

No. XVI.—ANTARCTIC SPECULATION. By JAMES ANDERSON.

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THE unwonted zeal with which Antarctic exploration is being taken up at this time has suggested to me that we might usefully air any theories which have been fruitlessly simmering in our brains, and let explorers know what information would be specially acceptable to us. Fine theories are useless while there is no hope and no opportunity of putting them to the test, but when explorers come forward ready to throw new light on the cheerless Polar regions we may find our musty ideas take on new life.

One of the most important subjects on which fresh light may be shed is the formation of Boulder-clay. I think I may safely say that no other geological material has received so much attention from the members of this Society. In that we are perhaps victims of circumstances, for in the West of Scotland it stares us in the face wherever we go. While the deposit itself is a very solid indisputable fact, the true method of its production has, in my opinion, still to be determined. We all admit that it was formed by ice, but how the ice did actually form and deposit those great beds is not so evident. Any of the great glaciers of to-day which admit of inspection show no signs of Boulder-clay. They all without exception originate on high ground, and from their very birth commence to move downwards; which movement never ceases till they become exhausted. In their course they break up large quantities of rock, grinding much of it into mud, and from under every one of them there flows a mud-laden stream. The rough debris of the broken-up rocks, after being carried down, is thrown on a terminal moraine, while the river disposes of the mud, and so far as can be seen no deposit is being formed under the glacier itself.

When we examine a bed of Boulder-clay it is quite apparent that it has not parted with any of its mud, from which we may infer that the glacier which formed it never had a river running underneath it. Further, as mud is an essential constituent of Boulder-clay, we may argue that no sheet of ice with a river flowing below it could ever have formed such a deposit.

I will now give my idea of an ice-sheet capable of forming

Boulder-clay. Let us take the basin of the Baltic for illustration, with the temperature so low that its whole extent remained permanently frozen over, as it is of course necessary for my purpose to pre-suppose a decided lowering of the average temperature. After the ice has ceased to thaw with the summer heat it would become thicker every year, and with the progress of time through hundreds of years the sea would become filled with a solid body of ice with no water underneath. This thickening would not take place from below, but would result from the accumulation of snow on the surface producing a growing thickness of ice which would settle down on the bed of the sea and eventually squeeze out all the water from beneath. Given a sufficient length of time, such an ice-sheet would grow until it spread over the surrounding low districts, and there would be nothing to hinder it growing until it attained a thickness of 2000 to 3000 feet, one which we have been in the habit of reckoning necessary to account for the familiar evidences of glaciation and Boulder-clay.

I have strong hopes that such an ice-sheet is at present actively at work within the Antarctic area. I have a vivid recollection of reading Sir James Clark Ross's description * of a wall of ice which formed an impassable barrier 450 miles long from east to west, and which rose 200 feet above sea-level. At least 1000 feet of it being below sea-level, there would be 1200 feet of a solid front of ice. That is radically different from the paltry glaciers of 50 or 100 feet deep, found in the Northern hemisphere, and as such an immense wall is continually subjected to the denuding action of rain and moist sea-air, we might expect to find that a few miles back from its face it attained a depth of 2000 feet or more. It is extremely probable that this great body of ice extends several hundred miles inland over level country, having originated in some basin such as the Baltic.

It may be beyond the possibility of proof, but I have a great belief that real Boulder-clay is presently being manufactured at the great ice-field described by Captain Ross. The account of his voyage while in contact with the ice is most interesting, and in some points highly significant. He took soundings frequently, and found the bottom at a remarkably uniform depth of 260 to 280

* "A Narrative of a Voyage of Discovery and Research in the Southern and Antarctic Regions from 1839 to 1843," 1847.

fathoms, but he was afraid to sail close up to the ice-wall, his usual distance from it being 10 to 20 miles. His remarks particularly on the absence of bergs, as for a stretch of 160 miles he saw none at all, and then came on several very large ones, all firmly fixed to the bottom. These were at a considerable distance from the ice-wall, which was only just visible from their position. Soundings gave the usual 280 fathoms on their south side, but only about 180 fathoms on their north or open-sea side. Captain Ross speaks frequently of the wide extent and uniform depth of the great bank he had discovered, but he does not seem to have suspected there could be any connection between the broad level terrace, or bank as he calls it, and the ice-wall which overshadowed it, or that there might be some relationship of cause and effect. He estimated the depth of the ice-wall above and below the water, and determined the depth of water over the bank in front of the ice, but the remarkable fact that the estimated depth of the ice below water-level and the depth of water on the bank coincided, does not appear to have suggested to him that the whole extent of the level bank he was sailing over was actually the floor of the ice-field which the 2000 feet of ice had rolled and levelled. There seems to be no room for doubt that such is the case, and that those bergs, which he found fixed to the bottom a long way out from the ice-wall, had probably at some comparatively recent time formed the front or head of the ice-field when a succession of severe seasons had enlarged it to nearly its fullest extent. Captain Ross mentions that the most violent action of the sea seemed to be crushed and subdued by contact with the great ice-wall, but still the destructive effect on the ice itself must be very rapid, and probably much more so than on detached bergs, round which the waves could play freely. "The great barrier of ice," as he calls it, can hardly form or give off floating icebergs in the ordinary sense. Apparently it rests with its whole weight on the bottom, and although a section becomes detached, like the isolated bergs, it could not float away.

While taking soundings all along the front of the "barrier," the lead constantly brought up what Capt. Ross calls "green mud," but in other places only sand and pebbles were found. Our own blue Boulder-clay tells us that it is largely composed of black shales and coaly matter; the white Boulder-clay reveals the fact

that it has come from a fireclay region ; while in a red sandstone district the colour of the Boulder-clay is as red as the sandstone itself. Doubtless, therefore, the "green mud" could tell us a good deal about the geological formation of the locality from whence it was derived.

Much valuable and exceedingly interesting information might be obtained by going over Capt. Ross's work even at this distance of time from his voyage, and plotting the actual position of "the great barrier," to show whether it has advanced or receded since 1842. Although a true ice-sheet can as a whole have hardly any true and persistent motion in any particular direction, yet an extensive snowfall towards one side of its area would cause it to move bodily towards the opposite side, and *vice versa*, so that any movement would be of an oscillating character. The yearly accumulations of snow over the whole ice-field would give rise to a lateral growth, which would be uniform all round, if its borders were all of uniform elevation. But doubtless it is to some extent bordered by rising ground, towards which the ice could not advance, so that its apparent lateral advance over low-lying districts would be more considerable, and, where it had the chance of advancing over the downward slope of the bed of the ocean, its progress would be distinctly accelerated.

The interesting question as to whether the ice-field is advancing outwards into the ocean at the present time might be determined with tolerable accuracy by taking soundings close to the barrier. If less than the usual depth over the bank was found close to the ice it might safely be assumed that the ice-field is growing and pushing a moraine before it as it advances. On the other hand, if soundings of the usual depth of 260 to 280 fathoms were found, it might safely be inferred that it is not advancing, but is perhaps actually shrinking.

It has always seemed to me a most interesting and remarkable circumstance, that, in the latitudes sailed over by Capt. Ross, open water should be found quite 10 degrees farther south than in any other section of the Antarctic regions, and extending to about 40 degrees of longitude ; but I do not know of any feasible explanation. The configuration and distribution of the land might readily be suggested, and also ocean currents, but if either of these have exercised a softening influence on the climate of that particular

region the facts have still to be noted and explained. Some of our early school-books taught us that currents of heated air rose from equatorial regions, and flowed at high levels towards the Poles. I do not recollect that the subject was exhausted by explaining where the heated air struck the Polar regions, but in this connection a more practical application might be possible.

A matter which has greatly interested me is the possible influence of the Magnetic Poles on air-currents. You may have heard of the "Chinook Wind"—a marvellous, beneficent phenomenon—which renders winter in the high latitudes of Western Canada not only endurable but enjoyable. It is not a wind in the ordinary sense; it does not tear across the country uprooting trees and overturning shanties; in fact, it is hardly correct to call it a wind at all. It comes from no particular direction, but when it does arrive the snow disappears infinitely quicker than in any thaw. It seems to be so dry that it absorbs the snow. Its influence is felt from British Columbia to Lancaster Sound, but more regularly and with fuller effect in the valleys of the North and South Saskatchewan than elsewhere. It is difficult to imagine it can be anything else than an equatorial air-current. That it happens to be directed to that part of the globe, and is at the same time altogether unknown in the same latitudes in Siberia, suggests some possible connection between it and the Magnetic Pole, which forms roughly a centre-point within the area benefited by the "Chinook Wind."

We should, of course, naturally expect that if there is any connection between the Magnetic Poles and equatorial or other currents of air, the same conditions as these would prevail on the Southern hemisphere, and it would be very interesting to find that similar conditions really do exist there. It is curious enough,—you may observe it noted on any chart—that explorers have been able to make their way to very much higher latitudes in the immediate neighbourhood of the South Magnetic Pole than at any other point in the whole circuit of the Antarctic. I have thought it even possible that a large area near the South Pole may be generally free of snow and ice. It must be at such a distance from the ocean that all snow driven by storms into it will remain dry and loose, and ready to be blown back again by storms from

the opposite direction. If a southern "Chinook Wind" does really prevail, it would greatly assist in keeping the area under its influence clear of snow.

The whole question is excessively interesting, but its solution will, I fear, be even more difficult than that of the formation and deposition of the Boulder-clay.