## Geological Climates

I HAVE read with much interest and attention the letters that have appeared in recent numbers of NATURE on the subject of "geological climates," and although it must appear presumptuous on my part to do so, I shall endeavour to show that each of the distinguished writers of these letters may be somewhat in error on at least one point, which—if I am right—must materially affect the correctness of the conclusions they have come to.

I think that Mr. Wallace, whilst very justly giving the Gulf Stream and other currents which *might* exist were certain lands submerged, credit for great influence in ameliorating the rigour of climate, does not take into sufficient consideration the fact that the waters of the Gulf Stream, although warmer, are, in consequence of holding much more salt in solution, heavier than the colder and less saline Arctic current.

Some experiments show, as clearly as anything done on a very small scale can, that two waters brought as nearly as possible to the conditions of the Gulf Stream and the Arctic current do not mingle when simultaneously poured into a long narrow glass trough; the Arctic water invariably taking its place on the surface.

Supposing then that these two currents meet somewhere about latitude 80° or 81° N., the Arctic water flowing south—if my experiments are of any value—will retain its position on the surface and the warm current pass underneath, and thus lose all its heating influence on the air over a Polar area about 1000 geographical miles or more in diameter.

We can have no stronger example of this effect of difference of density of ocean water than is shown by the two currents *in* and *out* of the Mediterranean Sea.

In NATURE, vol. xxiii. p. 242, Prof. Haughton says, "The thickness of this ideal ice-cap at the Pole is unknown, but from what we know of the Palæocrystic ice of Banks Land and Grinnel Land *must be measured by hundreds of feet, and its mean temperature must be at least* 20° F. *below the freezing-point of water.*"

With regard to both the above assumptions—which are in italics—I must beg to disagree entirely with the learned Professor. He appears to consider the so-called Palæocrystic ice as the normal state of the ice at and near the Pole, and as a natural growth by the gradual freezings or increase of a single floe during a series of years; whereas I am of opinion that this mis-called Palæocrystic ice is the result of a number of floes being forced over and under each other by immense pressure caused by gales of wind and currents.

The western and northern shores of Banks and Grinnel Lands are peculiarly well suited for the formation of such ice-heaps, as they are exposed to the full force of the prevailing north and north-west storms, which pile up the ice in a wonderful manner on these shores and others similarly placed, for a distance of miles seaward. The whole of the west shore of Melvile Peninsula is so lined with rough ice of this kind that sledging is impossible.

It will wholly depend upon the form of land—if any—at or near the Pole, whether or not any floebergs are there. If there is no land it is probable there will be few or none, as the ice will meet with no great obstruction, as it is driven by winds and currents.

I have no authorities by me that give the thickness of ice formed in one season at or near the winter quarters of any of the Arctic expeditions, except my own in 1853-4 at Repulse Bay, latitude 66° 32′ north.

The measurements of the ice—taken at some distance out in the bay where there was very little snow—and the mean temperature of the air are given on next page.

| 1853 | Ice thickness | Increase | Monthly Mean Temp. F. |
|---|---|---|---|
| December 20 | ... 4 feet 7 inches ... | — | ... −24°·5 below zero |
| 1854 | | | |
| January 24 | ... 5 feet 9 inches | ... 14 in 35 days | ... −30°·6 ,, ,, |
| February 25 | ... 7 feet 0½ inch | ... 16 in 32 days | ... −34°·9 ,, ,, |
| April 25[1] | ... 8 feet 1½ inch | ... 12¾ in 59 days | ... − 8°·5 ,, ,, |
| May 25 | ... 8 feet 1¼ inch | ... none 30 days | ... +24° above zero |

The above table shows that the ice ceased to increase in thickness some time between April 25 and May 25, after which it decreased rapidly; but I was unable to decide what proportion of this decrease was due to thaw and evaporation from the surface, and what amount from the lower part of the floe that was under water: no doubt by far the greater effect was produced by the two first causes.

Eight feet may perhaps be considered a fair or rather a high average of one winter's formation of new ice (not increase of an old floe) over the whole of the Arctic Sea, because Repulse Bay, although in a comparatively low latitude, was particularly favourable for ice-formation, there being no currents of any consequence. Where there are currents, one year's ice does not exceed three or four feet.

The winter's ice of 1875–6 at Discovery Bay, in latitude 81° 40′ N., did not exceed, if I remember correctly, six feet in thickness.

Even were these great compound floes, called Palæocrystic ice, found at or near the Pole, and of only the same thickness as those seen at Grinnel Land—instead of "hundreds of feet"—they would not probably have nearly so low an average temperature all the year round as 20° F. below the freezing-point of water, because only one-sixth of their mass would be exposed to very low temperatures for about six months of the year, the surface being during that time protected by a more or less thick covering of snow, whilst at least five-sixths of their bulk was under water, having a temperature for the whole twelve months at or above the freezing-point of the sea. The question is, how far the very low temperatures of an Arctic winter do penetrate a mass of, say sixty feet of ice, the surface of which is covered with a foot of snow, and fifty feet or five-sixths under water of a temperature at or above the freezing-point of the sea?

From my experience on a much smaller scale, I do not believe that the atmospheric cold would, under the circumstances mentioned, penetrate to the lower surface of ice sixty feet thick; and if it does not do so there would be no increase to its thickness during winter.[2]

An excellent example of formation of Palæocrystic ice, or floe-berg is afforded by the experience of the Austro-Hungarian Expedition under Weyprecht and Payer in the Barentz Sea in 1873–4. Their ship was lifted high out of the water by the pressure of the floes, which were forced over and under each other to a great thickness and extent in a very few days.

The ship and her crew were helplessly drifted about for many months, during which the floes were frozen together into one solid mass, and the inequalities of the surface in a great measure filled up with snow-drift.

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4, Addison Gardens, January 29