The Editor,
The Journal of Glaciology

SIR,

Glaciers of the Baffin Type

In Vol. 2, No. 2, of the *Journal of Glaciology* I found a paper by P. D. Baird and his co-workers on glaciers of the Baffin type, which are characterized by the lack of *névé*, the nourishment of the lower parts being achieved by the super-imposition of ice derived from frozen melt water.

May I draw attention to an analogy in the Cordillera de San Juan. There the glaciers apparently are more or less stationary, and even at the end of the winter they are without *névé* cover owing to ablation by the wind. The glacier tongues end at high altitudes, 4000 m. and more, and the climate is cold, dry and windy. Precipitation nearly exclusively occurs in the form of light and dry snow which is transported by the wind into the concavities of the mountain relief. The alimentation of the lower parts seems to be almost entirely accomplished by this wind-borne snow accumulation.

Corrientes 1516/*II*,
Buenos Aires
31 *July* 1953

GEORGE J. HEINSHEIMER

REVIEWS

A CLIMATOLOGICAL AND ASTRONOMICAL INTERPRETATION OF THE ICE AGES AND OF THE PAST VARIATIONS OF TERRESTRIAL CLIMATE. E J. ÖPIK. *Contributions from the Armagh Observatory*, No. 9 (Armagh, August 1952). Published by the Armagh Observatory, 1953. 79 pages, 23 diagrams.

CONTROVERSY on the cause of ice ages continues unabated, but the present swing is in the direction of attributing the major climatic changes directly to changes in the radiation emitted by the sun. The difficulties of this approach have been twofold: uncertainty about the effect of such changes on terrestrial weather, and ignorance of how changes in solar radiation could come about. In this paper Dr. Öpik attempts quantitative answers to both questions. He begins with an analysis of the climatic heat balance between incoming and outgoing radiation, allowing for the effects of water vapour and cloud. This is a very intricate matter, which is dealt with by fitting empirical constants to theoretical equations; the startling upshot is that a variation of the average world cloudiness from 0·4 to 0·6 would cause a change in the mean temperature of the Earth's surface from 21·4 to 9·0° C., sufficient to cover the whole range of geological climates. The present mean cloudiness is a little over 0·5. The increase of cloud with increase of solar radiation, as maintained by Sir George Simpson, could therefore be an important factor in climatic variations, but with present level of solar radiation or "luminosity" the actual changes of mean cloudiness are not likely to be anywhere near so great. The cooling effect of snow and ice surfaces is regarded as negligible—in fact the elevated surface of a continental ice sheet produces a *warming* effect on its edge at sea level! There is thus no impulse for a small ice cap to grow spontaneously. Other factors, such as variations of obliquity and eccentricity, and changes of land and sea distribution, are also found to be small. It is concluded that with the present solar luminosity, no possible combination of astronomical and geographical conditions could enable the polar ice cap to reach the low latitudes actually attained during the Quaternary. The glacial maximum requires a decrease of luminosity to 87 per cent of the present; against this a warm interglacial requires a luminosity of 102 per cent and the warm Tertiary 109 per cent. Anything less than 87 per cent persisting for more than 2000 years would result in the glaciation of the whole globe.

In Holmes' immortal dictum, when you have excluded the impossible, whatever remains, however improbable, must be the truth. Acting on the assumption, which not everyone will grant, that

https://doi.org/10.3189/S0022143000025326 Published online by Cambridge University Press

the factors he has excluded are actually impossible, the author goes on to outline a mechanism which could give the required changes of solar luminosity. This must satisfy certain criteria: the main minima must be roughly periodic at intervals of about 240 million years (Eocambrian, Permo-Carboniferous, Quaternary, perhaps also several Pre-Cambrian glaciations). Superposed on this must be much more rapid pulsations of only about 100,000 years to account for the succession of glacial and interglacial stages. Many possible stellar models are consistent with these phenomena; that which the author favours involves a process by which atomic fuel (hydrogen) is destroyed in the core of the sun. The hydrogen lost is replaced by diffusion from the surrounding layer, but this involves only about a quarter of the sun's mass. The diffusion of hydrogen from this layer increases the relative metal content and therefore the opacity, until instability sets in and ends in a convective disturbance. The result is an adiabatic expansion of the sun's magnitude, cooling of the outer layers and an ice age on Earth. The secondary fluctuations or pulses are due to secondary convective disturbances of the outer ("sub-photospheric") layers in which the metal content decreases outwards. The details of the combined processes envisaged are too complex to go into here, but it may be remarked that the accretion of hydrogen and helium from outer space forms part of the theory, being necessary to maintain the reserve of atomic fuel.

The paper is a gallant but perhaps over-ambitious attempt to solve the whole problem of geological climates by attack along a single front. The mechanism may be possible, but the agreement with the geological time-scale is more apparent than real, since it depends on several arbitrary assumptions. The main objection, from the geological aspect, is the association, now generally recognized, of ice ages with periods of orogenesis; it is surely too much of a coincidence that the time-scale of orogenic disturbances and major solar outbreaks should be identical. A more reasonable view would be that the solar outbreaks come at much shorter intervals, but only produce ice ages when they fall within a period of orogenesis. On the other hand the rapid climatic changes within an ice age cannot be due to orogenic changes and may well be accounted for by changes of solar luminosity, and if this work indicates a line of approach to the latter problem only, it will be a valuable contribution.

C. E. P. Brooks

GLACIER VARIATIONS AND CLIMATIC FLUCTUATIONS. H. W:son Ahlmann. Bowman Memorial Lectures, Series 3. New York: American Geographical Society, 1953. v+51 pages, illustrations, diagrams. $2.50.

This, the third Isaiah Bowman Memorial Lecture, is the first that has been devoted to what is primarily a physical aspect of geography, although the subject is not without its human implications. In the true Bowman tradition, Dr. Ahlmann's qualifications to analyse and assess the rapidly growing mass of physical data (much of which were inspired by his own researches) are unrivalled. The glaciologists will welcome equally this admirably concise review of one aspect of their science and the "fascinating presentation of its bio-geographical significance."

The idea of a simple, direct relationship between glacier variation and climatic fluctuation may appear plausible, and indeed in much past discussion such a relationship has often been assumed. Development of our knowledge has, however, demonstrated that the relationships between glaciers and climate are highly complicated and still far from clear.

In an early section, Ahlmann comments with parental modesty on the importance of the glaciological results of the Norwegian–British–Swedish Expedition to Queen Maud Land, as illustrated by the preliminary results produced by Schytt and Robin. In a succeeding section dealing with the factors influencing glaciation he emphasizes the changing relative importance of the individual climatic elements *through* the ablation season in an individual glacier and their regional variation as the controllers of the "state of health" of glaciers.

Recent studies have paid increased attention to the significance of the survival of ice masses from one climatic regimen into another, both in modern high polar glaciers and in the late Pleistocene ice sheets of lower latitudes. Delayed response to increased accumulation and survival of