

Karst Geology in Tennessee

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Sinkholes, which are one of the most common karst land features, occur across much of Middle and East Tennessee. These features correspond to areas where the underlying rock is carved or dissolved by water to form caves and caverns through which much of the groundwater flows. They develop when the soil collapses into the underlying voids in the rock below. The sinkholes and depression features may have been present and stable for many years, and are often used for livestock watering or pasture/forage production (Figure 1). However, sinkholes can also occur unexpectedly, damaging structures (Figure 2).

This document describes the geologic conditions in Tennessee leading to karst features, explains the differences in the features observed in East and Middle Tennessee, and identifies several common problems associated with karst. Other information about Tennessee caves and sinkholes can be found in the series of publications, [W 453-A: Guide to Caves and Sinkholes in Tennessee.pdf](#)

Tennessee Karst Geology

Tennessee, being a wide east-west oriented state, crosses many different landscapes and physiographic provinces (Figure 3). From the Blue Ridge

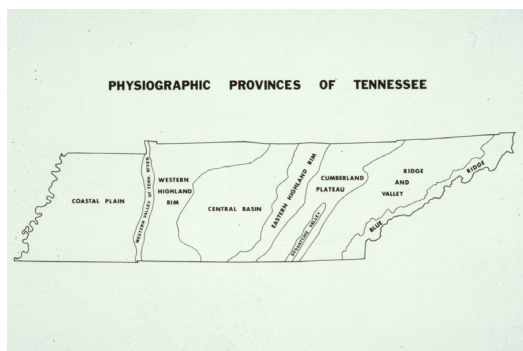


Figure 3. Physiographic Map of Tennessee. (Miller, 1974)



Figure 1. Large areas of karst landscape in Tennessee are in pasture, which is often used for grazing livestock. (All photos courtesy of Harry Moore except where noted.)



Figure 2. Sinkhole in a septic tank drain field in Hamblen County.

province in the east to the Mississippi River alluvial floodplain in the west, the state of Tennessee stretches across nine physiographic divisions and subdivisions.

Tennessee's karst landscape stretches from the coves in the mountains of the Blue Ridge in the east to the Tennessee River in the west as it courses its way north along the border of Middle and West Tennessee. As the geology

changes from East Tennessee to West Tennessee, so does the type of karst patterns that characterize an area. Karst lands in East Tennessee develop patterns differently and appear differently than those areas of karst in Middle Tennessee. In essence, karst can be found in two thirds of the state, east and middle (Figure 4). Karst is not typically found in West Tennessee, with the exception of a few caves along the western shore of the Tennessee River as it flows north to Kentucky.

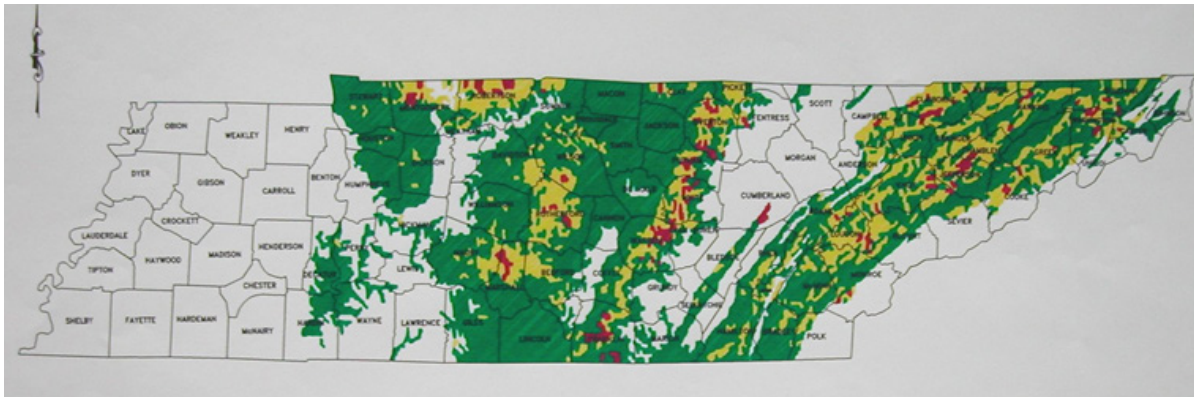


Figure 4. This map illustrates the sensitive karst areas of Tennessee; red indicates highest sensitivity to karst. (Beck et al. 1996)

What Is Karst?

The term “karst” comes from the German word for the Kras region of Slovenia where the terrain contains numerous limestone rock exposures and sinkholes as well as caves. The scientific community began to refer to sinkhole terrain as karst and this has been adapted and used by geoscientists worldwide.

When people think of karst they usually think of caves and sinkholes, which is correct. However, karst is much more than caves and sinkholes. Karst includes the landscape that is underlain by soluble rock like limestone, dolostone (dolomite), salt deposits, and gypsum deposits. It is characterized by surface features like sinkholes, cave openings, disappearing streams, dry valleys, and numerous rock outcrops and closed depressions on the surface. A moderate portion of the United States is underlain by karst (Figure 5).

In rural areas, sinkholes usually develop naturally from the normal weathering process. However, sometimes the grading for ponds or ground silos in soil underlain by cavernous rock can and often leads to the development of new sinkholes, as can the concentration of water flow in ditch lines or the re-routing of surface water.



Figure 5. Karst Map of the United States – Karst areas highlighted in red. (Beck et al. 1996)

Tennessee Karst Regions

East Tennessee Karst

East Tennessee karst is a landscape of gently rolling hills and valleys textured with sinkholes, cave entrances, sinking streams and outcroppings of weathered limestone (Figures 6 and 7). The bedrock is mostly folded and faulted sedimentary strata that has a northeast-southwest orientation, and generally has a dipping component that impacts the surface landscape. As a result, the land surface in East Tennessee, which ranges from mountainous to a series of parallel valleys and ridges, develops complex erosion drainage patterns. These may include trellis types, dendritic types and combinations of both.



Figure 6. The karst landscape is characterized by sinkholes and caves. Pictured is the entrance to a cave in Anderson County.



Figure 7. Tennessee caves often contain beautiful and unusual formations, formed by the movement of groundwater through the limestone bedrock.

Often, in heavily karst areas, there are no drainage features such as creeks and streams, since all of the drainage is beneath the ground surface. The subsurface drainage patterns are extremely complex and do not follow the same drainage patterns observed on the surface.

The relief of the ridges and mountains can be very dramatic and scenic. However, these unusual and often dramatic scenes can be interrupted by the sudden collapse of a roadway or a house or even the flooding of a sinkhole basin crossed by a road or occupied by a residential, public or commercial structure. The karst landscape can impact many areas of Tennessee, causing damage to houses, buildings, highways and the landscape (Figure 8). In some rare and dramatic cases karst may even cause bodily harm or injury.

As man has settled in karst areas over the years, there are instances where he has used the karst features for necessity (Figure 9).



Figure 8. A collapse sinkhole in Knox County, where thicker residual soil covers limestone (highway right-of-way, I-75).



Figure 9. Outhouse in floor of sinkhole, Carter County.



Figure 10. Karst in Middle Tennessee commonly exhibits a rocky, soil-barren landscape and numerous limestone outcrops, due to shallow soil cover.

Middle Tennessee Karst

In Middle Tennessee, the bedrock is normally flat-lying or gently dipping, and weathering of the land surface usually develops a dendritic drainage pattern, somewhat like the branching of a tree leaf where the edges of the leaf would drain toward the main branch of the leaf. In many areas of Middle Tennessee the bedrock is limestone and is usually exposed at the surface forming rocky ledges and barrens. These areas also develop into karst landscapes where sinkholes and caves are developed (Figure 10). A good

example is Cedars of Lebanon State Park, where numerous caves and sinkholes can be found, in addition to the rock barren landscape commonly called glades. Glades occur where limestone bedrock occurs near or at the surface, and most all glades in Tennessee associated with karst tend to be cedar.

Most sinkholes in the Central Basin of Middle Tennessee are rather shallow, being anywhere from a few feet in depth and width to 20 or 30 feet in depth and width. Numerous caves are found in Middle Tennessee, with the longest and deepest Middle Tennessee caves being found along the Eastern Highland Rim adjacent to the Cumberland Plateau. Some of these sinkholes may be as much as a hundred feet in depth and nearly as wide. The two longest caves in Tennessee are found in Middle Tennessee: Blue Spring Cave in White County and Cumberland Caverns in Warren County. Each of these caves has more than 30 miles of mapped passages.

Sinkhole Development

Within karst areas, sinkholes usually develop as surface water percolates downward into the subsurface. The surface water, usually precipitation of some kind, migrates into the subsurface by way of cracks in the soil, along tree roots, animal burrows, or simply capillary movement within the clay soil. As the surface water migrates downward, clay particles are taken from the soil/rock interface and carried into existing solution channels in the top of the bedrock; this is referred to as the epikarst zone.

Over a variable period of time, a cavity develops in the soil mass (on top of the bedrock) and enlarges from the bedrock surface upward toward the land surface. When the soil cavity enlarges to a point where the overlying soil cannot “bridge” the soil cavity, then the soil mass will collapse into the underlying cavity. This usually results in a surface depression or a collapse sinkhole (Figure 11) often referred to as a cover collapse sinkhole.



Figure 11. Cover collapse sinkhole along the ditch line of Tennessee Route 72, Loudon County.

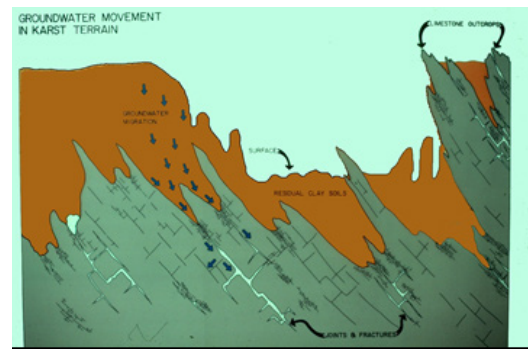
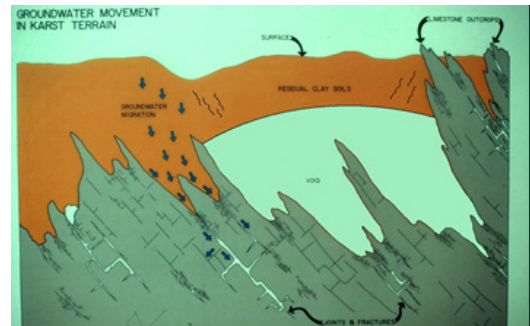
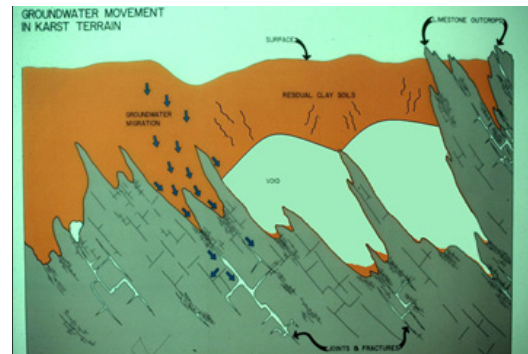
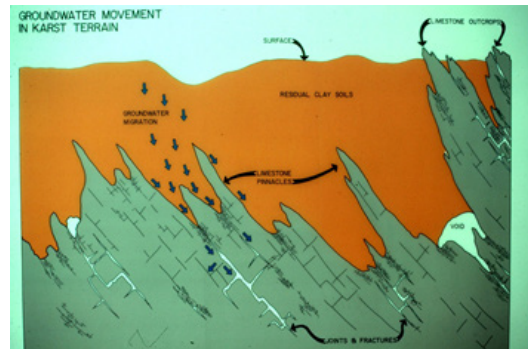


Figure 12. This series of drawings show the development of a cover collapse sinkhole, beginning at the top where the surface shows no evidence of subsidence and progressing down to the bottom where a sinkhole has formed. Note that the downward percolation of groundwater contributes to the soil loss.

The development of cover collapse sinkholes is very common in Tennessee. Fluctuations in the water table, particularly water table drawdown, can trigger collapse. Figure 12 illustrates the development of a typical cover collapse sinkhole.

Karst Groundwater

Sinkholes and surface depressions receive precipitation runoff which filters down through the soil and rock strata into the cavities in the rock and becomes part of the groundwater regime. This serves to replenish the groundwater supply. However, when trash and waste materials are dumped into the sinkholes and depressions, water that filters through the sinkholes then becomes contaminated, greatly affecting the groundwater supply. This polluted groundwater is commonly tapped by water wells (especially in rural areas) or issues to the surface as springs with possible negative effects on the population and environment (Figure 13).

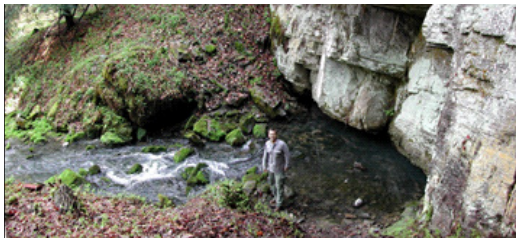


Figure 13. Many springs are found in karst terrain and provide water for livestock; such water is often considered “hard” and may even be contaminated (Sullivan County).

Another source of groundwater pollution in karst areas is nonpoint source pollution from runoff in both urban areas and rural farm landscapes. In urban areas the runoff picks up substances such as residues of tar, oil, grease, gasoline and other toxic materials from roadways and parking lots with the runoff flowing into nearby sinkholes and caves, thus polluting the groundwater environment.

In agricultural areas, fertilizers and chemical sprays used on croplands as well as the waste products from farm animal lots may drain into area sinkholes, affecting the groundwater in those areas. Quite often, wells are drilled into these same rock formations that are carrying the polluted groundwater.

Because sinkholes and associated depressions receive precipitation runoff, they often fill up with rainwater before slowly draining further down into the underlying cavernous



Figure 14. Livestock using water-filled sinkhole (Coker County).

bedrock. In some instances these sinkholes and depressions will become “plugged” or “stopped up” with trash or silt and clay resulting in a permanent pond of water (Figure 14). This circumstance can be very damaging if a structure or road is located within one of these sinkholes.

Additional Remarks

There are some conditions that may produce similar sinkhole-type features but are not actually karst related. These would include animal burrows (groundhogs, etc.) that collapse, subsidence related to old rotting tree stumps and roots, old trash and debris pits that have been covered up and are settling (commonly found around houses and building construction sites), and old cisterns and hand-dug wells. Other situations that may cause subsidence and appear to be a sinkhole include improperly compacted fill for houses, buildings and roads; moisture-sensitive clay soils (expansive clays); and leaking water and sewer lines. If these situations are located in karst areas, then they will enhance the effects of the sinkhole development.

Typically, where you have caves, you have karst. Many Tennessee counties contain a large number of caves and thus have large areas of karst. In 1994, there were 6,829 known caves according to the Tennessee Cave Survey. Today that number is over 10,000. Figure 15 illustrates the extent of karst across the United States.

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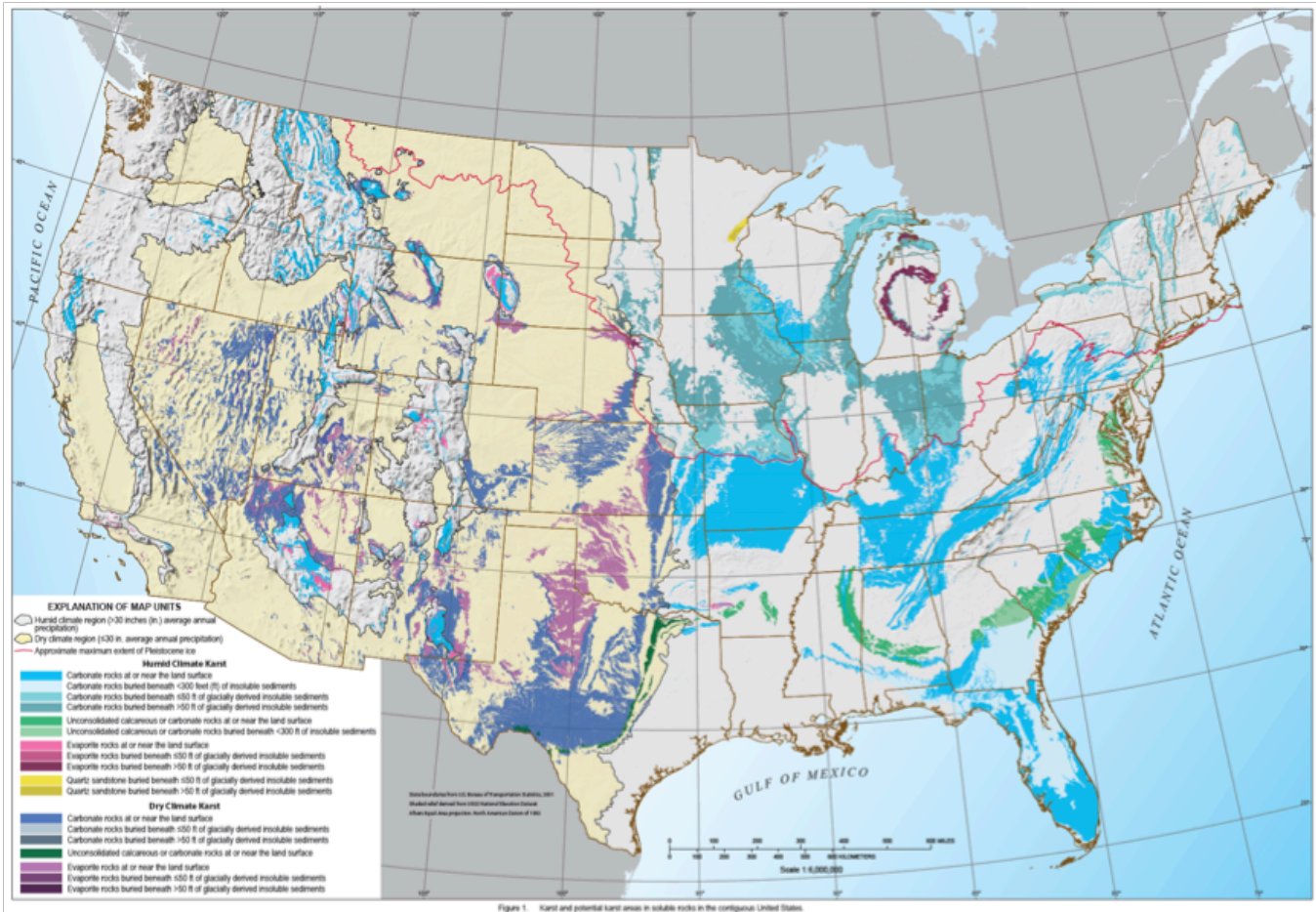


Figure 15. Karst map of the United States (reference Weary and Doctor, 2014).



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