CLIMATE AND TIME.

SIR,—The discoveries of Scott and Shackleton show that in the Antarctic, as in the Arctic, the climate is ameliorating. When Scott visited the Great Barrier in 1902 he found it had retreated many miles since the days of Ross, and Ferrar from other evidence concluded that the ice masses are gradually shrinking in size.

This raises a very interesting point concerning the theories which have been formed to account for warm and glacial periods. According to Croll's theory the cold and warm periods occurred during times of great eccentricity in the earth's orbit, and the cold and warm periods alternated between the north and the south polar areas owing to the precession of the equinoxes. In other words, the climatic changes taking place must be of opposite character in the northern and southern hemispheres, whereas the facts appear to be, as already stated, that the climate is now ameliorating in both hemispheres. Moreover, the great number of cold and warm periods Croll's theory requires seems to me to be greater than is warranted by the geological evidence available.

It is admitted that the total amount of heat received by the earth from the sun each year is only very slightly affected by changes in the eccentricity of the earth's orbit. There is also reason to believe that the obliquity of the earth's orbit has not varied appreciably. We are, therefore, constrained at present to admit that, at least as regards recent glacial periods, the cause of the climatic changes must lie in the variable way in which the heat is received from the sun and reflected or retained during the winter and summer seasons and the indirect results thus brought about.

The essence of Croll's theory is that at times of great eccentricity there are periods during which the difference between the amount of heat received during winter and summer is very great on one hemisphere, whilst on the other hemisphere the quantities of heat received during the two seasons is more equable. When the winters are sufficiently cold the precipitation is almost wholly in the form of snow, and if the snowfall is sufficiently great the summer sun is unable to melt it; for owing to the heat being reflected from the white surface, or intercepted by fog, the part of the hemisphere concerned does not profit proportionately by being nearer to the sun. A great amount of heat is also required merely to change the ice to water.

Now I would suggest that during periods of great eccentricity, when the winter of one hemisphere is in aphelion, the collection of ice and snow is so great that the warmth of summer when the same hemisphere is in perihelion is unable to melt it except in low latitudes, and glacial periods are thus produced concurrently in both hemispheres during times of great eccentricity.

When, during periods of great eccentricity, the equinoxes are in aphelion and perihelion the conditions are also favourable for the collection of snow and ice in both polar areas; for during the time one equinox is in perihelion the equatorial region receives a great amount of heat from the sun, evaporation is promoted, and the precipitation of snow at the poles is increased. On the other hand,

the equinox which is in aphelion is cool for both hemispheres. It appears to me that Croll has correctly stated the conditions of climate of the hemisphere the winter of which is in aphelion, but has over estimated the effect produced by the conditions favouring warmth in the hemisphere the winter of which is in perihelion.

The whole problem turns on the probability of the collection of sufficient ice during the ten thousand years of cold winters to resist appreciable melting during the succeeding ten thousand years of hot summers. It appears to me that when a large area has become ice-bound it will take a very long time for the sun's heat falling on that area during times of eccentricity to clear away the ice.

The edge of the Great Barrier is about 800 miles from the South Pole, and Scott found that the ice was moving northward at the rate of about 600 yards per annum. South of the Great Barrier edge there seems to be very little actual wasting of the ice due to melting, so, independent of evaporation, ice formed near the South Pole would take about 2400 years to reach the Barrier edge. It is clear, therefore, that when once a large area has become ice-bound the clearing away of the ice would be a very slow process, especially as the precipitation of snow never ceases.

Just as the coldest time of our winter does not coincide with the shortest day, so during times of great eccentricity the time of maximum cold will not coincide with the time of greatest eccentricity, nor would the periods of greatest warmth coincide necessarily with the moment of least eccentricity.

Croll calculated that during the next twenty-five thousand years the earth's orbit would become more and more circular, and then, in a similar period of time, having regained about its present eccentricity, it would remain nearly constant for another fifty thousand years. From the fact that the ice is shrinking on both hemispheres, the physical conditions resulting from the present degree of eccentricity are favourable to future warmer conditions concurrently in both frigid zones.

I do not assert that the distribution of sea and land with reference to the poles is of no importance from a climatic point of view. If there were no Antarctic land and the south polar area were covered by deep water, the ice formed on the sea near the pole would float into warmer latitudes and readily melt, and thus enable the sea to retain the heat of the summer sun.

Although there is deep water in the Arctic Sea, the sea is so land-locked that the collection of snow and ice formed during the winter cannot fully escape south during the summer, and a great part of the sun's heat is reflected from it into space.

It is possible that at remote periods of the earth's history the distribution of the land and sea may have been so favourable that during periods of small eccentricity very genial climatic conditions may have existed at times at one or other of the poles.

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