MAPS-TO-TEACHERS: LEARNING ABOUT WHERE WE LIVE

KGS has many earth science learning resources. How can we get them into schools?
Maps-to-Teachers program was created to get KGS earth science education resources into Kentucky schools.
Kentucky contains about 40,405 square miles, or 25,859,200 acres, of land and water. Even from space, the distinct regions of Kentucky can be seen.
The physiographic regions of Kentucky are defined by geology—Eastern Coal Field, Blue Grass, Knobs, Pennyroyal, Western Coal Field, and Jackson Purchase—shape the state and represent different land forms, cultures, and economies.

When the regions were made
Geologic era, rock types, million years ago (mya)

- Tertiary/Cretaceous: sand, clay, 2-140 mya
- Pennsylvanian: shale, sandstone, coal, 290-330 mya
- Mississippian: shale, limestone, sandstone, 330-360 mya
- Devonian: shale, limestone, 360-410 mya
- Silurian: dolomite, shale, 410-435 mya
- Ordovician: limestone, shale, 435-500 mya

Students can use KGS maps, diagrams, and posters to learn how and when Kentucky was formed.
Where was Kentucky during geologic history, what kind of creatures lived here, and why is the land the way it is?
Where was Kentucky when the rocks were born?
**Mississippian** rocks are exposed at the surface in the Mississippian Plateau (Pennyroyal or Pennyrile) Region and occur below the surface in both of the coal fields. Mississippian rocks are absent in the Blue Grass Region and in most of the Knobs. During most of the Mississippian, Kentucky was covered by shallow tropical seas (Fig. 8), although some very low lands may have been emergent at times in central Kentucky.

Black shale continued to be deposited briefly during the Mississippian Period but soon gave way to a great influx of muds, silts, and sands brought in by rivers and streams. Shallow seas blocked with millions of water currents and sea-bottom limestones. Limestones were deposited in Mississippian. Many caves were known as one of the world’s best cave systems, Mammoth Cave, is the largest.

Periodically, during the latter part of the Mississippian, tidal deltas and low coastal plains covered large parts of Kentucky. These periods of coastal environments alternated with periods when the sea came in and inundated the region.

Most of the Mississippian rocks found in Kentucky are marine, and many of the fossils in them are marine (sea-dwelling) invertebrates. Common Mississippian fossils found in Kentucky include corals (Cnidaria), bryozoans, brachiopods, trilobites, snails (gastropods), clams (pelecypods), squid-like animals (cephalopods), crinoids and blastoids (echinoderms), fish teeth (Pisces), and microscopic animals like ostracodes and conodonts. When there was emergent land in the form of low coastal plains, land plants and animals lived. Land plants such as seed ferns, true ferns, scale trees, and calamite trees grew in these coastal areas. Amphibians, such as the one recently found in western Kentucky, lived in estuaries and ox-bow lakes. Insects and other arthropods were probably numerous on land.

Many types of sharks lived in Kentucky at that time; some had teeth for capturing swimming animals and others had teeth especially adapted for crushing and eating shellfish such as brachiopods, clams, crinoids, and squid-like animals (cephalopods).

Only one amphibian fossil has been found in Kentucky (in 1995). It was found in Mississippian sandstones on the margin of the Western Kentucky Coal Field. This amphibian was about 5 feet long and had a long, streamlined body. It probably lived most of the time in water and ate fish and other small amphibians and reptiles.

**What were the plants and animals?**

The landscape of Kentucky is shown with the Terrain Map.
Topography: The Shape of the Land

Slope
- Level to rolling
- Rolling to hilly
- Hilly to steep
- Very steep

Slope and elevation also reflect regional differences. Elevations, in general, are higher in the south and east and lower to the north and west, and the land becomes less hilly.

Elevation (feet)
- 257* - 500
- 500 - 750
- 750 - 1,000
- 1,000 - 1,500
- 1,500 - 4,111
* excluding quarry pits
Water was carving the land by erosion for millions of years before humans appeared, turning a high plain into sharp ridges and narrow valleys.

Millions of years of erosion were required to reduce an ancient plateau to the ridges and valleys we now see. Floyd County (right) is completely dissected upland, with valleys and ridges occupying about equal amounts of land and elevation differences between ridge tops and valleys of as much as 900 feet. In Knott County (below right) the ridges are rounder and the hills float like humpbacked creatures in a vast sea. Photos by Dan Carey, Kentucky Geological Survey.
How The Rocks Shape the Land

A drive down Ky. 10 in Bracken County illustrates how rocks shape the land. Where there is more shale than limestone in the underlying rock, the land is hillier. Where limestone dominates, the land is flatter and better for agriculture.
Eastern Coal Field Region

The Eastern Kentucky Coal Field is a region of intricately dissected 350-million-year-old Pennsylvanian sandstone, siltstone, shale, and coal. It is bounded on the western edge by the Cumberland (or Pottsville) Escarpment formed by resistant beds of sandstone. Within the region, wooded mountain crests extend to the horizon in all directions. The mountain slopes are carved by ravines eroded through thick, flat-lying sequences of coal-bearing sedimentary rocks. The ravines are tributary to sinuous, narrow valley bottoms which wind between steep valley walls. Major rivers, including the Big Sandy, Licking, Kentucky, and Cumberland, meander through the mountains. Where shale predominates, their valleys widen to a mile or more; most of the human habitation is on terraces such as those in Ashland remnants of earlier valley bottoms.

Genesee, the sewer of the land, undercuts the valley walls, weathered debris (colluvium) that move down slope by debris avalanche, landslide, creep, and sheet wash. Deeply weathered soils are uncommon and occur on isolated, nearly level ridge crests and high-level terrace deposits. Cliffs of resistant sandstone cap many ridges and spurs. Scenic erosion remnants include pinnacles or "chimneys," shallow eaves known as "rock houses," and arches or natural bridges.

About 20 percent of the state’s population lives on the 28 percent of the state encompassed by this region, or 67 people per square mile.
Where sandstone dominates, slopes are steep. Where shale is prevalent, the topography is less rugged.
Rolling Terrain—Cumberland Plateau Region

Shale is more dominant in the bedrock of the Cumberland Plateau Sub-Region and the landscape is less rugged and amenable to agriculture, as typified in Morgan County.
The **Bluegrass Region** is bounded by the Knobs on the west, south, and east, and by the Ohio River in the north. Bedrock in most of the region is composed of Ordovician limestones and shales 450 million years old. Younger Devonian, Silurian, and Mississippian shales and limestones lie beneath the perimeter of the region. Much of the Ordovician strata lie buried beneath the surface. The oldest rocks at the surface in Kentucky are exposed along the Palisades of the Kentucky River. Limestones are quarried or mined throughout the region for use in construction. Water from limestone springs is bottled and sold.

The Bluegrass, the first region settled by Europeans, includes about 25 percent of Kentucky. Over 50 percent of all Kentuckians live there—on average 190 people per square mile, ranging from 1,750 people per square mile in Jefferson County to 23 people per square mile in Robertson County.

The **Inner Blue Grass** is characterized by rich, fertile phosphatic soils, which are perfect for raising thoroughbred horses. The gently rolling topography is caused by the weathering of limestone that is typical of the Ordovician strata of central Kentucky, pushed up along the Cincinnati Arch. Weathering of the limestone also produces sinkholes, sinking streams, springs, caves, and soils.

The **Outer Bluegrass** is mostly composed of interbedded Ordovician limestones and shales that are more easily eroded than the limestones of the Inner Bluegrass. It is less karstic, with fewer sinkholes and rolling hills. The shales impede the flow of groundwater, and there are fewer springs and wells.

Shale is more dominant in the **Bluegrass Hills**. The land is hilly, with limited agriculture. Slope stability may be a problem in development, particularly in the Greater Cincinnati area.

The Kentucky River Palisades are cliffs in the gorge or canyon along the Kentucky River where it cuts through resistant massive limestones and dolostones (High Bridge Group). These are the oldest rocks exposed at the surface in Kentucky.
The Knobs consists of hundreds of isolated, steep sloping, often cone-shaped hills lying at the outer edge of the Bluegrass Region. The hills are monadnocks or erosional remnants that were originally part of the Mississippian Plateau (Pennyroyal Region), but were separated from the plateau by stream erosion. Many of the knobs are still capped by erosion-resistant limestones or sandstones. The sloping sides of the Knobs are mostly composed of shales of the 350-million-year-old Mississippian Borden Formation, which are more easily eroded than the overlying limestones and sandstones. The Knobs are associated with the outcrop belt of Silurian and Devonian black and clay shales. Bernheim Forest (south of Louisville) and Berea, Kentucky are located in the Knobs Region.

Streams that flow through the Knobs and Shale Belt, such as the Rolling Fork River and Red River in the east, carve wide valleys with fertile alluvium deposits.
The Pennyroyal Region (Mississippian Plateau), stretches from the Eastern Coal Field and the Bluegrass to the Jackson Purchase, surrounding the Western Coal Field. It is primarily characterized as a limestone plain containing tens of thousands of sinkholes, sinking streams, streamless valleys, springs, and caverns. Sinkholes are depressions on the land surface into which water drains underground. Usually circular and often funnel-shaped, they range in size from a few feet to hundreds of feet in diameter. Springs occur when water emerges from underground to become surface water. Caves are solution-enlarged fractures or conduits large enough for a person to enter. This terrain, called karst, occurs because the bedrock in the eastern and southern parts of the region is dominated by thick deposits of Mississippian limestones. These limestones are soluble, which means they can easily be dissolved by waters moving through the ground. These groundwaters can form miles of passages beneath the surface, from tiny conduits only inches wide, to large caverns and rooms more than 100 feet wide. The Mammoth Cave—Flint Ridge cave system is the longest cave in the world (by far), with 365 miles explored to date.

The Pennyroyal includes 26 percent of Kentucky and 1 in 6 Kentuckians live there.
Western Coal Field Region

Subregion—Dominant Rocks
- Hills—Sandstone, siltstone, shale, some coal
- Uplands—Shale, sandstone, siltstone, coal
- Lowlands—Loess, river and lake deposits: clay, silt, sand, and gravel

The topography of the Western Coal Field Region ranges from nearly level bottomlands to rolling uplands to forested hills. The poorly-drained floodplains and terraces along the Ohio River and the wide valleys of the interior streams are underlain by loess, sand, silt, clay, and gravel. Outside the valleys, low hills predominate, underlain by 300-million-year-old Pennsylvanian shale, sandstone, siltstone, limestone, coal, and underclay. Around the boundary of the region the valleys are narrower and the terrain more rugged, with hills capped by erosion-resistant sandstone.

Eight percent of Kentuckians live on the region’s 12 percent of the land—about 60 people per square mile.
In recent geologic time, the Jackson Purchase was covered by a northern extension of the Gulf of Mexico. Most of the deposits are unconsolidated sediment instead of rock, therefore they are easily eroded, and, consequently, this part of Kentucky is relatively flat lying, with numerous lakes, ponds, sloughs, and swamps. Local relief is generally less than 100 feet. The loess plains—windblown deposits of silt from the Great Plains—provide a productive agricultural area of gently rolling uplands, broad bottomlands, and terraces. Grasslands and forested wetlands were once widespread, but have been replaced in many areas by cropland.

The area of the region is about 6 percent of the state, with 4.8 percent of the state’s population—about 75 people per square mile.
There are many things to consider when you are looking for a place to live. Maps can help you decide. What is the biggest town or city in your county? Why do you think they built it where they did? Where is your house? What kind of rock is your house built on?

www.uky.edu/KGS/announce/landuse_teacher.htm

Generalized geologic maps illustrate the geology and geography of each of Kentucky’s 120 counties.
Contour lines illustrate the shape of the land. Contour lines tell you the elevation of the land above sea level. Along a contour line the elevation remains the same. Highway U.S. 25 above follows the creek at an elevation of about 900 feet and avoids the hills. Northern Elementary and the residential streets are at the top of the hill at about 1,000 feet. When contour lines are close together, on hillsides, the land is steeper. In stream valleys, the land is flatter. Different maps have different contour intervals, 20-feet for this map. Find your school on your county map. What is the elevation? Is the land steep or level?
Aerial photos used to present better picture of local issues.

Mining near Eolia in Letcher County
What lies beneath our feet? What are the rocks and what do they look like?

Local geology
The Grier Limestone Member (Olg) lies above the Curdsville Member. The Grier has a rubbly appearance. Water dissolves the limestone and creates underground flow channels. When the ceiling of the underground channel becomes too thin to support the overlying soil, a sinkhole is formed. This exposure is at mile 100.0 on Interstate 75.

Where can the rocks be seen? Photo locations on map
A better understanding of geologic hazards can help us live in harmony with the land.

Awareness of potential geologic hazards can help avoid the $millions of annual damages in Kentucky.
If we live in a karst area, we need to understand what “karst” means in order to protect our environment and build wisely.
Using sinkholes for waste disposal, even in rural areas, can threaten valuable water resources.
More about Karst

If you live in a karst area, your map will show sinkholes like those below.

Karst in Warren County

There are many sinkholes in Warren County, shown above.

Do you see any streams?

The water flows through the limestone beneath the ground.
Even though there is no stream, you can still get flooded if you build your house near a sinkhole.
Sinkholes are not the only geologic hazard in Kentucky. You should be aware of possible hazards in order to avoid costly damages, or worse. What are the possible hazards in your county?
General Landslide and Geologic Map

Poster illustrates the landslide problem in many areas of Kentucky especially on steep slopes, are more susceptible to landslides. Note the areas of concentrated landslides and which geologic formations and type of rocks they occur.

- Locations from current field work
- Locations from Kentucky Transportation Cabinet reports
- Locations from existing geologic maps

An idealized translational landslide, moving along a planar surface. Many of these landslides occur at the contact between rock and soil. Source: USGS Landslide Fact Sheet FS2004-3072.
Finding a place to live

If you build your house on the side of a hill, the rocks may not be strong enough to hold it, or there may be a landslide. You need to know what kind of rocks will be below your house.

What kind of rock is beneath your house? What kind of rock is your school built on?
Swelling shales in Irvine buckled the floor of the new Estill County Middle School gymnasium. The floors were removed, loose shales were excavated, and the remaining shales were isolated from moisture and further oxidation by using an innovative process of covering them with resin. The remediation project cost millions of dollars.

Is there shale or swelling shale where you live?
Flooding

If you build your house too close to a stream, it might get flooded. Alluvium—yellow on the map—lies along streams and indicates possible areas of flooding, like those shown below in Floyd County. Also, some of the flood zones have been mapped. Can you find any flood zones on your map? Parks and athletic fields are a good use for floodplains.
Water in Kentucky

More than 32 trillion (32 million million) gallons of water normally falls from the skies over Kentucky each year. Where does our precipitation come from? Most of Kentucky’s water has been lifted from the western Gulf of Mexico by the sun (evaporation) and carried to us by southerly winds. The evaporation process leaves the sea salts behind and gives us fresh water. As the air cools, the water vapor condenses into droplets and falls as precipitation.
Stream densities, the length of streams per square mile, vary by region. In the Sinkhole Plain of the Pennyroyal Region, where many streams flow into sinkholes to underground conduits (flow channels), the surface stream density is half that of the rest of the state. On the impermeable (resistant to water infiltration) shale of hilly areas of the Bluegrass Region, there are nearly 3 miles of surface streams per square mile.
One way streams are characterized by hydrologists (those who study the movement, distribution, and quality of water throughout the Earth) is by the term “order.” Initial perennial streams segments in a watershed are designated as 1st order. Two 1st order streams combine to form a 2nd order stream, and so forth.

On your map, trace the boundaries of the watershed containing your school.
Maintaining Water Quality

Public Water and Sewer in Kentucky
March, 2010

- Water lines: 56,500 miles
- Sewer lines: 12,761 miles

There are 4 times as many public water lines in Kentucky as public sewer lines.

97 percent of Kentuckians are on public water, but only 52 percent are on public sewer. Groundwater and streams in areas not suited to conventional septic systems can become contaminated.

Geologic Limitations for Conventional Septic Systems
- Slight
- Moderate
- Severe

Data from the Kentucky Infrastructure Authority, Water Resources Information System
Kentucky streams follow the topography and flow primarily to the north and west. Nearly all the water (97%) that runs off flows to the Ohio River before entering the Mississippi River for the trip back to the Gulf.
River Basin maps help us to better understand the watersheds that we live in.
Maps can be customized to show watershed activities of school or environmental groups.
Wolfe County High School Educational Field Trips, Red River

Estill County High School Educational Field Trips, Millers Creek

Menifee County High School Environmental Field Days, Red River
Mill Creek Watershed

Two-meter aerial photos from the U.S. Department of Agriculture, Farm Services Administration, National Agricultural Imagery Program, 2006

Mill Creek Elementary School

1 inch equals 225 feet

GIS + Kentucky Data = Anyone can do it!
A Brief
(100-slide Power Point)
History
of Earth

kgs.uky.edu/kgsweb/download/geology/EARTHISTORY.ZIP

Beyond Kentucky
Some of the best minds of our generation have spent their lives studying the heavens and the Earth. They have concluded that the universe came into being 13.7 billion years ago with a massive, explosive expansion of pure energy, the Big Bang.

Within minutes, they tell us, the energy began to differentiate into atomic particles: quarks, electrons, protons and neutrons. Nuclear and electromagnetic forces arranged those particles into the lighter elements, hydrogen and helium.

Gravitational forces brought the newly created matter together into galaxies of stars. The stars began to burn with nuclear fire, and there was light. Heavier elements were cooked in the stellar ovens, and as the first stars burned out and died, they exploded, strewing across space the building blocks for the next generation of stars.

**The Big Bang – 13.7 BYA**
The beginnings of life on Earth

Molecular forces provided the mechanism by which many of the earliest forms—polymers, enzymes, proteins, mRNA (messenger RNA), DNA, and viruses—could reproduce.

Replication templates


### The Sixth Extinction

<table>
<thead>
<tr>
<th>Event</th>
<th>Time Ago</th>
<th>Cause(s)</th>
</tr>
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</table>
| Present                |          | Anthropocene Extinction  
                      Human activity  
                      ??% lost                                                  |
| 65 million years ago   |          | Cretaceous Extinction  
                      Impact and volcanos  
                      17% lost                                                  |
| 208 million years ago  |          | Triassic Extinction  
                      ??  
                      23% lost                                                  |
| 245 million years ago  |          | Permian Extinction  
                      Climate change?  
                      Plate movements?  
                      Impact?  
                      54% lost                                                  |
| 354 million years ago  |          | Devonian Extinction  
                      Climate change?  
                      19% lost                                                  |
| 438 million years ago  |          | Ordovician Extinction  
                      Climate change  
                      25% lost                                                  |

“In pushing other species to extinction, humanity is busy sawing off the limb on which it is perched.” – Paul Ehrlich

As the human population grows and our demand for natural resources increases, more and more habitats are devastated. Today, we may be losing 30,000 species a year—a rate much faster than at any time since the last great extinction 65 million years ago that wiped out most of the dinosaurs.

Can we stop the devastation of our planet and save our own species? We are in a biodiversity crisis — the fastest mass extinction in Earth’s history, largely due to:

- human destruction of ecosystems
- overexploitation of species and natural resources
- human overpopulation
- the spread of agriculture
- pollution

On behalf of our entire Science Department, I want to thank you for the beautiful map of Mason County. It is full of terrific learning opportunities for our kids.

I recently received the Floyd county map and it is wonderful. In fact it is so nice that the social studies teachers in my building and the rest of the science department asked if they could each get one. That is a total of 7 teachers. Just checking if it would be possible to get some more of those? Have a great day and great job on the map.
KGS Maps in Kentucky Classrooms

Teachers across the Commonwealth are using Kentucky Geological Survey maps in their classrooms to help students of all ages to learn more about the geology and landscape of their own and surrounding counties.

Maps in over 1,000 classrooms in 400 schools.

Whoo hoo!!
The bad news
KGS Maps and materials currently in fewer than 25% of schools!!

Goal
5,000 more maps to 2,500 classrooms and libraries in 1,000 Kentucky schools.
## Earth Science in the classroom: Learning about the place where we live

### Geology and Landforms
- **Sedimentary Rocks**
- Geologic History: The Building of Kentucky
- Fossils
- Stream Deposits
- Geologic Faults
- Physiographic Regions
  - How the Land has been Shaped
  - Karst

### Questions for the Classroom
- What are sedimentary rocks?
- What are the different rock types in your county?
- When and where were the sedimentary rocks in Kentucky formed?
- Why are the rocks older in central Kentucky than in eastern and western Kentucky?
- What is a geologic fault?
- What is alluvium?
- What is karst?

### What Students Should Know
- Younger rocks lay atop older rocks.
- How the rocks in their county were formed.
- Approximate ages of the rocks in their county.
- Kentucky once lay beneath the sea.
- The topography of Kentucky
- The relationship between geology and the shape of the land.
- The geology of karst.
- The Physiographic Regions: Eastern Coal Field, Knobs, Bluegrass, Mississippian Plateau, Western Coal Field, Purchase
- The region or subregion in which they live.

### Water
- The Hydrologic Cycle
- Kentucky Water Facts
  - Rainfall
  - Streams
  - Droughts
  - Floods
- Water and Early Development
  - Springs, Wells, and Streams
- Water for Communities, Industry, Agriculture, and Wildlife
  - Water Usage
  - Water Sources
- River Basins and Watersheds
  - River basin facts
- Ground Water
- Water in Karst Areas

### Questions for the Classroom
- What is a watershed?
- What is ground water?
- Why are there fewer streams in karst areas?
- How much water falls on Kentucky in an average year?
- Where does the water in your house come from?
- When they flush the toilet, where does it go?

### What Students Should Know
- What the hydrologic cycle is
- Where their water comes from.
- About how much water they use in a year.
- The major river basins of Kentucky
- Which river basin they live in and where.
- Why early settlers established towns where they did.

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**Next step, developing a curriculum to complement the maps**

**Draft ideas**
**Living with the Land**
Understanding the Land We Live On
Protecting the Air, Land, and Water
  - Water quality
  - Wastewater Treatment
    - Public, Domestic, Straight Pipes
  - Wetlands
  - Storm Water Management
  - Source and Ground Water Protection Areas
Air quality
Geologic Hazards
  - Flooding
  - Landslides
  - Earthquakes
  - Unstable Shales
  - Radon
  - Mined Areas
  - Shrinking and Swelling Shales
  - Sinkholes

**Questions for the Classroom**
- Where are the areas in your county that might get flooded?
- Are there shales in your county?
- Should you build a house on or near a sinkhole?
- Why should you not throw trash in a sinkhole?
- What is the risk of an earthquake where you live?
- Are there mined areas in your county?
- Why do we need to know about radon? Is it in your county?
- If you could live anywhere in your county, where would it be and why?
- If you could live anywhere in Kentucky, where would it be and why?

**What Students Should Know**
- Why wastewater treatment is important.
- Where geologic hazards may occur and what to do about them.
- Best uses for floodplains.
- What wetlands are and why they are important.
- Why it is important to understand the geology of where they live.

**Resources and Environment**
Minerals
- Energy Resources
  - Oil and Gas
    - How it was formed, How much we have
  - Coal
    - How it was formed, How much we have
- Electric Power
  - Coal-fired power plants
  - Usage of electricity by Kentuckians
  - Dealing with CO2
  - Hydroelectricity
Agriculture
- Importance to Kentucky economy
- Prime Farm Lands and Pasture Lands
Recreation
- Public Lands
- Wildlife Management Areas
- State and National Parks
- Lakes and Waterways
  - Large lakes, Ponds, Wetlands
  - Aquatic life
  - Fishing
  - Boat Ramps
  - Locks and Dams

**Questions for the Classroom**
- Is there a farmer's market in your county?
- Energy resources in the county?
- Minerals used in the community?
- What are the recreational areas in your county?

**What Students Should Know**
- How electricity is generated and where it comes from.
- Where their food comes from.
- The resources within their county.
LEARNING ABOUT WHERE WE LIVE
KENTUCKY’S LAND AND WATER:
EARTH SCIENCE RESOURCE MATERIALS FOR TEACHERS

Ask and try to answer every question you can think of about everything below, above, and on the ground where you live. There’s no better textbook, no better laboratory, no better place for teaching and learning earth science than right here.

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