

Common Hazards in Karst Terrain

*Benjamin Currens and Alan Fryar, Earth and Environmental Sciences; and
 Carmen Agouridis, Biosystems and Agricultural Engineering*

What is Karst?

Karst refers to terrain largely drained by subsurface conduits and caves. Karst landscapes are characterized by surface features such as springs, sinkholes, shallow depressions, and rolling hills (Figure 1). Karst regions are also known for their subsurface or below-ground features such as conduits and caves (Figure 2). What makes a karst region unique is the way runoff drains from the land. In karst regions, some of the runoff flows into surface features such as sinkholes where it then travels underground. Some of this infiltrated water re-emerges at springs (Figure 1a), and some continues moving underground.

An aquifer is a body of water-bearing rock located underground. Two important features of aquifers are how water is stored in the rock and how water moves through the rock. Rocks and sediment contain empty space known as pore space which can be filled with water (Figure 3). Different types of rocks and soil have different amounts of pore space, hence are able to hold varying amounts or volumes of water. In karst regions, the rock (also known as bedrock) is predominantly limestone or dolostone (dolomite). Within limestone and dolostone, the pore spaces are not large or interconnected, meaning these voids hold little water. Instead, karst aquifers store water mainly in the fractures in the rocks. Because the pore spaces are not well connected, water flow in karst aquifers occurs via fractures and conduits or large underground flow paths.

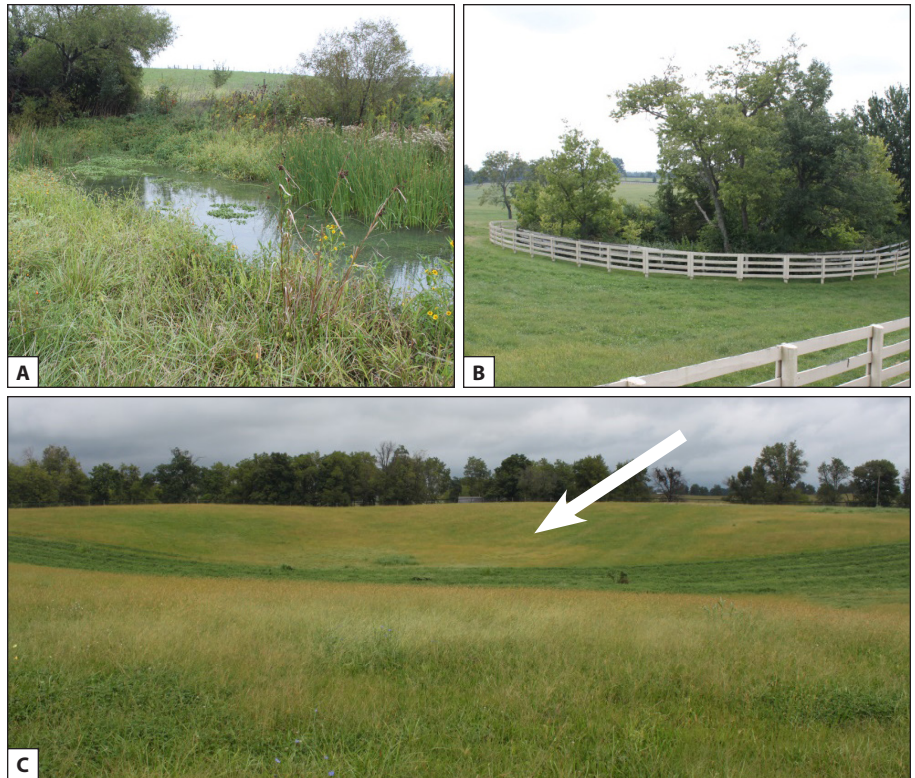


Figure 1. Features such as (a) springs, (b) sinkholes (this one fenced to keep horses and farm equipment out) and (c) shallow depressions (center of photo) are commonly seen in karst regions such as the inner bluegrass of Kentucky.

Source: Tyler Sanderson, Biosystems and Agricultural Engineering.

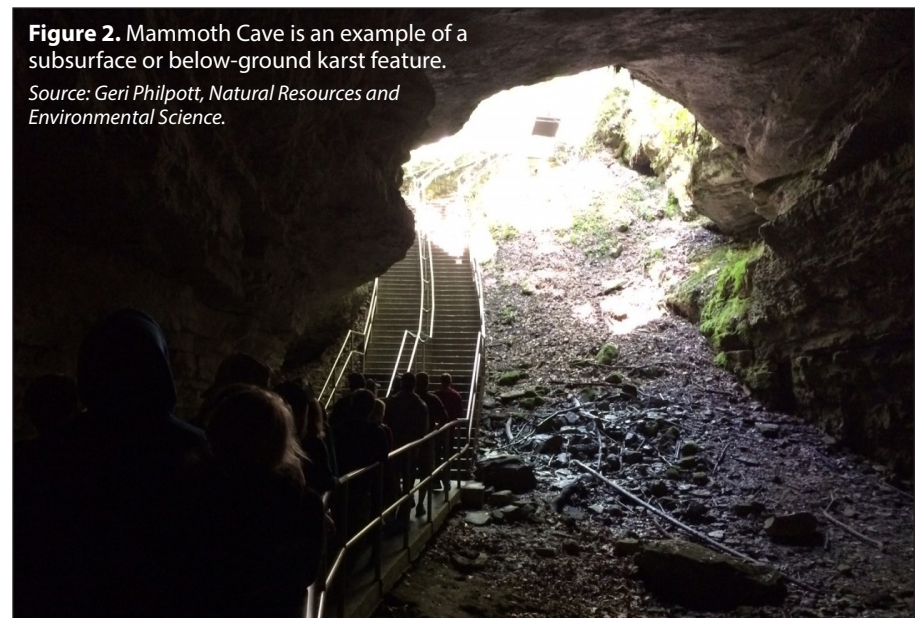


Figure 2. Mammoth Cave is an example of a subsurface or below-ground karst feature.

Source: Geri Philpott, Natural Resources and Environmental Science.



Figure 3. Pore space exists between individual particles of sediment and within sedimentary rocks.

Source: Nathan Wright, Landscape Architecture.

How Does Karst Form?

Karst formation is a product of climate and geology. As rain falls from the sky, a small amount of carbon dioxide (CO_2) gas is dissolved into rain drops. More CO_2 is dissolved as the water percolates through the soil (Figure 4). The CO_2 reacts with the water to form a weak acid known as carbonic acid (H_2CO_3). However, carbonic acid alone cannot form karst—the correct geology is required. When carbonic acid encounters limestone (CaCO_3) or dolostone ($\text{CaMg}(\text{CO}_3)_2$), the rock becomes weathered and slowly dissolves. The calcium (Ca) and magnesium (Mg) are carried away in solution, along with the CO_2 , and voids are formed. Small fractures become conduits which can then become caves.

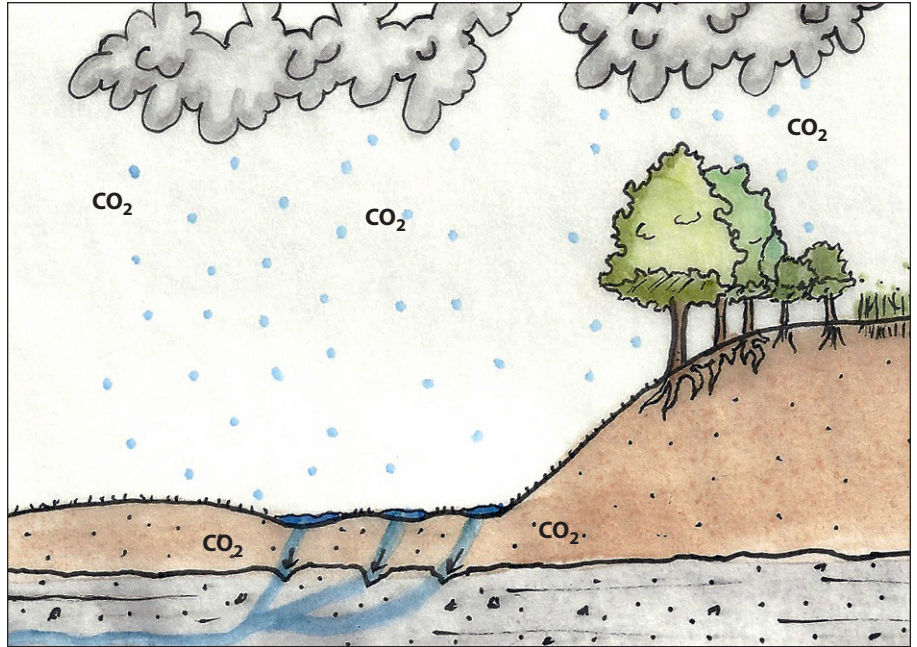


Figure 4. Carbon dioxide (CO_2) is dissolved in rainwater as it falls to the earth and percolates through the soil. When this rainwater encounters carbonate rich rock such as limestone or dolostone, a small amount of the rock is dissolved, creating openings.

Source: Nathan Wright, Landscape Architecture.

Where is Karst Found?

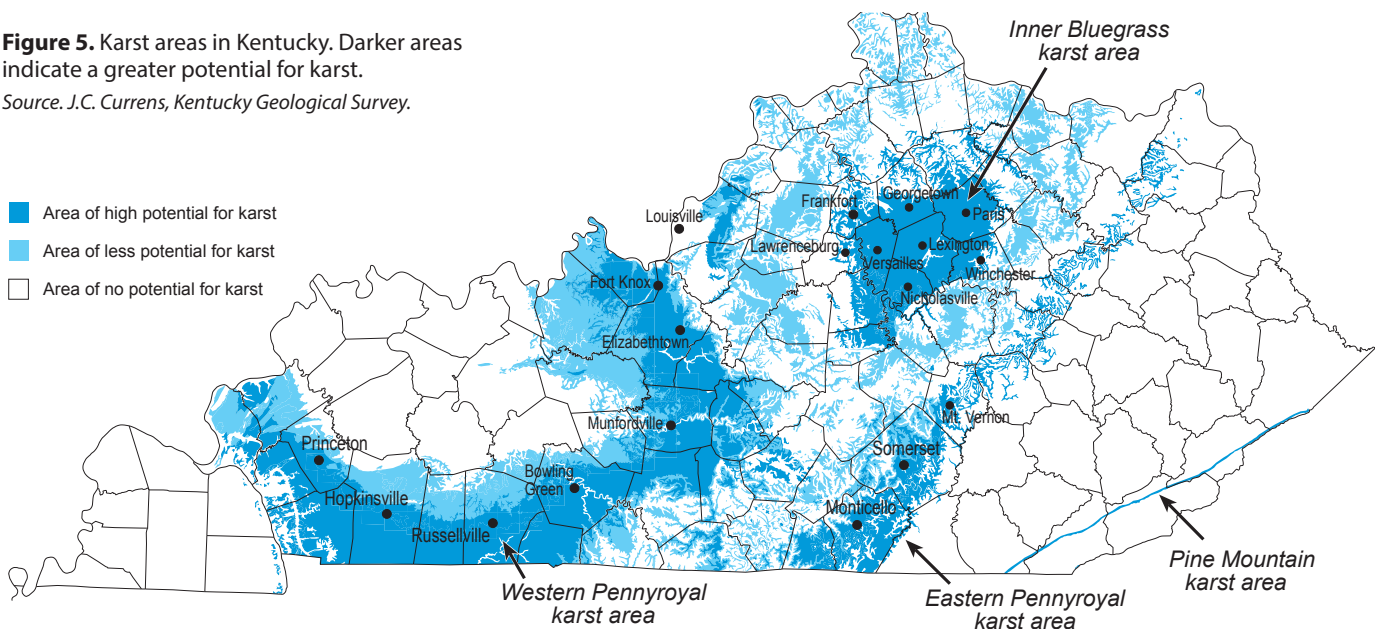
Karst can occur anywhere in the world that has the correct geology (carbonate rock) and sufficiently high rates of weathering, which depend on factors such as the amount of rainfall (past or present) and the amount of biological activity in the soil. In the U.S., most karst regions are found east of the Rocky Mountains. Florida, Iowa, Kentucky,

Missouri, and Tennessee have significant amounts of karst.

In Kentucky, karst is mainly found in the central and western regions although it is present in some eastern portions of the state (Figure 5). More than 55 percent of Kentucky is classified as karst terrain. Because of the difficulty in mapping karst, areas are designated as having the potential for karst, meaning karst may or may not be present.

Figure 5. Karst areas in Kentucky. Darker areas indicate a greater potential for karst.

Source: J.C. Currens, Kentucky Geological Survey.



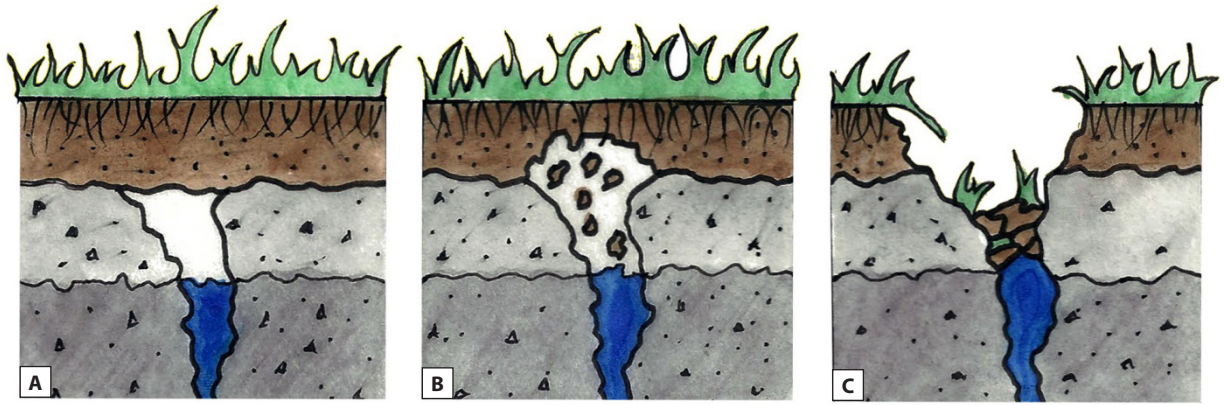


Figure 6. Sinkholes can form when rock is dissolved leaving a soil bridge (a). The soil bridge weakens as soil is carried away (b). When the soil bridge collapses, a sinkhole is formed (c).

Source: Nathan Wright, Landscape Architecture.

Special Considerations in Karst Terrain

Because of the way in which karst is formed, via the slow dissolution of bedrock, special consideration should be given to property and water quality protection.

Sinkhole Collapse

Sinkholes are naturally occurring depressions that are drained internally, meaning water only exits by infiltrating into the ground. Sinkholes form in one of two ways: the slumping of soil as rock is dissolved and carried away (slow formation) (Figure 6), or the collapse of a cave roof (quick formation). Cover collapse sinkholes can range from a few to tens of feet wide (Figure 7).

Avoiding sinkholes is difficult to do in karst terrain. Early building-related indicators of a forming sinkhole include out-of-square door frames and windows and the presence of cracks in drywall and foundation walls. Cracks in the soil and newly formed shallow depressions may also be early indicators. These potential karst indicators may also be caused by the shrinking and swelling of clay soils.

Once a sinkhole collapse occurs, making repairs is often difficult and costly. A sinkhole collapse under a building requires shoring up the foundation immediately. Such situations require the expertise of a professional geologist familiar with karst features and a geotechnical or civil engineer experienced in sinkhole remediation.

Farmers operating tractors and other heavy equipment in fields overlying karst should watch out for collapsed sinkholes. Heavy machinery can break through soil bridges during operation or shortly afterward. To reduce the risk of sinkhole collapse, it is a good idea to fence off portions of fields prone to sinkholes.



Figure 7. The February 12, 2014, sinkhole collapse in the National Corvette Museum in Bowling Green, Kentucky, is an excellent example of a cover collapse sinkhole.

Source: Bowling Green Daily News.

Sinkhole Flooding

Sinkhole flooding is caused when runoff entering the sinkhole exceeds the capacity of its conduits to drain it; flow is reversed back into the sinkhole because its outlet, such as a spring, is flooded; or a size reduction occurs for the conduits draining the sinkhole. Sediment and debris, trash, or collapses can reduce conduit size.

Sinkholes can vary significantly in size, and areas prone to sinkhole flooding may not be readily apparent. Speaking with neighboring landowners, carefully inspecting the topography, and inspecting property for prior signs of flooding can help identify potential problems with sinkhole flooding. As the conditions that cause sinkhole flooding may be infrequent, a lack of previous flooding may not indicate that sinkhole flooding will not occur in the near future. Once sinkhole flooding is discovered, consult with a professional geologist familiar with karst features.

Groundwater Pollution

Groundwater pollution occurs when contaminants enter the aquifer. In karst terrain, surface waters and groundwaters are closely linked via fractures, sinkholes, and conduits. These close connections mean that pollutants in runoff, such as fertilizers, pesticides, gasoline, and bacteria, can quickly reach the aquifer with little natural filtration from the soil and vegetation. Polluted waters are a human health and safety concern as surface waters and groundwaters are used for drinking, irrigation, and livestock.

Sinkholes should not be used for disposal, nor should livestock or runoff from livestock facilities be permitted to enter sinkholes. Septic systems should be checked regularly to ensure they are functioning properly. Protecting the groundwater also means protecting the surface water in karst terrain. Riparian buffers, which are vegetated areas located between water bodies such as streams and upland areas, can help filter pollutants in runoff.

Additional Information

Refer to the following Kentucky Cooperative Extension Service publications for more information:

- Reducing Stormwater Pollution* (AEN-106)
- Sinkhole Management for Agricultural Producers* (AEN-109)
- Groundwater Quality* (AEN-120)
- BMP4: Sinkholes* (FOR-67)
- Maintaining Conventional Septic Systems* (AR-166)

References

- Currens, J.C. 1999. Mass Flux of Agricultural Nonpoint-Source Pollutants in a Conduit-Flow Dominated Karst Aquifer, Logan County, KY. Kentucky Geological Survey, Ser. 12, Report of Investigations 1.
- Currens, J.C. 2002. Kentucky is Karst Country: What You Should Know about Sinkholes and Springs. Kentucky Geological Survey, Information Circular 4, Series XII. http://kgs.uky.edu/kgsweb/olops/pub/kgs/ic04_12.pdf.

- Currens, J.C. 2012. Cover-Collapse Sinkholes. Kentucky Geological Survey. <http://www.uky.edu/KGS/water/general/karst/keohazard.html>.
- Ford, D., and P. Williams. 2007. Karst Hydrogeology and Geomorphology. John Wiley & Sons Inc., Hoboken, NJ.
- Kentucky Geological Survey. 2012. Groundwater Contamination in Karst. <http://www.uky.edu/KGS/water/general/karst/gwvulnerability.htm>.
- Kentucky Geological Survey. 2012. Sinkhole Flooding. https://www.uky.edu/KGS/water/general/karst/sinkhole_flooding.htm.
- Reger, J.P. 2010. Foundation Engineering Problems and Hazards in Karst Terrains (Fact Sheet 11). Maryland Geological Survey. http://www.mgs.md.gov/geology/geohazards/engineering_problems_in_karst.html.
- Ruthven, C.L., and J.C. Currens. 2002. Karst Landscape—Astonishing Beauty and Hidden Hazards. In Focus 3(1). <http://www.uky.edu/KGS/pdf/InFocus/IFspring2002.pdf>.
- Sower, G.F. 1996. Building on Sinkholes: Design and Construction of Foundations in Karst Terrain. American Society of Civil Engineers.

Funding for this publication was provided in part by an Urban Waters grant from the U.S. Environmental Protection Agency.