

explain the existence of a more arctic climate in Scotland. There is no necessity to introduce causes for the production of cold which do not now exist. Those alterations of level, for which there is ample evidence, would involve re-arrangements of the relative proportions of land and water, and vital changes in the directions of the arctic currents. For the solution of the problems involved in the great history indicated by the fossil fauna of Canada and Scotland, we must first consult those great principles of physical geography, which may now be studied in hourly action over the surface of the globe.

L. *On the Reason why the CHANGE of CLIMATE in CANADA since the GLACIAL EPOCH has been less complete than in SCOTLAND.*
By Mr. JAMES CROLL.

(Read March 22nd, 1866.)

AT a former meeting, an interesting paper was read by the Rev. Mr. Crosskey, on the "Relationship between the Fossils of the Glacial beds of Canada and those of the Clyde." In that paper he has shown that the difference between the glacial shells of Canada and those now existing in the Gulf of St. Lawrence is much less marked than the difference between the glacial shells of the Clyde beds and those now existing in the Firth. And from this he justly infers that the change of climate in Canada since the glacial epoch has been far less complete than in Scotland. I agree with Mr. Crosskey in his remark that the true cause must have been a deflection of the Gulf Stream from our coasts during the glacial epoch. If it can be shown that during that epoch the stream was greatly diminished, or perhaps totally stopped, everything appears to me to be accounted for.

The stoppage, or at least great reduction, of the Gulf Stream during the glacial epoch is a consequence which has already been deduced from the Cosmical theory. It, of course, is not supposed that the stoppage of the stream was the cause of the cold of the glacial epoch. On the contrary, it was, we believe, the cold of that epoch which led to the stoppage; but the return of the Gulf Stream to our shores after the glacial epoch, and the consequent great additional rise of temperature due to its return, might

certainly be the cause why the change of temperature has been much greater in this country than in America. The cold of that period would no doubt be as severe in Canada as in Scotland, but the rise of temperature which succeeded would not be so great in the former country as in the latter. This is obvious, because the temperature of the former has never been raised by the influence of the Gulf Stream; but, on the contrary, has been positively prevented from rising to its normal condition by the cold polar stream from Davis Straits.

If the glacial epoch was due to the cause assigned on a former occasion, then we are almost certain the Gulf Stream must have been enormously reduced, if not altogether stopped, during that epoch. At present the Equatorial current of the Atlantic on approaching Cape St. Roque, divides itself into two portions, the principal portion flowing into the Gulf of Mexico, and forming what is known as the Gulf Stream; the other portion directing its course along the coast of Brazil into the Southern Ocean. The position of the equatorial current is determined in a great measure by the relative strength of the N.E. and S.E. trade winds. It has been proved that during a glacial period on the northern hemisphere the N.E. trades, owing to the great difference between the temperatures of the two hemispheres in polar regions, would enormously predominate over the S.E. trades, and the consequence would be that the equatorial current, the feeder of the Gulf Stream, would be driven considerably to the south of its present position. And in this case the greater portion, if not the entire current, would be turned into the southern branch along the Brazilian coast. The Gulf Stream would, therefore, be greatly diminished, if not altogether stopped. Any one may convince himself by an examination of a chart of ocean currents that if the equatorial current were to be pushed a few degrees to the south of its present position, not a single drop would probably flow into the Gulf of Mexico.

The return of the Gulf Stream has raised the mean annual temperature of Glasgow no less than 15° above the normal, while Canada, deprived of its influence, and exposed to a cold stream from polar regions, has been kept nearly as much below the normal.

Let us compare the present temperature of the two countries. In making our comparison we must, of course, compare places on the same latitude. It will not do, for example, to compare Glasgow with Montreal or Quebec, places on the latitude of the south of

France and north of Italy. It will be found that the difference of temperature between the two countries is so enormous as to appear scarcely credible to those who have not examined the matter. The temperatures have all been taken from Professor Dove's work on the "Distribution of Heat over the Surface of the Globe," and his tables published in the Report of the British Association for 1847.

The mean temperature of Glasgow for January is 38° F., while in some parts of Labrador, on the same latitude, and all along the central parts of North America lying to the north of Upper Canada, it is actually 10° , and in many places 13° below Zero. The January temperature at the Cumberland House, which is situated on the latitude of the centre of England, is more than 13° below Zero. Here is a difference of no less than 51° . The normal temperature for the month of January in the latitude of Glasgow, according to Professor Dove, is 10° . Consequently, owing to the influence of the Gulf Stream, we are 28° warmer during that month than we would otherwise be, while vast tracts of country in America are 23° colder than they should be.

The July temperature of Glasgow is 61° , while on the same latitude in Labrador and places to the west, it is only 49° . Glasgow during that month is 3° above the normal temperature, while America, owing to the influence of the cold polar stream, is 9° below it. The mean annual temperature of Glasgow is 50° , while in America, on the same latitude, it is only 30° , and in many places as low as 23° . The mean normal temperature for the whole year is 35° . Our mean annual temperature is therefore 15° above the normal, and that of America from 5° to 12° below it. The American winters are excessively cold, owing to the continental character of the climate, and the absence of any benefit from the Gulf Stream, while the summers, which would otherwise be warm, are, in the latitude of Glasgow, cooled down to a great extent by the cold ice from Greenland; and the consequence is, that the mean annual temperature is about 20° or 27° below that of ours. The mean annual temperature of the gulf of St. Lawrence is as low as that of Lapland or Iceland. It is no wonder, then, that the shells which flourished in Canada during the glacial epoch have not left the gulf and the neighbouring seas.

We have good reason to believe that the climate of America during the glacial epoch was even then somewhat more severe than

that of Western Europe, for the erratics of America extend as far south as latitude 40°, while on the old continent they are not found much beyond lat. 50°. This difference may have resulted from the fact that the western side of a continent is always warmer than the eastern.

In order to determine whether the cold was as great in America during the glacial epoch as in Western Europe, we must not compare the fossils found in the glacial beds about Montreal, for example, with those found in the Clyde beds, for Montreal lies much further to the south than the Clyde. The Clyde beds must be compared with those of Labrador, while the beds of Montreal must be compared with those of the south of France and the north of Italy, if any are to be found there.

Or: the whole, it may be concluded that had the Gulf Stream not returned to our shores at the close of the glacial epoch, and had its place been supplied by a cold stream from the polar regions, similar to that which washes the shores of North America, it is highly probable that nearly every species found in our glacial beds would have had their representatives flourishing in the British seas at the present day.

It is no doubt true that when we compare the places in which the Canadian shell beds, referred to by Mr. Crosskey, are situated, with places on the same latitude in Europe, the difference of climate is not so great as between Scotland and those places which we have been considering; but still the difference is sufficiently great to account for why the change of climate in Canada has been less complete than in Scotland.

LI. *On the Range and Occurrence of ANTHRACOSIA and OTHER SHELLS in the Coal Measures eastward of Glasgow.* By Mr. R. WHYTE SKIPSEY.

(Read February 1st, 1866.)

IN bringing these shells under the notice of the Society, the chief object is to direct attention to the conditions under which they are found. The area chosen for description is eastward of Glasgow, and extends from Shettleston eastward to Bargeddie—a distance of about five miles—and from the line of the Monkland Canal, on the