

***The Lay of the Land:
Effects of Kentucky Geology
on Culture***

**Seminar 2
Teacher's Packet**

A KET professional development workshop for educators approved for Professional Development Training by the Kentucky Department of Education.

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The Lay of the Land: Effects of Kentucky Geology on Culture

Overview of Seminar 2

Targeted Audience: Science teachers, all levels

For the second seminar in the series, geologist Dr. Frank Ettensohn journeys to the Appalachian or Cumberland Plateau, famous for its mountainous topography and major coal production. Joining Frank for this geologic tour of Appalachian Kentucky is Eric Thomas, the Region 7 science consultant and a former earth science teacher.

Frank and Eric visit the Cumberland and Pine gaps, two of a small number of geologically related gaps in the mountains of the Cumberland Plateau. Along with a few rivers, these gaps were once the region's only transportation links, making the people of the Cumberland Plateau both economically and culturally isolated. Only recently has the advent of major highways into the area opened some of the region to outside ideas and new types of economic development.

The program also explores how economic dependence on coal and lumber, two resources found in abundance throughout the region, has commonly depleted or destroyed the land and its natural beauty. Frank discusses how a new understanding is beginning to develop between these industries and the people of Appalachian Kentucky concerning their interdependence and the importance of the land as a continuing source of economic and cultural development.

In the final segment of the program, Frank travels to the Pottsville Escarpment and the Pine Mountain thrust block, both major geologic features which impeded travel into the region. He points out that the people who ultimately settled the region often valued freedom to live as they wanted more than economic development or contact with the outside world. The mountainous, isolated nature imparted by the region's geology was ideal for these settlers.

About This Teacher Packet

This packet includes a glossaries and discussion questions and links to useful Web sites. You'll find more details in the table of contents on page 3.

Series Format

This program was taped on location throughout the Appalachian region of Kentucky. Any information needed to participate in the seminar is included in the videotape or in this print packet.

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Materials Needed for Participation in the Seminar

- Pencil or pen
- Paper
- Teacher's packets for Seminars 1 & 2

Professional Development Credit

Stage of Participant Development: Practice/Application

The Kentucky Department of Education has approved all KET Star Channels Seminars for professional development credit if schools or districts choose to include them in their professional development plans. Districts or schools may choose to include preparation and/or follow-up time as part of professional development. For example, if a teacher participates in one 90-minute program and spends an additional 30 minutes in related activities, he or she could be awarded a total of two hours professional development credit.

Individual teachers who wish to use these videotapes for professional development credit should check with their school professional development chair or with their district professional development coordinator.

Professional development can also be used to satisfy requirements for the fifth year program. Contact your local university or the Division of Teacher Education and Certification at 502-564-4606 for more information.

Glossary & Questions for Study and Reflection

Lay of the Land, Seminar 2

Knobs

Knobs: A narrow, horseshoe-shaped belt of conical hills that encircles the Bluegrass Region on three sides. This region of gently sloping hills and ridges with flat broad bottoms in between was carved from the escarpment that separates the Bluegrass region from adjacent areas to the east, south, and west. The Knobs are erosional remnants formed on the poorly resistant Upper Devonian or Lower Mississippian shales with caps of resistant Mississippian siltstone and carbonates or Pennsylvanian sandstones. Where erosion has cut through the capping strata into the soft shales, the resistant caps protect underlying shales giving rise to the isolated rounded hills.

Black shale: A dark, papery, thinly laminated, highly carbonaceous shale, exceptionally rich in organic matter (4-21%) and iron sulfide (pyrite). The dark coloration is related to the accumulation of organic matter and pyrite in deep, stagnant seas which were deficient in oxygen. These shales are the sources of most of Kentucky's oil and gas. These shales accumulated in deeper seas that occupied Kentucky from Middle Devonian to Early Mississippian time, 375-350 million years ago. They are the only potential oil and gas shales in Kentucky and form the lower parts of most of the Knobs.

Oil or gas shale: A finely laminated, brown or black, organic-rich shale that will yield oil or gas on distillation.

Mississippian Period: The period of geologic time from 360 to 323 million years ago. In Kentucky, Mississippian rocks include black shales, gray siltstones and shales and most of Kentucky's major cave-bearing limestones.

Fissility: The ability of rocks, usually shales, to split easily into thin sheets or layers along closely spaced, parallel planes.

Pyrite: A common, brass-yellow mineral formed of iron sulfide (FeS_2). It is especially common in organic-rich rocks like black shale and coal. It is commonly called fool's gold. It breaks down upon weathering to form sulfuric acid and is a major source of acid-mine drainage.

Porosity: The amount of space or interstices between the individual grains in a rock, usually expressed as a percentage of the rocks bulk volume. It is the porosity that carries the water, oil, and gas found in rocks.

Big Sandy Gas Field: A major gas-producing area in eastern Kentucky including most of Pike, Martin, Floyd, Knott, and Perry counties, as well as smaller parts of Lawrence, Johnson, Magoffin, Leslie, and Letcher counties. Most of the gas is produced from the Devonian-Mississippian black shales.

Fracing: A method of stimulating the flow of oil and gas by pumping various fluids under extremely high pressures, sometimes containing solid grains like sand, into the producing formation in order “to part” or fracture it and then prop the fractures open, making channels for oil and gas to flow through them to the well bore.

Questions for Study and Reflection:

- Explain how the resistance to weathering of the contrasting rock types gives rise to the Knobs subregion.
- Explain why the Knobs area is generally poor agriculturally.
- Why are the Devonian-Mississippian black shales the sources of most of Kentucky’s oil and gas?

Pottsville Escarpment

Escarpment: A long, continuous cliff or steep slope facing in one direction formed by the erosion of weak layers above and below a resistant rock layer. An escarpment breaks the general continuity of the land by separating two level or gently sloping surfaces.

Pottsville Escarpment: A west-facing, high rock wall of several hundred feet in relief formed on the resistant Middle Pennsylvanian Lee Sandstones, which separates the planar Bluegrass Region from the Cumberland Plateau subdivision of the Appalachian Plateau. In places where the streams have cut through the sandstone, steep-walled gorges like Red River Gorge or major water falls like Cumberland Falls are common.

Highland Rim: A gently rolling, upland area, ten to 15 miles wide, developed on Mississippian siltstones or limestones, that is transitional between the Knobs and the Pottsville Escarpment.

Pennsylvanian Period: The period of geologic time from 323 to 297 million years ago. Rocks deposited during this period in Kentucky are the source of Kentucky's coal and comprise the eastern and western coal fields.

Lee conglomeratic sandstone: Lower to Middle Pennsylvanian rocks composed largely of quartz sand with quartz pebbles (conglomeratic) that occur near the base of Pennsylvanian rocks in eastern Kentucky. Because of their resistance to weathering, these sandstones form many major ridges (Pottsville Escarpment), gorges (Red River Gorge, Breaks of the Sandy), falls (Cumberland Falls), and mountains (Pine and Cumberland mountains). Upon weathering, these quartz sands generate silicic acid which is favored by acid-loving plants like pine trees.

Braided stream: A stream that divides into a network of several, smaller branching and reuniting shallow stream channels separated from each other by islands or bars made of gravel. Most of the Lee sandstones were deposited in broad channels of this sort in a series of streams that moved from mountains in the east and northeast to seas in the south and southwest. Such streams are typically overloaded with sediment, and during flood stage, the coarser grained sediments (gravels) are dropped as bars due to loss of energy, causing the streams to bifurcate into a series of smaller channels. The pebble accumulations in the Lee sandstones were probably deposited as bars in such stream channels.

Natural arch: A bridge-like span of sandstone, generally developed high on a divide and generally not spanning a ravine or valley, formed through the erosion of soft strata underlying the sandstone. Erosion of the soft underlying strata removes support for the sandstone which then collapses, leaving behind an alcove in the sandstone which can become an arch. The Lee sandstones form several natural arches along the Pottsville Escarpment.

Divide: A high ridge or narrow tract of high land that separates two drainage basins or that divides surface waters that flow naturally in opposite directions.

Sapping: A natural process of erosion along the base of a more resistant cliff that wears away the softer underlying layers, thereby removing support for the overlying rock which breaks off in large blocks from the cliff. Many of the natural arches in the Lee sandstones were formed in this

fashion. Most of the erosion is by water that percolates through the porous sandstones. The water not only dissolves away some of the cement holding the sandstone together, but when it hits the soft underlying shales, which are impermeable (do not allow water to pass through), it slowly exits the sandstone above the shale and actively removes some of the underlying shales until support for the overlying sandstone is gone.

Impermeable: A rock or sediment, usually clay-rich, that will not transmit water under pressure. The microscopic, overlapping clay platelets in such rocks prevent water from moving through the rock.

Case hardening: The process by which the surface of a porous rock, like the Lee sandstone, is coated with a cement, usually calcite, silica, or iron carbonate, due to evaporation of mineral-bearing solutions leached from the rock. The precipitation of the cement gives the rock a hardened exterior surface.

Concordant hill tops: Hilltops over a wide area that all have about the same elevation, suggesting that at one time they were part of an extensive, elevated flat surface or plateau. Subsequent downcutting by streams flowing on the surface generally dissects that surface into a series of steep valleys between flat-topped ridges. Judging from its concordant hilltops, the Cumberland or Appalachian Plateau, although deeply dissected by stream valleys, was apparently at one time such a broad, elevated plateau.

Downcutting: Stream erosion that is directed in a downward direction, often resulting in deep, narrow valleys or gorges. It may be caused by dropping sea level or regional uplift, both of which force streams to downcut more vigorously to keep pace with changing relative sea level. Much of the major downcutting noted in Kentucky may have begun about two million years ago with the advent of glaciation. As more seawater was included in the large northern glaciers, the sea level dropped, forcing streams to downcut in order to keep pace with falling sea level.

Reentrant: A prominent indentation into the side of a cliff. Although sometimes called a rockhouse or “cave,” these indentations are generally not formed in limestones. In the Cumberland Plateau area of Kentucky, these generally form in sandstones at the point where the sandstone meets an underlying shale layer due to sapping. The formation of a reentrant may be the first step in the formation of ridgetop arches.

Lighthouse: A subsequent stage in ridgetop arch formation, in which a reentrant from one side of a ridge meets a reentrant from the opposite side, generating a small hole through which light can pass unobstructed.

Joint: A natural break or fracture in rocks along which there has been no movement. Joints are usually planar features which occur as sets and are important in the processes of weathering because they provide various mechanical (roots, freeze and thaw) and chemical (water, air, organic acids) weathering agents access to the rock.

Mechanical weathering: The process of weathering by which physical forces (e.g., frost action, growing roots, temperature changes) break down or reduce rocks to smaller sizes; this process involves no chemical change.

Chemical weathering: The process of weathering by which chemical reactions (e.g., hydration, oxidation, solution, hydrolysis) transform rocks and minerals into new chemical combinations with different appearances, sizes, and shapes at the earth's surface.

Questions for Study and Reflection:

- How is the beginning of Northern Hemisphere glaciation about two million years ago related to the formation of major gorges throughout Kentucky?
- Why are most of Kentucky's natural arches on hilltop ridges?
- How can the Cumberland Plateau in Kentucky be both "mountainous" and a plateau?
- Explain the influence of mechanical and chemical weathering in the formation of Kentucky's landforms.
- How do joints in rock influence the development of landforms?

Pine Mountain

Pine Mountain: A single, linear mountain ridge that extends 125 miles from Breaks Interstate Park near Elkhorn City in Pike County, Kentucky, to Pioneer, Tennessee. The mountain rises 600-1000 feet above the hills of the Cumberland Plateau and marks the northwestern edge of a thrust sheet that was transported northwestward five to 11 miles into Kentucky more than 250 million years ago.

Thrust fault: A very low-angle (less than 45°) fault along which older rocks are generally superimposed on younger rocks. At the edge of the Pine Mountain thrust sheet, Devonian or Mississippian rocks on the sheet itself commonly overlie the Pennsylvanian rocks that make up the Cumberland Plateau to the west. At Pineville, however, the older Lee sandstone overlies the younger Pennsylvanian Breathitt Formation along the thrust fault.

Synclinal fold: A downfold in which the layers are folded concave upward. On the Pine Mountain thrust sheet, the layers are folded into a broad synclinal fold. When the resistant Lee Sandstone was folded as a part of the syncline, it was uplifted on each side or limb of the fold, forming resistant, linear ridges. The northwestern ridge is Pine Mountain and its southeastern equivalent is Cumberland Mountain. Both of the high, resistant ridges were difficult for early settlers to cross.

Limb: One side of a fold.

Rocky Face Fault: A fault that crosses the Pine Mountain thrust sheet from Cumberland Gap to Pineville at high angles. At the points where the fault crossed Pine and Cumberland mountains, the weak rocks broken by the fault were subject to more rapid weathering and erosion, forming erosional gaps in the mountains. Pine Gap formed where the fault crossed Pine Mountain, and Cumberland Gap formed where the fault crossed Cumberland Mountain.

Gap: A sharp break or opening through a mountain ridge.

Middlesboro Basin: A bowl-shaped basin about four miles in diameter and bound by a ring of faults. The city of Middlesboro sits in this basin, which is formed through the enhanced weathering and erosion of rocks pulverized by a meteorite impact, occurring less than 230 million years ago.

Ohio Corridor: The low-lying area along the Ohio River that served as a corridor for travel by early settlers trying to move through the Appalachian Mountains and into fertile, flat-lying farm lands to the west. The only other major corridor for settlers was the Cumberland Gap.

Questions for Study and Reflection:

- What was the effect of Pine and Cumberland mountains on the movement of early settlers through the Appalachian Mountains? How did they overcome this effect?
- Give an example of how faults may influence the lay of the land. How did they influence the development of transportation routes for early settlers?

Eastern Coal Field

Coal: A combustible rock containing more than 70 percent by volume of carbonaceous material, formed from the compaction and alteration of plant remains. In Kentucky, most coals formed in extensive, equatorial swamps during the Pennsylvanian Period.

Drift mining: Extraction of coal through horizontal, underground mines that are entered horizontally at the surface.

Contour strip mining: Extraction of near-surface coal by cutting out the overburden and collecting the coal along a narrow bench where the coal seam intersects the surface topography. Because the coal seams are generally flat, these benches appear to follow the contour of the hill.

Augur mine: After coal has been stripped off of the narrow bench, a large screw-like boring tool is used to remove some of the coal from adjacent parts of the hill where overburden is too thick to remove.

Mountaintop removal: In hilly or “mountainous” areas where the overburden is not too thick, entire mountaintops are removed as overburden to reach a coal seam. The removed overburden is commonly used to fill adjacent valleys.

Slump: A landslide characterized by failure of earth or rock debris along a curved (concave-upward) slip surface. This is one type of slope wasting or failure.

Rockfall: The free fall of a newly detached segment of bedrock from a cliff or steep slope. Detachment usually occurs along a joint where an influx of water helps to lubricate and ice wedging (expansion) helps to detach the rock.

Angle of repose: The angle of slope at which loose, cohesionless material will come to rest in a stable configuration. For most natural slopes, the angle is between 33 and 37 degrees. Slopes at higher angles are candidates for failure.

Questions for Study and Reflection:

How did the alternating layers of Pennsylvanian sandstones and shales give rise to the many ridges and valley bottoms that characterize the Cumberland Plateau?

How did the terrain control and influence the peoples’ lives in the area?

How do the steep slopes in the area influence where people are able to live?

Think about the cost-to-benefit ratio for coal mining in the area. How does coal mining influence economy, culture, land and health?

Internet Resources

Kentucky Geologic Society

www.uky.edu/KGS/

This site includes information about the geology of Kentucky; fossils and prehistoric life; K-12 education and earth science links; rocks and minerals; mapping; and KGS publications. The KGS publishes beautiful full-color geologic maps of Kentucky; teachers can visit this site to see what's available and how they can obtain these maps as well as other KGS materials.

Kentucky Paleontological Society

www.uky.edu/OtherOrgs/KPS/

This site provides information about fossils and fossil hunting, as well as photographs of fossils.

Electronic Field Trip to the Falls of the Ohio

www.ket.org/trips/falls/index.htm

In fall 1999, KET aired "Electronic Field Trip to the Falls of the Ohio." This important Kentucky geological site is explored in depth during the program. The Web site developed to accompany the field trip includes links to other resources, a teacher's guide for the program, information about the Falls' history and wildlife, and more.

Electronic Field Trip Through Geologic Time

www.ket.org/trips/geotime/

This field trip, led by Dr. Frank Ettensohn of the University of Kentucky, takes students to the Jenkins Pound Gap in Letcher County, the first site in Kentucky designated as geologically significant. The Web site includes links to other geology-related Web sites, a glossary, educational resources, and a geologic timeline.