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POSSIBLE MECHANISM FOR THE RAPID ADVANCE AND RETREAT OF THE LAKE MICHIGAN LOBE BETWEEN 13 000 and 11 000 YEARS BP*

(Abstract only)

by

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ABSTRACT

Radiocarbon dates of 13 000 a BP at the Cheboygan bryophyte bed in Michigan and 11 800 a BP at the Two Creeks site in Wisconsin bracket three ice advance/retreat cycles and one advance to the Two Creeks site of the Lake Michigan lobe. These advances are documented by individual till sheets separated by lacustrine fine sand and silt-clay units. The tills are distinguishable only by small differences in grain-size distribution and clay-mineral content. They probably reflect closely the composition of the sediment being deposited in the Lake Michigan basin between advances. Because of lack of exposure and probable erosion of pre-existing material by each successive ice advance, the maximum extent of retreat between the deposition of the tills cannot be documented. We can demonstrate, however, that a total of at least 850 and perhaps over 1 000 km of combined retreat and advance took place during this period of 1 200 a. This implies that the change in ice-margin position averaged 0.7 to 0.9 km a^{-1}, a rate higher than most recorded on modern glaciers. Since this is an average rate over 1 200 a and encompasses several advances and retreats, the actual rate of change in ice-margin position must at times have been considerably more rapid.

There is very little evidence in the pollen record of climatic changes that would explain rapid advances and retreats of this magnitude. This observation has led to suggestions that late Wisconsin age advances in various parts of the Great Lakes were surges unrelated to climate change.

We suggest instead that the shape of the Lake Michigan basin, and the substantial changes in water level that might have occurred in it, could have greatly amplified the smaller fluctuations of the ice margin that have been documented across the eastern United States (presumably resulting from changes in mass balance), and so could have produced the rapid advances and retreats seen in the stratigraphic record.

The Lake Michigan basin consists of two deep areas with a high area in between. Present water depths are over 280 m in the northern basin, less than 60 m on the mid-lake high, and more than 160 m in the southern basin. All of the ice advances discussed above seem to have stopped either on the northern (up-stream) side or on the crest of the mid-lake high. Even conservative estimates of the amount of isostatic crustal depression at that time suggest that if water could drain into the eastern Great Lakes during retreat of the ice to the north end of the basin, lake level could have dropped as much as 220 m. Although there is no stratigraphic evidence that drainage out of the north end of the basin took place between these ice advances, there are valleys cut in drift and bedrock extending from the north basin eastward toward the Lake Huron basin. It is possible that these valleys formed during the rapid draining of the lake between ice advances. Whenever ice advanced, blocking the northern outlet, lake level rose back to the Glenwood level (which has well-developed beaches), and the lake drained through the Chicago outlet to the south.

Our model is as follows. Consider a grounded ice sheet filling the northern basin and terminating at an equilibrium position on the crest or up-stream side of the mid-lake high. The ice sheet would be unstable in that any initial retreat of the grounding line (i.e. the boundary between the grounded ice and either floating ice or open water) would accelerate as the grounding line moved northward into deeper water. Now let a general marginal retreat occur. Rapid retreat of the grounding line follows until the grounding line passes the northern lake outlet. The consequent large drop in lake level

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leads then to a readvance of the grounding line, re-blocking the outlet and causing the basin to refill with water. A new equilibrium position of the grounding line is established on the northern side of the basin. As the mass balance increases again, associated with a general marginal advance of the ice sheet, an ice shelf forms (if it was not already there) and grows southward until it grounds on the mid-lake high. That then causes the grounding line to advance rapidly to the position of the margin, whereupon the process is ready to repeat. Each advance would be smaller than the previous because rebound would be tilting the north end of the lake upward, shoaling the water and causing ice shelves to ground further north on the mid-lake high. In addition, the mass of ice to the north was probably shrinking.

Grain-size distribution and mineralogic characteristics of the tills along the Lake Michigan shoreline have been analyzed extensively. However, the existence of a floating ice shelf in the basin at various times during this period cannot, at present, be deduced from the sediment.

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