

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

movements beyond the period of application of the causative stress are probably normal features of glaciers. Glaciers may have an inherent periodicity independent of climatic factors. On the basis of such complications, it is probably true to say that departure from a condition of being in equilibrium with environment is the general rule among glaciers.

A discussion of recent systematic studies by Wallén on the Kårsa Glacier and Schytt and Woxnerud on the Stor Glacier in Swedish Lapland leads to a general appraisal of the recent glacier recession in Scandinavia, Iceland, Spitsbergen and Greenland. Typical of the author's penetrating approach to glacier fluctuation is his comment on the remarkable 60-mile recession in Glacier Bay, Alaska, since the eighteenth century. He would put the stress on the great advance which took place in the eighteenth century and its cause, as the major problem, and suggests that the retreat should not be taken as evidence of the importance of the present climatic fluctuation.

A brief summary of some recent data on the present climatic fluctuation, with its complicated reversals of seasonal trends in the past decade, is followed by a consideration of the causes of the recent glacier recession and the present climatic fluctuation. The author critically reviews current theories of increased zonal circulation as a major factor, on the whole favourably, and notes the growing tendency to accept the "solar variation" origin for both short- and long-range fluctuations. He stresses the significant fact that of all the endless series of climatic fluctuations since the beginning of history, "the present one is the first that we can measure, investigate and, possibly, explain."

Turning to the field of bio-geography attention is drawn to the great economic significance of the present climatic fluctuation in the northern sea routes and fishery fields and, on land, in its influence on forestry, agriculture and hunting. This is especially the case in the marginal countries, as is shown, for example, by a recent symposium on this subject published by the Finnish Geographical Society.

Finally, the author visualizes the recent changes, in the broader setting, in the fluctuations of the past few thousand years and looks forward to a bright future for glaciological research.

Many of Dr. Ahlmann's friends and admirers will recall the inspiring foreword he wrote to the first issue of the *Journal of Glaciology* and rejoice that, in spite of heavy prior claims on his time, he is able to continue actively in the field where, as elsewhere, his influence is pre-eminent.

S. E. HOLLINGWORTH

ANTARCTICA: INTELLIGENCE; REGIONAL PHOTO INTERPRETATION SERIES.

Air Force Manual 200-30. U.S. Air Force (Department of the Air Force), 1953. v+171 pages, 343 plates, 2 maps.

THIS is a fascinating picture-book for anyone interested in Antarctic glaciology. The author, Mr. John H. Roscoe, has chosen air photographs to illustrate almost every kind of ice-surface feature likely to be seen from an aircraft. His material is up to date, consisting mainly of photographs taken during U.S. Navy operations in the 1946-47 and 1947-48 Antarctic summers, although he makes use of both ground and air photographs of earlier expeditions. The purpose of the book is to provide Air Force intelligence and operations units with a key for the rapid and accurate reading and interpretation of air photographs of areas inundated by continental glaciers. There is every reason to believe that it will succeed in this purpose.

The first two chapters give an introduction to the Antarctic as a whole and discuss the application of photo reconnaissance and photo interpretation to the area. There are sections on discovery and exploration, on the main geographical features of the continent, on accessibility and on methods of transport. The limitations of photo reconnaissance and photo interpretation are dealt with clearly and objectively. Navigation seems to be the bugbear, and it is a brave man who will take to the air after reading: "In short, it is difficult for the pilot to get to where he wants to go, to know when he is there and to know where he has been, if and when he can manage to return to his base."