NEWS AND VIEWS

Climatic Records from Ice Sheets

OXYGEN isotope profiles through the entire depth of the ice sheets of Greenland and Antarctica have already been shown to provide an excellent record of climatic changes which are similar in timing and character to the main changes recorded elsewhere in the northern hemisphere by other methods. Potentially, the oxygen isotope δ values provide a more sensitive and more continuous profile of changes during the past 10^5 years than is available by any other method. This has been shown by detailed profiles for the Greenland ice sheet (W. Dansgaard, *Science*, **166**, 377; 1969) and for the Antarctic (Epstein *et al.*, *Science*, **168**, 1570; 1970). Epstein *et al.* also showed that hydrogen–deuterium ratios changed in step with the oxygen δ values. Dansgaard's group (*Nature*, **227**, 482; 1970) have used analysis of their data for the past 800 years to determine periodicities in climatic oscillations, and hence to predict climatic trends.

Although the method is extremely effective in recording small fluctuations of climate in terms of changing δ values, there remains a weakness in dating the various events recorded in the profiles. Development of carbon-14 dating of ice at various depths by *in situ* methods of extraction of carbon dioxide from the ice promises in due course an independent method of dating ice cores. At present, however, dates are estimated from various modifications of the steady state theory of the deformation of ice sheets. The new report by Johnsen, Dansgaard, Clausen and Langway on page 429 of this issue of *Nature* shows that variations of δ value along the core from Camp Century, Greenland, could, in principle, be used to determine absolute dates of various layers by direct counting of the summer and winter layers in much the same way as is done for varve clays. Their results show that although the seasonal amplitude of δ values is around 10 per mille in freshly deposited snow in north-west Greenland, as the snow is consolidated into firn a smoothing and filtering of δ values take place as a result of sublimation processes in the porous firn. The seasonal amplitude is reduced to around 2 per mille and shorter period variations are eliminated in ice of 280 years age at 115 m depth. By 100 m depth the ice is no longer porous so that there is little change in amplitude below that level until diffusion processes become effective. These take place in the Camp Century core at about 1,000 m depth (total depth 1,390 m) in ice around 6,000 to 8,000 years old, when the annual layers have been squeezed from 35 cm thickness to about 5 cm.

In practice, use of a mass spectrometer to determine a large quantity of δ values is a relatively expensive and lengthy task. Johnsen *et al.* estimate that a sampling interval of about one-eighth of an annual layer is necessary for satisfactory identification of layering. Some 70,000 measurements would therefore be necessary to trace all layers in the past 8,500 years. This task is an order of magnitude greater than the already impressive accomplishments of Dansgaard's group, but continuous profiling of the material now available is also prevented by lack of continuity in the core, because of various breaks and shattering in the drilling process.

Johnsen *et al.* also report results on the core from Byrd station, Antarctica. They first attempted to see if it is possible to determine the annual layering in the core from seasonal fluctuations of δ values, but, as other workers have found elsewhere in Antarctica, regular seasonal variations of δ value are not sufficiently distinct in areas of relatively low precipitation for such use. Surprisingly, an apparently regular seasonal layering over a period of four years appears at 1,387 m depth in ice layers 5 cm thick corresponding to an age around 15,500 years BP. It seems likely therefore that locations may be found where annual layering can be usefully determined to somewhat greater ages than the 8,300 years found as the limit at Camp Century.

The second part of Johnsen *et al.*'s article discusses results of the authors' 3,000 determinations of mean δ values for the Byrd station core, taken over core lengths corresponding to periods ranging from 12.5 to 100 years. These present the important basic data for the core in more detail than the 80-odd determinations given in Epstein *et al.* (*Science*, **168**, 1570; 1970). Although there is general agreement between the results of the two groups, the greater detail in the later work sets Johnsen *et al.* on the trail of relating individual climatic events in the Byrd core to similar events in the Greenland core and elsewhere. It is clear from the three different models of flow of the ice sheet near Byrd station presented as possibilities by Johnsen *et al.*, plus the separate interpretation of Epstein *et al.*, that uncertainty exists as to how far up the flow line above Byrd station ice at various depths in the core originated. It also seems likely that during the period of nearly 10^5 years covered by the ice core, directions of ice flow near Byrd station may have varied significantly.

In spite of these uncertainties, the basic data present detailed quantitative evidence which is of great importance to the interpretation of past climatic events. The importance of the data will grow considerably when it can be dated more accurately and related to the past flow conditions. As more such records of δ values are obtained from different locations, it should be possible to correlate individual climatic events between the different cores, and thus improve confidence in the dating process.—From a Correspondent.

The Limits of Palaeogravity

A. D. STEWART's recent attempt (*Nature*, **235**, 322; 1972) to define the limits of long-term variation in the gravity field is important not only for what it has achieved against heavy odds but no less for the potential significance of the phenomenon it was designed to elucidate. It is now more than 30 years since Dirac (*Nature*, **139**, 323; 1937) first suggested on cosmological grounds that the so-called gravitational constant (G) might be decreasing slowly with time. He proposed that G varies inversely with time, a relationship which Gilbert (*Mon.*