Glaciation has had a pronounced effect on the landscape, subsurface strata, and soils of the state. This section will examine the occurrences, movements, extent, and impacts of glaciation on the physical surface of Wisconsin. A number of terms and definitions associated with glaciers and glacial geology will also be presented.

2-3.1 Terms and Definitions

An understanding of the following list of terms is important to understand glacial history and processes:

Glacier	A large ice mass flowing due to its own weight and gravity. Continental glaciers covered thousands of square miles of the earth's surface and were 1 to 2 miles thick in some areas.
Drift	A general term for glacially deposited material.
Till	A heterogeneous mixture of soil and rock fragments carried and deposited by a glacier.
End Moraine	A distinct ridge of till accumulated at the line of maximum advance of a glacier. Also called a terminal moraine.
Recessional Moraine	Distinct ridges of till formed behind end moraines as the glacier receeded. These features mark positions of glacial stagnation or renewed advance.
Ground Moraine	Till deposited in an indistinct manner as the glacier receded. Often consists of a relatively thin blanket of material marked by low hills and swales.
Glacial Lakes	Lakes that were formed along the front of a glacier due to the general contour of the land and the blockage of normal drainage channels. These lakes disappeared as the glaciers receded.
Lacustrine Deposits	Material deposited in glacial lakes forming the bed of those lakes. These deposits tend to be stratified and of finer texture.
Outwash	Water-sorted sand and gravel deposited by melt water streams flowing out from the face of a glacier during periods of melting.
Outwash Plain	A broad, nearly level to gently sloping sandy plain created by glacial melt waters flowing out from a moraine. Outwash plains typically consist of large deposits of clean, water-sorted sand and gravel.
Valley Train	Nearly level sandy outwash deposited in the valleys of major rivers of glacial melt water. Valley trains may extend for many miles beyond the glacial source.
Loess	Wind-blown silt size particles carried for many miles from the glacial source. Loess deposits are generally found outside of the glaciated area, and can accumulate to a number of feet in thickness.
Kame	A glacial feature in the shape of a conical hill typically composed of sand and gravel, and formed as an internal melt water feature during glacial waning.
Kettle	A distinct, steep sided depression left in an outwash plain or ground moraine resulting from the later melting of ice blocks buried by the outwash or till during deposition. Kettles can range in size from small bowls less than 100 feet across to large pits encompassing several acres.
Esker	A long sinuous ridge of water sorted sand and gravel formed in melt water channels inside of a waning glacier.

Drumlin	An elongated hill of glacial till formed by the re-advance of a glacier over existing till deposits. The long axis of a drumlin is aligned with the direction of glacier movement.

2-3.2 Glacial History

In the last approximately one million years, there have been four glacial advances across central and eastern North America. From the oldest to the youngest, these are the Nebraskan, the Kansan, the Illinoian, and the Wisconsin. However, some recent publications recognize only three stages which are termed as the Pre-Illinoian, the Illinoian, and the Wisconsin. Since the age of the older glacial deposits in Wisconsin is somewhat uncertain, reference to this material as Pre-Illinoian is appropriate for this manual. It is generally thought that the Pre-Illinoisan glaciation extended from about 800,000 years to about 230,000 years before the present time (bp) with several interglacial intervals. The Illinoian glaciation spanned from 170,000 years bp to about 120,000 years bp. The last glacial advance is named the Wisconsin glaciation, because of the many prominent land features left in the state by this advance. The Wisconsin glacial advance is thought to have occurred from about 75,000 years bp to about 8,000 years bp. However, the glacier actually entered Wisconsin about 30,000 years bp and left the northern part of the state about 10,000 years bp. There is evidence of both Pre-Illinoian and Illinoian glaciation in the north central and west central parts of the state. There are also deposits of Illinoian till in Green, Rock, and Walworth counties in southern Wisconsin, and in Portage County in central Wisconsin. However, it is the Wisconsin Glaciation that left the most visible and extensive deposits and formations in the state.

Figure 1, “Lobes of the Laurentide Ice Sheet” (https://wgnhs.uwex.edu/wisconsin-geology/ice-age/); Figure 2, “Glaciation of Wisconsin” (http://wgnhs.uwex.edu/pubs/download_es0362011/); Figure 3, “Ice Age Deposits of Wisconsin” (https://wgnhs.uwex.edu/pubs/000359/); and Figure 4, “Thickness of Unconsolidated Material in Wisconsin” (http://wgnhs.uwex.edu/pubs/000391/), all published by the WGNHS, show the extent of the Wisconsin Glaciation, landforms left behind by this glaciation, details of the various phases of that advance, and thickness of unconsolidated material across the state. The Figures show that there were six distinct lobes in the glacial advance designated as the Lake Michigan, the Green Bay, the Langlade, the Wisconsin Valley, the Chippewa, and the Lake Superior Lobes. These lobes moved somewhat independently, but were in contact with the adjoining lobes creating interlobate moraines. The most prominent of these is the Kettle Moraine in southeast Wisconsin formed by the contact between the Lake Michigan Lobe and the Green Bay Lobe. Each of the lobes left a distinct end moraine at its point of greatest advance. As is shown in Figure 2 and Figure 3, these end moraines form a continuous formation beginning in the southeast that extends through the south central, central, north central and west central parts of the state. In addition, Figure 4 indicates that the thickest sequences of unconsolidated material in Wisconsin are associated with buried bedrock valleys within the glacial deposits of the southeast, northeast and northwest part of the state.

Figure 1 – Ice Sheets

Figure 2 – Wisconsin Glaciation

Glaciation of Wisconsin

Lee Clayton, John W. Attig, David M. Mickelson, and Mark D. Johnson

Educational Series 36
1991 (revised 1992)

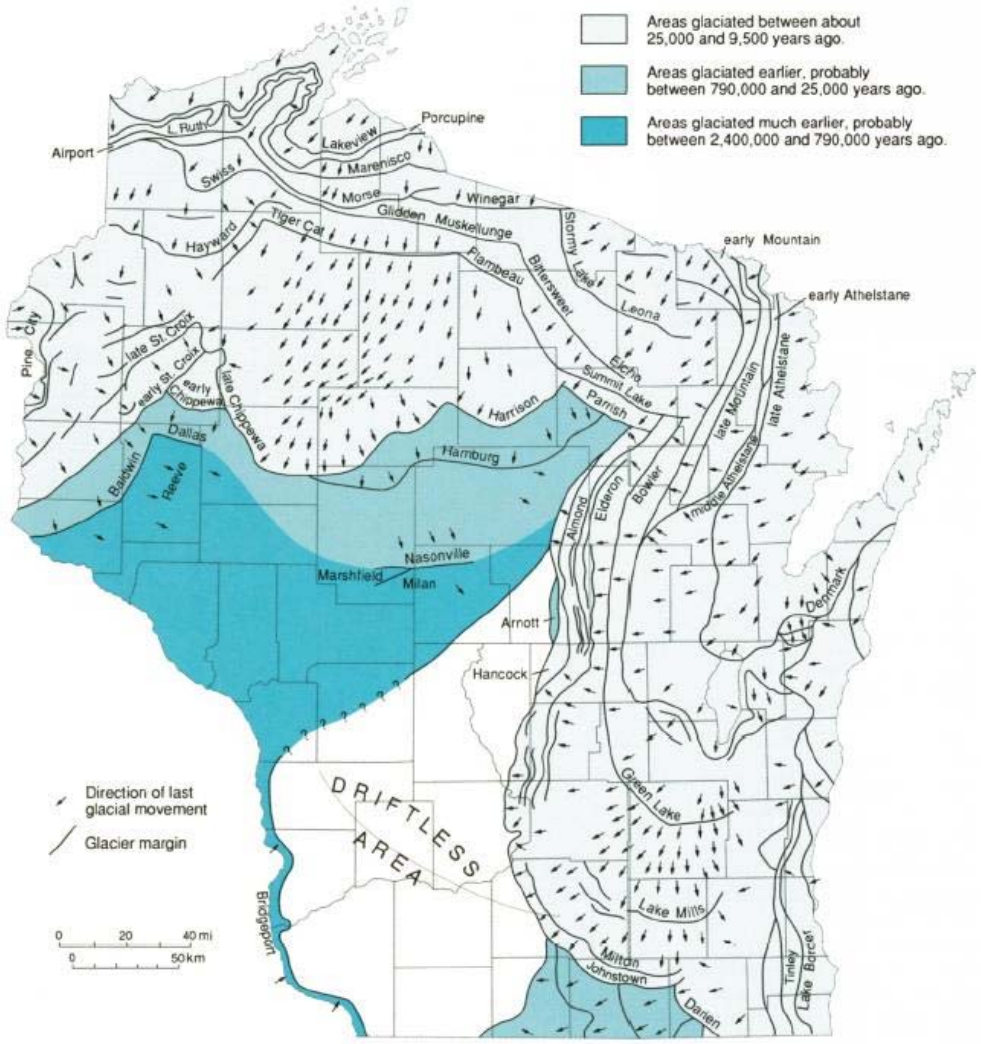


Figure 1. Phases of glaciation. Most phases represent at least a minor advance of the edge of the ice sheet. A phase, like a glaciation, is a geologic event rather than a period of time. Each line marks the southern edge of the Laurentide Ice Sheet during a phase of glaciation. For example, during the Johnstown Phase of the Wisconsin Glaciation, the southern edge of the Green Bay Lobe of the ice sheet (lobe locations are given in fig. 4) advanced to the line marked "Johnstown" in south-central Wisconsin; figure 3 shows that this occurred about 16,000 years ago. Only the most recent phase is shown at any location. Arrows indicate direction of ice movement.

Figure 3

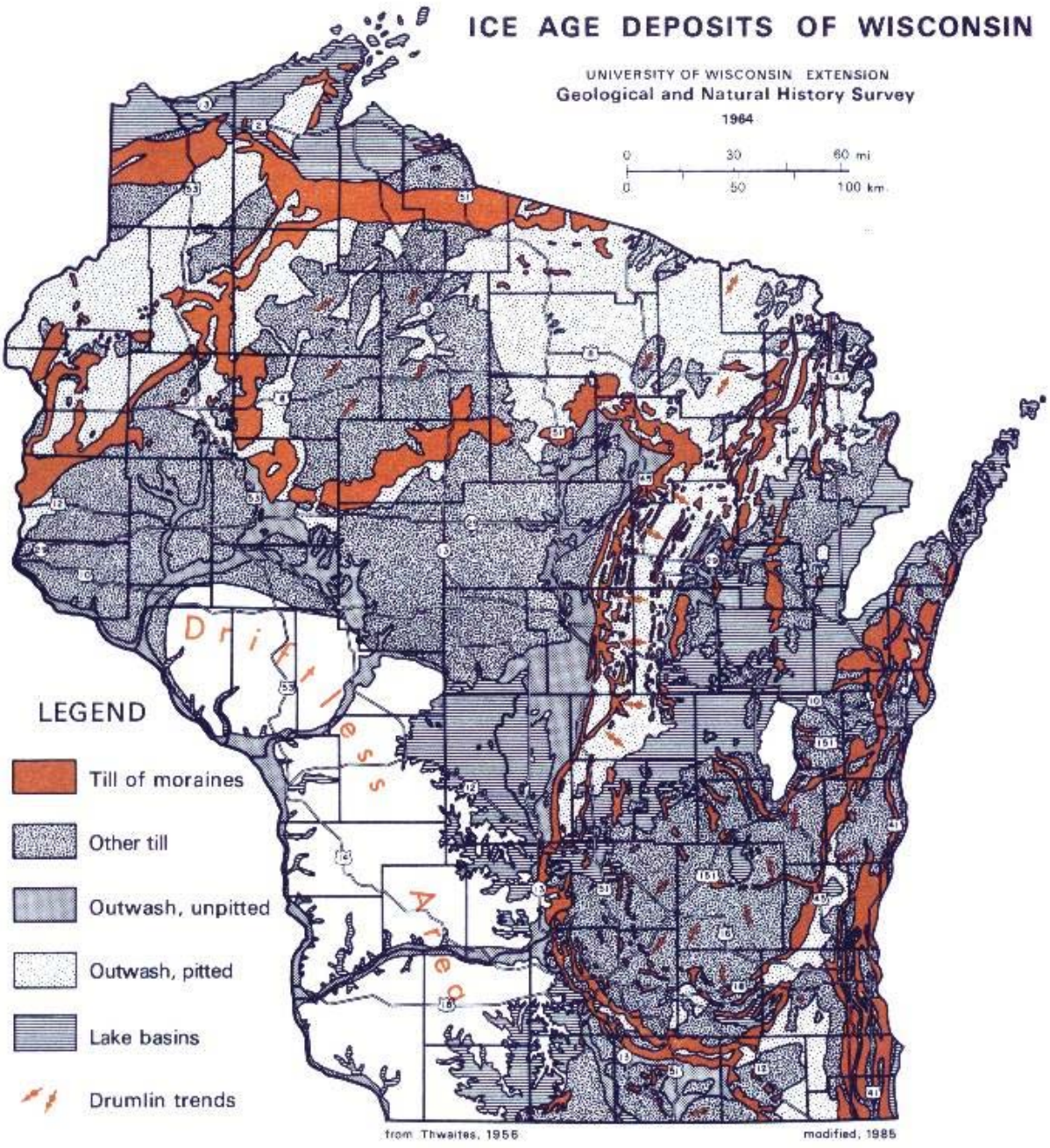
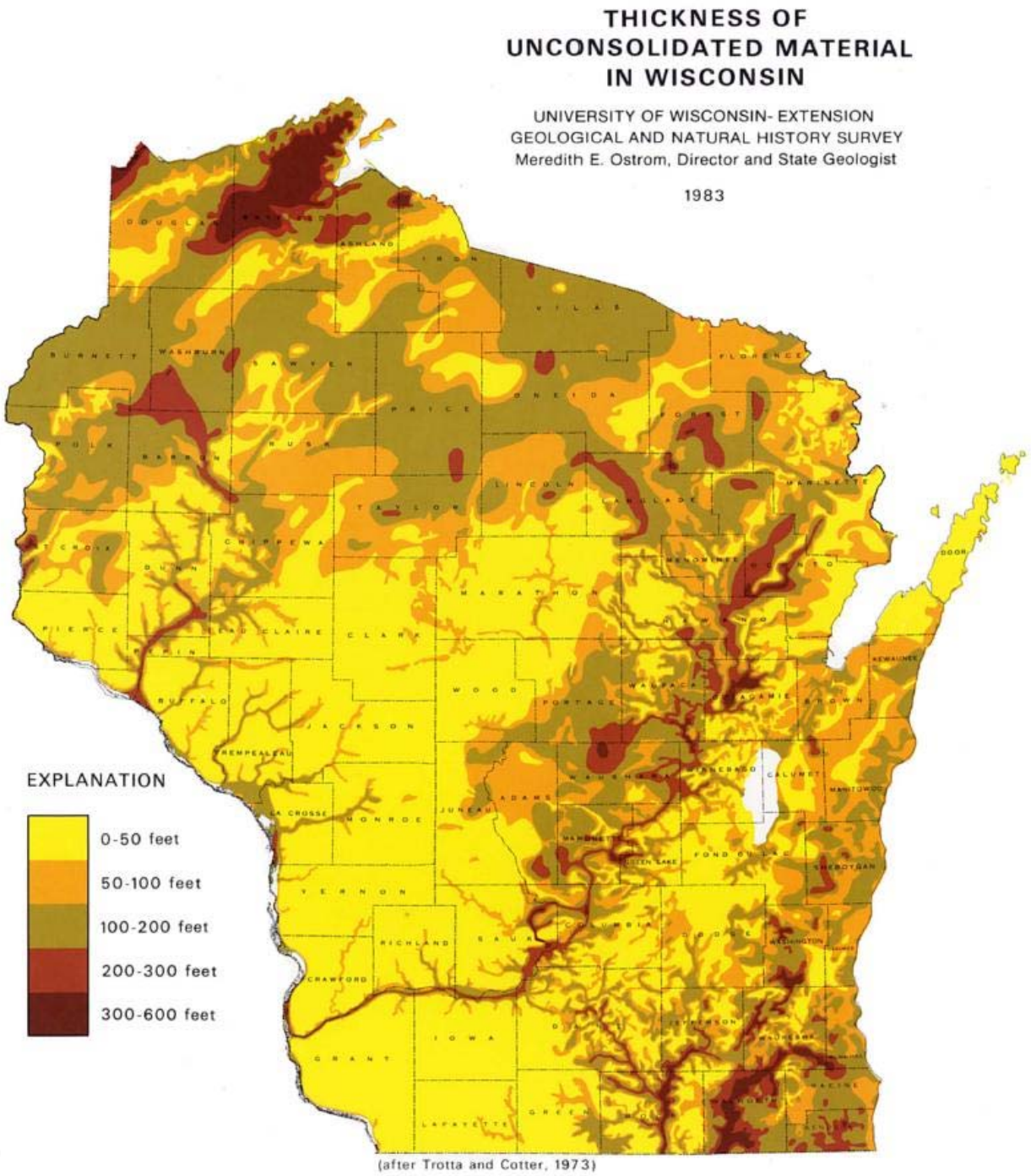

ICE AGE DEPOSITS OF WISCONSIN
UNIVERSITY OF WISCONSIN EXTENSION
Geological and Natural History Survey
1964
0 30 60 mi
0 50 100 km
LEGEND
Till of moraines
Other till
Outwash, unpitted
Outwash, pitted
Lake basins
Drumlin trends
from Thwaites, 1956
modified, 1985

Figure 4


THICKNESS OF
UNCONSOLIDATED MATERIAL
IN WISCONSIN
UNIVERSITY OF WISCONSIN- EXTENSION
GEOLOGICAL AND NATURAL HISTORY SURVEY
Meredith E. Ostrom, Director and State Geologist
1983
EXPLANATION
0-50 feet
50-100 feet
100-200 feet
200-300 feet
300-600 feet
(after Trotta and Cotter, 1973)

2-3.3 Glacial Landforms and Formations

Most of the surface features of Wisconsin are the direct result of glaciation and glacial deposition. In addition, the bedrock surface has been impacted by general erosion of the surface as well significant localized deepening of river valleys and lowlands. Tens to hundreds of feet of unconsolidated glacial material now cover the rock surface in many areas, while in other areas there is little overburden. Soil development in the glaciated regions has been strongly influenced by the texture of glacial debris and time.

While a complete description of the landforms and physical regions of the state is well beyond the scope of this manual, a general discussion is appropriate. The text, “The Physical Geography of Wisconsin” by Lawrence Martin (https://wgnhs.uwex.edu/pubs/000036/), is an excellent reference. The WGNHS also has a number of excellent maps and publications providing great detail on these topics (http://wgnhs.uwex.edu/).

Two of the most prominent glacial features of the state are Lake Michigan and Lake Superior. Both of the lakes have been formed in pre-glacial lowlands and river valleys. Successive glacial advances gouged out the underlying rock leaving behind the present basins. Today’s Lake Michigan boundary closely follows the shape of the Lake Michigan lobe of the Wisconsin Glaciation.

A number of glacial lakes formed during the Wisconsin Glaciation. The most prominent of these include Glacial Lake Wisconsin in the central part of the state and Glacial Lake Oshkosh in the east central area. Another large glacial lake formed in the north in the lowlands adjacent to present Lake Superior. Other smaller glacial lakes formed across the state. All of these lakes drained with the waning of the glacier, but evidence of their existence remains in the form of distinguishable basins, thick deposits of lacustrine material, and extensive surface formation of organic soils.

Several large sandy outwash plains occur along the end moraines. The largest of these are plains located in Adams, Waushara, Portage, and Marathon counties, near Antigo in Langlade County, and near Janesville in Rock County. Many other smaller outwash plains occur throughout the northern, east central and southeast parts of the state. Large sandy valley trains extend along the Chippewa River and its tributaries along with the Black River in the west central area, the Wisconsin River in the southern and western area, and the Mississippi River along the entire western border of the state. Extensive filling has occurred in each of these valleys.

The till deposited by the Wisconsin Glacier has several distinct zones. In the southeast, brown silty to silty clay till predominates. Extensive areas of drumlins occur in Dodge, Jefferson, Rock, Dane and Columbia counties. In the northeast, a distinct reddish silt and silty clay till is found. This till resulted from a late re-advance of the glacier and covers an area from the base of Lake Winnebago northward to the Michigan border. Sandy till predominates in the east central area as well as in the north central area. A siltier till is found in the northwest part of the state. In the far north, a large area of red clay till and lacustrine deposits are found extending southward from the shore of Lake Superior.

A large area of older Pre-Illinoian glacial till extends across the north central and the west central areas of the state. A smaller area of Illinoian till is found in the south, along the Illinois border. While glacial till is evident in these areas, most of the landforms associated with glaciation have been reduced by time and erosion. In addition, the till has been heavily weathered giving it a different appearance from the younger Wisconsin till. The remaining till often forms only a thin deposit over the local bedrock. However, the Marshfield Moraine in Wood and Clark counties forms a prominent ridge with till thickness of over 100 feet.

Numerous lakes and wetlands are prominent features in all of the Wisconsin Glaciation area. These were formed in depressions in the irregular till surface as the glacier waned. The position of the water table, the depth of the depression, and time caused some of these depressions to fill with organic material and become wetlands. The deeper depressions remain as lakes today while others remain as dry pits and kettles.

A prominent feature of the state related to glaciation is what is termed the Driftless Area of the southwest. As the name suggests, glacial drift is absent from this area. This may have resulted from a combination of the direction of the various glacial advances, the limit of these advances, and the topography. Although the area is surrounded by glacial till, it never existed as an unglaciated island in any of the glacial advances. The various glacial advances deposited till in different locations along the borders of the area. An overlapping of the till deposits eventually surrounded the area. However, effects of glaciation are present in the Driftless Area. Loess deposits derived from the glacial deposits to the north and east blanket the area, reaching depths of more than six feet in Grant County. The extensive outwash valley train along the Wisconsin River also passes through the area. The topography of the area is dominated by an extensive system of ridges and valleys created by millions of years of erosion.