Deglacial eolian regimes in New England

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ABSTRACT

Ventifact-bearing cover sands, wind-driven lacustrine spits, and fluted bedrock outcrops in New England indicate that a strong anticyclonic circulation under moist periglacial conditions accompanied early recession of the Laurentide ice sheet. Dunes from this interval are conspicuously absent. An abrupt shift to warmer and drier conditions during the Bolling/Allerod period (12.7–11 ka) was apparently associated with rapid accretion of transverse dunes built by northeast winds along the shore of New England's largest ice-recessional lake. By the time of lake drainage, however, the anticyclonic circulation had been replaced by a northwesterly wind regime, resulting in erosion of the older deposits, the development of parabolic dunes, and gradual stabilization associated with revegetation. Reactivation of the dunes was associated with a return to colder and windier conditions during the Younger Dryas (11–10 ka) and with anthropogenic changes during the historic period, but not during Holocene time.

INTRODUCTION

Climatic changes associated with recession of the Laurentide ice sheet in northeastern North America have been simulated in separate climatic experiments (Manabe and Broccoli, 1985; Kutzbach and Guetter, 1986; Rind, 1987). In each case, the morphology of the Laurentide ice sheet, the areal extent of sea ice, and changing insolation patterns were largely responsible for determining model output (Fig. 1). In spite of large uncertainties associated with transient changes in the ice sheet (Clark, 1992), all of the models require the following conditions. (1) A subcontinental scale anticyclonic circulation must have been present over the ice sheet, and its intensity must have diminished proportionately with glacier recession. (2) Colder-than-present temperatures, especially during summer, and the alignment of storm tracks along the Atlantic margin must have contributed to moist periglacial conditions during early ice withdrawal. (3) The breakdown of the glacial anticyclone would have allowed westerly airflow to resume.

Can these predictions be confirmed? The abundance of sedge and willow in the early pollen records (Davis, 1983; Webb et al., 1987) is consistent with simulations requiring colder and wetter conditions during the early part of the deglacial hemicycle (18–14 ka [1 ka = 1000 ^{14}C yr B.P]; COHMAP, 1988). Although the band of forb pollen south of the ice sheet at 12 ka suggests that the ice sheet had a peripheral effect on plant communities, the regional pollen stratigraphy cannot be used to confirm the direction, intensity, or seasonality of the wind regime. Other proxy climatic records (treeline variations, lake records, and insect macrofossils) are also not directly dependent on the paleowind regime and are generally restricted to the Holocene epoch. The localized, transient development of permafrost during glacier recession is suggested (Stone and Ashley, 1992) but not confirmed (Black, 1983) by the geologic evidence, and it provides no useful constraint on the paleowind regime.

In contrast to other proxy records, the eolian deposits of New England can be used to confirm some results of these climate simulations and to evaluate the terrestrial response to abrupt climate changes, because, unlike biological data, eolian deposits define limits for the direction, seasonality, and strength of former winds (Sweet, 1992), parameters integral to the design of atmospheric general circulation models (GCMs). Eolian bed forms (dunes and ripples) are especially valuable because their primary sedimentary structures reflect specific, instantaneous threshold conditions, rather than the integrated effects of biological and hydrophysical processes. For example, David (1981) used the eolian stratigraphy in the northern Great Plains to demonstrate not only the existence of the glacial anticyclone along the western sector of the Laurentide ice sheet during early Holocene time, but an abrupt reversal in the prevailing direction of sand-moving winds from southeasterly to westerly associated with its breakdown. Recent reconstructions in Alaska (Lea and Waythomas, 1990), the Pacific northwest (Barnosky et al., 1987), and in the north-central United States (Forman

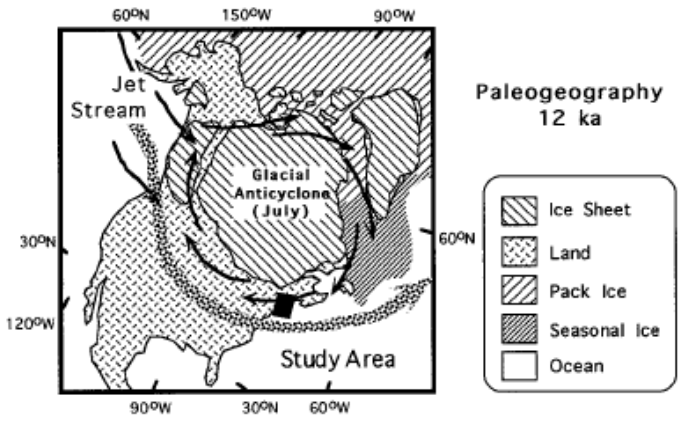

Figure 1. Environmental conditions at 12 ka showing the location of the study area relative to the anticyclonic circulation required by the presence of the Laurentide ice sheet. Adapted from COHMAP (1988).

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