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Late Quaternary Oscillations of the Hydrologic Budget: Implications for Climatic Change

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Dr Bowler, Department of Biogeography and Geomorphology, Australian National University, commenced his talk by pointing out the difficulty of obtaining proxy evidence of climate before the commencement of the instrumental record, and that the evidence could not be expressed in the form of precise temperature, evaporation, or wind estimates; nor in most cases could seasonal distinctions be made. However, he pointed out that the gap between geologists and physicists in the interpretation of much of the data was closing. The speaker then gave an interesting survey of the proxy data obtainable in Australia, particularly in relation to the time of the last major ice age, namely around 18 000 years BP (before present). He pointed out that glaciation in the Snowy Mountains of mainland Australia was light and of comparatively short duration, though Tasmania experienced a more substantial ice cover. Thus, unlike the classical glacial age studies of much of the northern hemisphere, most Australian work has been based on the study of periglacial features; in particular, the gravels and sands carried by the rivers, the extensive fossil dune systems, the ancient lake levels, and the geomorphology of the salt lakes. The question of the response of the Australian desert to the glacial and interglacial periods is important in the global context of climatic change.

A series of striking illustrations was displayed showing evidence of shore line change sequences in the Australian desert lakes, the orientation of fossil desert dunes, and the evidence of the presence of Aboriginal man, his middens and fireplaces enabling accurate radiocarbon dating of the then lake levels. In particular, human remains of c. 30 000 BP at Lake Mungo in the Willandra Lakes of western New South Wales, at but one level in a sequence of changing local environment, points to the many climatic changes man has experienced on the Australian continent. In summary, the lakes show a rise to high level commencing around 45 000 BP, peaking to overflow around 25 000 BP, and thence changing to aridity with the lakes drying out by 18 000 BP. Attention was drawn to the similarity of the sequences from the Willandra Lakes and Lake Keilambete (in Victoria) with those of Lake Chad and Lake Abhé in north Africa and also with the loess and soil interchange chronologies of southeastern Europe.

All the evidence points to coincidence of dry conditions with times of glacial periods, and a problem arises as to how the moisture was removed if lower evaporation followed from lower temperatures. A clue lies in the fossil dunes of Kangaroo Island, which record a glacial age paleowind direction as northwest in contrast to the present southwest. This suggests that more vigorous, dry winds coming from the interior of the continent in summer would be important in creating dry conditions around the presently humid continental margin - thus, even present southern Victoria and northern Tasmania (across a dry Bass Strait) would experience glacial aridity. Such a wind pattern suggests a major change from the present circulation pattern, and evidence of the great extent of wind blown material is found in the ocean bottom cores eastward of Australia. The more recent record of Lake Keilambete in Victoria shows interesting variations. It was dry at 15 000 BP, full at 10 000 BP, dropped at 3100 BP, rose again, and in the last 100 years has dropped 50 to 80 ft. This can be correlated with temperature and precipitation, but it appears that in order to dry the lake a precipitation reduction to 50 per cent of the present annual 800 mm would be necessary. The remarkable China loess deposits were then discussed, showing the detailed sequences of loess and soil episodes over a wide area that provide an extremely valuable chronology of paleoclimate.

Attention was then directed to the ^{18}O isotope data, which indicate globally a very rapid decay of icecaps compared with growth times from the past record, e.g. an icecap that might take 80 000 years to grow may apparently decay within 6000 to 8000 years. Current theories of ice ages concentrate on the external forcing of climate via the characteristics of the earth's orbit relative to the sun. The speaker suggested, however, that the great amount of dust produced from both the tropical and polar deserts at the peak of an ice age may have had a substantial effect, and that the advection of such dust may well be improtant in the decay of ice caps and sea ice via albedo changes; thus a self-controlling internal mechanism for ice growth might occur. If a time comparison is made between indices representing, on one hand, the intensity and duration of ^{18}O fluctuations, and on the other the duration and depth of the China loess/soil deposit sequences, a remarkable similarity is apparent. It appears that there is a marked tendency for each intense cold period to be followed by a substantial warm period, and for weak cold periods to be followed by weak warm periods. The opposite sequence does not, however, apply. Thus the evidence, while it is certainly not wholly conclusive, suggests an internal auto-catalytic feedback effect from dust generated in a period of ice age aridity leading to rapid ice cap decay. The study of such sequences may provide valuable insight into the character of future changes in the global climate.

In the discussion Dr Budd referred to the dust content sequences in glacial ice cores but pointed out that cause and effect interpretation is very difficult. Dr Webster discussed the Budyko view of ice age circulation being associated with deep ocean circulation; however, Dr Wells pointed out the much shorter (c. 1000 years) time of bottom water circulation in comparison with the longer time of major climatic variations. In reply to a question from Mr Streten, Dr Bowler emphasised the extent and homogeneity of the China loess deposits as a reliable climatic chronology. Mr Hunt drew attention to the comparatively small amount of ice at maximum glaciation in comparison to the vast ocean extent. However, it was pointed out that sea ice changes during ice ages were considerable, and that this ice cover appeared to be critical in the change of the global general circulation. In reply to a question from Dr Le Marshall and Mr Hunt, Dr Bowler pointed out the difficulty of interpretation of proxy evidence of the intensity of fossil winds and of oceanic rainfall.

N.A.S.