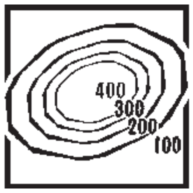


Chapter 4: Topography of the Midwestern US

Does your region have rolling hills? Mountainous areas? Flat land where you never have to bike up a hill? The term **topography** is used to describe the changes in elevation over a particular area and is, generally speaking, the result of two processes: deposition and **erosion**. These processes can happen on an enormous range of timescales. For example, a flash flood can erode away tons of rock in a matter of hours, yet which rock is broken down and which remains can depend on how it was formed hundreds of millions of years ago. In addition to these processes, the topography of the Midwest is intimately tied to **weathering** and erosional forces, along with the type and structure of the underlying bedrock.

Weathering includes both the mechanical and chemical processes that break down a rock. **Wind**, water, and ice are the media by which physical weathering and erosion occur. Streams are constantly trying to erode the bedrock down to sea level, creating valleys in the process. With sufficient time, streams can cut deeply and create wide flat **floodplains** on the valley floor.

Wave action on the shores of the **Great Lakes** contributes to the erosion of rocks and sediments. Ice plays a major role in the weathering and erosion of the Midwest landscape because of the frequent episodes of freezing and thawing in temperate latitudes. On a small scale, as water trapped in fractures within the rock freezes and thaws, the fractures widen farther and farther. This alone can induce significant breakdown of large rock bodies. On a larger scale, ice in the form of **glaciers** in mountain valleys and continental **ice sheets** can reshape the surface of a continent through physical weathering.

Working in conjunction with physical weathering, chemical weathering also helps to break down rocks. Some **minerals** contained in **igneous** and **metamorphic rocks** that are formed at high temperatures and pressures (far below the surface of the Earth) become unstable when they are exposed at the surface where the temperature and pressure are considerably lower, especially when placed in contact with water. Unstable minerals transition into more stable minerals, which results in the breakup of rock. Weak acids, such as carbonic acid found in rainwater, promote the disintegration of certain types of rocks. **Limestone** and **marble** may be rapidly broken down chemically as carbonic acid reacts with the **carbonate** mineral composition of these rocks, forming cavities and caverns in the rock. Other **sedimentary rocks** held together by carbonate cement are also particularly susceptible to chemical weathering.

See Chapter 2: Rocks to learn more about igneous, metamorphic, and sedimentary rocks.

Review

Great Lakes • *the largest group of freshwater lakes on Earth (by total surface area and volume), located on the US-Canadian border.*

glacier • *a body of dense ice on land that does not melt away annually and has sufficient mass to move under its own weight.*

mineral • *a naturally occurring solid with a specific chemical composition and crystalline structure.*

metamorphic rocks • *rocks formed by the recrystallization and realignment of minerals in pre-existing sedimentary, igneous, and metamorphic rocks when exposed to high enough temperature and/or pressure.*

sedimentary rock • *formed through the accumulation and consolidation of grains of broken rock, crystals, skeletal fragments, and organic matter.*

CHAPTER AUTHOR

Alex F. Wall

4 Topography

Review

Devonian • *a geologic time period spanning from 419 to 359 million years ago.*

recrystallization • *the change in structure of mineral crystals that make up rocks, or the formation of new mineral crystals within the rock.*

schist • *a medium grade metamorphic rock with sheet-like crystals flattened in one plane.*

sandstone • *sedimentary rock formed by cementing together grains of sand.*

till • *unconsolidated sediment that is eroded from the bedrock, then carried and eventually depositied by glaciers as they recede.*

plates • *large, rigid pieces of the Earth's crust and upper mantle, which move and interact with one another at their boundaries.*

crust • *the uppermost, rigid outer layer of the Earth, composed of tectonic plates.*

The specific rock type at the surface has an important influence on the topography of a region. Certain rocks are able to resist weathering and erosion more easily than are others; resistant rocks that overlie weaker layers act as caps and form ridges. The inland ocean basins of the Ordovician Taconic and the **Devonian** Acadian mountain-building events collected and preserved sediments that eventually became sedimentary rocks. Sedimentary rocks weather and erode differently than do the crystalline, and generally harder, igneous and metamorphic rocks that are more common in the Superior Upland province. **Silica**-rich igneous rocks have a crystalline nature and mineral composition that resists weathering far better than do the cemented grains of a sedimentary rock. The metamorphic equivalents of sedimentary and igneous rocks are often more resistant due to **recrystallization**. There are exceptions, however, such as **schist**, which is much weaker than its pre-metamorphic limestone or **sandstone** state. Landscapes of unconsolidated sediments like **soil** or glacial **till** are the least resistant to erosion.

See Chapter 1: Geologic History for more information about the mountain-building events that helped to shape the Midwest.

The underlying structure of the rock layers also plays an important role in the topography at the surface. Sedimentary rocks are originally deposited in flat-lying layers that rest on top of one another. Movement of tectonic **plates** creates stress and tension within the **crust**, especially at plate boundaries, which often deform the flat layers by folding, **faulting**, intruding, or overturning. These terms are collectively used to describe rock structure, and they can also be used to determine which forces have affected rocks in the past. The folding of horizontal rock beds followed by erosion and **uplift** exposes layers of rock to the surface. Faulting likewise exposes layers at the surface to erosion, due to the movement and tilting of blocks of crust along the fault plane. Tilted rocks expose underlying layers. Resistant layers erode relatively slowly and remain as ridges, while surrounding layers of less resistant rock erode away.

Glacial ice sheets of the most recent **ice age** covered most of the Midwest and had a dramatic effect on the topography of the area. Glaciers carved away at the land's surface as they made their way generally southward, creating characteristic glacial depositional features such as **drumlins**, **eskers**, and **moraines**. Hills were worn and valleys widened.

See Chapter 6: Glaciers for more about glacial depositional features.

Just as we were able to make sense of the type of rocks in an area by knowing the geologic history of the Midwest, we are able to make sense of its topography (*Figure 4.1*) based on the rocks and structures resulting from past geologic events.

Topography 4

Topography of the Superior Upland
Region 1

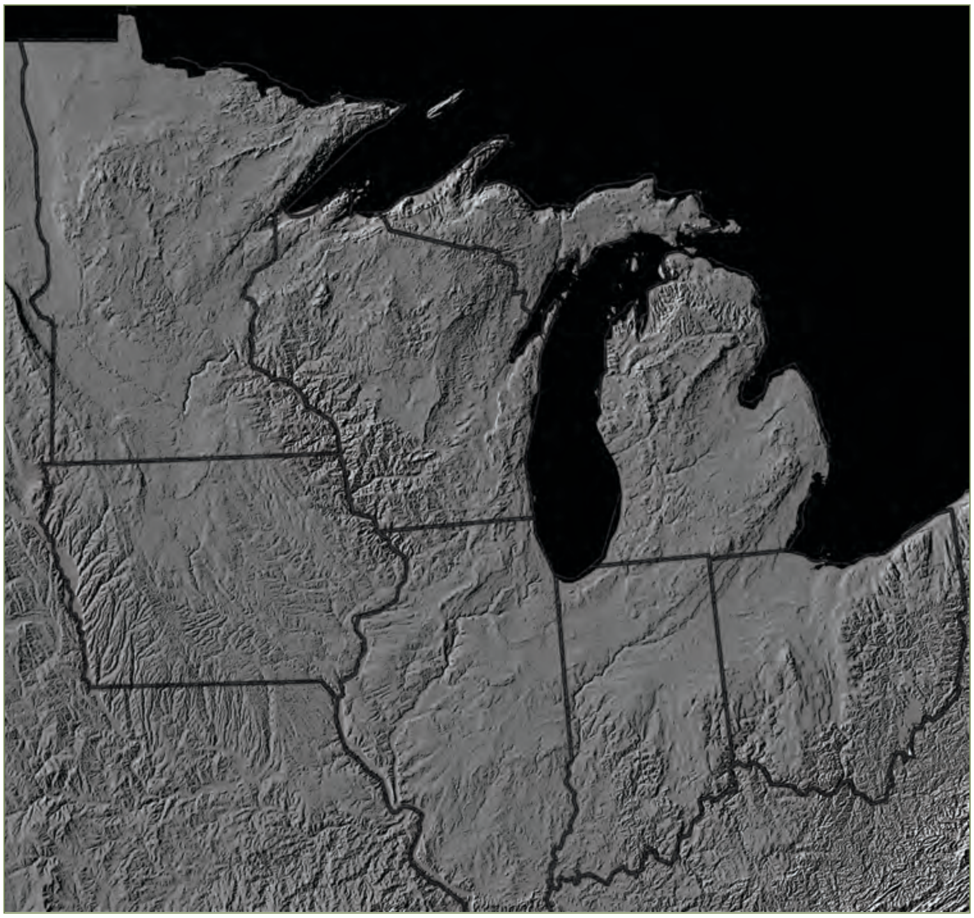


Figure 4.1: Digital shaded relief map of the Midwest.

While the Superior Upland is not mountainous, it has a more dramatic topography than does much of the Midwest. The highest points in each of the three states in the Superior Upland are found in that region, rather than in the southern portions of the states, which are part of the Central Lowland. The ice sheets of the last ice age heavily **scoured** much of the Midwest, but the hard metamorphic and igneous bedrock of this region was more resistant, retaining some of the relief of the mountain ranges that once existed here. Hills reach over 610 meters (2000 feet) above sea level, while the shores of Lake Superior are at about 180 meters (600 feet), and its bottom plunges to more than 210 meters (700 feet) below sea level.

The more easily eroded igneous and sedimentary rocks created during the Midcontinental Rift event 1.1 billion years ago are partially responsible for the depth of the Great Lakes. The **rifting** caused a basin to form that was

Region 1

fault • *a fracture in the Earth's crust in which the rock on one side of the fracture moves measurably in relation to the rock on the other side.*

ice age • *a period of global cooling of the Earth's surface and atmosphere, resulting in the presence or expansion of ice sheets and glaciers.*

drumlin • *a teardrop-shaped hill of till that was trapped beneath a glacier and streamlined in the direction of the flow of the ice moving over it.*

esker • *a sinuous, elongated ridge of sand and gravel.*

moraine • *an accumulation of unconsolidated glacial debris (soil and rock) that can occur in currently glaciated and formerly glaciated regions.*

4 Topography

Regions 1–2

lava • *molten rock located on the Earth's surface.*

Archean • *a geologic time period that extends from 4 billion to 2.5 billion years ago.*

repeatedly filled with **lava** flows and sediment. When glaciers scraped across the landscape, they gouged these rocks much more deeply than they did the surrounding **Archean** rocks (*Figure 4.2*).

See Chapter 1: Geologic History for more about this rifting event.

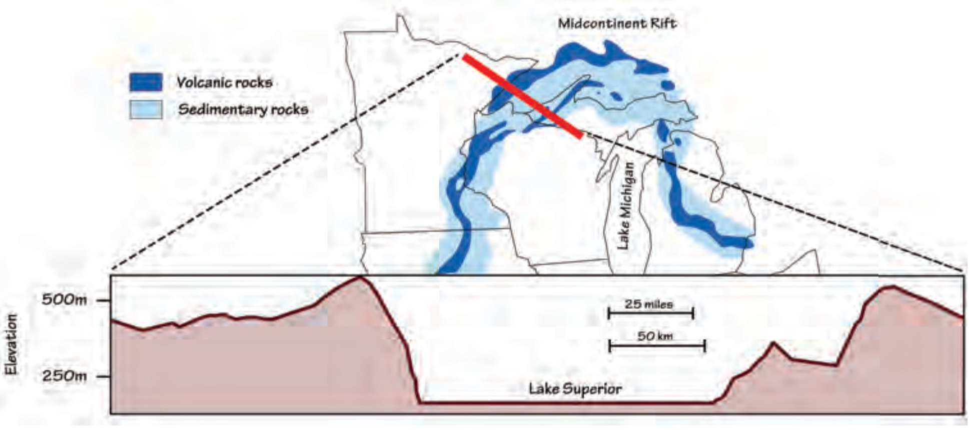


Figure 4.2: Cross-section showing topographic relief across rocks within the Midcontinental Rift.

In addition to wearing down the ancient rugged landscape, glaciers also left deposits on the Superior Upland. Much of the region has a thin layer of glacial till, but, for the most part, the topography is controlled by the underlying bedrock. The drumlin fields north of Duluth are an exception to this generality. These low hills are strongly elongated from the northeast to the southwest, indicating the direction the glaciers flowed while the sediment was deposited to a depth of 15 meters (50 feet).

Topography of the Central Lowland
Region 2

Nearly all of the bedrock in the Central Lowland is sedimentary and fairly easily eroded. During the last ice age, a series of huge ice sheets worked their way primarily southward and flattened most of whatever varied topography the region once had. Furthermore, as the glaciers retreated, they dumped sediment that formed the flatlands and the low, rolling hills that are characteristic of most of the region. There are several areas with present-day relief caused by glacial deposits, especially that created by hill-forming moraines and drumlins. While these formations stand out against the surrounding landscape, they do not usually rise more than 60 meters (200 feet) from base to peak.

Most of the topography of the Central Lowland is controlled by the rivers running through it. Since the ice last retreated from the region, rivers have had only

20,000 years, at the most, to shape the young terrain, so even the largest river valleys are not yet that deep.

Within the Central Lowland, the **Driftless Area** may be viewed as a window into the region's topographic past (*Figure 4.3*). The glaciers of the last several advances did not reach as far south as where the borders of Minnesota, Wisconsin, Iowa, and Illinois meet, leaving that area with bedrock similar to the surrounding landscape but with starkly different topography. Here, streams and rivers have had hundreds of thousands, and perhaps tens of millions, of years to carve steep relief into the same types of rocks that, just miles away, glaciers recently scraped flat. Both mechanical and chemical weathering here have created a **karst topography**, defined by bedrock that has been affected by dissolution in water to form features like sinkholes, caves, and cliffs. The highest points in Iowa and Illinois are both located in the Driftless Area. Given enough time, the rest of the Central Lowland might appear as the Driftless Area does today, after running water washes away the glacial sediment and cuts into the bedrock. West Blue Mound, with an elevation of 523 meters (1716 feet), is the highest point in the Driftless Area, while the Mississippi River is appreciably lower at 184 meters (603 feet). Ultimately, this does not result in huge changes in elevation, but the steep cliffs and valleys contrast dramatically with the nearby flatland.

See Chapter 6: Glaciers for more about the Driftless Area.

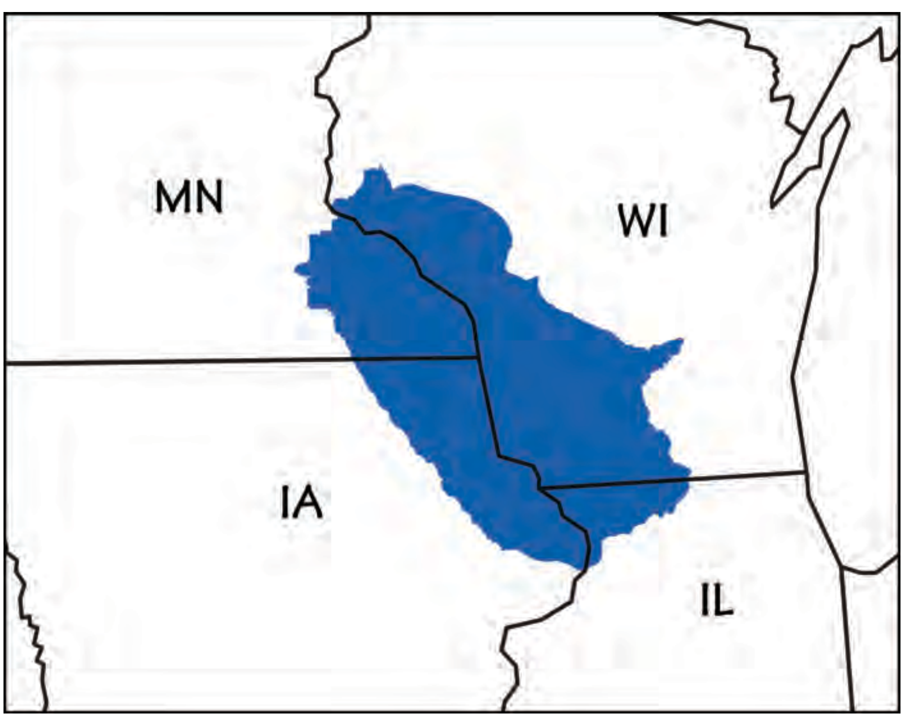


Figure 4.3: Map showing location of the "Driftless Area" of the Central Lowland.

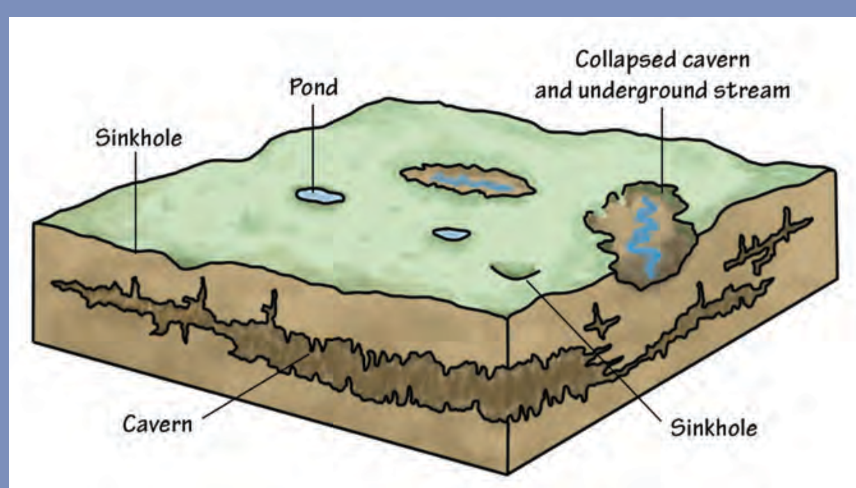
4 Topography

Region 2

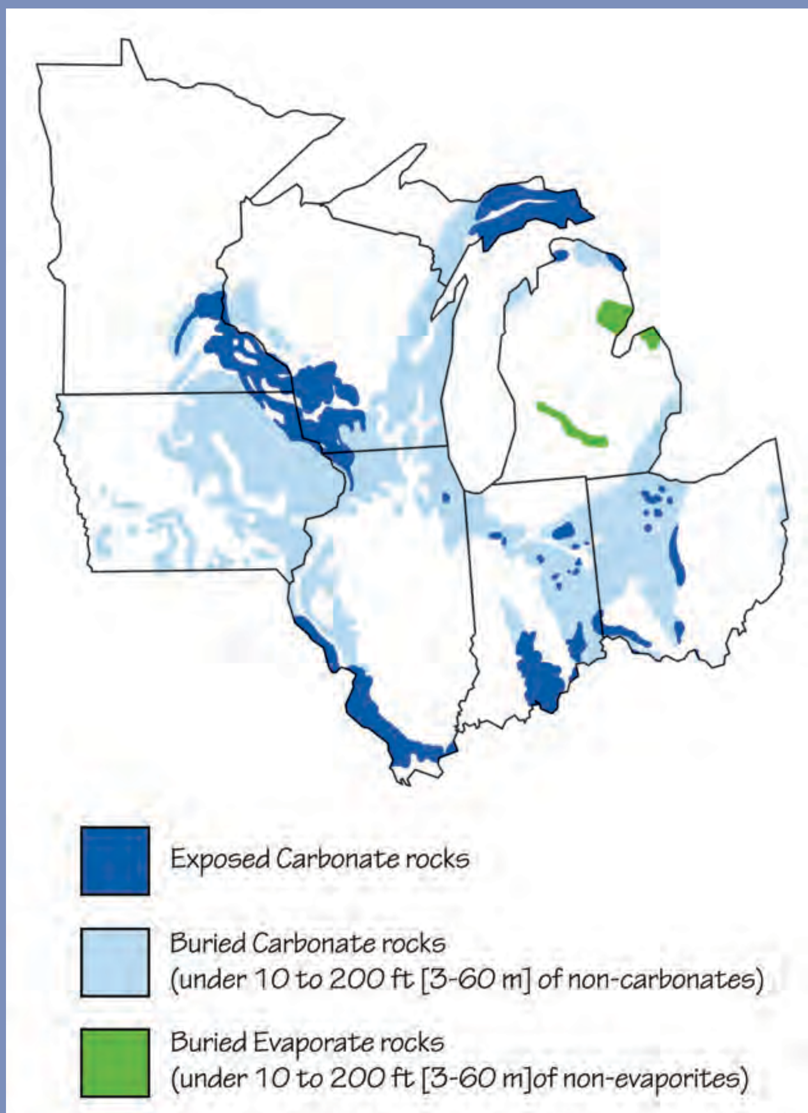
atmosphere • *a layer of gases surrounding a planet.*

Karst Topography

Karst topography refers to a region where the landscape's features are largely the result of chemical weathering by water, resulting in caves, sinkholes, disappearing and reappearing streams, cliffs, and steep-sided hills called towers. These structures form when water picks up carbon dioxide from the *atmosphere* and ground to form carbonic acid. Even this fairly weak and dilute acid dissolves carbonate rocks (such as limestone) relatively easily, resulting in dramatic features while other rock is comparatively unaffected. Karst is found in every state except Hawaii, and it is the source of a significant amount of our drinking water, particularly in the Midwest. While common, karst is not always easily identifiable since it is often not expressed at the surface or its topography has been affected by other factors. Karst topography is a relatively mature type of landscape, taking many tens of thousands of years to develop, and it can indicate that a region has been free of other forms of erosion, or deposition, for an extended period. Karst topography in the Midwest is found in places that were not eroded by glaciers during the last ice age, including northern Michigan, Mitchell Plateau and Muscatatuck Plateau in Indiana, and the Driftless Area. (See discussion above in Topography of the Central Lowland and Chapter 6: Glaciers.)



Karst Topography (continued)



inland sea • *a shallow sea covering the central area of a continent during periods of high sea level.*

Topography of the Inland Basin
Region 3

The Inland Basin is a large region that extends from southern Illinois to northern Alabama to central New York. Its rock formed primarily in the basins of **inland seas** many millions of years ago, and while its origin affects the way it is eroded, its topography is quite varied. In the Midwest, the region includes only eastern Ohio, southern Indiana, and the southernmost portion of Illinois.

4 Topography

Region 3

Most of the eastern half of Ohio is part of the Allegheny Plateau, which extends from northeastern Kentucky well into central New York. This portion of Ohio is further divided into glaciated and unglaciated areas (*Figure 4.4*). The glaciated northwest portion is quite flat, with relief features of little more than 30 meters (100 feet) high. The southeast portion of the state was never flattened by glaciers or buried in till, so relief here is several times greater, occasionally reaching up to 120 meters (400 feet). Millions of years of running water carving into the bedrock has resulted in high hills, steep cliffs, and gorges.

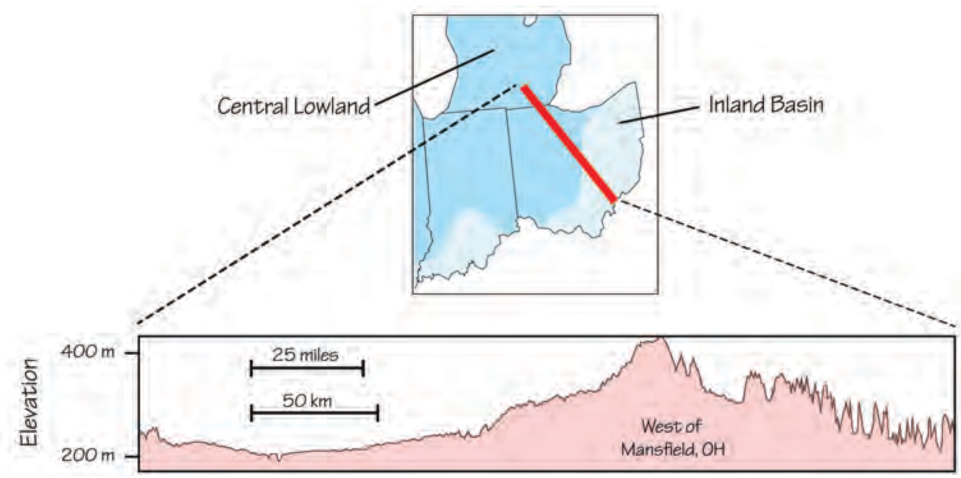


Figure 4.4: Inland Basin topography, showing the difference in elevation between glaciated and unglaciated areas.

The portions of southern Indiana and Illinois that were not glaciated have a landscape similar to that of southeastern Ohio: a modest degree of relief, but substantially more rugged than the northern (previously glaciated) portions of those states.

An important distinction is that, because much of the bedrock in the Inland Basin is carbonate, this area commonly displays karst features. Caves are not uncommon in Ohio, but many of them are located in the Central Lowland portion of the state. The bedrock of southern Indiana and Illinois is, in areas, riddled with limestone caves.

Highest and Lowest Elevations (by state)

Illinois

Charles Mound, Illinois' highest point at 376 meters (1235 feet), is located in the state's extreme northwest and is part of the Driftless Area. The state's lowest point, at 85 meters (280 feet), is the confluence of the Ohio and Mississippi Rivers at the state's southern tip.

Indiana

Extreme eastern Indiana is home to Hoosier Hill, which, at 383 meters (1257 feet), is the state's highest point. The confluence of the Ohio and Wabash Rivers is Indiana's lowest point at 97 meters (320 feet).

Iowa

Hawkeye Point, the highest point in Iowa at 509 meters (1670 feet), is just south of the Minnesota border in the northwest. Iowa's lowest point of 146 meters (480 feet), the confluence of the Des Moines and Mississippi Rivers, also marks the southeasternmost point in the state.

Michigan

Michigan's highest point, located on the Upper Peninsula, is Mount Arvon at 603 meters (1979 feet). Lake Erie is 174 meters (571 feet) above sea level, the lowest elevation in Michigan.

Minnesota

Eagle Mountain is the highest point in Minnesota at 701 meters (2301 feet). Interestingly, it is only 24 kilometers (15 miles) from Lake Superior, which, at 183 meters (601 feet) above sea level, is the state's lowest elevation.

Ohio

Campbell Hill, 472 meters (1550 feet) high, is located in the city of Bellefontaine, in eastern central Ohio, and it is the state's highest point. The southern extreme of the state's border with Indiana, on the Ohio River, is Ohio's lowest point at 139 meters (455 feet).

Wisconsin

At 595 meters (1951 feet) above sea level, Timms Hill, located in the northern central part of Wisconsin, is the highest point in the state. The state's lowest elevation is Lake Michigan at 177 meters (581 feet).

Resources

Books

Wyckoff, J., 1999, *Reading the Earth: landforms in the making*. Adastra West, Inc.: Mahwah, NJ.

Websites

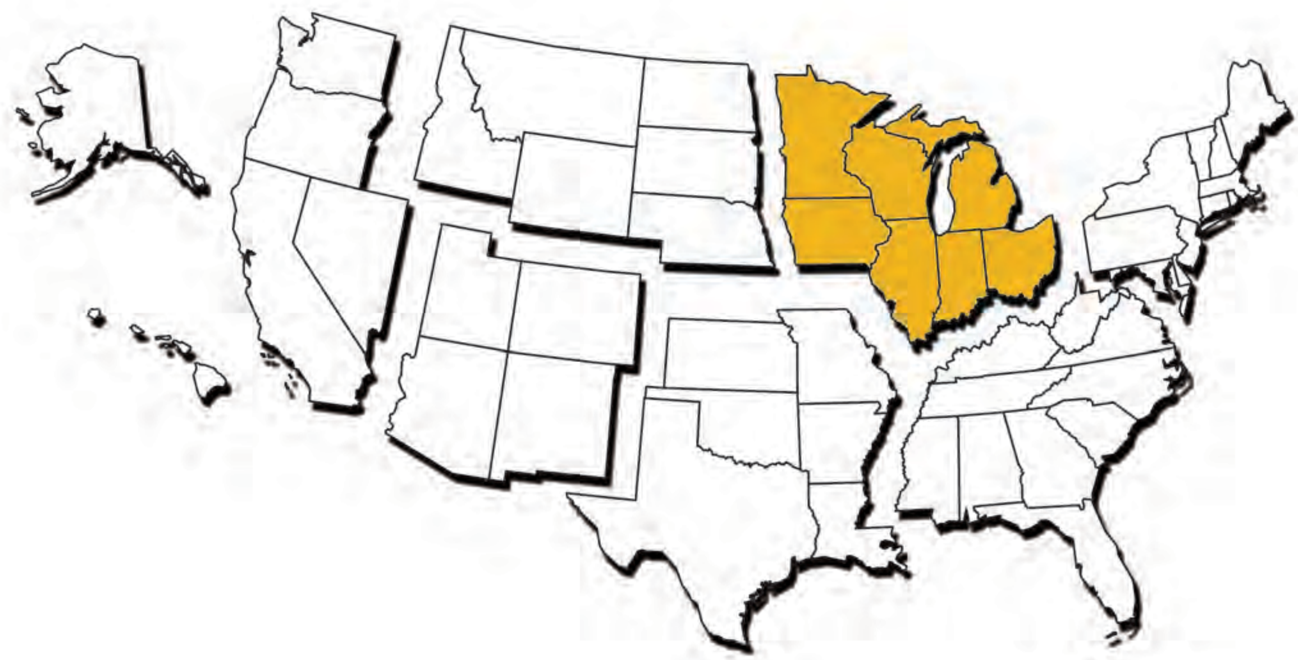
Color Landform Atlas of the US (Low resolution shaded relief maps of each state.)
http://fermi.jhuapl.edu/states/states.html.

[Wisconsin] Major landscape features. Wisconsin Geological & Natural History Survey.
http://wgnhs.uwex.edu/wisconsin-geology/major-landscape-features/.

[Wisconsin] Karst and sinkholes. Wisconsin Geological & Natural History Survey.
http://wgnhs.uwex.edu/water-environment/karst-sinkholes/.

The Teacher-Friendly Guide™

to the Earth Science of the Midwestern US



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Paleontological Research Institution
2014

ISBN 978-0-87710-507-7
Library of Congress no. 2014953666
PRI Special Publication no. 46

1259 Trumansburg Road
Ithaca, New York 14850 USA
priweb.org

First printing October 2014

This material is based upon work supported by the National Science Foundation under grant DRL-0733303. Any opinions, findings, and conclusions or recommendations are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. The publication also draws from work funded by the Arthur Vining Davis Foundations and The Atlantic Philanthropies.

The interactive online version of this *Teacher-Friendly Guide*™ (including downloadable pdfs) can be found at http://teacherfriendlyguide.org. Web version by Brian Gollands.

The Teacher-Friendly Guide™ series was originally conceived by Robert M. Ross and Warren D. Allmon. Original illustrations in this volume are mostly by Jim Houghton (The Graphic Touch, Ithaca), Wade Greenberg-Brand, and Christi A. Sobel.

Layout and design by Paula M. Mikkelsen, Elizabeth Stricker, Wade Greenberg-Brand, and Katherine Peck.

Cite this book as:
Lucas, M. D., R. M. Ross, & A. N. Swaby (eds.), 2014, *The Teacher-Friendly Guide to the Earth Science of the Midwestern US.* Paleontological Research Institution, Ithaca, New York, 316 pp.

Cite one chapter as (example):
Wall, A. F., and W. D. Allmon, 2014, Fossils of the Midwestern US. Pages 57–83, in: M. D. Lucas, R. M. Ross, & A. N. Swaby (eds.). *The Teacher-Friendly Guide to the Earth Science of the Midwestern US.* Paleontological Research Institution, Ithaca, New York.

On the back cover: Blended geologic and digital elevation map of the Midwest. Each color represents the age of the bedrock at the surface. Adapted from Barton, K.E., Howell, D.G., Vigil, J.F., *The North America Tapestry of Time and Terrain*, US Geological Survey Geologic Investigations Series I-2781, http://pubs.usgs.gov/imap/i2781.