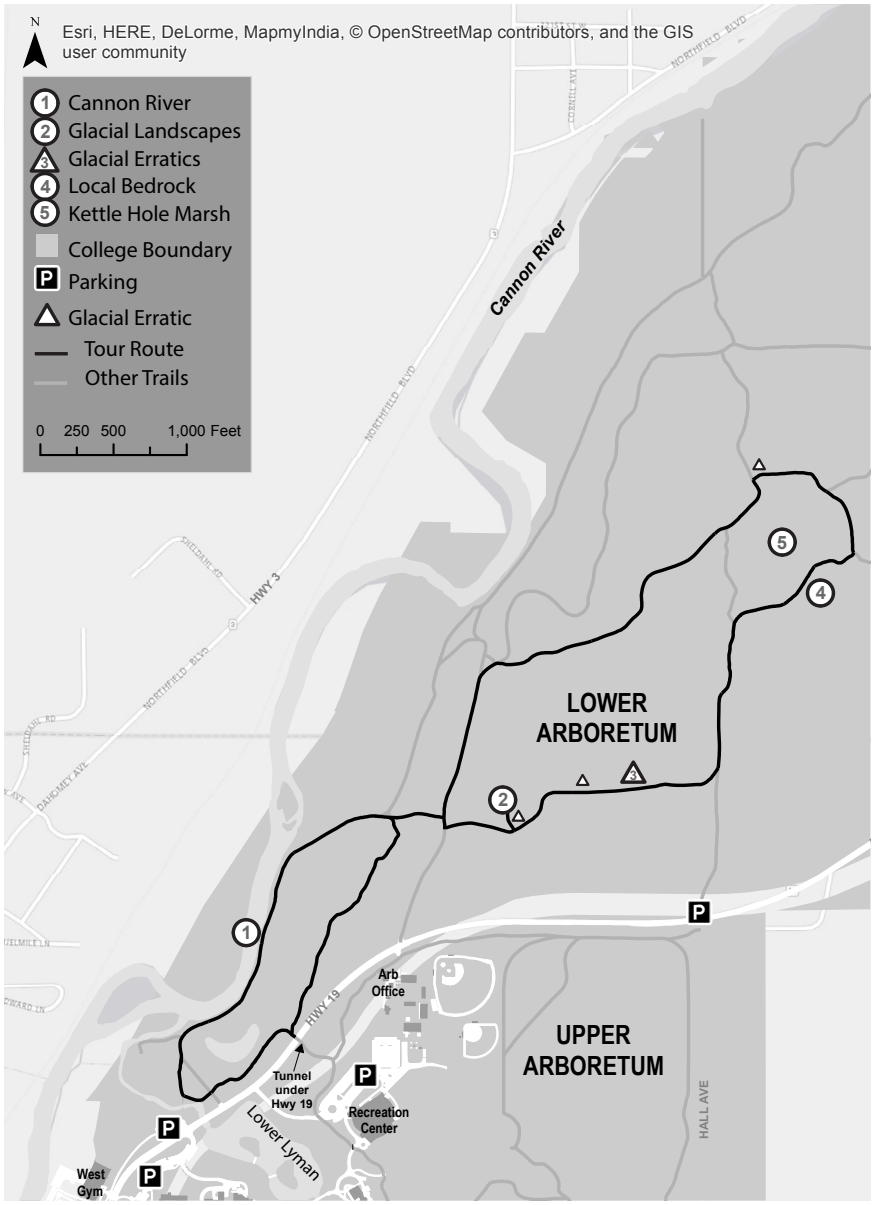
# Route Map

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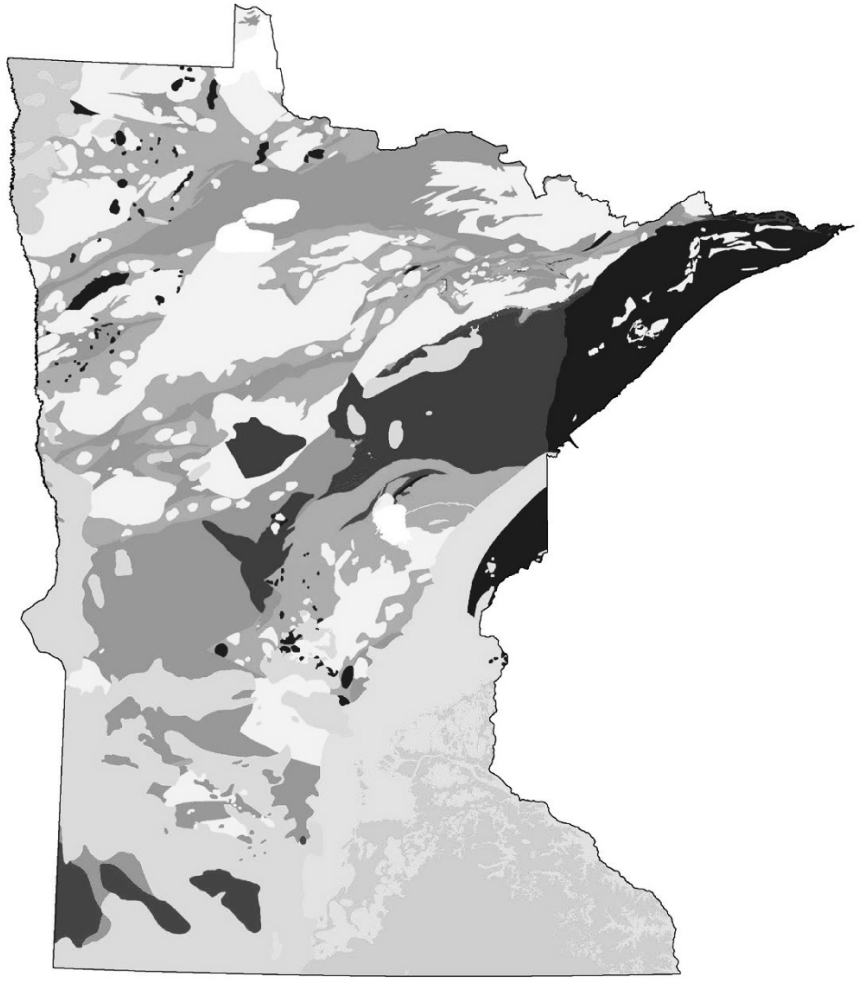
# Geology of the Carleton College Cowling Arboretum

## A Guided Tour



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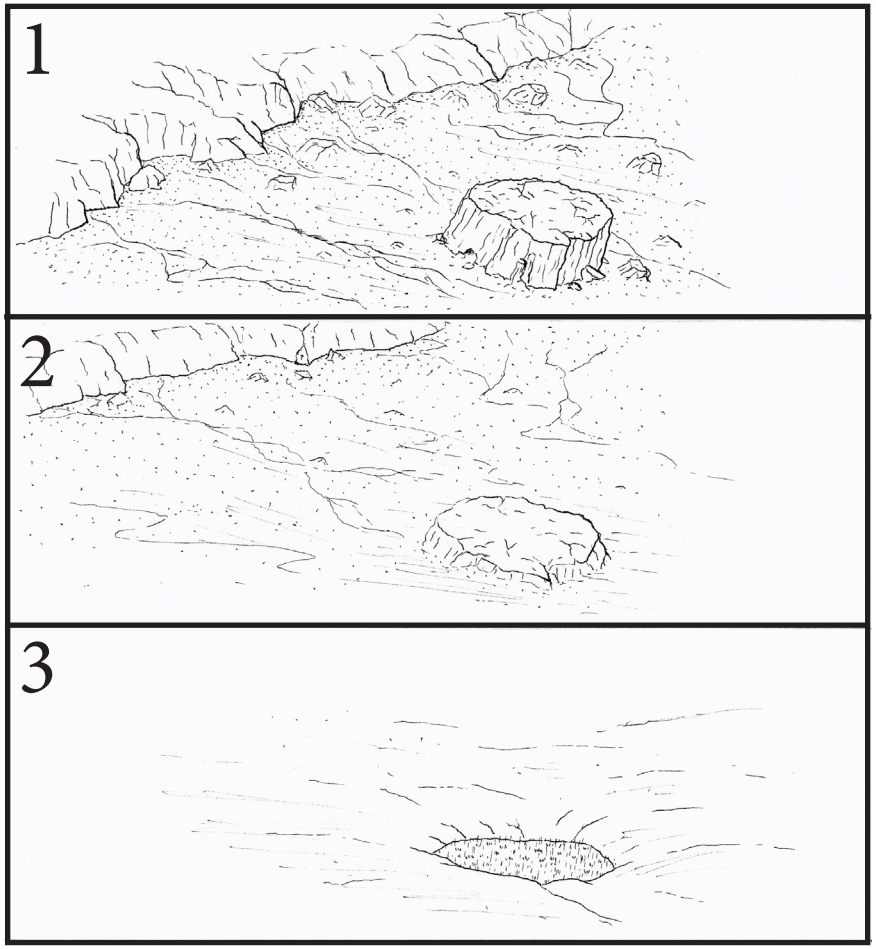
# Introduction

Hello and welcome to Carleton College's Cowling Arboretum. This 800 acre natural area, owned and managed by Carleton, has long been one of the most beloved parts of Carleton for students, faculty and community members alike. Although the Arb is best known for its prairie ecosystem, an amazing history full of thundering rivers, massive glaciers, and the journeys of massive boulders lies just below the surface. This geologic history of the Arb is a fascinating story and one that you can experience for yourself by following this self-guided tour. I hope it's a beautiful day for a walk hope and that you enjoy learning about the geology of the Arb as much as I did.

The route for this tour is about three miles long and will take you 1-2 hours to complete, depending on your walking speed. The route map can be found on the back page of this booklet, and the tour sites are arranged sequentially within the booklet. Opposite this page you can find a diagram that geologists call a stratigraphic column. This diagram is a timeline that illustrates when each rock formation was deposited in Northfield with the oldest rocks on the bottom and the youngest on the top.  Callouts along the left side denote when the events described in this pamphlet each took place. Keep this diagram in mind as you continue along this walk.

The map on the front cover of this book displays the extent of the many and varied rock types found throughout Minnesota. Minnesota has a rich and varied geological history and even though we may not be consciously aware of it, this history has helped shaped what it means to be Minnesotan.

This pamphlet was created by Callum McCulloch '15 and Forrest Williams '16 for the Cowling Arboretum. The fluvial terrace diagram and Minnesota geologic map are courtesy of the Minnesota Geological Survey. The Kettle Hole Marsh diagram is courtesy of Brendan Grant '12. Funding for this project was provided by the friends and family of Marc von Trapp '00.




This diagram depicts a possible way in which Kettle Hole Marsh could have been created. As the Des Moines Lobe retreated northward, some of the glacier broke off in chunks that were distributed across the landscape. If buried soon enough, the sediment and sand that covered the ice chunk could have insulated it and prevented it from melting for a long time. When the ice eventually did melt, a depression where the ice once stood would be left behind and this depression could have evolved into Kettle Hole Marsh as we see it today.

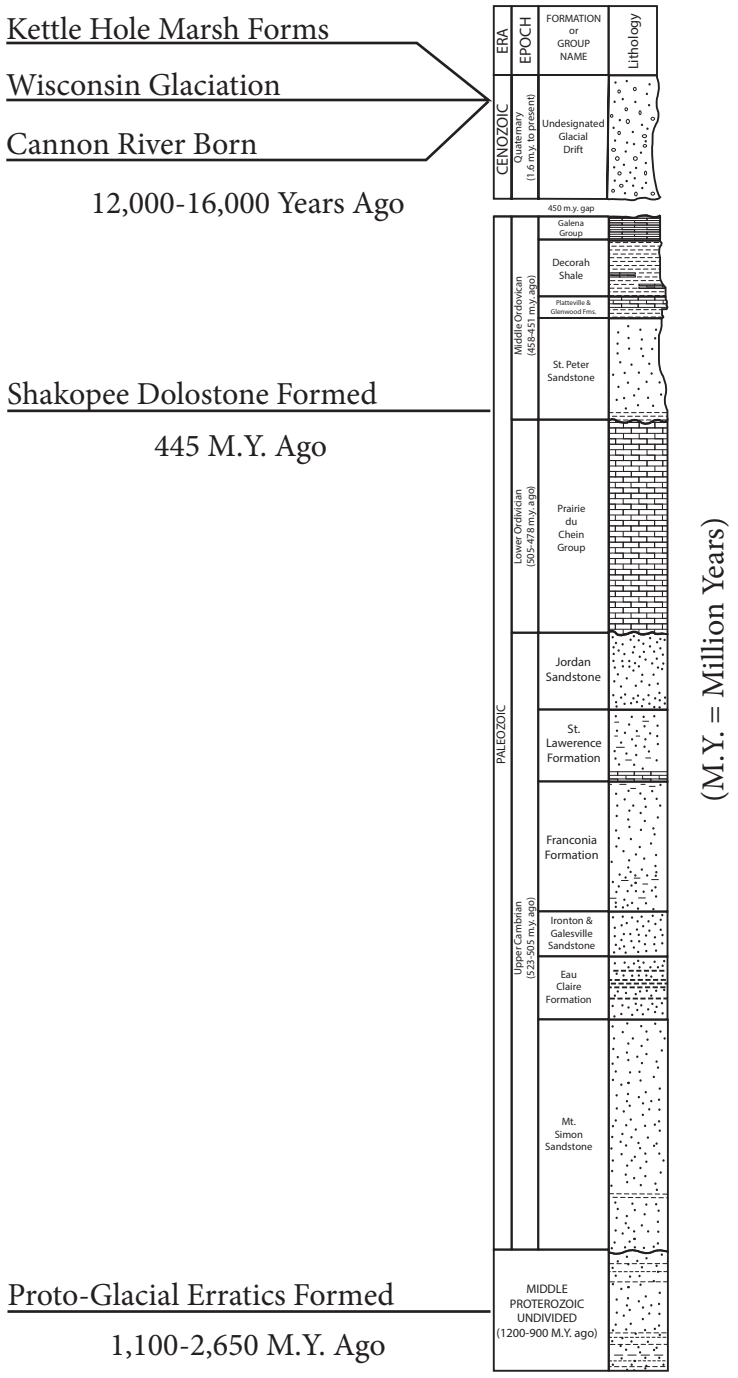
# 5. Kettle Hole Marsh

The most visible remnant of the glaciers in the Arboretum is Kettle Hole Marsh. The mechanisms that created Kettle Hole Marsh are not well understood, however there are some working hypotheses. Because the glacial Cannon River served as a major channel for the Des Moines Lobe meltwater, ice chunks as wide as 100 ft could have fallen off the edge of the glacier and floated downstream. During a severe period of flooding, ice chunks could have washed on shore in what would become the Arboretum. Then, glacial sediment could have covered the area around the block of ice or may have wholly covered it. When the ice melted, a water filled depression would be left behind.

Kettle Hole Marsh could have also been created by glacial ice left in the wake of large-scale glacial recession. In this scenario the ice chunk would again be covered by rock as the glacier retreated and the depression left once the ice block melted would be filled with water. This mechanism is the most common way for shallow lakes and wetlands to form in Minnesota, but there is no definitive evidence proving either theory.

Kettle Hole Marsh is a collection point for much of the water and sediment that comes from the local farmland and prairies and is unique in that it is the only waterbody in the Arb that does not drain into the Cannon River. The rate of sediment deposition accelerated during the early to mid 1900s when the fields to the south of Kettle Hole were in intense cultivation, but deposition has since returned to pre-settlement rates due to native prairie plantings and conservation-minded farming practices.

# Stratigraphic Column



# 1. The Cannon River

The first portion of the tour takes us along the bank of the Cannon River. The Cannon River acts as a superhighway, carrying large amounts of sediment, nutrients, invertebrates, and fish species through the Arboretum. Notably, the Minnesota Department of Natural Resources has designated the Cannon River as one of the few remaining wild and scenic rivers in the state.

Flooding is a natural part of the Cannon's life and helps to create many of the Lower Arb's most notable features. Much of the Lower Arb in fact is comprised of a low-lying flat area directly adjacent to the river. This area is called the floodplain, since it is where the water from the Cannon spreads to if it overflows its banks. The regular inundation of water in this area can have a debilitating effect on most plants, causing a distinct ecosystem to arise. The oaks and grasses that comprise the highland prairies are incapable of surviving under constant threat of flooding and instead we find flood tolerant species like boxelder, willow, green ash and silver maple.

The Cannon also has a much longer history than we normally consider. During the last glacial period, the Cannon River was a vast glacial river that carried more than a hundred times the amount of water it carries now. In order to accommodate such a large flow, the Cannon at this time covered the majority of the Lower Arboretum and Carleton's central campus, where it deposited flat terraces composed of glacial sediments. The steep east and north sides of Carleton's campus, like Bell Hill, represent the backside of the major terrace that was later sidecut by Spring Creek. Excavations around Carleton's campus have shown over ten meters of terrace deposits in some places.

# 4. Local Bedrock

The bench you're most likely sitting on at this point is a block of Shakopee Dolostone. The Shakopee Dolostone is a member of the Prairie du Chien group, a set of carbonate rocks that as an aquifer, which is a body of rock that stores the groundwater that comes out of our taps. The Shakopee Formation is a sand rich dolostone that contains stromatolites. Stromatolites are large fossils created by cyanobacteria that have trapped sediment around their bodies. Stromatolites provide some of the earliest records of life on Earth. Some samples are (not found in the Shakopee) are close to 3.450 billion years old!

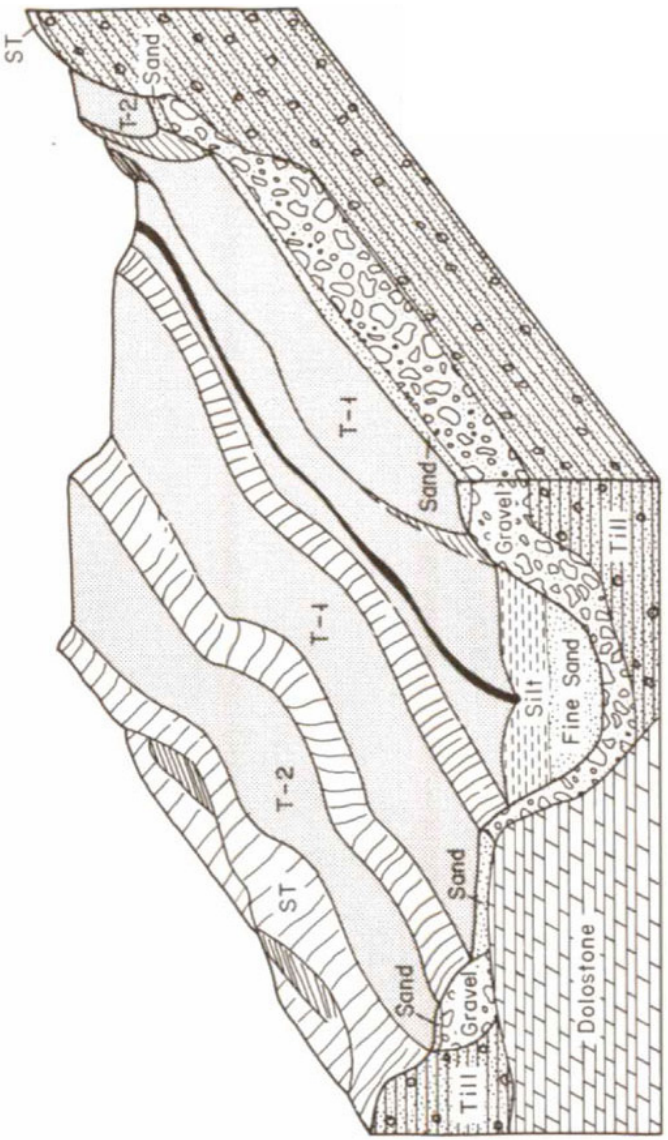
Although most dolostones start out as the mineral calcilte, over time magnesium can replace some of the calcium of the calcite to form dolomite. The Shakopee Dolostone contains approximately a 60/40 ratio of magnesium to calcium. Many fundamental questions about dolostone still remain unanswered. Geochemists still do not agree on the source of the magnesium that replaces the calcium within calcite. In addition, the conditions under which dolostones might have formed are not present in the majority of Earth today, so it is very difficult to study the formation of dolostone.

The bedrock is very close to the surface in northeastern Rice County and in some places it is exposed at the surface. Due to its wide availability and its strength, the Shakopee Dolostone was widely used as a building material in older buildings and the majority of barn foundations in the area. In fact, both Scoville and Boliou Hall use the Shakopee Dolostone as their primary building material

# 3. Glacial Erractics

This large rock, sometimes referred to as the "Bread Loaf", formed much earlier and further north than the local bedrock and has completed an arduous journey in order to arrive here. The Breadloaf is over 1100 million years old, which is more than 500 million years older than any of the Arb's native bedrock. Within the last million years, Glaciers ripped the Breadloaf from its northern home and carried it south. During this process the Breadloaf and other glacial erractics were pummeled by the ice, jostled against other rocks, and scraped across the landscape until they were ground down into their current smooth shapes. As the glaciers retreated these were left behind and were laid to rest in Dakota County, but were moved to their present location by Arboretum staff. Rocks that have undergone these processes are called glacial erractics and can be found throughout southern Minnesota.

Geologists classify rocks into three main categories; igneous, metamorphic and sedimentary rocks. Igneous rocks are formed when lava cools either above or below the Earth's surface. The Breadloaf and the rock holding the Von Trapp plaque, which are granites, and the gabbro near Kettle Hole Marsh are both examples of igneous rock. Metamorphic rocks are created when igneous or sedimentary are exposed to intense heat and pressure, which causes the form of the rock to change radically. The smaller erratic just south of the Breadloaf is composed of two different types of metamorphic rock; a schist and a gneiss. The bench where we will next stop is composed of a sedimentary rock called dolostone. Sedimentary rocks are created through the erosion and deposition of the crystals that make up igneous and metamorphic rocks, or through biogenic processes. The majority of the rocks that underlie the Arb are sedimentary rocks that were deposited several hundred million years ago when this section of Minnesota was still underwater.



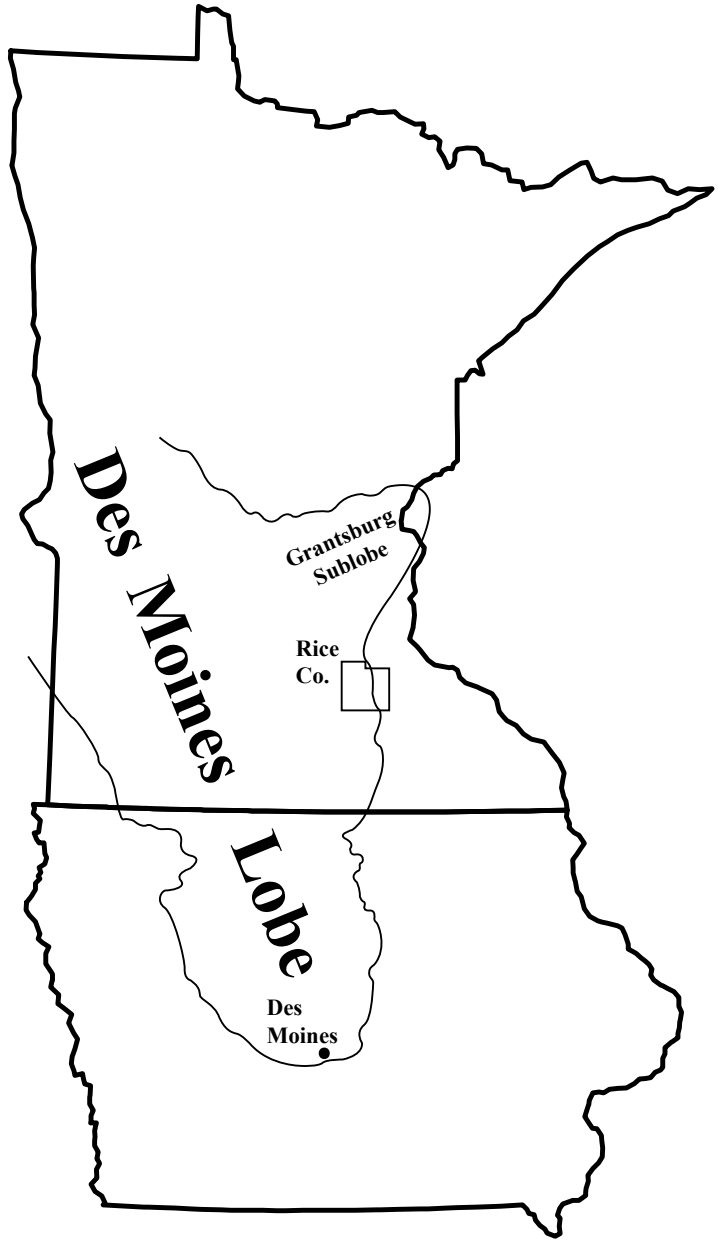

This cross-sectional view of a glacial river depicts how fluvial terraces (successive deposits of river sediments) are created. The terrace labeled T-2 was first deposited during a time when the river was depositing more sediment than it was eroding. When the river started eroding more than it deposited however, the river cut down into the T-2 terrace and deposited terrace T-1 when deposition took over again. This process often repeats itself multiple times until a series of terraces stepping down towards the river are created.

# 2. Glacial Landscapes

For the past million years, glacial processes have dominated the shaping of the landscape. The last glacial period that occurred in the Upper Midwest was the Wisconsin Glaciation which lasted from roughly 110,000 to 10,000 years ago. This marks the time period between the Sangamon interglacial period and the current interglacial period. During the Wisconsin, the massive Des Moines Lobe of the Laurentide Ice Sheet began extending from Canada to its namesake city Des Moines, Iowa. The eastern boundary of this advance (the Des Moines Lobe) lies about half a mile east of the Upper Arb and about one mile east of the Lower Arb.

As the glaciers melted and retreated, the Cannon River and Spring Creek carried much of the glacial runoff into Rice County. Seismic surveys (a technique used to map the subsurface of the earth) have indicated that Spring Creek was about 100 feet deeper and much wider during this period, but both Spring Creek and the Cannon River have filled with large amounts of glacial sediment as the glaciers retreated northward. Along with river deposits the glaciers left behind large amounts of unsorted gravel and sand, called glacial till, and loess, which is a windblown silt that is deposited on the edges of glacial terrains.

Since the last glaciation, many areas of the Midwest, including the Cowling Arboretum, have been covered by prairie vegetation, which has built a thick layer of rich organic material above the glacial deposits. The combined efforts of glacial terraforming and years of biological activity have created the soils which make the growth of the fertile prairies possible today. Likewise, the combination of organics, biologically essential elements, and water retention allow for the intensive, high-yield farming that is characteristic of southeastern Minnesota.




Extent of the Des Moines Glacial Lobe during the Wisconsin Glaciation