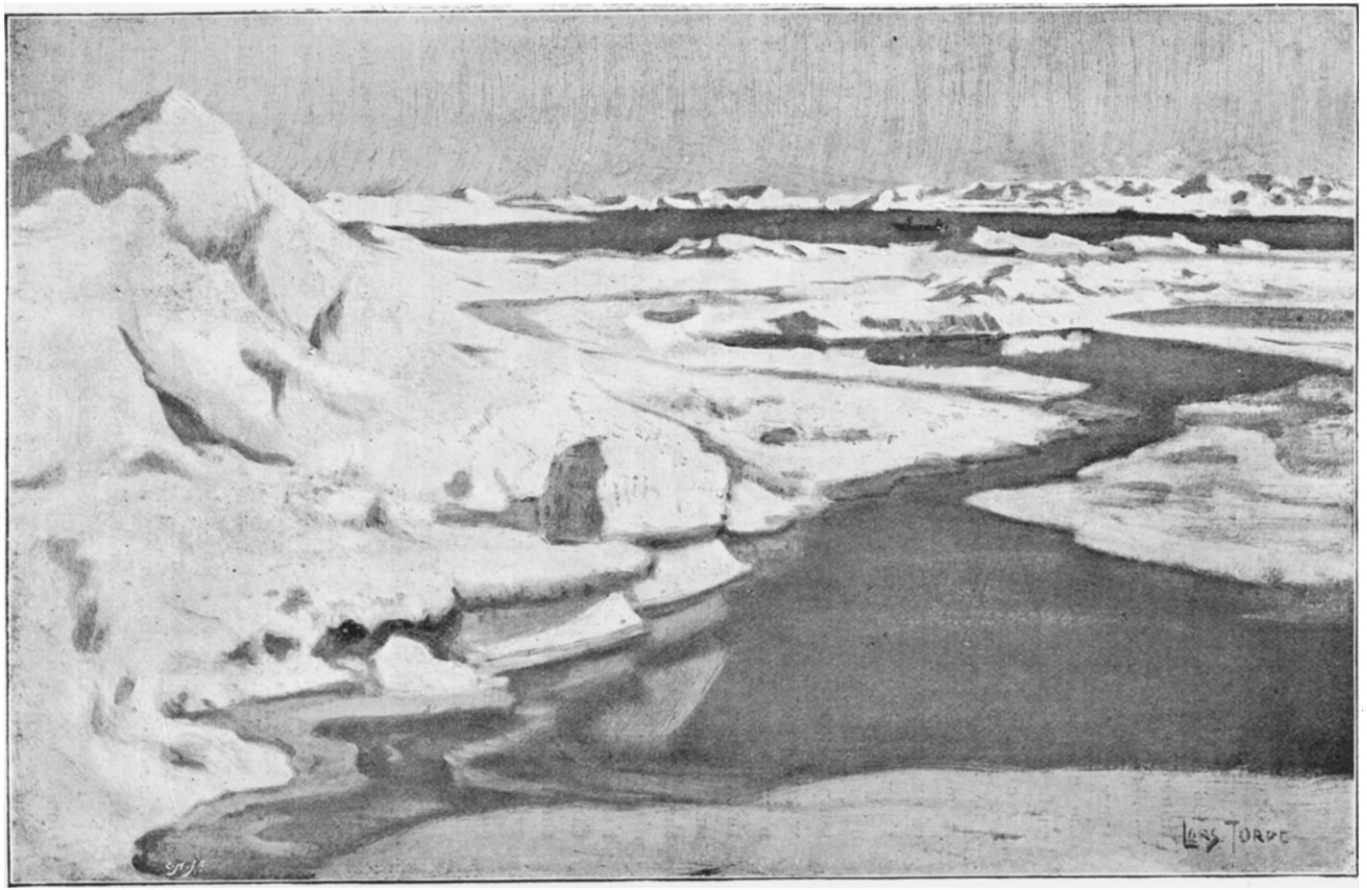
PECULIAR ICE-STRATIFICATION, APRIL, 1895.

towards our goal—the drift became very rapid. On the other hand, if the winds came from the contrary direction, setting us back towards the south-east, the masses of ice were very sluggish and difficult to set in motion; it seemed as if something were keeping them back. As the prevailing winds change very much with the season of the year, our drift was also very periodical.

As a rule the wind was most favourable in the winter; in the summer —particularly the latter part of the summer—it was as generally unfavourable. No sooner were we fast in the ice the first autumn, than we experienced an unfavourable period and were set back towards the New Siberian islands; this was a very dark period in our drift, and everything seemed to go backwards. Then came the winter with good progress, until from June onwards to the autumn of the next year there was again retrograde movement. Then came another winter with good progress, and we gained a point north of 84° N. The summer following this was not particularly favourable either, but the succeeding winter —it was last winter—sent the *Fram* right north again to 86° N. Then came the spring with a long pause in the drift of the *Fram*, until she finally broke loose out of the ice as far north as above 83° N. and made her way down to Spitzbergen—a distance through which no vessel has hitherto broken its way through ice so massive as that which there surrounded her. But, according to my opinion, it is not merely chance winds which influence the drift of the ice; I thought, too, that at times there was evidence of a slight current in the water, under the ice, which also went in about the same direction. Nor do I think that the drift of the ice quite coincides with the direction of the prevailing winds. I had the impression that it often carried us a little further north than did these latter; but our abundant material is not yet calculated out, and before this is done it will not be possible to say anything for certain on the subject.

Our experience with regard to the drift provides a complete picture of how this ice is in continual motion; how there is not a single stationary spot on the whole of this great sea-surface covering the region around the pole. From the whole of this area the winds and the current carry the ice out towards the openings which lead to the Arctic Ocean, chiefly through the large gap between Spitzbergen and Greenland, but also down through the narrower sounds between Greenland and the islands of the North American archipelago. The massive ice-mantle, with which so many of our great polar explorers have sought to cover our pole, has disappeared. Instead of it, we have the ever-wandering ice-fields like a link in the eternal round of nature.

Of the character, formation, and freezing of this ice, our expedition has gleaned valuable information. It would, however, lead me too far away to enter more fully upon this subject, and I will confine myself to the mention of the thickness which this ice attains by direct

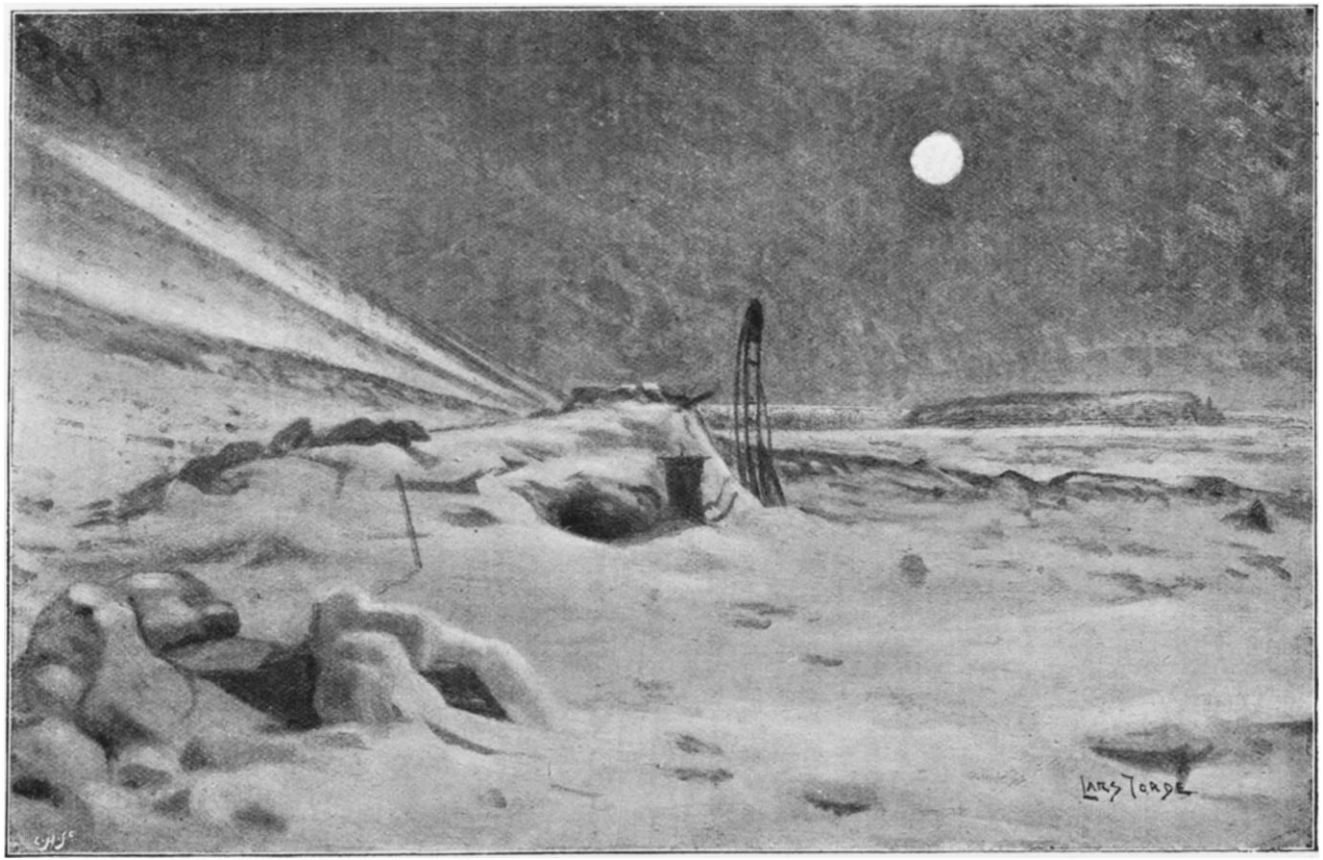


CHANNELS IN THE ICE, JUNE 24, 1895.

freezing. As soon as this ice is formed it grows very rapidly, but as the thickness increases the growth becomes slower and slower, as the loss of heat, by radiation during the long winter night, has then more difficulty in penetrating down to the underside of the ice. The ice which was formed in October and November of the first autumn, 1893, had in April, 1894, attained a thickness of $7\frac{1}{2}$ feet, but it continued to increase steadily during the summer. On June 9 it had reached a thickness of 8 feet 3 inches, and this in spite of the fact that there was already a severe thaw on the surface caused by the rays of the sun. On June 20 the thickness was still the same; the thaw on the surface was considerable, and there were large fresh-water pools in every direction. The rest of June the ice continued about the same, until on July 10 it suddenly received a new layer underneath, so that altogether it measured a thickness of 9 feet, despite a decrease by thawing of an inch or two a day on the surface. This formation of new ice on the underside was owing to the layer of fresh water, which, by reason of the surface thaw of the ice, now floated above the cold salt water, the temperature of which was considerably below the freezing-point of fresh water, and which cooled the latter off so effectually that at the line between the fresh and the salt water, at a depth of about 8 feet, a thick layer of fresh-water ice was formed. This lasted through the summer, but then began to decrease slowly—the united thickness of the old layer plus the new layer—until in September the thickness was about $6\frac{1}{2}$ feet. The growth began again in October; on November 10 the thickness had become 6 feet 7 inches; on December 11, 7 feet; and thus it continued to grow slowly during the winter. On February 6 the thickness was 8 feet 4 inches. During the spring the ice went on growing; on May 11, 1895, it had become 9 feet 10 inches; and it was about the same on May 30.

It will thus be seen that the ice does not attain any excessive thickness by direct freezing, and this ice had made the journey from north of the New Siberian islands to the sea north of Franz Josef Land, that is to say, across no inconsiderable part of the polar basin. A floe which was measured the following winter on November 4, 1895, was 11 feet thick; it continued to grow thicker during the course of the winter; and on May 4, 1896, had reached 13 feet 6 inches—quite a respectable thickness when it is a case of forcing a ship into it. But the ice, of course, attains much greater thickness by the constant upheaval from pressure, and it is the enormous piled-up hummocks and rubble caused by this, coming down with the polar current along the east coast of Greenland, which give this drift-ice its character.

The constant pressure to which this ice is subjected gave the expedition a good opportunity of making observations. It proved, as has already been found by several earlier expeditions, that this pressure is dependent in no small degree on the tidal current. This was particularly



OUR WINTER HUT, DECEMBER 31, 1895.

the case on the outer margin of the polar basin in the proximity of the open sea. Thus, for example, the pressure in the ice during the first autumn, 1893, was so regularly dependent on the spring tides, that we could almost say beforehand when it was going to take place. We had two regular recurrences during the month—a period at new moon, when the greatest pressure took place; another period of less pressure at full moon. At these periods the pressure would recur twice during the twenty-four hours, and could be rather violent.

A similar, regular, tidal pressure was experienced by the *Fram* during the last spring and summer, when she had entered the sea north of Spitzbergen; the pressure recurred at such regular intervals that during one week in July, the *Fram* was twice a day gently and steadily lifted up, almost out of the water, by the ice, which then closed together again around her. The pressure was less regular in the interior of the polar basin, particularly during the winter. It sometimes happened, for instance, that when the wind had been blowing for a long time from the south-east, and the ice had got into a good drift in the right direction, and the wind changed suddenly in order to drive the ice into other paths, the latter would, in a way, make resistance by its sluggishness, and violent pressure ensued. The chief mass would come pressing onwards from behind, while other masses of ice further in front were set in motion towards it. If the wind went over to the south-east again, the pressure would cease altogether. It was pressure of this kind to which the *Fram* was subjected at New Year, 1895, and which seemed to have the greatest desire to bury her.

By this movement of the ice, occasioned partly by the tide, partly by these winds, seams and lanes are formed in it, which often run at right angles to the direction of the movement. These lanes often have a great extension, and form large lakes. When, then, pressure suddenly takes place, the ice at either side of these seams and lanes is forced forward, the floes partly underrun each other, are partly piled up in long ridges (*skrugarer*), which consequently come to assume a position at right angles to the direction of the movement. By degrees, as this direction changes, the new ridges cross and recross each other, until the whole surface of the ice is cut up into an intricate network of lanes and ridges, which make progress with sledges and dogs a very difficult matter, as Johansen and I experienced during our journey in 1895.

Investigations as to the temperature and the various depths of the sea-water were made during the entire drift of the *Fram*. As is known, the water which floats from the east Greenland polar current into the Atlantic Ocean is extremely cold to a great depth, and therefore the whole of the north Atlantic Ocean is filled deeply with cold water from the Arctic Ocean of a temperature of 29·3° Fahr. (−1·5° C.). It was, therefore, perhaps to be expected that a similar temperature would be

found in the entire polar basin from surface to bottom. I had, indeed, had my daring doubts of this beforehand, seeing that I assumed the Gulf Stream to enter this basin from several quarters, as I represented at the meeting of the Society before my departure, and I thought that a current of this kind must make its influence felt. Great, however, was my astonishment when, as far east even as the sea north of the New Siberian islands, I found undoubted traces of such a warm current. The surface-water of the entire polar basin is, no doubt, very cold, seeing that it keeps to about the freezing-point of salt water, *i.e.* 29·3° F. to 29·12° F. (−1·5° to −1·6° C.). When, however, I penetrated through this layer to a depth of 200 metres (110 fathoms), I suddenly came on warm water, the temperature of which would be as much as 32·9°, even 33·44° F. (+0·5° C. and + 0·8° C.). At a greater depth the temperature varied somewhat, but remained about the same to a depth of 400 to 500 metres (220 to 270 fathoms), after which it sank slowly towards the depths, though without sinking to the cold temperature of the surface-water. Near the bottom it again rose quite slowly. These conditions were fairly uniform in that part of the sea over which we travelled, and where investigations were made; when I, therefore, give one such series of temperatures from the surface to the bottom, it will be sufficient to characterize the conditions taken as a whole.

TEMPERATURE SERIES, TAKEN AUGUST 13–17, 1894.

	C.	F.		C.	F.
Surface*	+ 1·92°	= 35·60°	450 metres ...	+ 0·36°	= 32·65°
2 metres ...	− 1·32°	= 29·63°	500 „ ...	+ 0·34°	= 32·60°
20 „ ...	− 1·33°	= 29·61°	600 „ ...	+ 0·20°	= 32·36°
40 „	− 1·50°	= 29·30°	700 „ ...	+ 0·14°	= 32·25°
60 „	− 1·50°	= 29·30°	800 „ ...	+ 0·07°	= 32·12°
80 „	− 1·50°	= 29·30°	900 „ ...	− 0·04°	= 31·93°
100 „	− 1·40°	= 29·48°	1000 „ ...	− 0·10°	= 31·80°
120 „	− 1·24°	= 29·77°	1200 „ ...	− 0·28°	= 31·50°
140 „	− 0·97°	= 30·26°	1400 „ ...	− 0·34°	= 31·40°
160 „	− 0·58°	= 30·96°	1600 „ ...	− 0·46°	= 31·17°
180 „	− 0·31°	= 31·44°	1800 „ ...	− 0·60°	= 31·00°
200 „	− 0·03°	= 31·90°	2000 „ ...	− 0·66°	= 30·80°
220 „	+ 0·19°	= 32 34°	2600 „ ...	− 0·74°	= 30·67°
240 „	+ 0·20°	= 32·36°	2900 „ ...	− 0·76°	= 30·64°
260 „	+ 0·34°	= 32·60°	3000 „ ...	− 0·73°	= 30·69°
280 „	+ 0·42°	= 32·75°	3400 „ ...	− 0·69°	= 30·76°
300 „	+ 0·34°	= 32·60°	3700 „ ...	− 0·65°	= 30·83°
350 „	+ 0·44°	= 32·80°	3800 „ ...	− 0 64°	= 30·85°
400 „	+ 0·35°	= 32·63°			

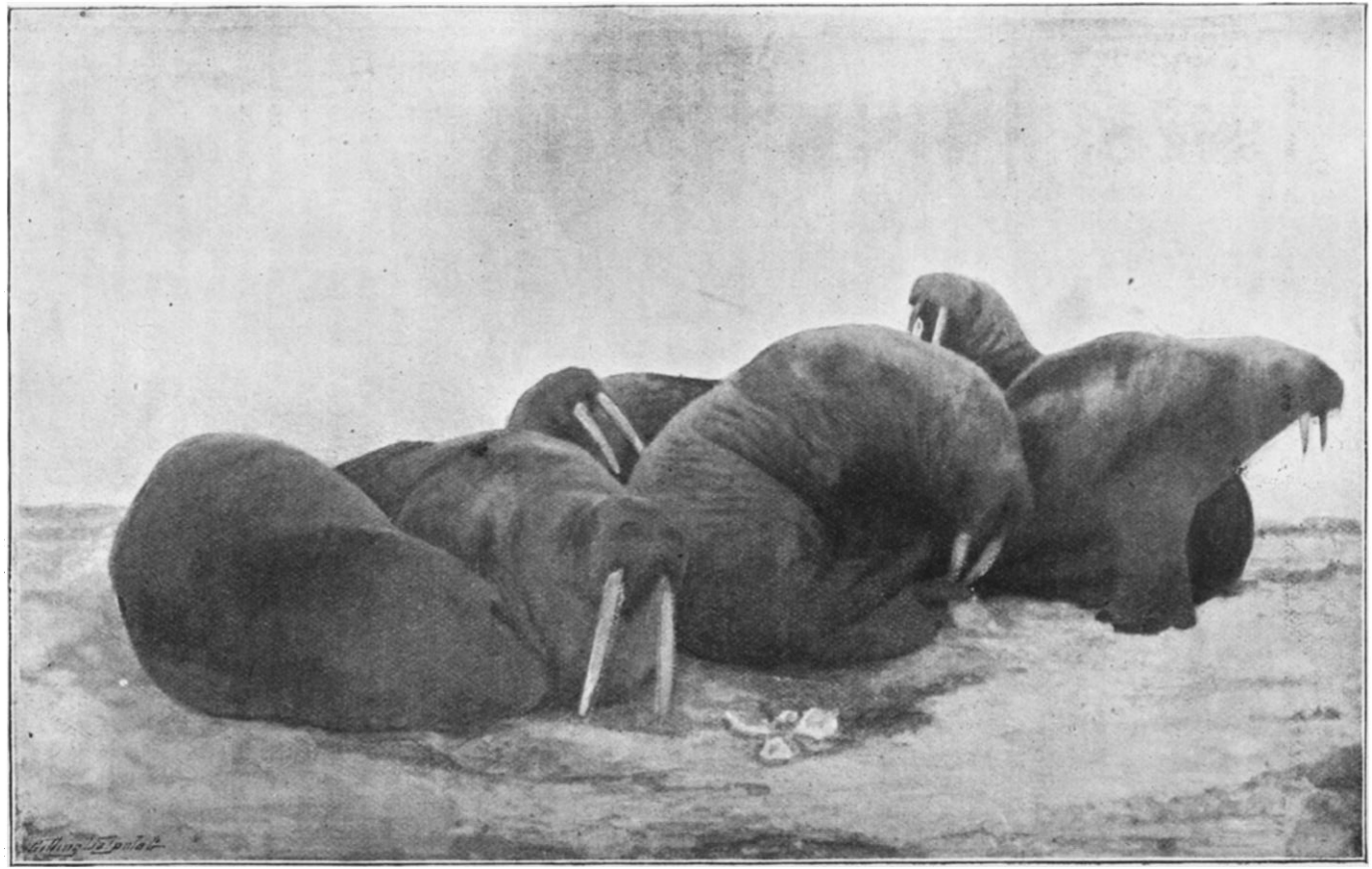
These water temperatures are remarkable in several ways. First, the temperature, as it will be seen, sinks from the surface down to 80

* Two metres are equal to about $1\frac{1}{10}$ fathom. Roughly, metres may be converted into fathoms by dividing by 2.—ED. *G. J.*

metres; it then rises till a depth of 280 metres is reached; sinks again at 300 metres, and again rises at 325 metres (where it was 32·88° F. = + 0·49° C.). It then sinks to rise again at 450 metres, then sinks steadily down to 2900 metres, and rises again slowly towards the bottom. Similar risings and sinkings were found in nearly all the temperature series, and the variations from the one month to the other were so small that at the different depths they often only amounted to a couple of hundredths of a degree. Sometimes, however, the temperature in the warm-water layers would rise higher even than is here given. Thus, on October 17, the temperature at a depth of 300 metres was 33·52° F. = + 0·85° C.; at 350 metres, 33·36° F. = + 0·76° C.; at 400 metres, 33·40° F. = + 0·78° C.; and at 500 metres, 30·11° F. = + 0·62° C., after which it sank gradually until towards the bottom it began to rise again as noted above.

I have now mentioned most of what it is possible for me to enter upon here. There is still a great deal which ought also to be noticed, but this does not lend itself to discussion at present, as the material must first be worked out. This is particularly the case with the meteorological observations, which, being extended over a period of three years, will afford a valuable contribution to the understanding of the climatic conditions of these regions. I can, nevertheless, say as much as that our observations did not bring to light any meteorological surprise, as did those on our expedition across the "inland ice" of Greenland. The temperature seems to be distributed over this sea in about the same manner as might be assumed beforehand; and when, in setting forth my plan of the expedition, I represented that the winter temperatures in the unknown polar sea would probably be found to be higher than those of Siberia, for instance, I was correct. The sea seems to make its presence felt here, and our lowest temperatures (− 62·6° F. = − 52·6° C.) were not immoderately low, when it is remembered that in Verkhoyansk, in Siberia, which is inhabited, temperatures as low as − 90° F. = − 68° C. have been registered.

The weather in the winter up there was unusually clear, and often for a long time together there was not a cloud in the heavens. In the summer, when there were open lanes and the snow melted on the floes, there could, however, be much mist, even in the interior of the polar basin. On the whole there seems to be much equableness in this atmosphere, and the winds were not particularly strong; they seldom amounted to what we should call a gale here. This was most apparent in the eastern part of the polar basin; but by degrees, as we approached the Atlantic and the parts between Spitzbergen and Greenland, there was a change in this respect, the winds sometimes blowing with much greater violence. There was, however, a conspicuous difference, on the whole, between the winds and the climate in the north along the *Fram's* route in the drift-ice, and the climate which Johansen and I experienced



WALRUSES.

during our winter in Franz Josef Land. If in the north, in the long still winter night, there had been a remarkable quiet and equableness, the reverse was now the case. Storms howled round us continually. Matters came to such a pass that one day the wind even carried away Johansen's kayak, and we nearly lost it altogether in the darkness. Another day my sledge went off. A third day a ski, which was standing up in the snow by the side of the hut, had the end blown right off; and although the temperature in Franz Josef Land was very much milder than that we had experienced north in the polar basin, yet it cannot be denied that now and then we both longed for the profound stillness we had left behind.

We had unusually good opportunities of observing the northern lights, and they were exceedingly frequent. I think I may say that not a single night or day passed during the winters up there without the aurora being seen, provided the weather were clear enough for it. Furthermore, I must mention that it appeared to me that the sky was always covered by a faint even veil of light, which, as far as my spectroscopic investigations could determine, seemed to be a constant aurora-veil. This veil was thick enough to almost hide the Milky Way, so that we could never discern it with certainty. On the whole I received the impression that the aurora-belt which surrounds the pole extends, on this side, a good deal further north than is generally supposed. I also made observations with regard to the electricity of the atmosphere. This seems to vary very much, and at times was considerably greater than has generally been supposed; at other times it was quite difficult to show any trace of electricity. Lieut. Scott-Hansen made a long and valuable series of magnetic observations during the three years. It is to be hoped that when this material has been worked out, it will afford valuable contributions to the comprehension of this difficult subject.

With regard to animal life in these parts, there is a good deal that is new to be told, which space, however, does not admit of. There were naturally numerous animals, particularly crustaceæ, in the sea, even in the highest latitudes. As a remarkable fact in this respect, I must mention that even north of 84° N., and near 85° N., schools of narwhals were observed near the *Fram*—a proof that they must be able to find sufficient nourishment in this sea. Seals were frequently seen in the summer, and the first winter I even came across a walrus in the middle of the sea between the New Siberian islands and Franz Josef Land. What it was doing there is still a puzzle to me. Bear were shot on board the *Fram* north of 84° N., and Johansen and I saw the tracks of foxes in 85° N. It will be seen by this that even mammalian life exists very far north on our globe, and it may even reach the pole itself. We saw birds every summer. I think I have made quite an interesting discovery in the number of the mysterious Ross's gulls, or

roseate gulls (*Rhodostæthia rosea*), that we saw on the north side of Franz Josef Land, near the islands discovered by us, *i.e.* Hvidten Land. They were so common that I have no doubt whatever that they have breeding-grounds in the neighbourhood. Unfortunately, time did not admit of our investigating this further. On board the *Fram*, too, we shot several specimens of quite young birds of this species in their hitherto unknown garb.

While speaking of animal life in the far north, I ought perhaps to mention the vitality I found in the summer in the pools on the drifting ice. As soon as the summer sun is able to melt the snow off the ice in these parts, a comparatively rich plant and animal life begins to develop in the fresh-water pools caused by the thaw on the surface of the ice. They look like brown patches and accumulations, and might easily be taken for mud, but under the microscope they reveal themselves to be pure vitality—chiefly minute plants, diatoms, and some algæ. But among these there also exists a crowd of tiny microscopic animals—infusoria—and I also discovered small bacteria, so that even these regions are not free from this noxious animal. It is a remarkable proof, in my eyes, of the fruitfulness of Nature: even on this ice she finds conditions for the calling forth of life.

Before concluding this paper, I must point out what suggestions the expedition may possibly afford to the future exploration of the regions of the polar sea which are still unknown. First of all, I think, the expedition has clearly proved the efficiency of the mode of travel which we adopted. That a ship can be built able to withstand the pressure to which it would necessarily be subjected on a drift through these regions, I think we have proved. It can hardly be doubted that the *Fram* was exposed to difficulties of this kind as great as can reasonably be imagined. Worse pressure than that we had in January, 1895, I, at any rate, have never heard of. The *Fram* was at that time beset in ice over 30 feet in thickness; the temperature was very low so that the ice was about as hard as it could be, and during the pressure a prodigious ice floe overran the thick floe in which the *Fram* was beset with tremendous force against her port side. For the first time the *Fram's* timbers creaked and groaned; it seemed almost incredible that human work should be able to withstand where such stupendous forces were set in motion. But the *Fram* held her own, broke loose from the ice, and rose slowly from her icy bed without a hint of damage in any part of her. I infer from this, and several similar experiences, that the polar sea can be traversed with reasonable safety in the manner we adopted, if only proper provision be made. One is exposed to dangers, of course, though they are not so great as those entailed by many other modes of travel; and given this to be the case, then I think this manner of travelling offers such great advantages that it is quite warrantable, and ought to be adopted in the future,

seeing that a ship drifting like the *Fram* through unknown regions affords the best means of making scientific investigations of all kinds. It is only by a sojourn of years that sufficient material can be collected to enable a fully satisfactory conception of the physical conditions of these regions to be formed. In a vessel like the *Fram*, it would be possible to take on board with one laboratories where even the most elaborate scientific investigations could be made. Could an expedition of this kind go north through Bering Straits and enter the ice thence in a northerly, or perhaps north-easterly direction, I think it would bring with it, when it eventually emerged into open water on this side of the pole, a sum of information which would quite put the *Fram* and her men in the shade.

But such a drift would take a longer time than ours did, and, many people might urge in objection, would expose its members to certain dangers, as it is stated that a sojourn of years in these parts would be injurious to health. I cannot, however, agree in this. From my experience, I must say that I found the arctic regions a very healthy place of resort, and as a proof of this I may mention that when I returned from wintering on Franz Josef Land I was stouter than I had ever been in my life before. On the trip from the *Fram* to Jackson I gained no less than twenty-two pounds in weight. Something of the same kind was also my experience when on board. As far as I could see, the rest of the party were perfectly well, and the physiological examinations which were made on board seemed to point in the same direction. This may be very important material for coming expeditions, and will throw light on the hygienic conditions during our expedition; but, unfortunately, the material is not sufficiently worked out to allow me to set it forth here. I dare only say that the malady which has hitherto been feared more than anything else in arctic exploration ought not to occur again, as it is undoubtedly very easily avoided when proper precautions are taken.

Dr. Torup, professor of physiology at the University of Christiania, has come to the conclusion, after examining the subject, that scurvy must arise from poisoning, caused, in particular, by badly preserved meat and fish. He thinks that in the decomposition which takes place in the meat from bad preserving—in salt meat, for instance—there is poisonous matter allied to the so-called ptomaines, which, when constantly partaken of, engenders the malady we call scurvy. Particular attention was paid to this at the time of our equipment, and from our experience and the investigations I had the opportunity of making during our journey, I can entirely subscribe to Torup's opinion in this matter. It is to be hoped that in a near future there will be scientific elucidation of this important point; and it is equally to be hoped that certain means for avoiding this hitherto so fatal disease may be shown.

Another thing with regard to the mode of investigation of the arctic regions which our expedition learned was perhaps this—that even with small means good results can be obtained. By acting on the hints given by the Eskimo, and pushing forward with "kayaks," sledges, and dogs, one is enabled to penetrate into and cover considerable distances in regions which have hitherto been considered very difficult of access. In this way the drift-ice itself can be travelled over at a considerable distance from land—even where it is in motion; and I think this must be one of the ways in which it should be endeavoured to investigate the great unknown region between the North American arctic archipelago and the pole. Here, no doubt, many interesting problems are awaiting their solution. May a not far-distant future see those tracts traversed by human feet!

THE NORTH POLAR PROBLEM.*

THE PRESIDENT: When Dr. Nansen was so good as to read us the interesting account of his expedition last month, owing to the peculiar circumstances of the occasion we were unable to take the usual discussion of the paper at that time. I therefore propose that we should take it this evening, and I shall read a short paper intended as a hook upon which the discussion may be hung.

It has taken centuries to obtain even a very general idea of the north polar region. Three centuries ago Mercator adopted the theory, which was derived from the mysterious Nicholas of Lynne, that four great rivers flowed down a chasm at the pole. Later there was Maury's theory of an open polar sea; and the most recent opinion that has prevailed was that the polar sea was shallow, with land, in the form of islands, extending north from Franz Josef Land.

Facts could not keep pace with theories, but they have gradually and painfully refuted them, and revealed to us the truth. It has long been known that a great stream of heavy ice flows down the east coast of Greenland. The archipelago of ice-capped islands, known as Spitsbergen, had its general outline made known by British seamen 270 years ago; and more recently it has been ascertained that the sea to the north of it is of great depth; while warm currents, proceeding from the Gulf Stream, flow up the Spitsbergen western coast, and eastward to Novaya Zemlya. The coast of Siberia was also known to be bordered

* Report of a discussion at the Royal Geographical Society, March 22, 1897. Map, p. 588.

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SKETCH MAP SHOWING
ROUTE OF THE 'FRAM'
AND NANSEN'S AND JOHANSEN'S SLEDGE JOURNEY.

Nautical Miles

0 60 120 180 240 300

The Dark Blue indicates Open Water
The Light Blue indicates Drift Ice
Unexplored Regions left white

Depths in fathoms
1050 No bottom reached
? Depth doubtful or approximate

Track of the 'Fram' in Open Water
The 'Fram's' Drift in the Polar Ice
Nansen's & Johansen's Sledge Journey

John Bartholomew & Co.