b29 The Eemian < ice volume, summer insolation, MIS, Bermuda Rise >

The Holocene has been a time of warmth that began abruptly 11,800 years ago. The most recent time of comparable warmth before (during the Pleistocene) lasted for about 9000 years and began 127,000 years ago. During that time, an epeiric sea, named the *Eemian Sea*, flooded in from the North Sea, shallowly inundated much of north Europe, and made Scandinavia an island. Microfossils (foraminifera in the clayey sediments that accumulated in this shallow sea and pollens in its fresh-water swamp margins) allow for precise correlations. The time recorded is internationally called the *Eemian*.[1]

The *Eemian* interglacial or marine isotope stage(s) (MIS, see ***Figure b29.1***) 5e (called the *Sangamon* in North America, the *Ipswichian* in the UK, and the *Riss-Würm* in the Alps) 118,000-127,000 years ago, as the Greenland ice core record shows, "was stable," Kurt M. Cuffey writes, and for several millennia before its end was "5°C warmer" than is the present.[2] However, MIS 5e, which lasted for 9,000 years, was driven mainly by greater northern summer insolation. Then, global mean sealevel was 4-6 m higher than during the Holocene. A marine sediment core from the Ocean Drilling Program (ODP) site 646 into the continental rise of southern Greenland, records that the Greenland ice sheet was sufficiently shrunken to allow for the development of peripheral boreal spruce and pine forests during MIS 5e, 11, and 13. Holocene northern summer insulation is as MIS 11, which lasted for 50,000 years beginning 425,000 years ago. However, Greenland has remained too cold for forests during the Holocene and this also appears to have been so for the durations of MIS 7 and 9.[3]

Jess F. Adkins and his team have discovered, from the analysis of a North Atlantic deepsea core, that the end of an interglacial can be abrupt indeed.[4] The core they analyzed extends back to just before the Eemian (MIS 5e). It was obtained where North Atlantic Deep Water, which constitutes the lower limb of the Atlantic's heat-carrying conveyer thermohaline circulation that results primarily from downwelling in the Nordic and Labrador Seas (see ***Figure b32.1***, p.121) and upwelling throughout the rest of the ocean, sweeps over nutrient-rich Antarctica bottom water. Deep penetrating gyres, which spin off the surface Gulf Stream, act to re-suspend fine-grained bottom sediments over a broad region of the Sargasso Sea and deposit these preferentially on the Bermuda Rise. This sediment "focusing" is the explanation for core-site accumulation rates being 10-100 times the average for the open ocean. The swept-in (from the south) material is mostly dark clay. From overlying water, particulate, white in color, calcite ($CaCO_3$) falls down to accumulate. The $\%CaCO_3$ (grey scale) is a proxy for variations in the accumulation rate of the sediments. The precise accumulation rate, and age, for all parts of the core (which is 5300 cm long) can be known for the (100 cm) length of it that lies between two oxygen isotope age control points: the beginning of the 5d/5e transition 114 Ky BP (at 4,280 cm) and the 5e/6 transition 131Ky BP (at 4,380 cm).

The end of 5e is a scant 400 year-long transition to a harsher climate. Over this short time, Cd/Ca ratios, percentage fragmentation, red/yellow color balance, and clay flux, synchronously change to values that record bottom waters with a higher proportion of swept in "southern-source component." During stage 5e, was 9,000 years of climate stability in both surface and deep waters over the Bermuda Rise core site. Variance of all climate tracers during stage 5e was smaller than in the following cold substage 5d and the preceding from-glacial transition 5e/6. ❑

Figure ***b****29.1* The standard deepsea oxygen isotope chronology of marine isotope stages (MIS) (numbered going back in time) developed by the SPECMAP group *(Imbrie et al.*, 1992, 1993) from core-down averaged $\delta^{18}O$ curves for benthic foraminifera.[5]