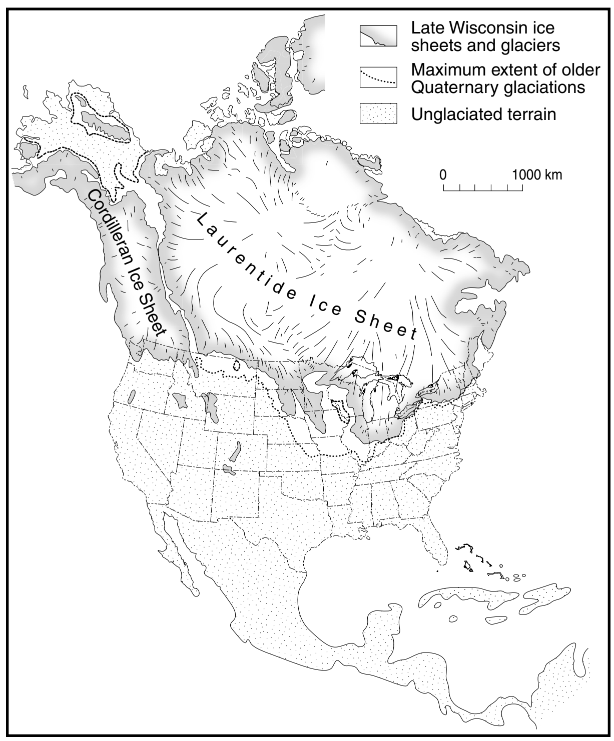
Quaternary Glaciations in Illinois

ORIGIN OF THE GLACIERS

Over the past 1.6 million years, known as the Quaternary (kwa-TURN-ah-ree) Period of geologic time, most of the northern hemisphere above the 50th parallel was repeatedly covered by glacial ice. The cooling of the earth's surface began at least 2 million years ago, and with that cooling, ice sheets eventually formed in sub-arctic regions and spread outward until they covered the northern parts of North America. With ongoing climatic change during this period, these ice sheets would form and reform many times.

Early studies of the glaciated landscape concluded that four separate glacial episodes had occurred in North America. The deposits from each episode were separated from each other by buried soils, which formed on the land during warmer intervals between glaciations. More recent studies have shown that there were more than four glaciations, but the actual number is not yet known. These studies, based on buried soils and glacial deposits, estimate 4 to 8 episodes of ice advance and melting over Illinois. We now know that the older glacial sediments are more complex than originally thought and probably represent more than one episode. Until we know more, all of the glacial deposits before the Illinois Episode (from 300,000 to 125,000 years ago) are classified as pre-Illinoian deposits.



The North American ice sheets developed when the mean annual temperature was perhaps 4° to 7°C (7° to 13°F) cooler than it is now and winter snows did not completely melt during the summers. Because this time of cooler conditions lasted tens of thousands of years, thick masses of snow and ice accumulated to form glaciers. As the ice thickened, the great weight of the ice and snow caused the glaciers to flow outward at their margins, in several instances for hundreds of miles. As the ice sheets expanded, the areas in which snow accumulated probably also increased in extent.

Several times, huge tongues of ice, called lobes, flowed southward from two different centers, one east and one west of present-day Hudson Bay, and converged in the central lowland between the Appalachian and Rocky Mountains. There the glaciers made their farthest advances to the south. The sketch at right shows the centers of flow, the general directions of flow from the centers, and the southern extent of glaciation. Because Illinois lies entirely in the central lowland, it was invaded by lobes from both accumulation centers.

EFFECTS OF GLACIATION

Quaternary glaciers and the waters melting from them changed the landscapes they covered. The glaciers scraped and smeared the landforms they overrode, leveling and filling many of the minor valleys and even some of the larger ones. Moving ice carried colossal amounts of rock and earth, commonly for hundreds of miles; the glaciers scoured the land surface and kneaded much of the rock debris into the moving ice.

The continual floods of glacial meltwaters entrenched new drainageways and deepened old ones, and partly refilled them with the great quantities of rock and earth carried by the glaciers. According to some estimates, the amount of water that was drawn from the sea and changed into ice during a glacial episode lowered the sea level by 300 to 400 feet below its present level. When these continental ice sheets melted, tremendous volumes of water eroded and transported sediments.

In most of Illinois, glacial and meltwater deposits buried the previous rocky, low, hill-and-valley terrain and created the flatter landforms that became our prairies. The glaciers deposited across roughly 90% of the state a mantle of ground-up rock debris, gravel, sand, and clay that at points reaches thicknesses of 400 to 500 feet. These deposits are of incalculable value to Illinois residents because they are the parent material of our rich soils, the source of drinking water for much of the state, and provide large amounts of sand and gravel for construction.

GLACIAL DEPOSITS

Drift is the term for all the deposits of earth and rock materials moved by glacial activity. ***Till*** is the type of drift deposited directly by glacial ice. Because till was not moved much by water, this sediment is unsorted, containing particles of many different sizes and compositions. It is also unstratified (unlayered). A till may contain materials ranging in size from microscopic clay particles to large boulders. Most tills in Illinois are pebbly clays with only a few boulders. For descriptive purposes, a mixture of clay, silt, sand, and boulders is called ***diamicton***. This term describes a deposit that could be interpreted as till or as a product of a different process called mass wasting, which includes such things as rockslides or other similar gravity-propelled earth movements.

End moraines are the arc-shaped ridges that formed when till piled up along a glacier's leading edge when the ice was melting at roughly the same rate as the flowing ice moved forward. Till also formed ***ground moraines***, or ***till plains***, which have gently undulating surfaces formed as the ice front melted back. Deposits of till identify areas once covered by glaciers. The many alternating ridges and plains in northeastern Illinois are the successive end moraines and till plains formed by the retreating Wisconsin Episode glaciers (about 25,000 to 13,500 years ago).

Outwash is the sorted and stratified sediments deposited by meltwater flowing away from the glacier. Outwash deposits are layered in beds because the flow of water that moved the material varied in gradient, volume, velocity, and direction. As a meltwater stream carried the rock materials along, it sorted them by size. As stream velocity decreased, heavier gravels and cobbles were deposited before fine sands, silts, and clays, which were deposited farther downstream. Typical Quaternary outwash in Illinois consists of multilayered beds of sands and gravels and some silts. These beds look much like modern stream deposits in some places. Outwash tends to be coarser and less weathered than stream sediment (alluvium), which is generally finer than medium sand and contains variable amounts of weathered rock debris.

Meltwater deposits are found not only in the area once covered by the glaciers but also in areas far beyond it. Meltwater streams ran off the top of the glacier, in crevices within the ice, and under the ice. In some places, the cobble-gravel-sand filling of the bed of a stream that flowed within or under the ice is preserved as a sinuous ridge called an ***esker***. Some eskers in Illinois are made up of sandy, silty, gravelly deposits and contain mass-wasted diamicton material. Cone-shaped mounds of coarse outwash, called ***kames***, were formed where meltwater plunged through crevasses in the ice.

The finest outwash sediments, the silts and clays, formed bedded deposits in the ponds and lakes that filled glacier-dammed stream valleys, the low-lying areas on till plains, and some low till plains where meltwaters were diked behind end moraines. Meltwater streams that entered a lake rapidly lost velocity and dropped the sands and gravels they carried, forming deltas at the edge of the lake. Very fine sands and silts were commonly redistributed on the lake bottom by wind-generated currents, and the clays, which stayed in suspension longest, slowly settled out and accumulated with them.

Along the ice front, meltwater ran off in innumerable shifting, cross-cutting, and short-lived streams (called braided streams), which laid down an ***outwash plain***, a broad, flat blanket of outwash. Outwash was also carried away from the glaciers in valleys cut by floods of meltwater. The Mississippi, Illinois, and Ohio Rivers occupy valleys that were major channels for meltwaters and that were greatly widened and deepened during the greatest meltwater floods. When the floods waned, these valleys were partly filled with outwash far beyond the ice margins. Such outwash deposits, largely sand and gravel, are known as valley trains. Valley train deposits may be both extensive and thick. For instance, the long valley train of the Mississippi River Valley is up to 200 feet thick in places.

LOESS, EOLIAN SAND, AND SOILS

One of the most widespread types of sediment resulting from glaciation was carried not by ice or water, but by wind. ***Loess*** (rhymes with "bus") is the name given to windblown deposits dominated by silt-sized particles. Most of the silt was derived from wind erosion of the valley trains. Wind action also sorted out sand, which commonly formed ***sand dunes*** on the valley trains or on the adjacent uplands. In places, sand dunes have migrated up to 10 miles away from the principal source of sand. Flat areas between dunes are generally underlain by ***eolian*** (windblown) ***sand*** that was usually reworked by water action. On uplands along the major valley trains, loess and eolian sand are commonly interbedded. With increasing distance from the valleys, the eolian sand thins and disappears, often within one mile from the valleys.

Eolian deposition occurred when certain climatic conditions, most likely following a seasonal pattern, were met. Deposition was probably in the fall, winter, or spring when low precipitation volumes and low temperatures caused meltwater floods to abate, exposing the surfaces of the valley trains and permitting them to dry out. Throughout the Quaternary Period, prevailing westerly winds deposited loess more thickly on the east sides of the source valleys. Although the loess thins rapidly away from the valleys, it extends over almost all of Illinois.

Each glacial episode was followed by an interglacial episode that began when the climate warmed enough to melt the glaciers and their snowfields. During these warmer intervals, when the climate was similar to that of today, drift and loess surfaces were exposed to weather and the activities of living things. Consequently, over most of the glaciated terrain, soils developed on the glacial deposits and altered the composition, color, and texture of the deposits. Such soils were generally destroyed by later glacial advances, but some were buried. Those that survive serve as "key beds," or stratigraphic markers, and are evidence of the passage of a long interval of time.

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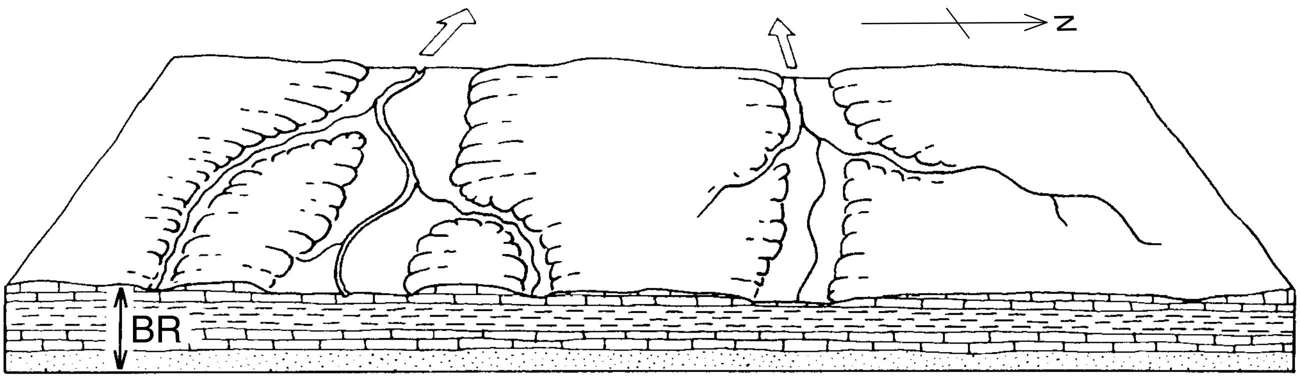
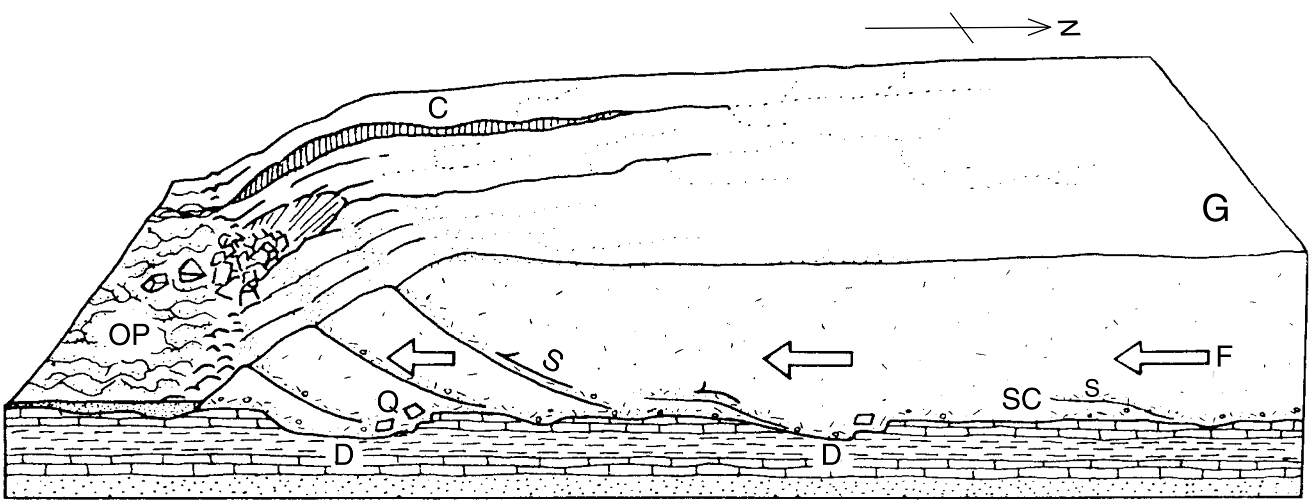
GLACIATION IN A SMALL ILLINOIS REGION

These diagrams show how a continental ice sheet might have looked at various stages as it moved across a small region in Illinois. The diagrams illustrate how the ice sheet could change the old terrain and create a landscape like the one we live on. To visualize how these glaciers looked, geologists study the landforms and materials left in the glaciated regions, as well as present-day mountain glaciers and polar ice caps.

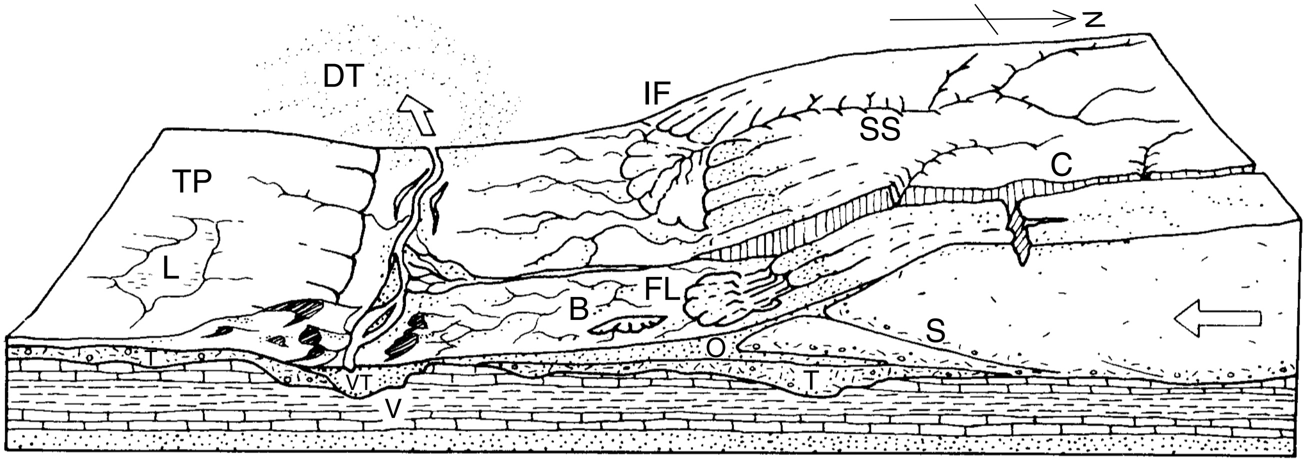
The block of land in the diagrams is several miles wide and about 20 miles long. The vertical scale is exaggerated; layers of material and landforms are drawn proportionally thicker and higher than they actually are so that they can be easily seen.



1 The Region Before Glaciation — Like most of Illinois, the region illustrated is underlain by almost flat-lying beds of sedimentary rocks—layers of sandstone ( ), limestone ( ), and shale ( ). Millions of years of erosion have planed down the bedrock (BR), creating a terrain of low uplands and shallow valleys. A residual soil weathered from local rock debris covers the area but is too thin to be shown in the drawing. The streams illustrated here flow westward and the one on the right flows into the other at a point beyond the diagram.



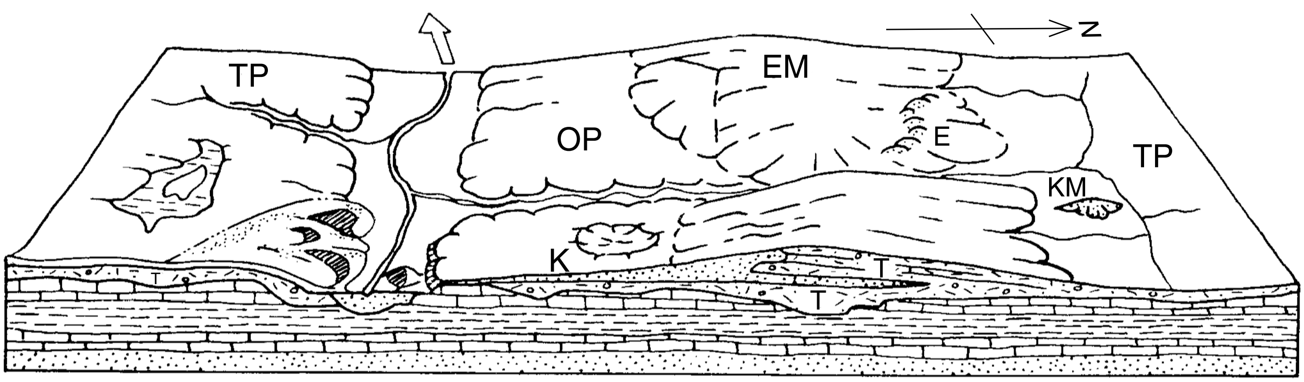
2 The Glacier Advances Southward — As the glacier (G) spreads out from its ice snowfield accumulation center, it scours (SC) the soil and rock surface and quarries (Q)—pushes and plucks up—chunks of bedrock. The materials are mixed into the ice and make up the glacier's "load." Where roughness in the terrain slows or stops flow (F), the ice "current" slides up over the blocked ice on innumerable shear planes (S). Shearing thoroughly mixes the load. As the glacier spreads, long cracks called "crevasses" (C) open parallel to the direction of ice flow. The glacier melts as it flows forward, and its meltwater erodes the terrain in front of the ice, deepening (D) some old valleys before ice covers them. Meltwater washes away some of the load freed by melting and deposits it on the outwash plane (OP). The advancing glacier overrides its outwash and in places scours much of it up again. The glacier may be 5,000 or so feet thick in Canada and tapers to the margin, which was probably in the range of several hundred feet above the old terrain. The ice front advances perhaps as much as a third of a mile per year.



3 The Glacier Forms an End Moraine — A warming climate halts the glacier advance across the area, and the ice begins to melt as fast as it advances. The ice front (IF) is now stationary, or fluctuating in a narrow area, and the glacier is forming an end moraine.

As the top of the glacier melts, some of the sediment that is mixed in the ice accumulates on top of the glacier. Some is carried by meltwater onto the sloping ice front (IF) and out on to the plain beyond. Some of the debris slips down the ice front in the mudflow (FL). Meltwater runs through the ice in a crevasse (C). A supraglacial stream (SS) drains the top of the ice, forming an outwash fan (OF). Moving ice has overridden an immobile part of the front on a shear plane (S). All but the top of a block of ice (B) is buried by outwash (O).

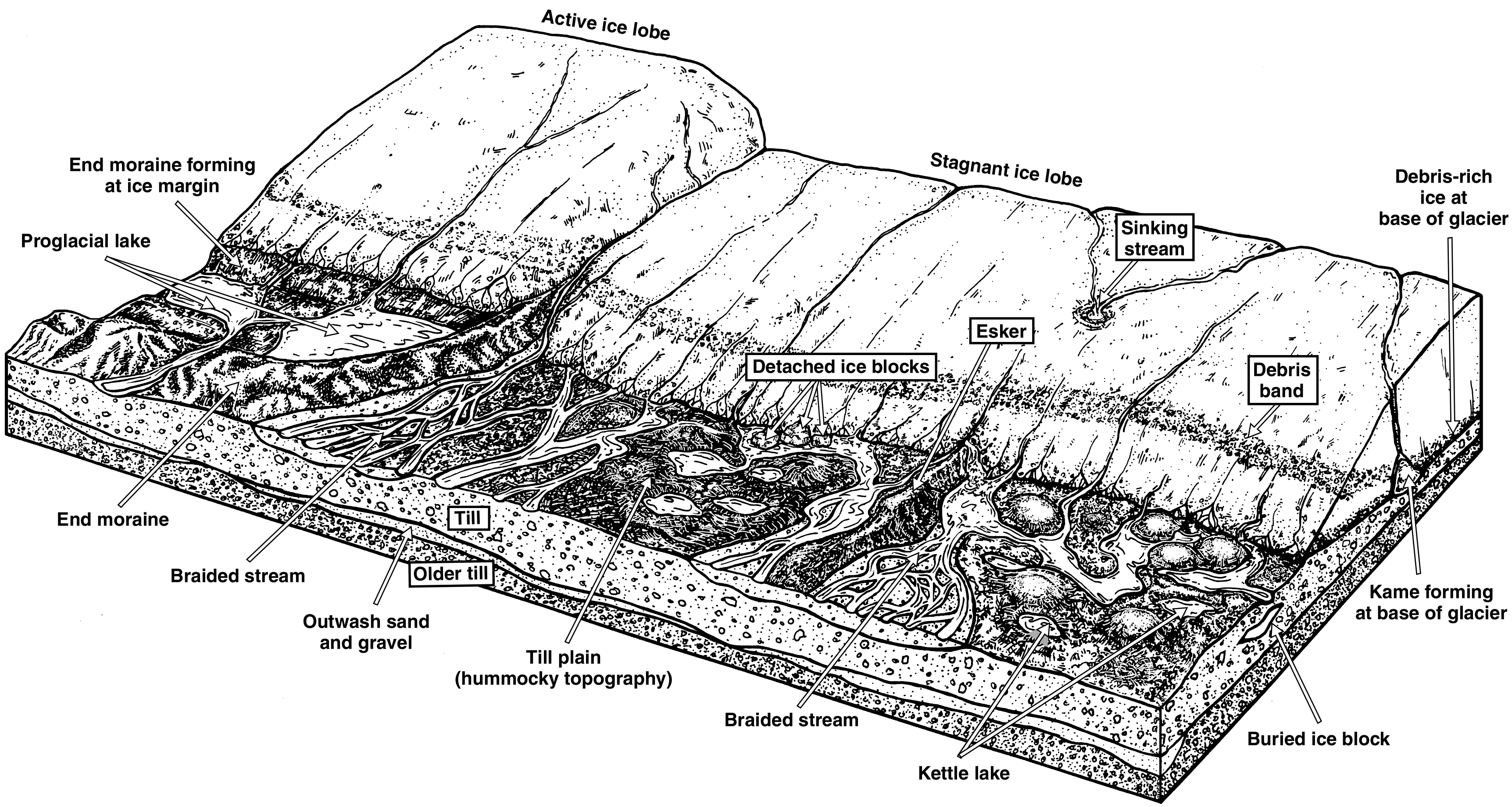
Sediment from the melted ice of the previous advance (figure 2) remains as a fill layer (T), part of which forms the till plain (TP). A shallow, marshy lake (L) fills a low place in the plain. Although largely filled with drift, the valley (V) remains a low spot in the terrain. As soon as the ice cover melts, meltwater drains down the valley, cutting it deeper. Later outwash partly refills the valley: the outwash deposit is called a valley train (VT). Wind blows dust (DT) off the dry floodplain. The dust will form a loess deposit when it settles. Sand dunes (D) form on the south and east sides of streams.



4 The Region after Glaciation — As the climate warms further, the whole ice sheet melts, and glaciation ends. The end moraine (EM) is a low, broad ridge between the outwash plain (OP) and till plains (TP). Run-off from rains cuts stream valleys into its slopes. A stream flows through the end moraine along the channel cut by the meltwater that ran out of the crevasse in the glacier.

Slopewash and vegetation are filling the shallow lake. The collapse of outwash into the cavity left when the ice block melted has formed a kettle (K). The outwash that filled a tunnel draining under the glacier is preserved in an esker (E). The hill of outwash left where meltwater dumped sand and gravel into a crevasse or other depression in the glacier or at its edge is a kame (KM). A few feet of loess covers the entire area but cannot be shown at this scale.

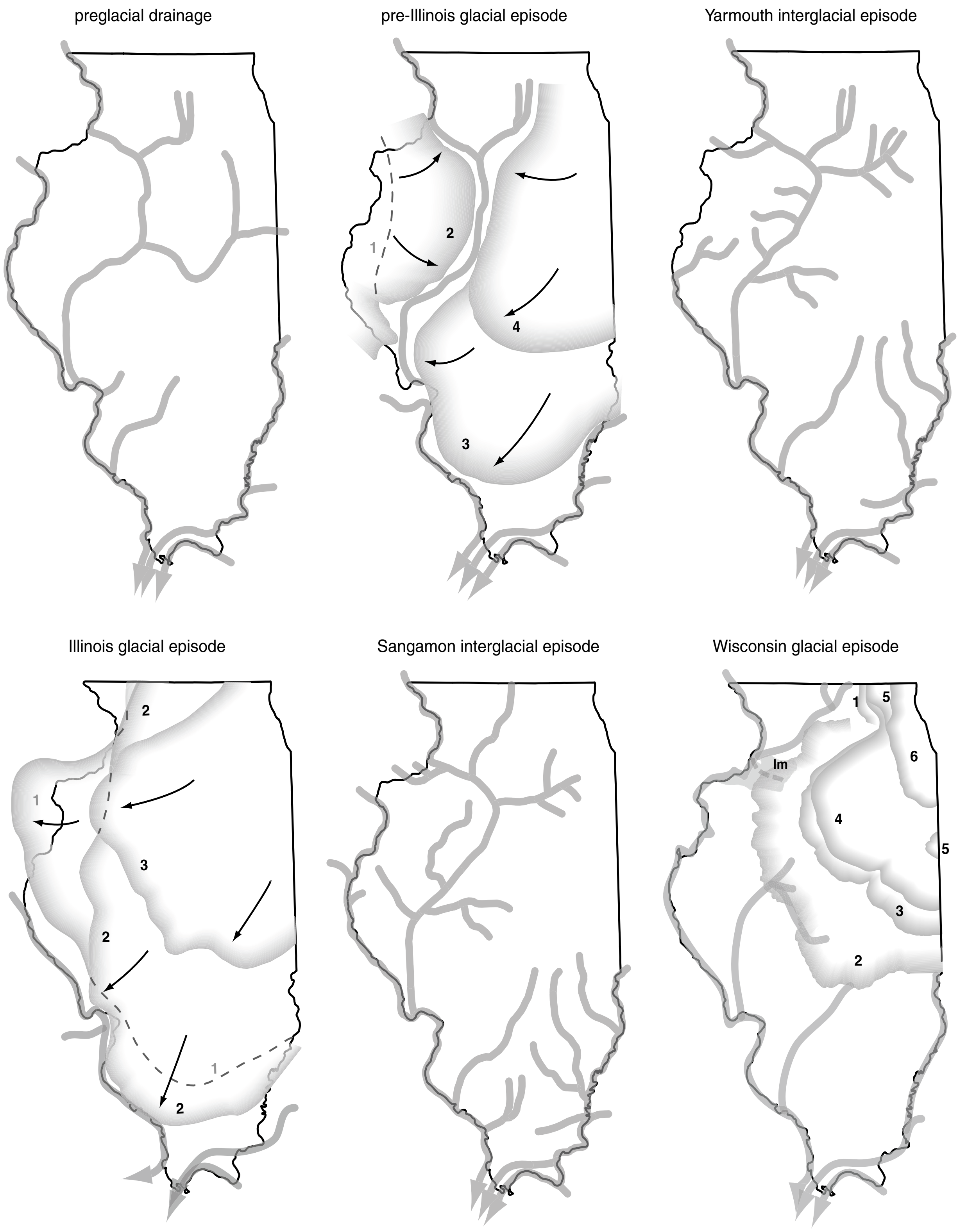
Continental Glacier



TIME TABLE OF EVENTS IN THE ICE AGE IN ILLINOIS

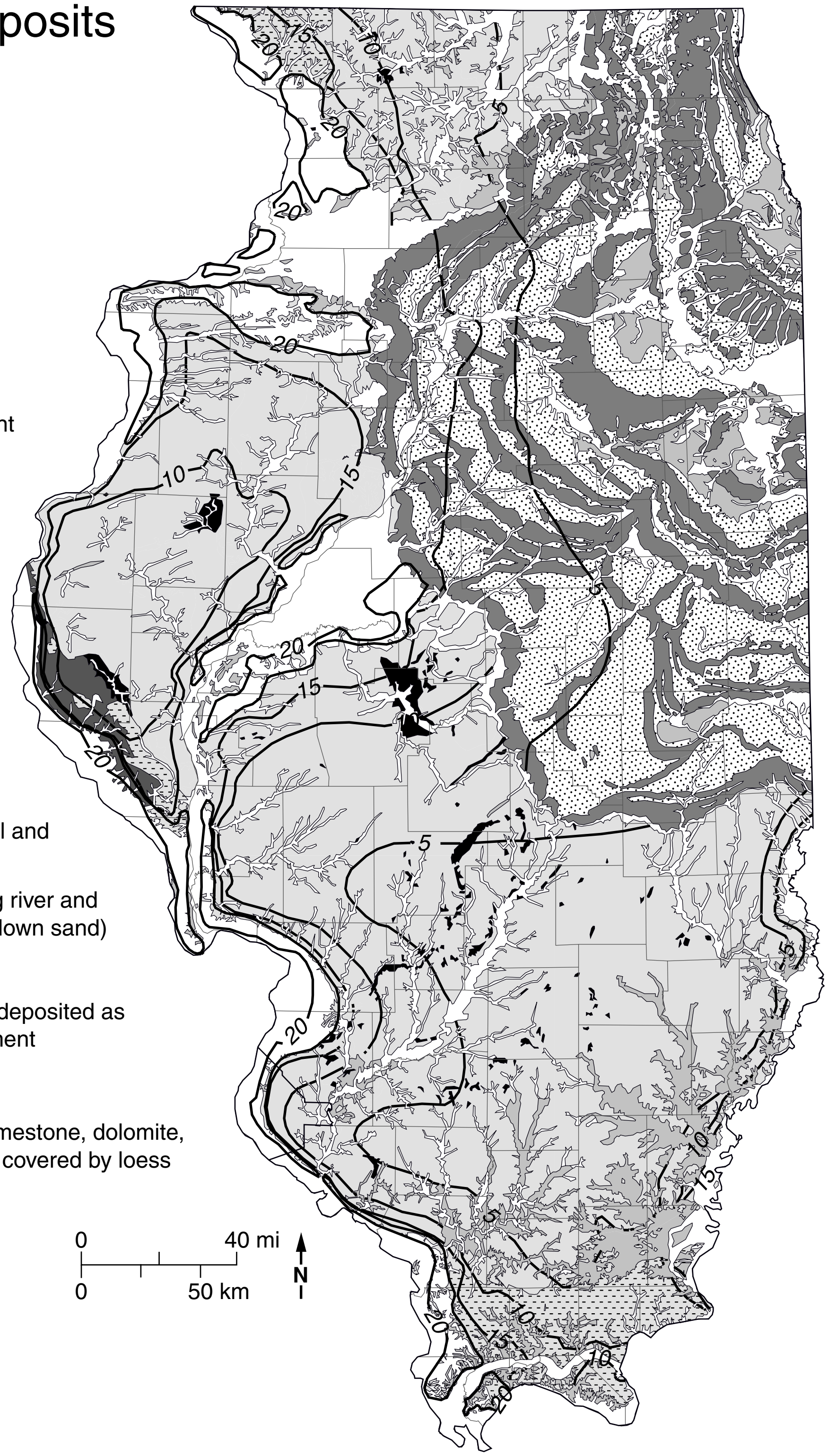
Epoch	Years before present	Time-distance diagram Interglacial and glacial episodes	Sediment record	Dominant climate conditions Dominant land-forming and soil-forming events
HOLOCENE		interglacial episode	River, lake wind, and slope deposits.	Warm; stable landscape conditions. Formation of modern soil; running water, lake, wind, and slope processes.
PLEISTOCENE EPOCH (not to scale)	10,000	WISCONSIN (late) glacial episode; glacial ice	Till and ice-marginal deposits; outwash and glacial lake deposits; loess.	Cold; unstable landscape conditions. Glacial deposition, erosion, and land-forming processes (e.g., formation of end moraines, outwash plains, valley trains, proglacial lakes, kettles), plus running water, lake, wind, and slope processes
	25,000	WISCONSIN (early and middle) glacial margin north of Illinois	Loess; river, lake, and slope deposits.	Cool; stable. Weathering, soil formation (Farmdale Soil and minor soils); wind and running water processes.
	75,000	SANGAMON interglacial episode	River, lake, wind, and slope deposits.	Warm; stable. Weathering, soil formation (Sangamon Geosol); running water, lake, wind, and slope processes.
	125,000	ILLINOIS glacial episode	Till and ice-marginal deposits; outwash and glacial lake deposits; loess	Cold; unstable. Glacial deposition, erosion, and land-forming processes, plus proglacial running water, lake, wind, and slope processes; possible minor soil formation.
	300,000	YARMOUTH interglacial episode	River, lake, wind, and slope deposits.	Warm; stable. Long weathering interval with deep soil formation (Yarmouth Geosol); running water, lake, wind, and slope processes.
	425,000	? PRE-ILLINOIS glacial and ? interglacial episodes	Till and ice-marginal deposits; outwash and glacial lake deposits; loess plus nonglacial river, lake, wind, and slope deposits.	Alternating stable and unstable intervals of uncertain duration. Glacial deposition, erosion, and land-forming processes, plus proglacial and interglacial running water, lake, wind, and slope processes; interglacial weathering and soil formation.
	1,600,000 and older			

Sequence of Glacial and Drainage History of Illinois



Sketch maps showing Quaternary drainage history, including glacial Lake Milan (lm), and inferred maximum ice-margin positions in Illinois during the preglacial drainage, pre-Illinois glacial episode, Yarmouth interglacial episode, Illinois glacial episode, Sangamon interglacial episode, and Wisconsin glacial episodes. Numbers indicate sequence of ice-margin advances. Dashed lines indicate ice margin positions. Based on published data from Horberg (1950b), Willman and Frye (1970), Curry (1998), Hansel and Johnson (1992, 1996), and Herzog (1994).

Quaternary Deposits of Illinois



Wisconsin Episode and Later

River sediment and dune and beach sand

Fine-grained lake sediment

5 Thickness of silt deposited as loess (5-foot contour intervals)

Wisconsin Episode Diamicton and Ice-marginal Sediment

End morainic system

Ground moraine

Illinois Episode

Diamicton deposited as till and ice-marginal sediment

Sorted sediment including river and lake deposits (and wind-blown sand)

Older Glacial Episodes

Predominantly diamicton deposited as till and ice-marginal sediment

Bedrock

Mostly Paleozoic shale, limestone, dolomite, or sandstone; exposed or covered by loess and/or residuum

END MORAINES of the WISCONSIN GLACIAL EPISODE

Wisconsin Episode moraines arc across northeastern Illinois and indicate position of temporary stationary ice fronts as the ice retreated.