

THE PALIMPSEST

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Facts and Principles of Glaciation

Did you know that at one time the Mississippi River flowed in a course that lay west of Mason City and Iowa City? That at another time the River flowed eastward from near the present site of Clinton to the Illinois River? That at still another time it flowed into and out of a lake that occupied the lower portions of the valleys of the Iowa and Cedar rivers including the site of Iowa City? That the rapids and gorge at Keokuk are thousands of years older than the Rock Island Rapids? That these and other changes in the course of the River were caused by the advance and retreat of great glacial ice sheets?

The history of the Mississippi, especially in Iowa and adjacent Illinois and Wisconsin, can be traced through the relentless march of gigantic ice sheets.

Continental Ice Sheets

About 120 years ago it was discovered that during the most recent division of geologic time (called the Pleistocene epoch) great sheets of ice

covered large areas in northern Europe, where such ice sheets do not exist today. Features known to have been caused by ice near the ends of existing glaciers in the Swiss Alps were found to be distributed widely over the surface. Soon thereafter similar features that had been known to exist in northern United States and Canada were ascribed also to the work of glaciers. These evidences of former glaciation are so clear that what was known a century ago as the "Glacial Theory" is now considered a fact. The glaciated and unglaciated parts of North America are shown on the map on the inside back cover.

Where and when more snow falls each winter than is melted the following summer, ice that results from compaction of snow accumulates. When the mass of ice is thick enough it spreads slowly out from the area of accumulation. The rate of motion of the ice exceeds the rate of melting at the ice border, and the ice edge moves slowly forward. When and if ice motion is balanced by melting, the ice border remains stationary. If the climate then so changes that less snow falls in the area of accumulation, or the border ice melts faster, or both, melting comes to exceed motion and the ice edge retreats.

After a continental ice sheet has advanced and retreated, a *drift sheet* is left covering the surface. That part of the drift that is deposited directly from the ice is not sorted and contains

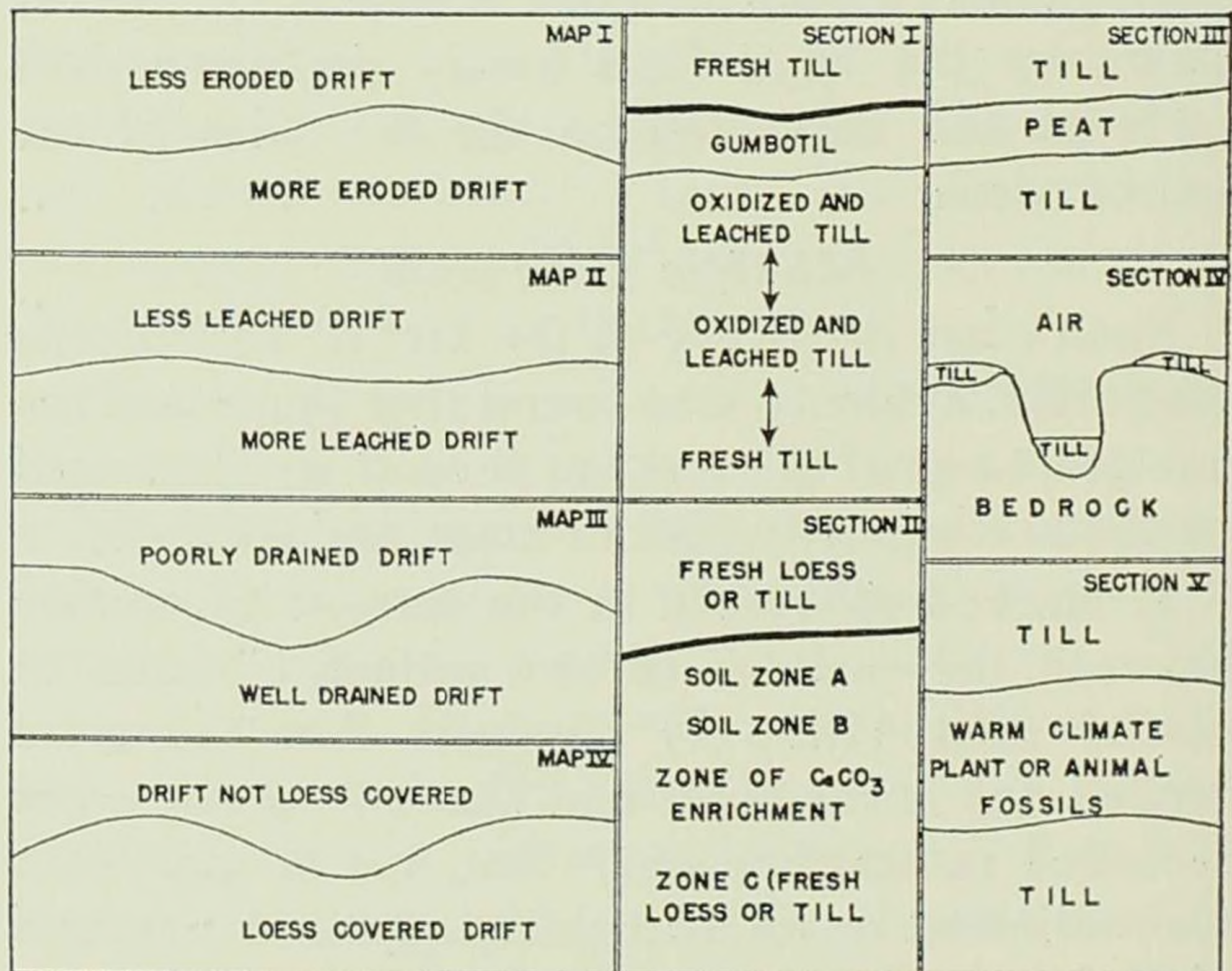
mixed boulders, cobbles, pebbles, angular rock fragments, sand, silt, and clay. This is called *till*. At and near the border of the ice sheet melt-water receives from the ice the finer portions of the glacial load and deposits material that is sorted to form layers of gravel, sand, silt, and clay. Such materials, called *outwash*, take the form of *outwash plains* or *valley trains*. *Loess* is silt that is blown by the wind from newly deposited drift surfaces and deposited on the lee sides of the source areas.

Multiple Glaciation

Soon after discovery of the fact of Pleistocene glaciation, evidence was found that there was not one great age of glaciers but several, as illustrated on the accompanying set of maps and sections.

A marked difference in the amount of erosion between the surfaces of two adjacent bodies of glacial drift (Map I) suggests that the more eroded one is the older and that two glaciers are recorded rather than one. One age of glaciation was followed by an interglacial age and a second glacial age. Similarly, the fact that the soluble materials of the southern drift (Map II) have been dissolved (leached) out to a greater degree than the northern drift indicates that the surface of the southern drift has been exposed to weathering for a longer time than the northern drift and is the older. Surfaces of newly exposed drift sheets are normally poorly drained and have

many lakes and marshes. With time such undrained depressions become connected by streams that develop valleys and finally drain the lakes and swamps. Thus, a well drained drift surface (Map III) is likely to be older than a poorly drained one. Map IV suggests that loess derived from drift has been deposited on an older drift.



Sketch maps and diagrammatic sections illustrating evidences of plural or multiple glaciation.

Similarly, and with some overlapping, the vertical sections illustrate evidences of ages of glaciation separated in time by interglacial ages. Such sections are exposed at the surface naturally — as on undercut valley walls or steep hillsides; or artificially, as in highway or railway cuts, quar-

ries, or pits. Even where there are no exposed materials, "subsurface" information may be gained from well logs, cores and cuttings, or from shallow drilling or boring for samples.

Gumbotil is thoroughly weathered till and takes a long time for its formation. In the typical section, gumbotil grades down through partially weathered till to fresh till. In Section I it is recorded that a drift sheet was deposited in one glacial age, the ice sheet retreated and there was a long time of weathering and this was followed by a second ice sheet that deposited the overlying fresh till in a new glacial age. Section II illustrates a "buried soil profile." Glacial material was deposited first and then weathered to form soil zones, after which loess, till, or other glacial material was deposited on the older soil. Again two glacial ages and an interglacial age are recorded. The peat of Section III, lying between two tills, was known as a "forest bed" by early glacial geologists. The significance of such a sequence is clear. Section IV shows an upland till deposited before the valley was cut, and a valley till that is younger than the valley. The time consumed in valley cutting is the measure of duration of an interglacial age. Section V records a glacial climate, a warm interglacial climate, and a second glacial climate.

Still another method of determining plurality or multiplicity of Pleistocene glaciation, not illus-

trated diagrammatically, is known as the radio-carbon or C-14 method. When a plant or animal dies it contains a known amount of carbon-14 but this "isotope" breaks down as it becomes older. The rate of this radioactive change is known. In about 40,000 years all of the C-14 is gone from a buried log, bone, or shell, and the material is said to be radioactively dead. By careful laboratory measurement of the C-14 content of fossil plants or animals, or of peat, the "absolute age" of the inclosing or burying glacial or interglacial material can be determined. In this way one drift sheet may be found to be about 25,000 years old and a directly overlying drift 10,000 years old. The two glacial subages are separated by an interglacial subage.

A glacial age is considered to start when the ice begins to spread and to end when the ice sheet has melted back to the center of accumulation. An interglacial age then is the time from the total disappearance of one glacier to the beginnings of the next one. In general, interglacial ages are much longer than glacial ages, and are measured in many thousands of years. Interglacial subages are much shorter. The subage glaciers retreat considerably, but not back to the source, and then readvance.

Pleistocene (Glacial) Classification

By application of such criteria and many man-years of careful field and laboratory work, it has

now been determined that during the Glacial (Pleistocene) epoch of geological history there were four glacial ages, in which great ice sheets invaded the northern portions of the Mississippi Valley, and three long interglacial ages. It is also concluded that the fourth or Wisconsin glacial age is divisible in the upper Mississippi Valley into five glacial subages, as shown on the accompanying chart.

CLASSIFICATION OF PLEISTOCENE (GLACIAL) TIME

Epoch	Age	Subage
Recent		
Pleistocene or Glacial	Wisconsin (glacial)	Mankato
		Cary
		Tazewell
		Iowan
		Farmdale
	Sangamon (interglacial)	
	Illinoian (glacial)	
	Yarmouth (interglacial)	
	Kansan (glacial)	
	Aftonian (interglacial)	
	Nebraskan (glacial)	

Absolute dates and durations of pre-Wisconsin glacial and interglacial ages cannot be determined directly, for materials containing carbon older than the Wisconsin age are radioactively dead. But the Wisconsin age began less than 40,000 years ago, and many age determinations of sub-

age drift sheets have been made. The climax of Mankato glaciation took place about 12,000 years ago. Similar figures for the other Wisconsin sub-ages are about as follows: Cary, 14,000; Tazewell, 17,000; Iowan, 20,000; Farmdale, 26,000. From the amount of weathering and erosion that are known to have taken place during the pre-Wisconsin interglacial ages, it seems reasonable that the duration of the Sangamon may have been something like 75,000 years and that the durations of the Yarmouth and Aftonian may be measurable in hundreds of thousands of years.

Glacial Map of North America

Reference is here made again to the glacial map of North America on the inside back cover. From the Keewatin center of accumulation west of Hudson Bay and the Labrador center east of Hudson Bay the several ice sheets spread southward into Iowa and Illinois and also into states farther west, south, and east. In the middle states the line separating the glaciated and unglaciated areas follows roughly the courses of the Missouri and Ohio rivers.

It should be understood, however, that the glacial map does not represent the distribution of the ice at any one particular time. West of the Mississippi River the Kansan and Nebraskan ice sheets reached about 200 miles farther south than did younger glaciers. East of the Mississippi it was the Illinoian glacier that reached farthest

south. On the east coast and in the Dakotas the deposits of the late Wisconsin ice sheets mark the line between the glaciated and unglaciated areas.

The Driftless Area

A map of the Driftless Area (see inside back cover) shows there was no single age or subage when the Driftless Area, as its boundaries are drawn, was surrounded by ice. The drift at the west border marks the east margin of the Nebraskan ice sheet. The drift marking the east border is of Cary age. In northwestern Illinois the bordering drift was originally mapped as Illinoian but it may be Farmdale. The extreme southwestern portion of the Driftless Area in Iowa is bordered by Kansan drift. Kansan and Farmdale drifts form the north boundary. The point is that each ice sheet avoided this particular area. Glaciers one after another approached the Driftless Area but none covered it.

Why all the Pleistocene glaciers failed to cover the Driftless Area was explained by T. C. Chamberlin in the nineteenth century, and his idea is still good. An area known as the Wisconsin Highland or the Wisconsin Arch has been uplifted from time to time and has always been higher than its surroundings. The rocks are generally resistant to erosion. Less resistant sedimentary formations dip away from the highland to the west, south, and east. In Glacial times this highland was bordered on the east by the much lower

Lake Michigan basin and on the west by the Lake Superior basin. As the ice sheets spread southward, great lobes were led forward down these troughs and there was simply not enough ice between the lobes to cover the highlands.

In general it may be said that the glaciers that covered Iowa west of the Driftless Area advanced from the Keewatin center through the Lake Superior lowland and that the ice sheets that affected Illinois came down the Lake Michigan basin from the Labrador center. However, the Kansan ice sheet from the Keewatin center crossed Iowa and moved into Illinois, and the Illinoian glacier from the Labrador center moved into southeastern Iowa from Illinois.

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