PALAEOCLIMATOLOGY

# Core correlations

*Rainer Zahn*

THE past two years have seen a revolution in our thinking on climate variability, largely because of the signs of ultra-fast climate oscillations found in deep ice cores. But the ice-core records for part of the last interglacial period disagree, and other evidence for the variability of the climate during this period has been eagerly sought — after all, it might be a model for our own interglacial. On pages 323 and 326 of this issue, Keigwin *et al.*[1] and McManus *et al.*[2] provide welcome evidence for how far oceanic records from the same period correlate with the ice-core data.

The story begins in September 1992, when the first results to emerge from the Greenland Ice-Core Project (GRIP), one of two international teams drilling at Summit in Greenland, indicated that the last glacial period had been punctuated by surprisingly warm intervals[3]. Within months, results from the nearby GISP2 core[4] had confirmed this and shown that ultra-fast, high-amplitude climate 'flickers' were common in the glacial period[5]. So a vigorous search started among marine palaeoclimatologists and modellers for clues to how the oceans' circulation might have contributed to these climatic lapses.

In September last year, Bond *et al.*[6] obtained high-resolution records of planktonic foraminifera abundances from a North Atlantic sediment core, and found that these were a near-perfect match with the ice-core records over the past 90,000 years (back through the last glacial period, but not the previous interglacial). The foraminifera abundances vary according to ocean surface temperature, so this provided part of the urgently sought link with the North Atlantic's thermohaline circulation. Bond *et al.* suggested that glacial climates were repeatedly perturbed by collapses of the North American ice sheet: huge iceberg surges flooded

## Linking ice-core records to ocean circulation

**Shown here are the positions of the Greenland 'Summit' ice cores (labelled 1) and the sediment cores used by Keigwin *et al.*[1] (4) and McManus *et al.*[2] (2 and 3) on pages 323 and 326 of this issue to monitor the North Atlantic's circulation during the last interglacial. The North Atlantic polar front (the circulation boundary between cold polar and warm boreal water masses) may be viewed as a door which opens and shuts in the course of climate shifts between interglacial and glacial conditions.**

**For our present age, the Holocene (left), the ice-core record implies a stable interglacial mode with no major perturbations (BP, before present). The 'door' in the North Atlantic is wide open and allows warm subtropical water masses to flow far to the north, thus driving the thermohaline circulation and heating up most of northwestern Europe.**

**During the last glacial period (centre), the 'door' was shut. Warm waters did not penetrate to the north, so the North Atlantic region cooled and continental ice sheets grew. The North Atlantic's thermohaline circulation was much weaker than today. The ice-core record for this period shows rapid climate oscillations thought to be linked to iceberg surges (triangles) coming from the North American 'Laurentide' ice sheet. Quasi-periodic ice-sheet collapses resulted in alternating maximum and minimum rates of iceberg and meltwater discharge to the North Atlantic[6], which destabilized the glacial mode of circulation to the extent that the polar front door opened, producing intermittent spurts of enhanced thermohaline circulation.**

**For the peak-interglacial Eemian period (right), the record from the Greenland Ice-core Project GRIP, though not from the sister core GISP2, implies large-scale and rapid climate oscillations. If the North Atlantic's thermohaline circulation was involved, this would imply rapid retreats and advances of polar water masses which would have resulted in fast shifts of the polar front. The new marine records[1,2] imply that this conceptual model may hold for the wider interglacial stage 5. For the peak interglacial Eemian, they suggest rather that surface water conditions and deep-water flow in the North Atlantic were stable; but large-scale fluctuations in the Eemian section of a terrestrial pollen record (ref. 9; labelled 5) might be the elusive terrestrial analogues of the climate instabilities seen in the Greenland ice-core record.**

**R. Z.**