CHANGES IN WORLD GLACIATION

A GEOPHYSICAL Discussion of the Royal Astronomical Society in conjunction with the British Glaciological Society was held at Burlington House, London, on January 29, the subject being "Changes in World Glaciation". The principal speakers were as follow: Prof. F. E. Zeuner (Institute of Archæology, University of London), Dr. J. D. H. Wiseman (British Museum (Natural History), London), Prof. G. Manley (Bedford College, London) and Mr. F. Hoyle (St. John's College, Cambridge), in that order. Mr. Gerald Seligman, president of the British Glaciological Society, was in the chair.

Without doubt such a subject of discussion ranks with several others of a cheerfully provocative kind in which it is not given to any one group of scientists to provide the answer. In a sense, such major issues offer not only a meeting-ground but also a much-welcomed stimulus. It has long been proverbial that he who wants to set a university by the ears with the view of encouraging the students can scarcely do better than arrange a symposium on such subjects as submarine canyons or cloud physics. In a symposium on climatic change the geologist busy with his muds lifts his eyes again to the stars; the astronomer is suddenly reminded that he must bring down his time-scale to cope with the mundane requirements of the botanist; the environmental archæologist seeks more fundamental reasons for the pathetic squalor of his kitchen-middens. The physicist is led to reconsider the yielding of masses of ice under varying conditions of temperature; and the meteorologist, eternally distracted by the hourly irregularities of his elusive goddess, begins to wonder whether her pattern of behaviour can be led to display a major alteration through gentle persuasion or through sudden blows.

Opening the meeting, Mr. Seligman referred to the need for further work on the causes of changes in world glaciation, whether within the earth's system or without, and directed attention to Dr. H. W. Ahlmann's emphasis on the great value of such studies in the interrelation of the sciences. A large and highly diversified audience attended; but it became evident that co-ordination of the approaches made by workers in several fields is still not easy, and a two-hour meeting on such a vast subject could but leave the appetite whetted.

Prof. Zeuner began by very appropriately stressing the need for further collection of facts. He believed that the integration of evidence both in space and time is first necessary, and the new techniques of dating successions for purposes of correlation are still in an early stage. He demonstrated the complexity of the problem of glaciation in relation to the evidence for eustatic changes of sea-level in the Pleistocene in those areas which might reasonably be deemed free of isostatic complications. Quite apart from the effects of the several successive phases of the Ice Age, there appears to have been an overall lowering of sea-level during the past million years or so throughout southern and south-western Europe[1]. If that is so, the relationships between large-scale terrestrial changes, presumably of tectonic origin, and glaciation is not simple and requires further elucidation. With the aid of a diagram he pointed out that in the Post-Glacial the prevailing rate of fall of sea-level relative to the land underwent what might perhaps be rhythmic fluctuations with a period of the order of 1,800–2,000 years, a fact deduced from close studies of the Thames terraces and of numerous beach-levels[2]. The relationship of such fluctuations to variations in the tectonic forces at work or to variation in the rate of melting of ice-caps is still open to discussion.

Dr. Wiseman gave a brief but critical account of the recent results he and his colleagues have obtained from a close study of cores, collected in the equatorial Atlantic Ocean by the Swedish Deep-Sea Expedition, 1947–48, under the leadership of Prof. Hans Pettersson. Although Dr. Wiseman has recently published a preliminary paper[3], work is still in progress and some exciting glimpses of these new results were given to the meeting. It is apparently possible, in suitable deep-sea cores where specified conditions have been satisfied, to determine the past temperature changes in the upper layer of the sea by three different methods.

The first method is to determine the mass contribution of calcium carbonate per c.c. per year in a series of sections throughout the length of the core; the second method is to determine the species distribution of planktonic foraminifera; and the third to determine the oxygen-18 content in specific planktonic foraminifera. A core nearly 14½ m. in length has been investigated at every 5 cm., and more detailed investigations have been carried out on a series of sections taken continuously down a short pilot core. The graph showing the yearly mass of calcium carbonate deposited per c.c. in the short pilot core shows a series of minor oscillations superimposed on a major curve. There is an apparent correlation between these minor oscillations and the known minor climatic oscillations of more temperate regions. Dr. Wiseman pointed out that the conclusions arrived at from the rate of sedimentation of calcium carbonate were supported by the species distribution of planktonic foraminifera as well as by the oxygen-18 determinations on specific planktonic species carried out by Dr. Emiliani. For example, where the yearly rate of sedimentation of calcium carbonate is relatively high—namely, 990 μgm./sq. cm.—the calcareous tests of *Globigerinoides sacculifera* were apparently deposited at 24·3° C., while at a depth of 26·3 cm. from the top of the core where the yearly rate of sedimentation of calcium carbonate has fallen to 330 μgm./sq. cm. the tests of *Globigerinoides sacculifera* were deposited at 20·1° C.

Dr. Wiseman has found it possible to make age determinations by three different methods. The sources of error were briefly mentioned, and much work has and is still being carried out to show the justification of certain basic assumptions. It is of great interest to note that the minor oscillations in the rate of sedimentation of calcium carbonate are apparently synchronous with the minor climatic oscillations of more temperate latitudes. For example, at a depth of 22·4 cm. corresponding to an age of 9300 B.C., there is a minor oscillation in the rate of sedimentation of calcium carbonate. This oscillation would seem to be synchronous with the Allerød oscillation in Denmark[4], the age of which

according to recent carbon-14 measurements is 8800–9900 B.C.

Dr. Wiseman stressed the necessity for more work of this nature, and was careful to point out that the techniques used are not applicable to all cores, but can only be used where suitable conditions of sedimentation have existed. Finally, he showed a chart giving the many localities in the Atlantic where foraminiferal analysis has revealed cooler conditions in the past in the upper layer of the sea; and he pointed out that in four nearby cores collected from the Equatorial Atlantic, Dr. D. B. Ericson[5] has recently been able to make correlations from core to core and has concluded that the deposition is continuous and normal, and that there is no obvious evidence of turbidity currents, erosion, slumping or re-worked older sediments.

Prof. Manley emphasized the need for more attention not to the mere existence of ice but to the changes in its extent. Referring to the advances and retreats during the past three centuries, it is clear that a marked degree of parallelism existed around the North Atlantic, shown by the series of curves from numerous sources in several countries which have been assembled by Dr. H. W. Ahlmann in his recent Bowman Lecture[6]. With a further diagram he showed that the overall agreement between the fluctuations of the southern Icelandic glaciers and what is known of the fluctuations of the mean summer temperature in England is temptingly attractive. The eccentric position of the Pleistocene glaciation in the northern hemisphere on either side of the Atlantic suggests that the key to the greater events of the past may well lie in studies around that ocean. Whatever other causes are sought, changes in the configuration, depth and surface temperature of the North Atlantic are still deserving of further consideration, and Prof. Manley said that he was glad Prof. Zeuner had directed attention to the same problem in another way. He went on to demonstrate the minor irregular fluctuations of the order of two to three decades in length which have also been recognized in tree-ring series and other annual deposits. While these may reflect small changes in the character of the general circulation of the atmosphere, they have all occurred in the presence of a warm North Atlantic. The greater phenomena of the past and especially the low snow-line in the Ice Age require a much cooler ocean off north-western Europe[7]; and, as the development of the greater glaciations took a long time, perhaps of the order of two to three thousand years, the sea surface must have been cooled well before the maximum of glaciation, and we should decide how this could happen. He gave reasons for the opinion that each of the minor Late-Glacial re-advances in Britain was preceded by a fall of temperature of the same order as that which sufficed for the maintenance of maximum glaciation, but lasting for a much shorter time. A very rough calculation based on the size of the revived Post-Allerød glaciers in the Lake District in England appears to indicate that fifty to a hundred years would suffice for the re-advance, after which the ice lasted for four centuries or so. It would therefore appear that each of the changes in glaciation represented by advance could have taken place relatively rapidly and that they were succeeded by a much longer stage of stagnation or slow retreat. If that were so, we are faced with the problem of explaining why the pattern of the world's atmospheric circulation could be displaced, or biased, from its present state for varying lengths of time, and why patterns which are now merely ephemeral could become more persistent.

Mr. Hoyle developed a new line; he thought that the change in the amount and character of world glaciation in the period from the Late-Glacial to the Climatic Optimum represents a climatic change so remarkable as to be outside the operation of the earth's meteorological system. Astronomers are not happy about such rapid changes in solar variation, and he referred to the other type of external influence which might result from local variations in the density of interstellar matter between sun and earth. Such effects, which he had outlined in earlier discussions[8], are now calculable and cannot now be allowed as sufficient. Solar radiation might otherwise become intensified by the picking-up by the sun of material from interstellar clouds; but as the sun would need to move very slowly through such clouds it would not be able to do so sufficiently often to explain the observed effects. He thought that the recent work by Dr. E. G. Bowen in Australia[9] reopens the position completely. Bowen has studied the remarkable tendency for intensification of rainfall on certain days of the year in Australia; this is now confirmed elsewhere in the southern hemisphere, and also in Britain, and it is also related to the observations of noctilucent clouds. The possibility exists that this results from the provision of nuclei arising from the incidence of showers of meteoric dust at particular seasons and falling to the right levels. Mr. Hoyle therefore suggested that one of the most satisfactory ways of changing climate would be to tamper with the 'greenhouse effect' through knocking out some of the water vapour; and that the necessary material might be provided by the breaking-up of a particularly large comet. The figures for the mean mass of comets are, he said, in agreement with this possibility, and the particles providing the zodiacal light are of the right size. Alternative explanation can still be sought in changes of the rate of movement of a gas passing through the solar system.

Subsequent speakers were much exercised by Mr. Hoyle's suggestions, and Mr. D. J. Schove asked if any evidence could be obtained from deep-sea sediments of variations in the abundance of such meteoric material. Dr. Wiseman replied that work is in progress on the nickel and cobalt content of deep-sea cores, and it is hoped that it will shortly be possible to decide whether the nickel was or was not of cosmic origin. Mr. E. Gold asked if anything is known of the effects of other meteoric streams—for example, those in August—and thought there is very little water vapour at the great heights mentioned; Mr. Hoyle thought that the time of sinking of the fine particles through the atmosphere might vary and could be of the order of twenty days.

The discussion was perforce, like many of its kind, inconclusive; but the numerous problems brought to light go far to show that although the issues are being gradually narrowed we still need more exact knowledge of what we are trying to explain; and, indeed, the problem of climatic change is increasing in complexity. Prof. Zeuner's contribution calls to mind the need to avoid the uncritical reliance on the results of changes in the extent of land and sea and of the relief in high latitudes; subsequent re-emphasis of the character of the open North Atlantic in relation to the location of the continental ice-sheets raises the question of how, and over what

length of time, cooling took place, an answer to which must await the work of Dr. Wiseman and his colleagues. There is evident need for further investigation of the extremes of climatic displacement which have resulted at various times in different parts of the world. The fact of the snow-line having been by no means uniformly lowered over the world as a whole, and the very variable length of the glacial phases, needs further study. The meteorologist is well capable of outlining pressure maps for the Ice Age; the importance now lies in the process by which transition was effected, and further evidence, from the field sciences, of the time required for such transitions may enable the meteorologist to provide an answer. The challenge of Mr. Hoyle's statement, that the change from Glacial to Climatic Optimum lies outside the operation of the earth's meteorological system, is one which will unquestionably stimulate further thought. Even the man of science on his Alpine holiday can reflect upon the conspicuous results of the seventy-odd years of decline of the Rhône glacier as a possible portent.

Gordon Manley

[1] Zeuner, F. E., "The Pleistocene Period", p. 250 (1945).
[2] Zeuner, F. E., "Dating the Past", 1st ed., p. 93 (1946). Florin, S., *Geol. För. Stockholms Forh.*, **70**, 17 (1948).
[3] Wiseman, J. D. H., *Proc. Roy. Soc.*, A, **222**, 296 (1954).
[4] Iversen, J., *Science*, **118**, 9 (1953).
[5] Ericson, D. B., Tech. Rep. Submarine Geol., No. 1, Lamont Geol. Obs., 1 (1953).
[6] Ahlmann, H. W., "Glacier Variations and Climatic Fluctuations" (Bowman Lecture, No. 3). Amer. Geog. Soc., N.Y. (1953).
[7] Manley, G., *Geogr. J.*, **117**, 43 (1951).
[8] Discussion on Post-Glacial Climatic Change, *Quart. J. Roy. Met. Soc.*, **75**, 161 (1949).
[9] Bowen, E. G., *Aust. J. Phys.*, **6**, No. 4, 490 (1953).

NEW INSTITUTE OF CLINICAL SCIENCE AT THE QUEEN'S UNIVERSITY, BELFAST

THE Institute of Clinical Science of the Belfast Medical School was opened recently on behalf of the Duchess of Gloucester by Lord Wakehurst, the Governor of Northern Ireland. The purpose of the new Institute is to provide additional room for teaching and to increase the research facilities of the school. Owing to certain building restrictions, it was necessary to divide the building so that the Institute consists of two buildings united by a closed-in bridge.

The west block contains two large lecture theatres capable of seating 282 and 221. In these, special attention has been given to acoustics, and a very efficient and pleasing result has been obtained. They are mechanically ventilated and furnished with modern projection apparatus of various types. Teaching facilities are also supplied in eight tutorial rooms, each capable of seating thirty students, and furnished with projection and other apparatus for demonstration. The west block also contains the Departments of Therapeutics, Obstetrics and Gynæcology, Child Health and Social and Preventive Medicine, as well as a photographic unit and an artist's studio.

The Medical Library is also in the west block. It has been provided as a War memorial, and in addition to the main reading rooms has three separate reading rooms for undergraduates, postgraduates and staff, which serve as memorials to three young graduates who fell in the Second World War. These rooms are panelled in various woods, and the main room contains six paintings by Mr. Norman Wilkinson, depicting the counties of Northern Ireland. This building is linked to the Institute of Pathology and to the teaching wards of the Royal Victoria Hospital.

The east block contains the Departments of Medicine and Surgery. The third floor is designed for experimental research. Each member of staff has a private laboratory, while in addition each department has at least one communal laboratory. A great deal of thought has been given to the services for the whole building, and these are carried in the ceilings of the corridors; but they are readily accessible above the false ceilings and can be easily expanded to meet further developments. This distribution of the services renders maintenance a relatively easy matter.

The link with the hospital, and the provision of lifts, render it possible for a patient in bed to be wheeled to any floor for detailed investigation.