GEOLOGY OF ILLINOIS

Illinois is rich in rock and mineral resources. A great diversity of these materials are found beneath the land's surface. The geologic resources are important to all of the state's industries, including agriculture, construction, manufacturing, energy production, information delivery and transportation.

Beneath the Illinois landscape are numerous layers of soils, clay, silt, sand and gravel, that bury the bedrock lying under them. In Illinois, economic minerals are present deep underground in many places. For example, coal is mined to a depth of 1,000 feet, and oil is produced from porous rock layers, called pay zones, at depths of several thousand feet. Lead and zinc ores, fluorspar, silica sand, limestone, sand, gravel, clay and shale are all found at shallower depths.

Geologists gather some information about the state's subsurface directly by looking at and taking samples from outcrops, quarries and mines. For most of the state, though, geology is "seen" and understood mainly from descriptions (logs) and samples (cores) of the sediments and rocks penetrated during shallow and deep drilling. Other instruments that provide information are geophysical logs, seismic reflection and electrical resistivity surveys.

Through several billion years of geologic time, the geology of the region that includes what is now Illinois underwent many changes. The oldest rocks in the state belong to the Precambrian basement complex. Little is known about these rocks because they are not exposed at the surface anywhere in Illinois and can't be seen directly. Only a few drill holes have reached deep enough to sample these igneous and metamorphic rocks.

These rocks were once exposed at the land surface, from about one billion to about 0.6 billion years ago. From the time of their formation through the middle Cambrian Period, they were deeply weathered and eroded. During this time tectonic forces in the midcontinent region began to rip apart the North American continent, forming rifts – long, narrow, continental troughs.

From about 543 to 323 million years ago, during the Cambrian through Mississippian Periods, the rifting stopped, and the region's landscape began to sink slowly, allowing the invasion of a shallow, tropical ocean from the south and southwest. Illinois was immersed in this shallow sea. The sands deposited in those oceans became sandstone, and the formation of carbonate mud and the deposition of billions of marine organisms, such as shells, algae and corals, formed limestone. The extensive beds of the Mississippian Period are more than 3,000 feet thick in some parts of Illinois and contain limestone deposits that hold large amounts of oil and fluorspar.

From about 323 to 290 million years ago, during the Pennsylvanian Period, the oceans advanced and retreated many times. During retreats, large river systems buried the shallow ocean bed under a series of deltas. Vast swamps grew on the ancient deltas and formed thick deposits of peat. Eventually these peat deposits were buried and compressed over millions of years to form the coal beds found in the Pennsylvanian rocks. All of the coal in Illinois comes from this time period. The Pennsylvanian rock, which is widespread in Illinois, also contains important deposits of limestone, shale, clay, sandstone and some oil and gas.

The deltas of the Pennsylvanian Period later covered the entire state, building up great thicknesses of sediment as the land underneath gradually subsided over millions of years. These sediments compacted to form layers of rock that are more than 2,000 feet thick in southern Illinois. During this time of oceans and deltas, as tectonic forces gently folded the bedrock of Illinois, a large basin was formed centered in the southeastern part of the state. This basin is known today as the Illinois Basin. Because of the basin shape, the Paleozoic Era rocks are much thicker in southern than in northern Illinois.

During the last part of the Paleozoic Era (Permian Period, 290 million years ago), throughout the Mesozoic Era (248 to 65 million years ago), and through most of the Cenozoic Era (65 to 1.8 million years ago), Illinois had a rolling topography. With time, water carved valleys into the exposed and weathered rocks of the ancient ocean and deltas, and great rivers flowed through Illinois removing sediment, much like today. The combination of flowing waters, blowing wind and the freeze-thaw cycles eroded the bedrock and transported the sediments, thus creating an eroded land surface.

GLACIATION IN ILLINOIS

About 85 percent of what is now Illinois was covered by glaciers at least once during the Pleistocene Epoch (1.6 million to 10,000 years ago) of the Cenozoic Era. The glacial periods affecting Illinois are known as the pre-Illinoian, Illinoian and Wisconsinian. Only the extreme northwestern and extreme southern parts of the state along with Calhoun County and parts of Pike, Jersey, Monroe and Randolph counties were not glaciated. No one is sure what caused this ice age. It could have been due to a cyclic pattern of factors relating to the earth's orbit and tilt on its axis, shifts in the Gulf Stream in the Atlantic Ocean, reversals in the earth's magnetic fields, volcanic activity, galactic dust clouds, or other reasons. The evidence does show that the glaciation occurred as the result of abrupt climatic changes, not gradual ones. Ice sheets began to grow from regions near the North Pole at this time when the summers were about 7 to 13 degrees Fahrenheit cooler than those of today, and the winter snows did not completely melt. Low maximum temperatures, not low minimum temperatures were necessary for the glaciers to develop. Because the time of cooler conditions lasted tens of thousands of years, thick masses of snow and ice accumulated to form glaciers. As the glacial ice thickened with more snow, its great weight caused it to flow outward at the edges, often for hundreds of miles. As the ice sheets expanded, the areas in which show accumulated also increased in size. Glaciers were able to continue to grow until the climate warmed enough so that the rate of melting was greater than the rate of expansion.

Pleistocene glaciers and the waters melting from them changed the landscapes that they covered. Some sections of the glaciers in northern Illinois were about 2,000 feet thick, while other areas of the state were covered by ice masses about 700 feet thick, as tall as a 60-story building. The glaciers moved the land they overrode, leveling and filling many valleys. Moving ice carried colossal amounts of rock and earth, for much of what the glaciers wore off the ground was kneaded into the moving ice and carried along, often for hundreds of miles.

The continual floods released by melting ice carved new waterways, deepened old ones and partly refilled both with sediments as great quantities of rock and earth were carried beyond the

glacier fronts. According to some estimates, the amount of water drawn from the sea and changed into ice during a glaciation was enough to lower the sea from 300 to 400 feet below its level today. Consequently, the melting of a continental ice sheet provided a tremendous volume of water that eroded and transported sediments. In most of Illinois, glacial and meltwater deposits buried the old hill-and-valley terrain and created the flatter land forms which would become the prairies. Glaciers left a mantle of soil and buried deposits of gravel, sand and clay over about 90 percent of the state.

Pre-Illinoian (1.6 million to 300,000 years ago) glaciers invaded Illinois from the west and east. There may have been several glaciers advancing into Illinois during this period, but not much evidence of them remains because it was so long ago and wind, water and other glaciers have mostly destroyed it.

The Illinoian stage glaciation was extensive in Illinois. At this time glaciers extended to the most southern point that they have ever reached in the northern hemisphere. That place was in Illinois, near Carbondale. About 85 percent of what is now Illinois was covered by this ice sheet.

The Wisconsinian glaciation started about 15,000 years ago and covered much of the northern and east-central parts of our state. The Illinois area of this glaciation would generally become the Grand Prairie natural division. The moraines and Lake Michigan in northeastern Illinois are all remnants of this glacial period. About 12,000 years ago the climate warmed, and the glaciers began to melt and retreat, forming large lakes. As the melting continued, the lake waters eventually eroded their banks and created enormous floods. The flood know as the Kankakee Torrent was mainly responsible for the deposition of sand along the Illinois River, where sand prairies developed.

Resources

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INTO THE COLD: PLANTS, ANIMALS AND ENVIRONMENTS OF THE ICE AGES IN THE MIDWESTERN U.S.

During the last 2 million years, Illinois has been subject to profound climatic changes. Because of these climatic changes, massive glaciers have advanced over portions of the state about a dozen times. At their maximum, glaciers extended as far south as Carbondale.

The Ice Age environments of Illinois were very different than those of today. The plants and animals were also quite different than those found in Illinois today. Many of the plants that grew in Illinois during the Ice Ages are now found only north of the state today. The animals that lived in the state included many animals that are now extinct, such as mammoths, mastodons, stag-moose, ground sloths and giant beavers. In addition to these extinct animals, many animals that are found here now, such as cottontail rabbits, deer mice, gray squirrels, white-tailed deer and raccoons, also lived in the Ice Ages. Other animals found in Illinois during the Ice Ages are ones that were found in Illinois until recently. These include black bears, wolves, bison and elk. Some animals that lived in Illinois during the Ice Ages are now found only north of Illinois. Arctic shrews, starnose moles, snowshoe hares and red-backed voles are among these species.

ICE AGE FACTS

- During Ice Ages, glaciers advance and retreat in response to changing climates. Glaciers have advanced and retreated over much of North America at least a dozen times during the last 2.5 million years.

- At the height of the last Ice Age (about 20,000 years ago) glaciers extended over eastern Illinois to as far south as Charleston and Shelbyville. The location of the following Illinois cities were covered with ice at that time: Aurora; Bloomington; Champaign; Chicago; Danville; Decatur; and Peoria.

- During the last Ice Age, the location of present-day Chicago was covered with glacial ice from about 24,000 years ago until about 13,500 years ago.

- A warm period between Ice Ages is called an “interglacial.” The earth is currently in the middle of an interglacial period that began about 11,000 years ago.

- During the last Ice Age, Illinois was somewhat cooler than today (especially in the summer).

- During the last Ice Age, tundra-like vegetation was found along the glacial margin in northern Illinois. Much of the rest of the state was covered with open spruce woodlands and wetlands.

- Approximately 70 species of large mammals became extinct at the end of the last Ice Age (about 11,000 years ago). Their extinction may have been caused by environmental change, human over hunting or a combination of these factors.

- People are thought to have first entered Illinois near the end of the last Ice Age (about 12,000 years ago). These people came into North America from Siberia across the Bering Strait (a land bridge during Ice Ages). They were nomadic people who hunted mammoths, mastodons and other large animals. They also hunted smaller animals and gathered various plants for food.

- Most of Illinois is covered with a thick layer of sediment (rock, gravel, sand, and mud) brought from Canada, Wisconsin and Michigan by glaciers during the last two Ice Ages.

- Large rocks that glaciers dragged into Illinois from Canada are called “erratics.” Many of these are used as ornamental stones in yards.

- Areas in Illinois not covered by sediment moved by glaciers are called “driftless areas.” Driftless areas in Illinois include the northwest corner (near Galena), the narrow finger between the Mississippi and Illinois Rivers (Pike and Calhoun counties) and the area south of Carbondale.

- Because a huge amount of the water on earth was trapped as ice in large continental glaciers, sea level was about 300 feet lower than today at the height of the last Ice Age.

- The next-to-last Ice Age (from about 300,000 to 130,000 years ago) is called the Illinoian because of the extensive deposits its glaciers left in Illinois (as far south as Carbondale).

EXTINCT ICE AGE ANIMALS OF ILLINOIS

American Mastodon (*Mammut americanum*)
- distant relative of modern elephants
- seven to 10 feet tall
- weighed four to six tons
- ate mainly trees, shrubs and herbs
- lived mainly in forests and woodlands
- found throughout North America
- fossils common in Illinois

Mammoth (*Mammuthus sp*.)
- close relative of modern elephants
- 10 to 12 feet tall
- weighed six to eight tons
- ate mainly grasses
- lived in grasslands and woodlands
- several species found in Illinois including Columbian and woolly mammoths
- found throughout North America and Eurasia
- fossils common in Illinois

Stag-Moose (*Cervalces scotti*)
- large deer with very complex antlers
- appearance was like a cross between an elk and a moose
- taller than modern elk or moose, with very long legs
- long legs probably allowed it to wade in bogs and other wetlands
- found mostly in the Midwestern United States
- fossils fairly common in Illinois

Woodland Muskox (*Bootherium bombifrons*)
- large animal similar to modern muskoxen

- may have been two different kinds of muskoxen in Illinois
- males had larger horns than females
- found throughout North America
- relatively common as fossils in Illinois

Giant Beaver (*Castoroides ohioensis*)
- very large relative of the modern beaver
- approximately the size of a black bear
- probably did not gnaw trees or build dams
- lived mainly in wetlands and ate wetland plants
- found throughout eastern North America
- relatively common as fossils in Illinois

Peccaries (*Platygonus compressus* and *Mylohyus nasutus*)
- pig-like animals
- primarily ate plants but probably ate just about anything
- *Platygonus* probably lived in small to medium-sized packs; *Mylohyus* was solitary
- *Platygonus* found throughout North America; *Mylohyus* found in the eastern United States
- *Platygonus* found in Illinois as fossils; *Mylohyus* has not, but probably lived in the state

Ground Sloths (*Megalonyx jeffersonii* and *Glossotherium harlani*)
- large to very large animals (hippo- to elephant-sized)
- herbivores
- relative of modern tree sloths, anteaters and armadillos
- have large claws on both their front and hind feet
- found in much of North America
- both species have been found in Illinois

Horse (*Equus* sp.)
- similar to modern horses
- several species, ranging from the size of a pony to the size of a draft horse
- lived mainly in open (grassy) habitats
- became extinct in North America 11,000 years ago but were reintroduced by Spanish explorers in the 1500s
- found throughout North America
- fairly uncommon as fossils in Illinois

Beautiful Armadillo (*Dasypus bellus*)
- Like modern armadillos but about 40 percent larger
- ate insects
- probably did not tolerate very cold conditions
- found mainly in southern Illinois
- fossils have been found in Illinois

Saber-tooth Cat (*Smilodon* sp.)

- lion-sized cat with long, sharp, serrated canines (sabers)
- probably stalked and ambushed prey
- not closely related to the modern tiger or lion
- found in much of North America
- has not been found as a fossil in Illinois, but has been found in Missouri just south of St. Louis, and almost certainly lived in Illinois as well

Short-faced Bear (*Arctodus simus*)

- very large bear (about 40 percent larger than a modern grizzly bear)
- had long legs and probably ran well
- largest and probably most fierce carnivore in North America during the last Ice Age
- found in much of North America
- has not been found as a fossil in Illinois, but has been found in Missouri and Indiana, so almost certainly lived in Illinois as well

Dire Wolf (*Canis dirus*)

- large wolf-like carnivore
- about 25 percent larger than the modern gray wolf
- wear and breakage on teeth of fossils shows that they were probably bone-crushers
- may have been scavengers
- found throughout North America
- have not been found in Illinois but was originally described from a find from near Evansville, Indiana, which is very close to the Illinois border

ICE ON THE ROCKS: HOW GLACIERS SHAPE THE LAND

Glaciers form during climatic episodes when more snow accumulates in the winter than melts away in the summer. Over time the snow thickens and, under the pressure of its own weight, is compressed into ice and begins to flow outward. During warm climatic episodes, glacier ice melts, and the glaciers recede. During cold episodes, more snow accumulates than melts, and the glaciers advance. Rocks and soil frozen in the base of the glacier are dragged along. These materials act like sandpaper to smooth the landscape over which the glacier passes. This abrasion can smooth the face of rocks, round out hills and gouge out valleys. On some exposed rock surfaces you can find evidence of this type of glacial scouring in the form of glacial striations, the parallel lines carved into the rock.

Like rivers, glaciers tend to follow the path of least resistance. The glaciers that flowed into the northern United States from Canada during the Ice Ages followed the courses of former river valleys that were eroded into the least-resistant rocks. The glaciers gouged out rock from the base and sides of these valleys, creating the troughs occupied today by the Great Lakes.

When glaciers melt, they leave behind whatever they were carrying. These materials may consist of a mixture of rock debris and old soils, called till, that was ground up and deposited from the base of the glacier. Some of the most striking reminders that our Illinois landscape was once

covered by glaciers are boulders and cobbles, called erratics, that dot the landscape. Unlike the rock that can be found in local quarries, these are exotic rocks, meaning that they came from somewhere else. In Illinois, erratics are often granitic rocks like those you can find today hundreds of miles away in Canada.

Glacial meltwaters carried ground-up rock debris away from the glaciers. In the valleys of major meltwater streams, such as the Mississippi and Illinois river valleys, this debris settled out as outwash – layers of silt, sand and gravel. On dry, windy days, the finest particles of this outwash were blown across the landscape in glacial dust storms. These particles settled across the landscape to form a blanket of silt-sized particles, called loess. Loess is the main "raw material," the parent material, of most of the young, rich soils of the northern plains of the United States.

MINERAL RESOURCES OF ILLINOIS

Coal

- occurs in and is mined from deltaic rocks (Pennsylvanian age) that occur at the bedrock surface throughout most of the southern three-fourths of the state
- uses: burned to make steam for generating electricity

Oil and Gas

- occur in and are produced from the ancient sandstones and limestones (Ordovician to Pennsylvanian age) in Illinois; occur as a fluid and gas in the pore spaces of the rocks
- uses: refined to make gasoline and motor oil; raw material for making plastics and thousands of other substances; heating source for homes and factories

Fluorite

- occurs in and was mined from marine rocks (Mississippian age) in southeastern-most Illinois (Hardin and Pope counties); The last Illinois fluorite mine closed in 1995 because of competition – fluorite can be mined less expensively in China. Illinois was the leading producer of fluorite in the United States for many years, and the mineral was named the official state mineral in 1965.
- uses: anhydrous ammonia fertilizer and many other chemicals; raw material for many chemicals; source of fluoride in toothpaste; flux for use in making aluminum, steel, glass, uranium and ceramics; welding rod manufacture; used in "Freon" (chloro-fluoro-carbon chemicals) for refrigerators and air conditioners (manufacturing of some of these has been banned in the United States)

Lead and Zinc

- lead (galena, PbS) and zinc (sphalerite, ZnS) occur in marine rocks (Ordovician age) in northwestern Illinois (Jo Daviess County); These minerals were mined in small amounts prior to 1700. Smelting began by 1740. The last mine closed in 1973. These minerals were also mined with fluorspar (Mississippian age) in Hardin and Pope counties. Illinois was the leading state in lead production during the mid-1800s. Small amounts of silver have been recovered from the galena in Hardin County.
- uses of lead: automobile batteries; solder, seals and bearings, bullets, shotgun pellets, sinkers for fishing lines; leaded glass for TV picture tubes, radiation shielding

- uses of zinc: zinc-based alloys (e.g. brass and bronze); galvanizing and zinc-plating to prevent rust and corrosion of steel

Tripoli

- occurs in and is mined from marine rocks (Devonian age) in southwestern Illinois (Alexander County; The state produces 70 percent of all the tripoli in the United States.
- uses: filler in pints to provide whiteness, hardness and resistance to weathering and most chemicals; filler in plastics to provide uniformity, strength and electrical insulation; abrasive in automotive buffing compounds, cleansing products, metal polishers and finished optical lenses

Dolomite and Limestone

- found in marine rocks of all ages and mined when at or near the surface; quarries are common in northern Illinois, western and southern fringes of Illinois and parts of eastern Illinois; dolomite and limestone quarries also found in scattered areas throughout central and southern Illinois. Illinois production ranks fifth among the states.
- uses: aggregate for making concrete and asphalt; agricultural lime (finely ground) to neutralize soil acidity; scrubbers to trap sulfur in coal-burning power plants; ballast for building railroad beds; raw material for making cement and some chemicals

Sand and Gravel

- occur in consolidated materials (Tertiary and Quaternary age) in and adjacent to ancient and modern stream/river valleys and flood plains throughout Illinois and in glacial features, particularly in northeastern Illinois
- uses: aggregate for making concrete and asphalt; fill for road construction; fill for lining underground utilities; fill for improving surface drainage; sand for children's sand boxes

Industrial (Silica) Sand

- occurs in and is mined in Ogle and La Salle counties (Ordovician St. Peter Sandstone) and in dune sands (Quaternary) in Mason County; Illinois leads the nation in the production of industrial sand.
- uses: raw material for making glass, computer chips, fiber optic cables for telecommunications, fiberglass for insulation, heat-resistant surface tiles on the space shuttle and molded parts of cars, trucks and boats; an abrasive (as a fine powder); filler and extender in paints, plastics, adhesives and rubber

Absorbent Clay

- (early Tertiary) occurs in and is mined in southernmost Illinois in Pulaski County
- uses: kitty litter; oil and grease absorbents; carriers for insecticides; soil conditioner

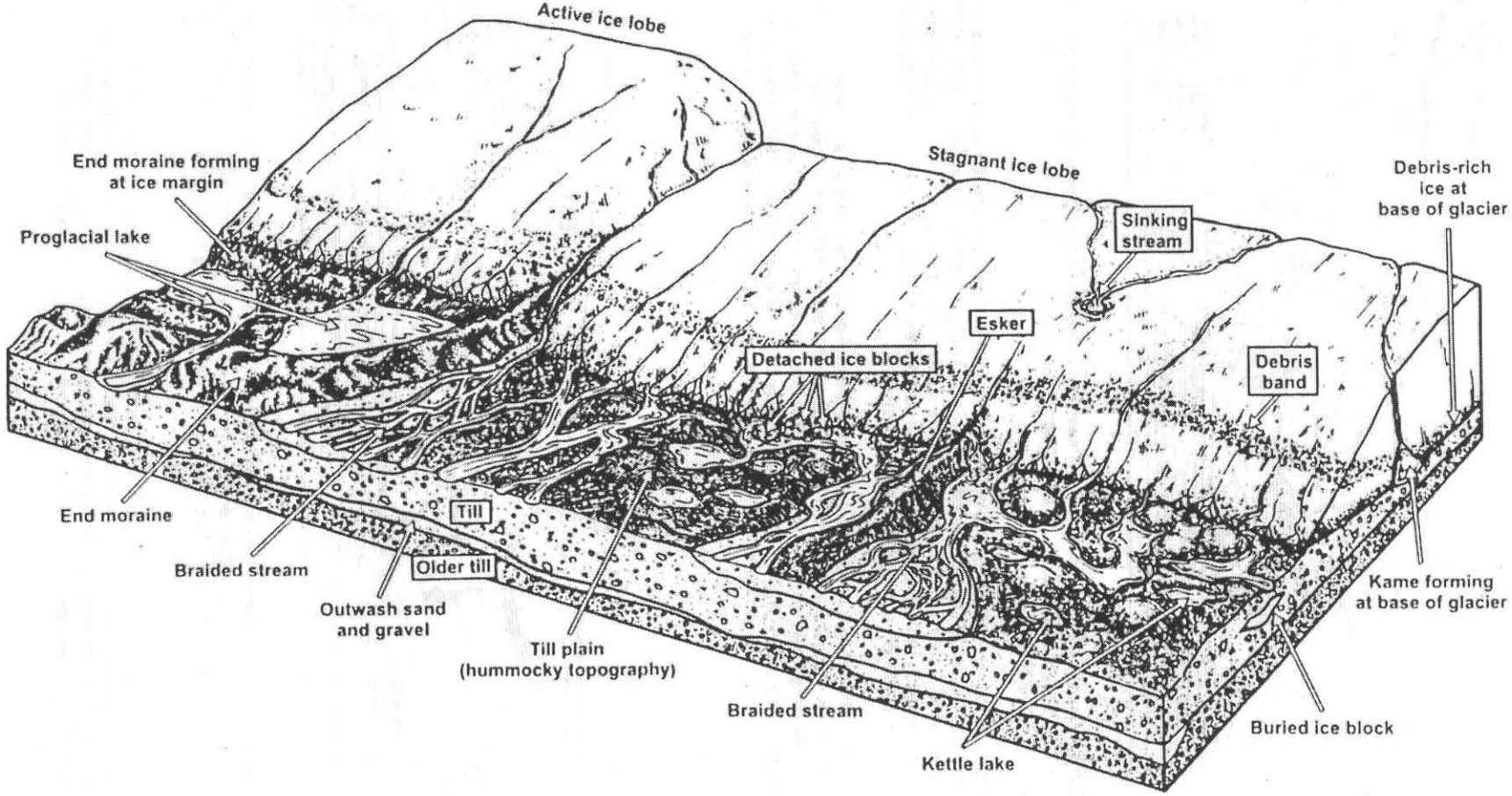
Clay

- occurs throughout Illinois (Quaternary, middle Tertiary, Pennsylvanian) and, where it occurs shallow enough, is mined, mostly in open pits and scattered areas around the state
- uses: raw material for making bricks, sewer pipes, drain titles, Portland cement, lightweight aggregate, porcelain, ceramic tiles, lavatories and toilets

Peat

- occurs in and is mined from unconsolidated materials (Quaternary) in Whiteside County and in northeastern Illinois (Cook, Kane and Lake counties)
- uses: soil conditioning

Continental Glacier



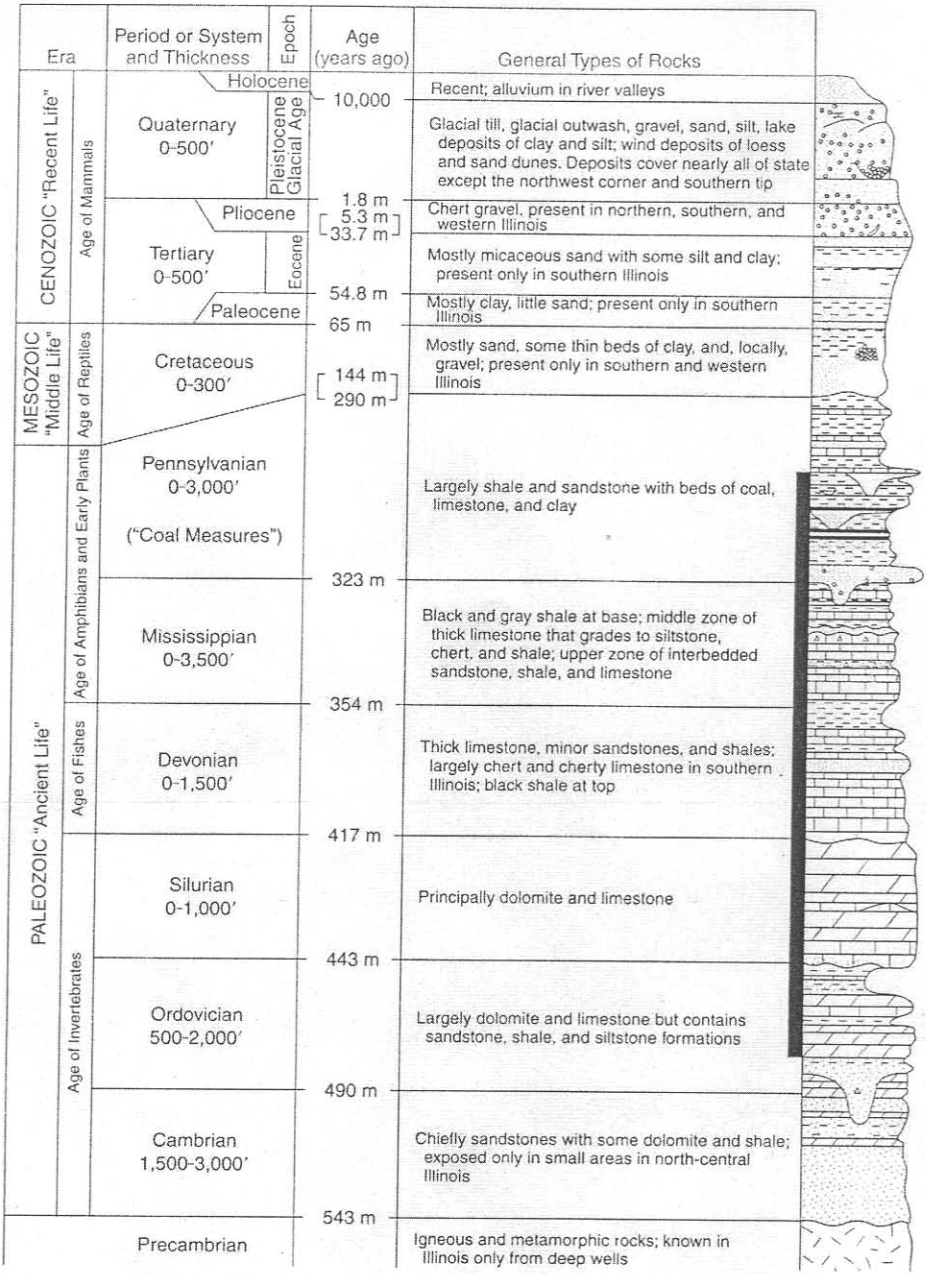
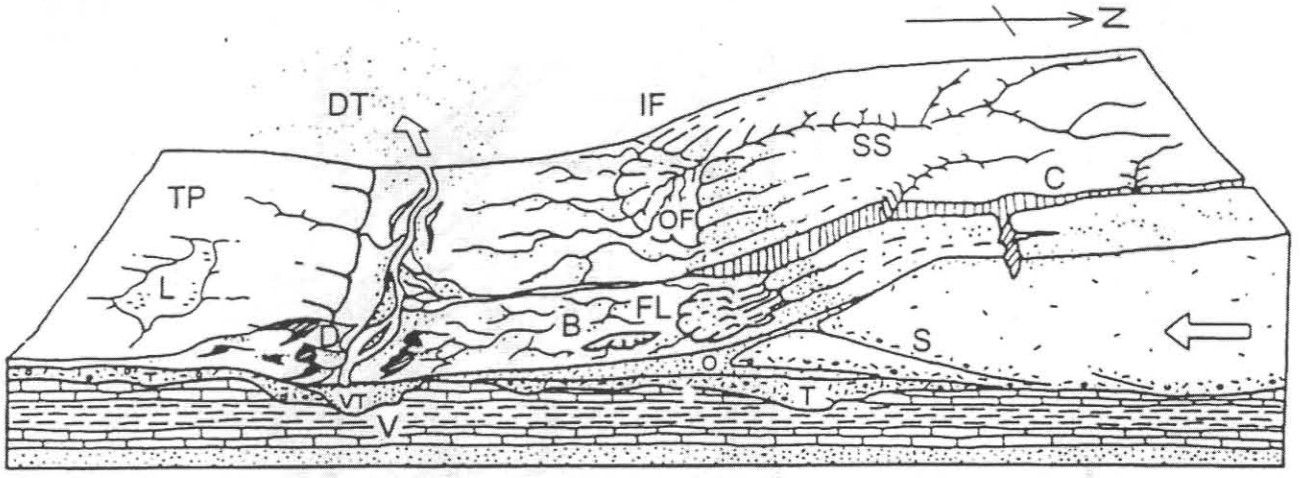


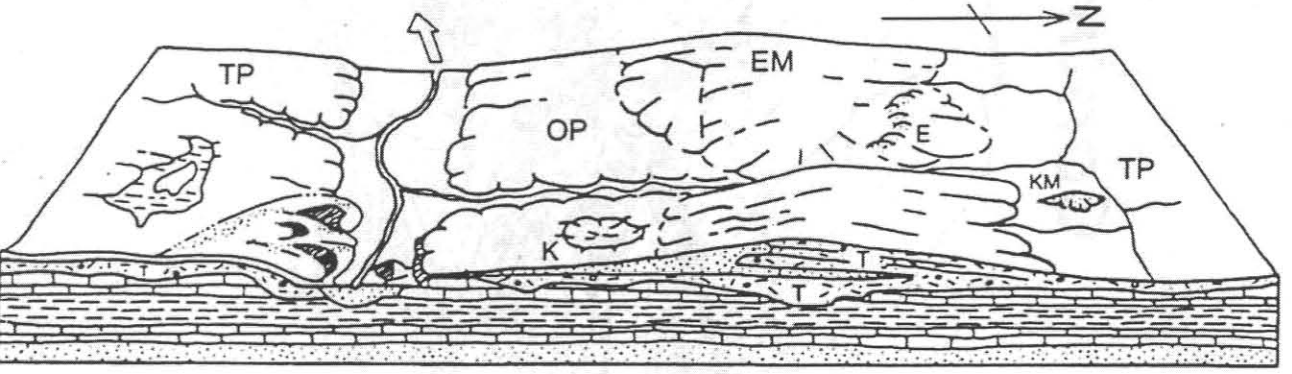
FIGURE 1 Generalized geologic column showing the succession of rocks in Illinois (thick black line indicates rocks with known oil reserves).



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 onto the plain beyond. Some of the debris slips down the ice front in a 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.



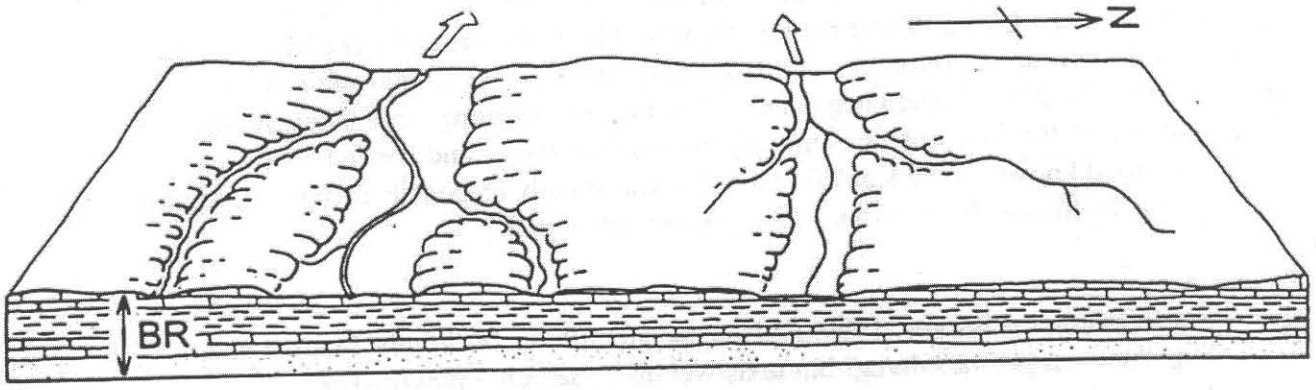
4 **The Region after Glaciation** — As the climate warms further, the whole ice sheet melts, and glaciation ends. The end moraine (EM) is a low, broad ridge between the outwash plain (OP) and till plains (TP). Run-off from rains cuts stream valleys into its slopes. A stream flows through the end moraine 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.

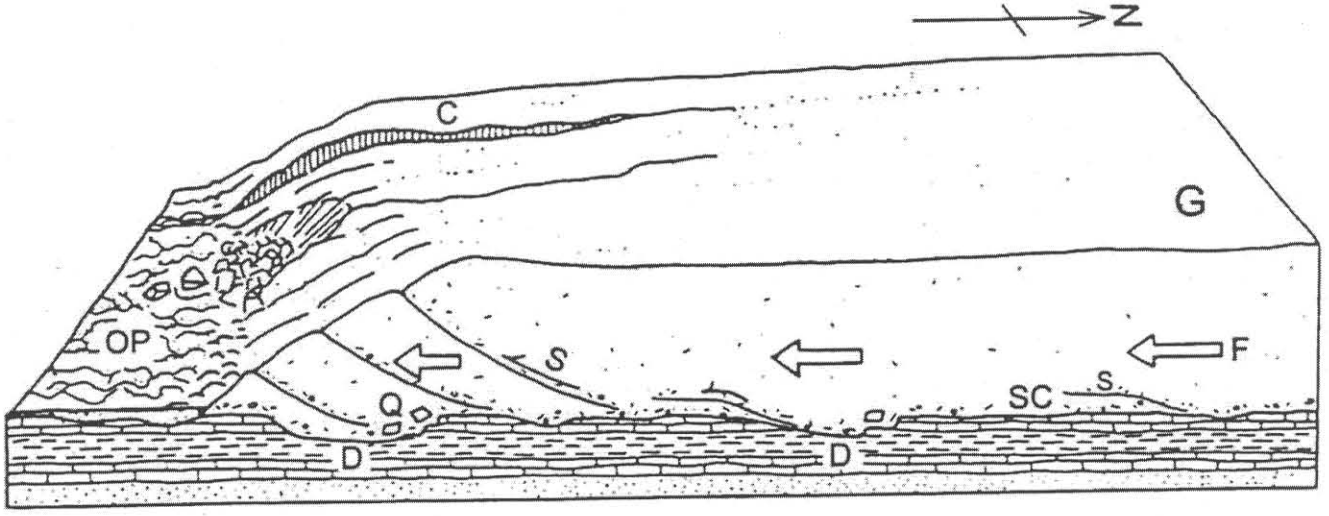
GLACIATION IN A SMALL ILLINOIS REGION

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 10 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.

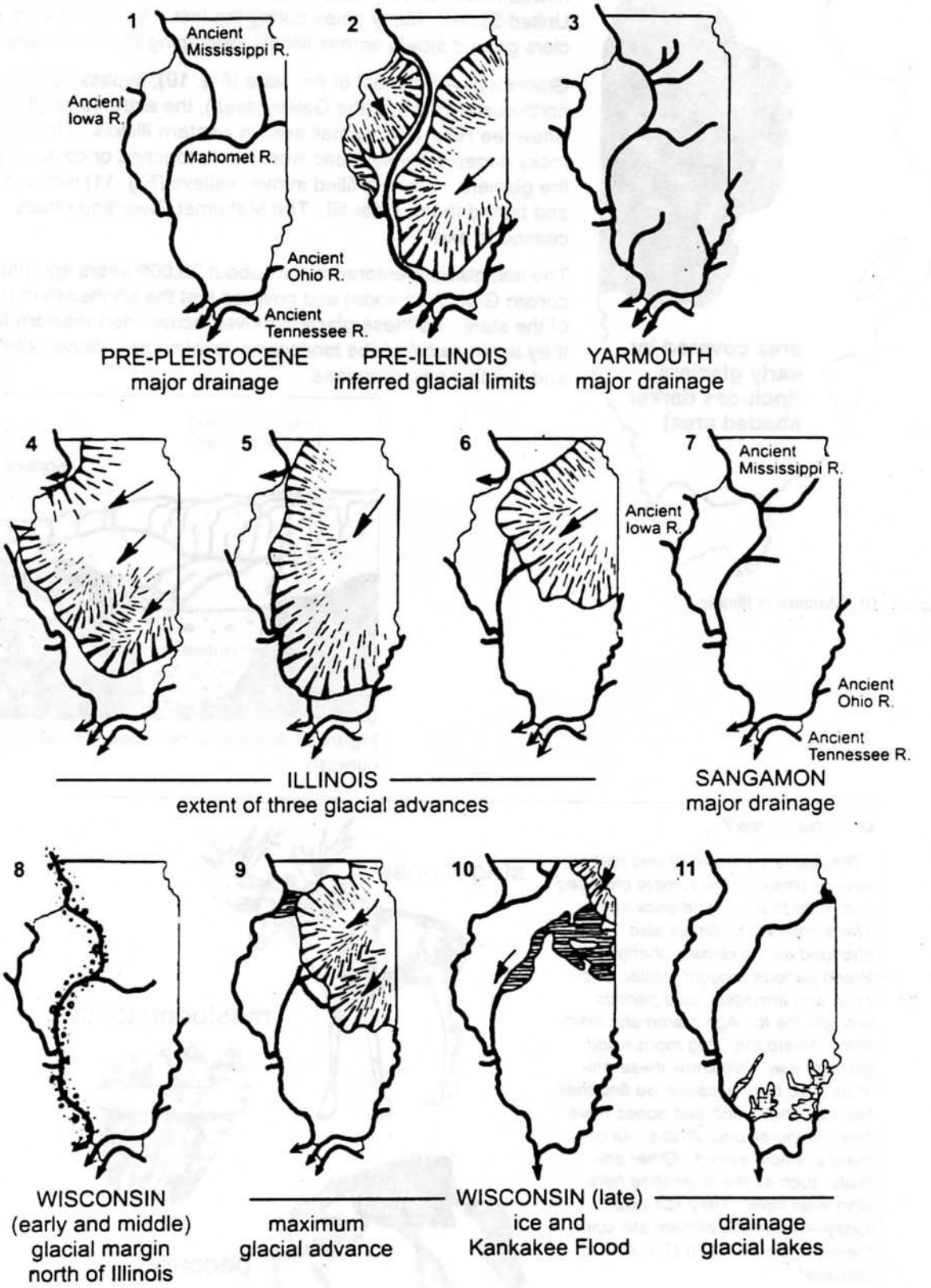


1 The Region before Glaciation — Like most of Illinois, the region illustrated is underlain by almost flat-lying beds of sedimentary rocks—layers of sandstone ( ), limestone ( ), and shale ( ). Millions of years of erosion have planed down the bedrock (BR), creating a terrain of low uplands and shallow 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.

SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



TIMETABLE OF EVENTS IN THE ICE AGE IN ILLINOIS