"Observations on Arctic Sea-water and Ice." By Staff Surgeon EDWARD L. MOSS, M.D., R.N., late of H.M.S. "Alert."

Communicated by Sir GEORGE NARES, Captain, R.N., K.C.B., F.R.S. Received May 3, 1878. Read May 23.*

In order that observations on the specific gravity of sea-water should be made in the Arctic Expedition of 1875, by the method successfully used on board Her Majesty's ship "Challenger,"† Sir George Nares, when he left that ship to take command of the expedition, brought with him one of Mr. Buchanan's hydrometers.

Professor Hartley superintended the construction of its graduated weights, and suggested the supply of apparatus for the volumetric estimation of chlorine; and, on the departure of the expedition, both sets of observations were allotted to me.

Storms interfered with observations in the Atlantic, but they were begun on entering Baffin's Sea, and continued till the ships finally rounded Cape Farewell. Most of the samples of water examined were from the surface, or from close beneath the floes; but whenever the exigencies of ice navigation permitted, samples were obtained from various depths by means of "Buchanan's bottle." The "bottle" was also used in winter quarters, at first through holes made in the new ice, and afterwards of greater depths, when tidal fissures formed wide enough to let it pass down between the heavy floes. In very cold weather, or when surface fresh water lay over a salt stratum with a temperature below the freezing point, it was found necessary to be specially careful to prevent the addition or withdrawal of ice by the cold brass of the bottle; and during winter, water, however obtained, had to be re-mixed after it had acquired the temperature of my cabin, for ice formed in transit from the floes to the ship, melted, and lay in a differently refracting layer on the surface. The temperatures were ordinarily taken with an open scaled centigrade thermometer, verified at its zero. Its readings were constantly checked by observations with the Miller-Casella and Negretti and Zambra instruments, by which all the temperatures away from the surface were obtained.

In the reduction of the specific gravities to a common temperature, Hubbard's coefficients were at first used, but all the observations on sea-water in the subjoined tables have been re-calculated by the formulæ published during the absence of the expedition by Professors Thorpe and Rücker.‡ In the few instances in which the observations were made at minus temperatures, the reductions have been arrived at

* See *ante*, p. 446.

† Mr. J. Y. Buchanan, "Proc. Roy. Soc.," vol. xxiii, 1875, p. 301.

‡ "Trans. Roy. Soc.," vol. clxi, Part II, p. 405.

by extrapolation; but taking Hubbard's curve as an extreme, the error possible in the small range of temperature involved cannot extend beyond the fifth place of decimals. The uncertainty of the process has, however, induced me to discard a column in which the specific gravities were expressed at the natural temperatures. In both tables Stampfer's coefficients have been used for the waters from melted ice.

But that an Oertling balance and a reserve of pure nitrate of silver were supplied, the chlorine estimations must have been omitted, for the standard silver solutions were destroyed by freezing—a disaster which considerably curtailed the number of experiments.

The water of the polar basin, to such depths as we reached, had already acquired the low specific gravity characteristic of outflowing polar currents. This low specific gravity was maintained during winter and spring, after nine months' perpetual freezing. It is to be remembered, however, that the samples were from no great depth, and from a zone of the Polar Sea that annually receives, not only its own precipitation, but also the precipitation of the neighbouring shores, and that, too, at a comparatively high temperature.

The channels between the Polar Sea and Smith's Sound contain two strata of sea-water, not owing their temperatures to local causes—an upper stratum of polar water overlies a warmer northward flowing extension of the Atlantic. The specific gravity observations show that the relative position of the layers is due to salinity influencing their density more than temperature. To overlie the polar water, the denser stratum would require a temperature above 10° C. The highest deep temperature obtained was below the freezing point, but there is sufficient range between the specific gravities of the deepest samples obtained and of Atlantic water to permit warmer Atlantic water to exist at a greater depth.

In places where the deep water yet retains some temperature above the freezing point, direct dilution at its own depth, with fresh water from deep icebergs or subglacial streams, may so far reduce its salinity as to let it carry warmth to the surface, and thus help to occasion the well known "rottenness" of floes in the neighbourhood of icebergs and glacier cliffs.

In addition to low specific gravity and temperature, the waters of outflowing polar currents possess a third characteristic in the disturbed proportion between their chlorides and sulphates, pointed out by Forchhammer.* His great range of observations gives an oceanic proportion of 11·87 of sulphuric acid to 100 of chlorine; while his polar currents show an average increase in the proportion of sulphates amounting to ·52. The sealed samples of water brought home by me

* "Phil. Trans.," 1865, Part I, p. 228.

for verifications yielded 11·21 of sulphuric acid* (SO_3) to 100 of chlorine in the deep warm water of Smith's Sound, and 11·59 in the polar water, showing an excess of ·38 in the latter.

Forchhammer attributes this disturbed proportion either to a scarcity of fucoidal plants or to the vicinity of volcanoes.

If it be assumed that the dilution of outflowing polar currents is due rather to shore precipitation than to transference of polar precipitation through the perennial floes, the littoral character of the currents will alone account for the increase of sulphates.

On quitting Robeson Channel, Her Majesty's ship "Alert" found herself on the shores of a sea covered exclusively with the heavy ice before met with only in outlying fragments. The pack edge grounding along the shore in fourteen fathoms, and forced upwards towards the beach, formed a barrier reef, inside which the ship found shelter. As soon as new floe consolidated it, it was found that the grounded masses, resembling icebergs in their size and stratification, differed from them in being salt, and the first chlorine estimations were made in search of ice fit for the ship's use during winter.

On the return of daylight, further observations both on the composition and structure of the ice were begun, in the hope that they would throw some light on the place and mode of growth of the stupendous floes.

All but the surface of the floating ice was out of reach, but plenty of sections were afforded by the great fragments forced upwards on the beach.

A floe grounded a quarter of a mile ahead of the ship had split into several rectangular segments. Its largest masses were separated by a narrow cleft passing vertically through the ice and exposing a fresh section, measuring 47 feet at right angles to the plane of stratification. The floe was belted with a shelf of ice, marking the sea-level previous to its last upheaval. The cleft intersected this tide-mark 11 feet from its top surface. The floe sides under the mark were grooved with the vertical channellings of last season's subaqueous thaw, but neither the tide mark nor the groovings passed into the cleft, and the sharp edges of the latter had evidently not been exposed to the warmth of last summer.

Dr. Rae has pointed out† how readily salt ice may lose its entangled brine by drainage; it thus also loses its cryohydrates when the temperature rises above their freezing points; but since the upheaval of this floeberg was recent, and since the temperature of the air was yet below what the ice possessed when submerged, it was fair

* Precipitated with barium chloride instead of nitrate, as the latter, used by Forchhammer, requires much manipulative skill in its subsequent separation from the sulphate.

† Dr. Rae, "Proc. Phys. Soc.," Part I, p. 14.

to infer that this fragment of floe had lost little of its saltness, certainly none of its salt ice by drainage; moreover, it afforded decided facilities for obtaining samples of ice from every height of a considerable section, and accordingly serial chlorine estimations were made from top to bottom of it.

The lowest part of this section was probably not the bottom of the floe, but samples of deep ice were obtained from an almost overturned mass, exhibiting the mammillary elevations common on the under side of the floes, and in one part studded with stones and grooved by motion against the bottom. Our watering berg offered a section where 30 inches of snow-formed ice lay over what had once been a superglacial pool in the hollows of a "blue-domed" floe. It will be seen, on reference to the tabulated chlorine estimations, that, while the annual floe of one winter's quarters held one-sixth, the chlorine of sea water, the most salt parts of the polar floe held but one-fifteenth. The chlorine, however, does not represent all the salts, and water from such ice is quite too brackish to drink.

If the salinity of the polar floes leaves their mode of growth doubtful, evidence much more to the point is supplied by their structure. The upper ice of upheaved segments, not only at Floeberg Beach, but along the shore as far as my sledge journeys extended, displayed more or less distinct horizontal stratification, like that of glacier *névé*. The stratification was strikingly regular and parallel, decreasing in width from above downwards, sometimes ending abruptly, but generally becoming indistinct and gradually disappearing 20 feet or more from the top. Each stratum consisted of an upper white, merging into a lower blue part, the difference in colour depending on the greater or less number and size of the air-cells in the ice. The lower blue passed abruptly, but without break in structure, into the spongy white of the layer beneath. After spring, when all exposed ice-surfaces became white and granular, the stratification was to be detected only by the unequal disintegration of the white and blue parts, causing in well-marked floebergs a crenulated outline in the profile of a section; the blue, hard and unchanged, lying in the angle, and the white, granular and swollen, in the convexity. This unequal disintegration is to be attributed to the lesser transparency of the white parts to solar radiation rather than to any difference in salinity represented by the trifling and possibly experimental difference in specific gravity, shown by estimations Nos. 106 and 107. The indistinctness of stratification produced by summer is not permanent. The old floebergs worn into "blue domes," and "pie" shapes were well marked in early spring, though they had evidently borne the thaws of many seasons. The stratification was most readily seen from a little distance. I have marked it in a sketch of a floeberg at Cape Joseph Henry, made quite a quarter of a mile off, but frequently the limits of

the layers could not be decided upon at arm's length, and in getting samples and measurements the easiest method of procedure was to stick on pieces of paper and adjust them to the layers, by retiring to a distance of 20 or 30 yards. The thinnest strata observed occurred in the sides of a water-worn ravine in a floeberg off Cape Rawson; in the middle of the bank, where the sections were nearly vertical, they measured 7 inches. An iceberg off Cape Napoleon had strata only 4 inches wide. The widest I have any notes of were in the top of the cleft floeberg already described. Here they were 3 feet deep; but, 28 feet lower down, the lowest distinguishable strata were 18 inches deep. Although the extremes differed so widely, the great majority of the stratifications showed layers between 10 and 15 inches wide. In instances where stratification ceased abruptly, the ice immediately beneath was a sort of conglomerate formed of masses broken from older floes cemented together by frozen sea-water,* with differently inclined lines of air-cells, and occasionally enclosing aggregations of bright-yellow *Diatomaceæ*. One such aggregation from a floeberg grounded on an island in Black Cliffs Bay, has been submitted to Rev. Eugene O'Meara. He has identified the *Diatomaceæ* in it, and informs me that they are all of decidedly marine growth. Stratification was not distinguishable in the masses of which the conglomerates were composed; indeed, submersion appears to play an important part in its obliteration.

On the 28th March, 1876, I cut a pit through the snow on the top of our watering berg and filled it in with minute-crystalled snow from a little under the surface. On the 8th of May, the lower crystals were adherent to the ice beneath, and had become distinctly larger and granular, differing little from those in the undisturbed snow beside them, which were by this time like small transparent hailstones, often already grown together into rods and groups. The temperature of the air in the meantime, though rising, had never reached 0° C., while the ice yet retained much of the cold of early spring.

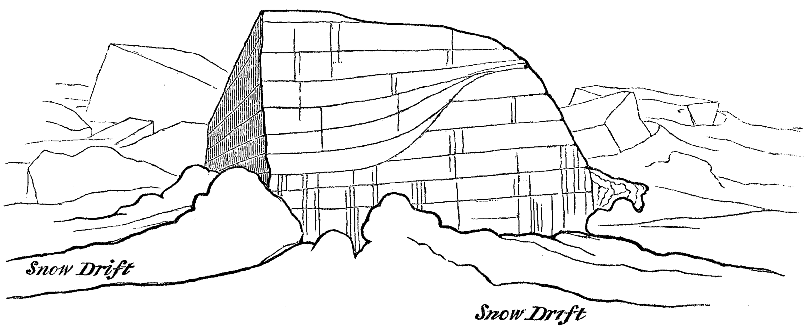
A similar growth towards the cold, but upwards instead of downwards, takes place while the temperature of the air is below that of the floes or the earth, and helps the wind to harden and crust the upper snow. With a hope of testing this growth, two cubes were cut out of the same block of snow, and made to weigh exactly 50 grms. each. No. 1 was suspended level with the ground, and No. 2 4 feet 8 inches above it, in a niche in a snow-house. They were then built up and left for ten days, meantime the temperature of the air averaged −35°·5 C., while the ground under 5 feet 6 inches of snow was −20°·6. On re-weighing, No. 1 had lost 1·15 grms., and No. 2 had gained ·3. After the lapse of a second ten days, with an air temperature of

* The "Porphyritic ice" of Parry, 4th voyage, p. 88.

— 37°·4 C., No. 1 had lost an additional ·9, and No. 2 gained an additional ·6.

Admiral Wrangell, in describing the heavy ice grounded along the northern shores of Siberia, accounts for both its thickness and its stratification by the sliding one upon another of thinner floes.* Admiral Belcher referred some of the great ice mases in Wellington Channel to the same cause,† but the stratification of the floes met with by our expedition cannot be thus accounted for. The behaviour of strata overlying an old surface-dome, best shown in the accompanying little diagram (fig. 1)—a copy of a pencil sketch made from nature—is utterly inconsistent with the sliding-up hypothesis.

Fig. 1.



The subject of this sketch afforded the only instance of stratification overlying a "blue dome" seen by me. Any deviations from the horizontal and parallel were in fact extremely rare, and one of the first convictions forced upon me by the facts of the stratification was that the floes which showed it could not have been formed in such a region of chaotic disturbance as lay about us.

Massive floes drifted from the westward into the channels of the Parry group, or floating southward in Spitzbergen seas, have made arctic travellers familiar with the glassy "blue tops" or domes of ice standing up through the surface snows.‡ The upper part of many of our grounded floes exhibited such domes in section, and in every case the wavy outline cut through the horizontal strata. The larger mounds often occurring in miniature mountain ranges on heavy floes are not to be confounded with "blue domes." They occur along ancient lines of fissure, and are simply old hummocks rounded off by snowdrift.

The occurrence of air-carried dust on the surface of both glacier and

* Wrangell's "Siberian Journey," edited by Sabine, Appendix, p. 393.

† Belcher's "Last of Arctic Voyages," vol. i, p. 101.

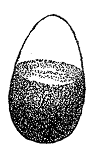
‡ The journal of Lieutenant Mecham of the "Resolute" gives a typical description and sketch of them.—Parl. Reports, 1855, vol. xxv, p. 694.

floe ice has been frequently recorded; sometimes it is clearly traceable to neighbouring land, at others, as in the case of the kryokonite of Professor Nordenskiöld,* and the dust of the East Greenland,† and Spitzbergen ice-fields,‡ its source is more or less conjectural.

At Floeberg Beach every breeze strewed the ice with dust from shore, consisting of fine sand from the neighbouring hills (effervescing with acid), and organic *débris* of all sorts, bits of saxifrage and moss and lemming pellets predominating. Such dust was generally confined to the surface of the ice, but a fragment from a bud of *Saxifraga oppositifolia*, recognised by its claw, was found in a dust-line 45 feet deep in the ice of a large berg off the "south ravine," and a dust-line 4 feet deep in the ice of our watering berg, marking the bottom of one of three successive "super-glacial lakes,"§ yielded a lemming hair and a shred of bird's down.

Another kind of dust of less obvious origin commonly occurred in, as well as on, the floes. It was first noticed in the "Cleft Floeberg," already described in connexion with the chlorine estimations. The walls of the cleft exhibited duplicate sections of an old surface pool, and the bottom of the pool was marked with a dust-line. A similar, but fainter, line passing through the whole berg, lay 8 feet deeper down without any appearance of a pool over it. In these and other dust-lines observed in the floes the line consisted of scattered black points in the ice, sometimes two or three in a cubic inch, oftener only the same number in a cubic foot. Each spot consisted of a single air-cell, rarely more than $\frac{1}{20}$ inch in diameter, with its lower half lined with impalpable dust, but otherwise like the air-cells around it. The spot was

Fig. 2.



sometimes quite solid. Specimens were obtained for examination by chipping out lumps of ice holding granules or freighted cells, washing them in their own surface-melting, and putting them into clean bottles till the cells released a little bubble and the dust fell to the bottom, often retaining its shape till shaken. As the surface of a wasting floe progressively lowers, these granular masses are collected into groups, and keep below the general surface in little pits.

Enough dust was obtained from the "Cleft Floeberg" and from the

* Prof. Nordenskiöld's "Expedition to Greenland," Arctic Manual, p. 325.

† "German Arctic Expedition." Koldewey, p. 290.

‡ "Parry's" 4th Voyage, pp. 73–75.

§ "Parry," 4th Voyage, p. 75.

subglacial surface of the salt ice of our watering berg to study its characters *en masse.* Similar dust, but in microscopic quantity, was procured from a line 2 feet deep in a heavy floe, a mile in diameter and two from the shore, drifted into a curve of the coast south of Cape Joseph Henry, and at the same depth from an old "blue top" in Black Cliffs Bay, and also from the dust-line already mentioned as containing the saxifrage leaf at a depth of 45 feet.

A very much worn floe to seaward of the ship supplied a large quantity of dust with precisely similar inorganic contents, but enormously magnified in apparent quantity and converted into a slimy, granular, sour-smelling mud by a growth of a phycochromaceous Alga.* Some of the granules deep in ice were altogether inorganic, others held another Alga composed of groups of dark brown spheres $\frac{1}{3000}$ inch in diameter, associated with spined hemispherical cups $\frac{1}{1600}$ inch diameter, apparently the skins of zygospores. In dust-spots underlying distinctly salt ice *Diatomaceæ* naturally attached † were not uncommon.

The inorganic part of the dust consists of a reddish impalpable sand of even-sized particles, rarely reaching $\frac{1}{200}$ inch in diameter, but averaging one-tenth of that size. Placed in a Sonstadt's solution, specific gravity 2·72, it separates into a red part that floats, and a much smaller dark green part that sinks. The former consists of angular and rounded transparent quartz and rounded red quartz. The fraction that sinks contains rounded grains of hornblende, angular and rounded augite, brown scales of mica, and numerous crystals of magnetite, sharply angular and often imbedded in augite or quartz.

The dust becomes bright red on incineration, but some of the particles still remain magnetic. I searched carefully for, but never found, a magnetic particle capable of reducing sulphate of copper.

Two samples of ice-dust were obtained from icebergs, the one at Cape Frazer, the other at Cape Louis Napoleon. In both instances the dust was in granules imbedded 20 feet or more from the top surface of the berg. Neither contained any organic matter. One remained on the filter-paper aggregated in the granules or oolite-like grains. Both effervesced with hydrochloric acid, but otherwise possessed the same mineral characters as the floeberg dust.

During winter at Floeberg Beach an attempt was made to collect atmospheric dust by means of an extemporised Maddox aereoscope, but it invariably got blocked with snow when there was any wind, and was of course useless when there was none. A sheet of glass, exposed in absolutely calm weather on top of Thermometer Hill, was more successful. When the minute prisms of ice constantly falling (even in an atmosphere so clear that our astronomer made successful observa-

* Identified by Professor Dickie as *Nostoc aureum.*

† Identified by Rev. Eugene O'Meara as *Fragillaria oceanica.*

tions on a star of $3\frac{1}{2}$ magnitude $2^\circ 15'$ from the horizon) were swept off into a clean stoppered bottle, and brought on board the ship and melted, a very small, but quite distinct, sediment formed, consisting of quartose particles, a few red grains, and very minute opaque nodules; thus fairly representing the chief constituents of the ice-dust.

I have to regret the incompleteness and absence of pre-arranged order in the observations that were made, but most of the subjects were altogether unforeseen, and it was necessary to take them up and make the best of them just as they presented themselves.

My notes have perhaps little bearing on the place of growth of the so-called "polar floes;" any hypothesis on that subject must give full weight to their wide distribution on both the oceanic and littoral confines of the unknown area; but the stratification of the floes unmistakeably indicates that the precipitation of the region where they form accumulates where it falls. The "conglomerate" sometimes underlying it tells of slow lateral removal by fission and intermediate freezing, while the "blue-topped" floes and the wasting grounded ice mark a region where temperature gathered in summer by the naked land releases the precipitation and restores it to the sea in the shape of outflowing arctic currents of low specific gravity.

Estimations of the Specific Gravity and Percentage of Chlorine in Sea-Waters. (Arranged according to Latitude.)

Number.	Place.	North latitude.	West longitude.	Date.	Depth.	Temperature *in situ*.	Temperature of observation.	Specific gravity. Water at 4° = unity. At T. of Observation.	At 0.	Percentage of chlorine.	Remarks.
1		82° 27′	61° 42′	17 Sept., 1875	Surface..........	−1°·4	− 1°·4	1·02615	1·02608		The sea-water north of 81° 42′ was blue in colour.
2		,,	,,	12 Oct., 1875	Under floe	−1·9	− 1·1	1·02662	1·02657	1·97	That in Kennedy Channel and Smith's Sound a
3		,,	,,	1 Nov., 1875	4 ft. below floe	−1·9	+ 8·1	1·02576	1·02655	1·97	decided green.
4		,,	,,	29 Nov., 1875	,, ,,	−2·1	+ 6·6	1·02606	1·02671	1·96	† Some *Copepoda* and one small *Pleurobranchia*
5	H.M.S. "Alert's"	,,	,,	24 Dec., 1875	Under floe	−2·1	+ 8·5	1·02516	1·02597	1·92	were captured in this water.
6		,,	,,	30 Dec., 1875	27 feet bottom	−2·1	+ 9·4	1·02573	1·02672	1·95	*
7	Winter Quarters,	,,	,,	27 Jan., 1876	Under floe	−2·1	+ 8·3	1·02587	1·02669	1·96	†
8		,,	,,	6 March, 1876	,, ...	−2·1	+12·5	1·02510	1·02663	1·97	
9	1875–76.	,,	,,	21 June, 1876	27 feet bottom	−1·5	+10·3	1·02517	1·02630	1·85	* Sealed sample examined after return of Expedi-
10		,,	,,	15 July, 1876	11 fms. bottom	−1·8	+16	1·02384	1·02608	1·80	† tion, gave by volume bottle, specific gravity
11		,,	,,	15 July, 1876	Surface..........	+ ·1	+16	1·00027	1·00138	·46	1·02682 at 0. Water at 4° = unity.
12		,,	,,	21 July, 1876	47½ fms. bottom	−1·7	+ 9·8	1·02580	1·02687	1·89	*
13		,,	,,	21 July, 1876	Surface..........	0	+20·5	·99976	1·00110		Chlorine .... 1·89 per cent.
14	Off Black Cape......	82 21	61 10	1 Sept., 1875	,, ...	−1·3	+ 1·4	1·02610	1·02603		Sulphuric acid... ·2146 ,,
15		82 20	61 10	29 May, 1876	Under floe	−1·4	+ 8·5	1·02603	1·02694	1·93	* Total solids ...... 3·761 ,,
16		82 15	61 10	2 Aug., 1876	Surface..........	−1·1	+ 6	1·02607	1·02658		
17	Robeson Channel .	82 6	61 40	30 Aug., 1875	,, ...	−1·3	− 1·3	1·02615	1·02608		
18		81 51	63 10	7 Aug., 1876	,, ...	−1·1	+12	1·02460	1·02602		
19	Discovery Harbour	81 42	64 48	28 Aug., 1875	,, ...	−1·3	− 1·2	1·02558			
20		81 42	64 48	18 Aug., 1876	7 fathoms	...	+12	1·02473	1·02616		
21		81 40	65 75	20 Aug., 1876	5 ,, ...	...	+12	1·02480	1·02623		
22		80 39	66 5	22 Aug., 1875	Surface..........	−1·6	− 1·6	1·02606			
23	Kennedy Channel .	80 36	68 20	20 Aug., 1876	,, ...	−1·1	+ 6·5	1·02538	1·02592		
24		80 10	69 0	21 Aug., 1875	,, ...	−1·4	+ 1·4	1·02541			
25		79 47	71 48	23 Aug., 1876	,, ...	−1·7	+14·7	1·02446	1·02643	1·89	Floe ice 400 feet distant.
26		79 47	71 48	24 Aug., 1876	70 fathoms	−1·1	+12·8	1·02606	1·02769	1·99	*

* Temperature *in situ* by Deep-Sea Negretti and Zambra Thermometer. When not otherwise specified the Thermometer used was an open scaled centigrade instrument, verified at its zero, † Temperature *in situ* by Deep-Sea Miller-Casella Thermometer.

Estimation of the Specific Gravity and Percentage of Chlorine in Sea-Waters. (Arranged according to Latitude.)—*continued.*

Number.	Place.	North latitude.	West longitude.	Date.	Depth.	Temperature *in situ*.	Temperature of observation.	Specific gravity. Water at 4° = unity. At T. of Observation.	At 0.	Percentage of chlorine.	Remarks.
27		79° 46′	71° 13′	19 Aug., 1875	Surface	−1°·2	−1°·2	1·02558	1·02551		
28		79 40	71 45	17 Aug., 1875	,,	−·6	−·6	1·02500	1·02496		
29		79 40	72 10	25 Aug., 1876	,,	−1·4	+13·4	1·02443	1·02612		
30		79 40	72 50	28 Aug., 1876	9 feet	−1·1	+13·4	1·02224	1·02382		
31		79 40	72 50	28 Aug., 1876	20 fathoms	−1·5	+13·5	1·02506	1·02679		Full of *Fragillaria*.
32		79 40	72 50	28 Aug., 1876	40 ,,	−1·2	+13·4	1·02553	1·02727		Contained a few rods of *Fragillaria*.
33		79 32	73 10	31 Aug., 1876	115 ,,	−·6	+12·4	1·02634	1·02791	2·01	* Two litres filtered through a small plug of cotton wool yielded no organism.
34		79 37	71 13	16 Aug., 1875	Surface	−1·0	−1	1·02588	1·02583		
35		79 39	74 13	4 Sept., 1876	Under floe	−·1	+7·8	1·00358			
36		79 30	74 13	4 Sept., 1876	2 fathoms	−1·1	+11	1·01835			* A litre filtered yielded two rods of *Fragillaria*.
37		79 30	74 13	4 Sept., 1876	3 ,,	−1·4	+14	1·02422	1·02602		*
38		79 21	74 40	10 Aug., 1875	2 feet	−·3	+1	1·00600			
39		79 21	74 40	10 Aug., 1875	15 fathoms	−1·4	+10	1·02523	1·02631		† Sealed sample examined after return of Expedition, gave by volume bottle, specific gravity 1·02724 at 0. Water at 4° = unity.
40		79 17	74 35	8 Sept., 1876	56 ,,	−1·1	+8·2	1·02641	1·02724	1·95	* Chlorine .... 1·95 per cent. Sulphuric acid... ·2187 ,, Total solids ...... 3·7922 ,,
41	Buchanan Strait ...	79 8	74 28	9 Sept., 1876	Surface	−1·7	+8	1·02486	1·02561		
42		79 2	76 20	6 Aug., 1875	,,	−·2	+2·2	1·02440	1·02454		
43	Payer Harbour......	78 52	76 0	5 Aug., 1875	,,	+1	+3·3	1·02492	1·02513		
44		78 43	74 24	1 Aug., 1875	,,	0	+7·6	1·02590	1·02693		
45		78 43	74 24	2 Aug., 1875	,,	0	+6	1·02580	1·02638		
46		78 40	74 23	9 Sept., 1876	,,	−1·3	+8·3	1·02539	1·02627		
47		77 30	74 30	10 Sept., 1876	,,	−1·0	+11·2	1·02503	1·02633		
48		77 16	71 5	11 Sept., 1876	,,	−1·0	+14	1·02444	1·02626		
49		76 33	70 37	13 Sept., 1876	,,	0	+9	1·02503	1·02594		*Sagittæ* and two genera of *Appendicularia* together with *Ceratium* and other *Peridinea* occurred in samples of water raised for examination in Smith's Sound.
50		76 9	73 16	14 Sept., 1876	,,	−1·0	+13·8	1·02422	1·02597		
51		75 20	66 19	25 July, 1875	,,	+3·3	+3·3	1·02467	1·02488		
52		75 10	75 5	15 Sept., 1876	,,	+1·1	+10·2	1·02553	1·02666		
53		74 19	61 72	19 Sept., 1876	,,	+·5	+11·5	1·02460	1·02592		Filter choked with *Ceratium tripos*.
54		73 50	69 44	18 Sept., 1876	,,	+2·0	+9	1·02564	1·02657		
55		73 40	73 7	17 Sept., 1876	,,	−·8	+7	1·02460	1·02521		
56		73 33	63 19	24 July, 1875	,,	−1	+9	1·02162	1·02241		Many bergs in sight.

57		73 33	76 59	16 Sept.,	1876	,, ...	− ·5	+13·8	1·02338	1·02509		A change from green to blue in colour of the water.
58		73 33	58 48	20 Sept.,	1876	,, ...	+1·0	+11·2	1·02503	1·02631		
59		73 30	56 56	23 July,	1875	,, ...	+1·7	+10	1·02470	1·02576		
60		73 07	58 26	21 Sept.,	1876	,, ...	+1·0	+ 9·8	1·02512	1·02614		
61		71 58	60 19	22 Sept.,	1876	,, ...	0	+11·2	1·02414	1·02539		Very blue in colour.
62		71 12	57 37	23 Sept.,	1876	,, ...	+2·5	+ 8·2	1·02574	1·02655		
63		70 23	55 53	24 Sept.,	1876	,, ...	+2·0	+ 7·8	1·02513	1·02585		
64		69 45	54 35	24 Sept.,	1876	,, ...	+2·8	+10·9	1·02560	1·02663	1·92	Close to position of Rink's sample, July, 1849, examined by Forchhammer.
65	Egedesminde Harbour	69 20	54 26	25 Sept.,	1876	,, ...	+2·8	+11	1·02527	1·02652		
66				30 Sept.,	1876	,, ...	+3·3	+10	1·02624	1·02736		
67		67 59	55 37	3 Oct.,	1876	,, ...	+3·6	+ 8	1·02639	1·02719		
68		66 40	54 30	4 Oct.,	1876	,, ...	+3·6	+10	1·02553	1·02662		
69		64 46	56 29	6 Oct.,	1876	,, ...	+3·3	+ 5	1·02531	1·02579		
70		63 42	54 32	7 Oct.,	1876	,, ...	+3·3	+12	1·02457	1·02599		
71		61 55	54 41	8 Oct.,	1876	,, ...	+5·5	+14·2	1·02499	1·02688		
72		58 39	46 4	26 June,	1875	,, ...	+5·0	+ 9	1·02670	1·02767		
73		58 13	54 7	10 Oct.,	1876	,, ...	+6·6	+10·2	1·02676	1·02793		
74		55 44	35 38	19 Oct.,	1876	,, ...	+7·8	+15	1·02620	1·02833		

* Temperatures *in situ* by Deep-Sea Negretti and Zambra Thermometer. When not otherwise specified the Thermometer used was an open-scaled centigrade instrument, verified at its zero.

† Temperatures *in situ* by Deep-Sea Miller-Casella Thermometer.

Estimations of the Percentage of Chlorine, and Specific Gravity of Water from various sorts of Sea Ice.

Number.	Date of observation.	Nature of the ice.	Position and character of sample.	Percentage of chlorine.	Specific gravity of ice water at 0°, unity at 4° C.
		Polar floe.	"*Cleft Floeberg.*" A mass of polar floe, grounded 400 yards north of H.M.S. "Alert's" winter quarters, afforded a recent fissure where samples of ice could be obtained from various depths of a section measuring 47 feet across the planes of originally horizontal stratification.		
75	26 Feb., 1876.		1 foot from surface	·033	
76	16 March, ,,		5 feet ,, ,,	·104	
77	14 ,, ,,		11 ,, ,, ,,	·126	
78	16 ,, ,,		15 ,, ,, ,,	·156	
79	18 Feb., ,,		19 ,, ,, ,,	·059	
80	18 ,, ,,		21 ,, ,, ,,	·071	
81	18 ,, ,,		22 ,, ,, ,, undulating bed of an old "superglacial pool" interrupting the horizontal strata under it, and marked by an irregular line in which the air-cells of the ice are here and there coated with atmospheric dust	·041	1·00025
82	26 ,, ,,		25 feet from surface	·097	
83	28 ,, ,,		25 ,, ,, ,, but 40 feet from last	·100	
84	16 March, ,,		30 ,, ,, ,, occasional dust-coated air-cells	·123	
85	14 ,, ,,		38 ,, ,, ,,	·031	
86	11 ,, ,,		41 ,, ,, ,,	·117	
87	26 Feb., ,,		47 ,, ,, ,,	·040	
88	14 March, ,,		47 ,, ,, ,, 1 foot deeper into ice than last	·036	
89	14 ,, ,,		47 ,, ,, ,, 10 feet from last	·079	
90	28 Feb., ,,		Old tide ridge projecting as a shelf from side of floeberg, and from 9 to 16 feet from top	·085	

		„ „	“ *Glaciated Floeberg.*” An inverted berg exposing part of its bottom, which has been in contact with the beach, and is studded with scratched stones.		
91	11 March, „		Bottom ice with very small air-cells in planes	·102	1·00162
92	24 „ „		5 feet from, and originally above first sample	·107	
93	24 „ „		10 „ „ „ „ „	·101	
94	24 „ „		19 „ „ „ „ „	·146	
		„ „	“ *Watering Floeberg* ” aground in 80 feet of water. Top surface measures 245 feet by 171. The small part of its section which is exposed shows—		
95	27 „ „		1st. A foot of recent snow, becoming granular in its lower four inches	·0007	
96	16 Oct., 1875.		2nd. 30 inches of white ice with numerous large air-cells never submerged	·0003	1·00013
97	25 March, 1876.		The same in another place 50 feet off	·006	
98	24 „ „		3rd. Ice of a frozen “ superglacial pool ” without cells	·003	
99	25 „ „		The same 50 feet off	·004	
100	25 „ „		Centre and last frozen parts holding vertical air-tubes as large as crow-quills.	·030	
101	25 „ „		4th. The usual blue cellular ice with its original undulating surface dotted with dust-lined cells. Highest undulation 2 feet 6 inches from present surface	·053	
102	25 „ „		6 feet 6 inches from present surface	·078	
103	24 „ „		10 feet; the lowest attainable	·137	
104	24 „ „	„	“ *Pyramid Floeberg* ” at the end of “ Ladies' Mile ” ice above a “ dust layer ” 45 feet from top surface	·053	
105	24 „ „		Ice 3 feet below	·017	
			Pie-shaped floeberg near ship. The unequal decay of blue and white parts of the stratification causes the outline of the dome to be crenulated.		
106	21 June, „		White and convex part of stratum	..	1·00067
107	21 „ „		Blue in recess	..	1·00077

Estimations of the Percentage of Chlorine, and Specific Gravity of Water from various sorts of Sea Ice—*continued*.

Number.	Date of observation.	Nature of the ice.	Position and character of sample.	Percentage of chlorine.	Specific gravity of ice water at 0°, unity at 4° C.
108	23 Aug., 1876.	Iceberg.	Grounded iceberg off Cape Louis Napoleon (opposite Humboldt Glacier), samples unavoidably taken from below tide mark. The exposed cliff of the berg exhibits innumerable regular horizontal strata 4 inches deep, below two somewhat deeper above	·010	1·00028
109	30 ,, ,,	,, ,,	Iceberg in Dobbin Bay	·001	1·00010
110	5 May, ,,	Annual floe.	One season floe, formed between the barrier of grounded polar floes and the shore, 18 inches deep	·203	1·00409
111	5 ,, ,,		3 feet deep	·357	1·00479
112	5 ,, ,,		6 ,,	·363	1·00522
113	19 April, ,,		Frozen sea-water free of snow from ice of "fire hole" 40 days frozen	·456	1·00656
114	21 March, ,,		Frozen sea-water from ice of tide hole	·675	
115	9 May, ,,		Ice fresh formed in temperature −17°·7 where sea-water rises about the grounded "floebergs"	·860	1·01298
116	21 March, ,,	"Slush."	Pasty slush over the ice and snow where water has risen in tide cracks, remaining unfrozen in temperature −29° C.	5·112	1·06118
117	8 May ,,	Efflorescence.	Efflorescence forming in temperature at −17°·7 C. after the sun had left the surface of "floeberg" ice containing chlorine percentage ·078	·178	

118	9 „ „		Efflorescence in temperature −16° similarly forming on "floeberg" ice with chlorine percentage ·126	·216	
119	9 „ „		Efflorescence in temperature −17°·7 from new floe ice with chlorine percentage ·860. This efflorescence melted at −3°·4 C.	2·787	
120	4 March, „		Efflorescence at temperature −31°·8 on fresh frozen "slush."	3·789	
121	16 June, „	Icicles from floebergs.	Icicles depending from "floeberg" ice containing ·018 per cent. chlorine	·004	
122	6 March, „	Successive crops of ice from sea-water.	1,529 cub. centims. of sea-water, sp. gr. at 4° 1·02630, percentage of chlorine 1·979, exposed in a beaker to air at temperature −50° and constantly stirred, yielded crystals above −1°·5. The crystals drained and pressed in gauze melted below −1°·3, and water from them measured 165 cub. centims.	1·525	1·02100
123			A second crop from mother-liquor, formed above −1°·8 and melted below −1°·7, measured 410 cub. centims.	1·624	1·02176
124			A third crop, formed above −2°·0 and melted below −1°·7, measured 390	1·819	1·02475
125			A fourth crop, formed above −2°·7 nearly all melted below −1°·1, but a few crystals remained unmelted in −1°·7, measured 354.	2·003	1·02746
126			The mother brine remaining measured 210 cub. centims., and it alone deposited bubbles on the sides of the containing vessel	2·987	1·04033

Fig. 1.

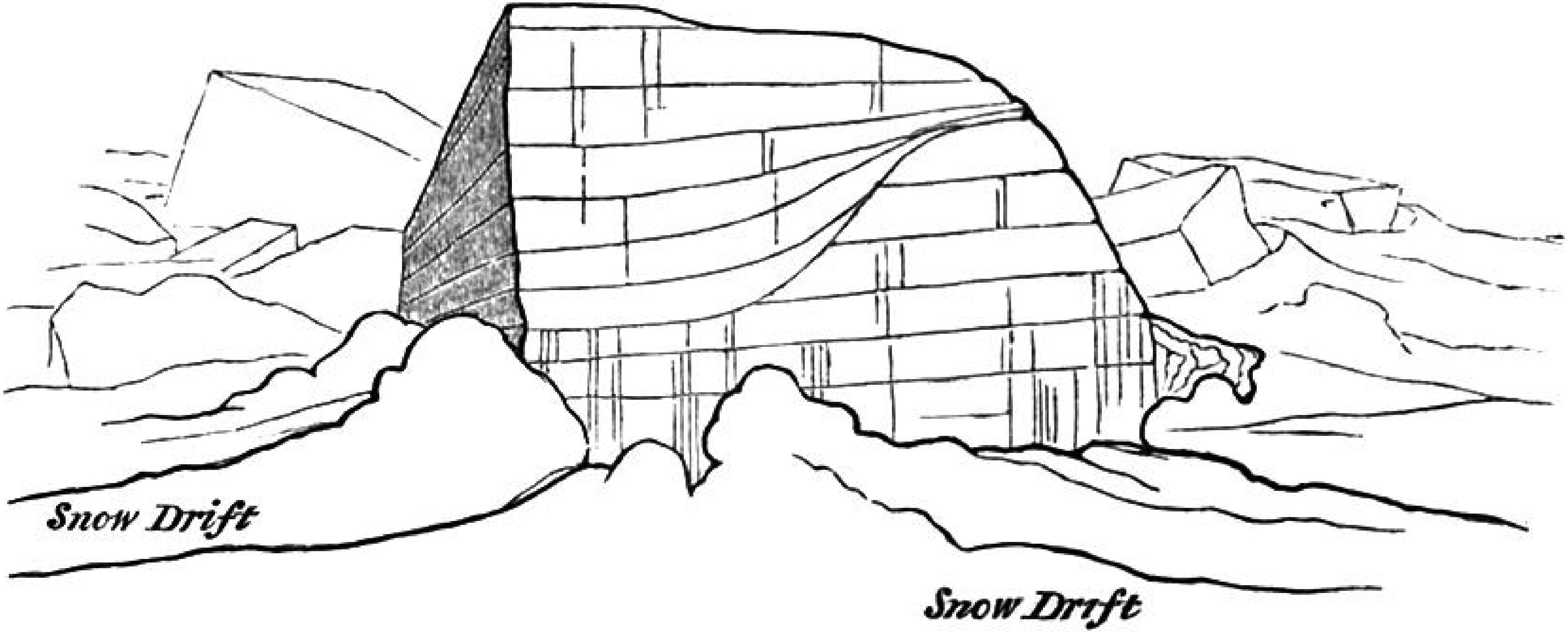


Fig. 2.