Kansas Field Conference
June 22–24, 2022

Southeast Kansas

History, Industries, and Transformation

Field Guide

Blair Schneider

Kansas Geological Survey Open-File Report 2022-22

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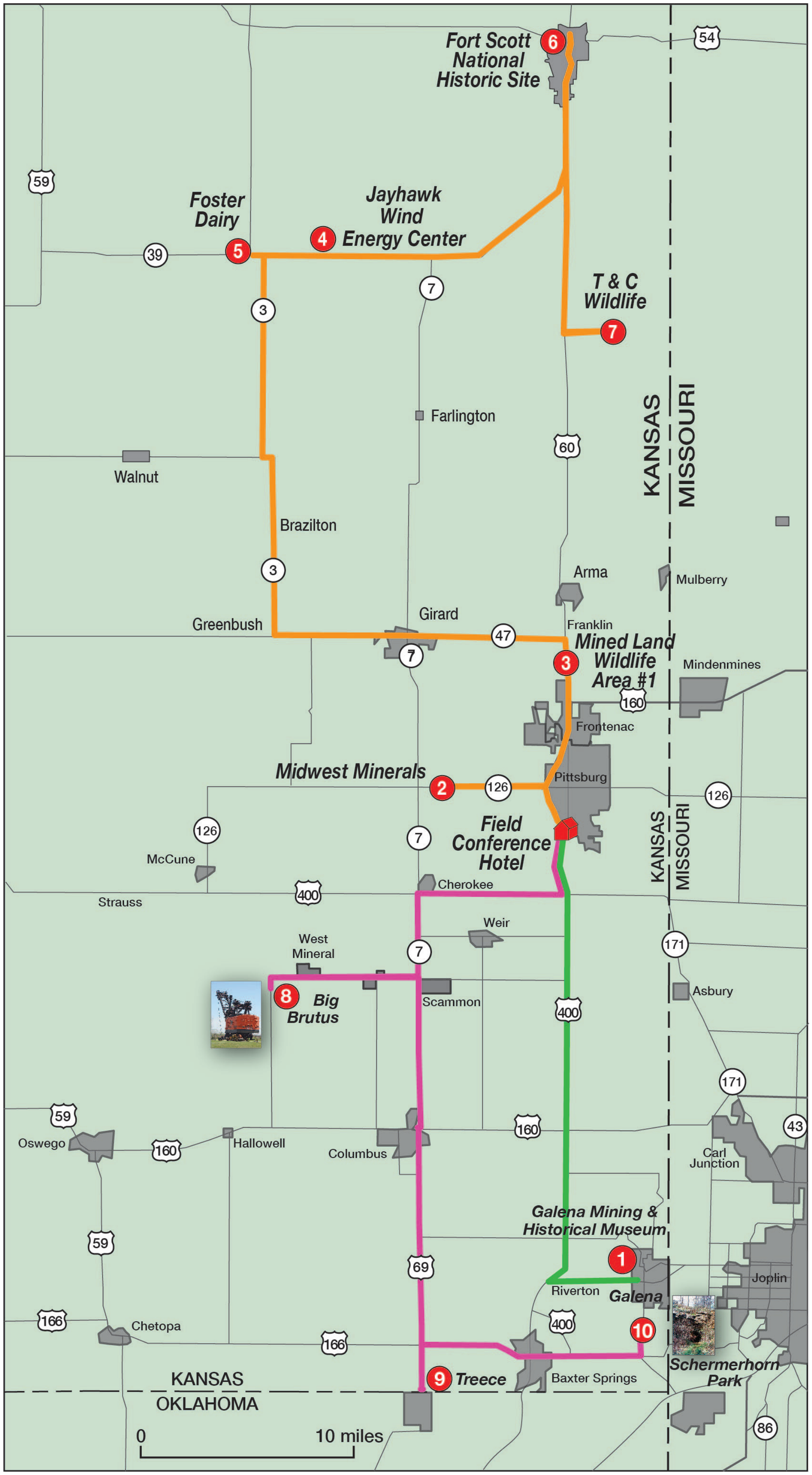

Fort Scott National Historic Site
Foster Dairy
Jayhawk Wind Energy Center
T & C Wildlife
Farlington
Walnut
Brazilton
Arma
Mulberry
KANSAS
MISSOURI
Greenbush
Girard
Franklin
Mined Land Wildlife Area #1
Mindenmines
Frontenac
Midwest Minerals
Pittsburg
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McCune
Strauss
Cherokee
Weir
West Mineral
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Galena Mining & Historical Museum
Riverton
Galena
Joplin
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Treece
Baxter Springs
Schermerhorn Park
KANSAS
OKLAHOMA
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10 miles

Route map.

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NOTES

Southeast Kansas

History, Industries, and Transformation

June 22–24, 2022

Welcome to the 27th year of the Kansas Field Conference. We hope that you find this to be an informative and engaging tour that addresses the past, present, and future of Kansas natural resources in the southeast region. This year's tour also presents a unique opportunity for state legislators and policymakers to network with board members of the Kansas Water Authority.

The sites on the 2022 tour encompass three broad categories: history, industries, and transformation. Historically, this region of Kansas has had a significant impact on both the economy and the environment of Kansas. As we review this history, we will see how our past industries have evolved into new directions that contribute to the Kansas economy and livelihoods of the local communities. Finally, the overarching theme that connects the stops on this field trip is transformation. Exploitation of the natural resources in this region has resulted in the need for significant environmental remediation efforts. Together, local communities are working with state and federal agencies to transform the region into a landscape that is once again beautiful and productive.

History

In the southeastern tip of the state within the Ozark Plateau region, you can find outcrops of the oldest rocks found at the surface in the state. These rocks were deposited during the Mississippian Subperiod between 359 million years ago and 323 million years ago. During this geologic period, the region experienced cycles of shallow seas and dry land, which resulted in deposits of limestone, sandstones, shales, and chert. Chert is much harder and more resistant to weathering than limestone, and erosion of the softer limestone has left a thick blanket of chert gravel on hilltops and ridges. Other notable deposits in the region include the minerals galena and sphalerite. Galena is a lead sulfide (PbS) and the principal mineral of lead ore. Sphalerite is a zinc sulfide (ZnS) and is a mineral of economic value for its zinc content.

Moving north and west across the rest of the southeast region, you will find surface outcrops of rocks that were deposited during the Pennsylvanian Subperiod between 323 million years ago and 299 million years ago. During this geologic period, the region experienced cycles of shallow seas, swamps, and river channels that resulted in deposits of limestone, sandstone, and shale. Rivers and streams flowed into the sea during the Pennsylvanian Subperiod and deposited sand and other sediments in estuaries and deltas. Layers of coal, found mainly underground, formed from vegetation that accumulated in swamps during this time.

By the turn of the 20th century, coal mining had become a predominant industry in the region and has had a lasting impact on the region's modern landscape. Lead and zinc were also heavily mined in the 19th and 20th centuries. This history of mining, its effects on the environment, and the steps that have been taken to remediate the damage done will be a focal point of our stops across all three days of the conference. Day one begins at the Galena Mining and Historical Museum to get an in-depth historical background of the economic and environmental impact that lead and zinc mining had on this community. Day two stops will focus primarily on the history of coal mining when we visit Big Brutus and the Mined Land Wildlife Area. We will wrap up day two with a tour of the Fort Scott

National Historic Site. Fort Scott represents a community that was both dependent on coal and directly contributed to the westward migration of settlers into the "Free State" of Kansas. Day three will provide a deeper dive into the history of Treece, a once-prominent mining community that has since become a ghost town.

Industries

We will visit four industries during this tour. The first stop of day two is at Midwest Minerals. Midwest Minerals provides crushed limestone aggregate materials throughout southeast Kansas, northeast Oklahoma, and southwest Missouri. Aggregate materials are used in construction materials, such as cements, mortar, asphalts, and road gravel. The mining aggregate industry provides a large boost to the Kansas economy every year. There are currently six active mines and mineral plants across Crawford, Cherokee, and Bourbon counties.

After Midwest Minerals, day two will take us to see two other industries in the region. The first in Crawford and Bourbon counties uses a free, and ample, resource in Kansas — wind. The Jayhawk Wind Energy Center, a 190-megawatt wind facility, opened in December 2021. The majority of wind farms in Kansas were constructed in the west and southwestern portions of the state, providing almost 45% of renewable energy resources to residents of the state, tens of thousands of jobs to the economy, and economic benefits for landowners. The Jayhawk Wind Energy Center is one of three wind farms recently established in the southeast portion of the state.

The third industry that we will see on day two is Foster Dairy Farms, the only remaining dairy farm in Bourbon County. Foster Dairy uses some of the most innovative technology available in the dairy agricultural arena. Once inside, you will see a robot milk a cow with precision and care. The Fosters will show you firsthand the voluntary initiatives that they participate in to conserve natural resources and move toward sustainable practices.

Stops at the Galena Mining and Historical Museum, the Mined Land Wildlife Areas, the Southeast Kansas Nature Center, and Big Brutus provide a view of another prominent industry in this region: tourism. Tourism contributed more than $5 billion dollars to Kansas's economy in 2020, attracting more than 31 million visitors to locations across the state. Southeast Kansas brought in more than $370 million in tourism money in 2019, with Crawford County contributing the most among the 17 counties in the region.

Transformation

A major focus of this tour will highlight how the state is working to transform and reclaim the land that was previously destroyed by the mining industry. On day two, we will learn about the conservation and reclamation efforts of surface-mined areas at the Midwest Minerals and the Mined Land Wildlife Area stops. Industries and communities work with the Kansas Department of Agriculture and the Kansas Department of Wildlife, Parks and Tourism to turn these properties into areas that can be used for farming, grazing, fishing, hunting, and other wildlife activities. Day two stops at Foster Dairy and the Jayhawk Wind Energy Center also provide a look at how technology can be used to boost the economy and better meet the needs of communities in a sustainable way.

Day three will focus on the reclamation efforts underway by the Kansas Department of Health and Environment and the Environmental Protection Agency at Treece, efforts that will require several more years of work to complete. These agencies have made abundant progress to transform the environmental damage left in the wake of past mining activities in the region into productive landscapes once more. The last stop of the trip at the Southeast Kansas Nature Center will also highlight reclamation efforts underway by the Kansas Department of Health and Environment and the Kansas Department of Wildlife, Parks and Tourism to address water contamination in Shoal Creek from the Tri-State mining district.

About the Kansas Field Conference

The Kansas Field Conference is designed to give policymakers the opportunity to explore and discuss natural resource issues. Participants have a chance to see what effects government and business decisions can have on natural resources and communities and to talk with government officials, business owners, researchers, and others who are directly involved with the various sites. We aim to provide a broad, informed perspective that will be useful in formulating policies and programs.

The annual field guide furnishes background about each site and can serve as a useful reference long after the conference is over. Field guides also are posted on the KGS website (www.kgs.ku.edu). You are encouraged to ask questions and contribute to the discussions. The bus microphone is open to everyone. Please remember that the intent of this conference is not to resolve policy or regulatory conflicts. By bringing together experts, we hope to go beyond merely identifying issues; we want the combination of firsthand experience and interaction among participants to result in a new level of understanding about the state's natural resources and concerns.

When possible, we attempt to provide a forum for all sides of a contentious issue. The opinions presented during the conference are not necessarily those of the Kansas Geological Survey or the field conference co-sponsors. Nonetheless, we believe it is important for participants to hear various viewpoints on complex issues. The Kansas Geological Survey and co-sponsors appreciate your attendance at this year's conference.

Sponsors

The Kansas Field Conference is made possible and kept affordable through the generous support of many groups. In addition to the co-sponsors listed below, the 2022 field conference received support for socials and meals from Gencur Svaty Public Affairs and Midwest Dairy. We thank them for their support.

Kansas Geological Survey

The KGS is a research and service division of the University of Kansas. Its mission is to study and report on the state's geologic resources and hazards. Much of the KGS focus is on energy, water, and a better understanding of the state's surface and subsurface geology. By statutory charge, the KGS role is strictly one of research and reporting. The KGS has no regulatory functions. Headquartered on KU's west campus, the KGS also has a Kansas Geologic Sample Repository in Wichita.

The following KGS staff are participating in the 2022 field conference:

- Blair Schneider, Geologist/Outreach Manager
- Rolfe Mandel, Director
- Scott Ishman, Associate Director for Research
- Franek Hasiuk, Associate Scientist
- Doug Louis, Manager, Kansas Geologic Sample Repository

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The Kansas Department of Health and Environment (KDHE) mission is to protect and improve the health and environment of all Kansans. KDHE has several divisions, including the Division of Environment, which has regulatory responsibility for air quality, environmental remediation, waste management, and water quality. The Division of Environment is the regulatory body that addresses harmful algal blooms, permits public water supply quality, permits industrial and municipal wastewater, and identifies quality-impaired lakes, streams, and wetlands. It also regulates underground hydrocarbon salt cavern storage and underground disposal wells unrelated to the oil and gas industry.

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Kansas Department of Transportation

The Kansas Department of Transportation (KDOT) is charged with providing a statewide transportation system to meet the needs of Kansans. Its primary activities are road and bridge maintenance; transportation planning, data collection, and evaluation; project scoping, designing, and letting; contract compliance inspection of material and labor; federal program funding administration; and administrative support.

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The Kansas Department of Wildlife, Parks and Tourism (KDWPT) is responsible for managing the state's living natural resources. Its mission is to conserve and enhance Kansas's natural heritage, wildlife, and wildlife habitats. Its responsibilities include protecting and conserving fish and wildlife and their habitats while providing for the wise use of these resources and associated recreational opportunities and providing public outdoor recreation opportunities through state parks, state fishing lakes, wildlife-management areas, and recreational boating on the state's public waters.

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The Kansas Department of Agriculture (KDA) has a mission to support the agriculture sector in Kansas, including farmers, ranchers, food establishments, and agribusiness, and the consumers they serve. KDA has several divisions, including the Division of Water Resources (DWR) and the Division of Conservation. DWR regulates how water is allocated and used, the construction of dams and levees, Kansas's Groundwater Management District Act, and the state's interstate river compacts. It also coordinates the national flood insurance program in Kansas. The Division of Conservation works with the county conservation districts, organized watershed districts, and other special-purpose districts to improve water quality, reduce soil erosion and flood potential, conserve water, and provide local water supply.

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The Kansas Water Office (KWO) is the water planning, policy, coordination, and marketing agency for the state. The KWO evaluates and develops public policies, coordinating the water-resource operations of agencies at all levels of government. The KWO administers the Kansas Water Plan Storage Act and the Water Assurance Act and advises the governor on drought conditions. The KWO develops the Kansas Water Plan, which addresses the management, conservation, and development of water resources in the state. The Kansas Water Authority, statutorily within and a part of the KWO, advises the governor, legislature, and director of the KWO.

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www.kwo.org

Acknowledgments

The following people helped make this an informative and successful field conference: Secretary Brad Loveless, Southeast Kansas Nature Center Director Jennifer Rader, and Wildlife Manager David Jenkins, Kansas Department of Wildlife, Parks and Tourism; Deputy Secretary and Director of Environment Leo Henning, Environmental Specialist Peyton Witham, and Chief of Assessment and Restoration Joe Dom, Kansas Department of Health and Environment; Secretary Mike Beam, Director of Conservation Andrew Lyon, and Assistant Director Scott Carlson, Kansas Department of Agriculture; Director Connie Owen and Assistant Director Matt Unruh, Kansas Water Office; and Chief Geologist Kyle Halverson and District 4 Engineer Wayne Gudmonson, Kansas Department of Transportation. Mark Schoneweis, KGS graphic designer, prepared the route map. Special appreciation goes to Julie Tollefson, KGS editor, for her extensive help editing and laying out the field guide. The KGS extends our appreciation to the presenters at each of the stops, without whom this conference would not have been possible. We would also like to thank Invenergy and Gencur Svaty Public Affairs for sponsoring the lunches provided on Thursday and Friday of the conference this year.

Invenergy

Gencur Svaty PUBLIC AFFAIRS

NOTES

Wednesday, June 22, 2022

2 p.m. Check into La Quinta Inn & Suites, Pittsburg
Park your car in the hotel lot and check in with Blair Schneider at the table in the front lobby

2:45 p.m. Introductions and Orientation
La Quinta Inn lobby
Rolfe Mandel, Director, Kansas Geological Survey
Blair Schneider, Outreach Manager, Kansas Geological Survey

3:30 p.m. Drive to Galena Mining Museum, Galena
We encourage participants to carpool to the museum to conserve parking space

4 p.m. **Stop 1: Galena Mining Museum, Galena**

Welcome
Brad Loveless, Secretary, Kansas Department of Wildlife, Parks and Tourism

Tour of Museum
Linda Phipps, Museum Director, Galena Mining and Historical Museum

6 p.m. Return to Pittsburg

Dinner on your own

Popular Pittsburg restaurants:

- Colton's Steak House & Grill, 4001 Parkview Drive
- RibCrib BBQ, 2909 N. Broadway
- Napoli's Italian Restaurant, 1301 N. Broadway
- El Charro, 3102 N. Broadway
- Guadalajara Mexican Grill, 1620 S. Broadway
- Jim's Steak and Chop House, 1912 N. Broadway
- Brick + Mortar, 401 N. Broadway
- Chatter's, 2401 S. Rouse

NOTES

Galena Mining and Historical Museum

Galena, incorporated in 1877, represents the beginning of the Tri-State mining district in Kansas. The district — which covers parts of southwestern Missouri, northeastern Oklahoma, and southeastern Kansas — was once one of the major lead and zinc mining areas in the world. The town of Galena contains a wealth of history that will be a prominent theme throughout the field conference. At its prime, Galena was one of the most important towns west of New York City, serving as a major producer of lead from 1850 to 1950.[1]

Where did all this lead come from?

In 1877, the year Galena was incorporated, a man named Egidius Moll found several stones heavy with lead ore on his land.[2] Lead ore is found in the mineral galena, which formed within the Mississippian-age cherty limestones of the area (fig 1.). The limestones and cherts were deposited within shallow seas that covered portions of North America at the time. Over millions of years, the limestones were exposed at the land's surface and selectively weathered and eroded away. This erosion caused the beds to collapse, leaving chunks of chert

KEY FACTS

- Galena was one of the most important towns west of New York City, serving as a major producer of lead from 1850 to 1950.
- From 1918 to 1941, the entire Tri-State mining area was a significant producer of zinc and lead ores used for wartime production.
- The Kansas portion of the Tri-State district produced more than 2.9 million tons of zinc, with an estimated value of $436 million, and 650,000 tons of lead worth nearly $91 million.
- East Galena's historic business district was placed on the National Register of Historic Places in 2003.
- The Galena Mining and Historical Museum sits inside the old Missouri-Kansas-Texas train depot, which served as a station for the "Katy" that connected major cities from St. Louis to Houston.

Figure 1. Sample of the minerals galena (lead ore) and calcite outside the Galena Mining and Historical Museum.

surrounded by very porous and permeable limestones. The seas returned during the Pennsylvanian Subperiod (323 million years ago to 299 million years ago), and shales were deposited atop the Mississippian cherts and limestones.

Millions of years later, hot, metal-bearing fluids rose along major faults and fractures up to these broken cherty beds.[3] The shales atop the beds prevented the hot fluids from rising farther and forced them to spread laterally instead (fig. 2). These hot fluids then cooled and crystallized into deposits of calcite, galena, sphalerite, chalcopyrite, pyrite, marcasite, dolomite, quartz, and jasperoid. Of these deposits, only galena and sphalerite were economically important during the Tri-State mining boom. Figure 3 shows the location of these mineral deposits across the Ozark Plateau physiographic region in Kansas, Missouri, and Oklahoma.

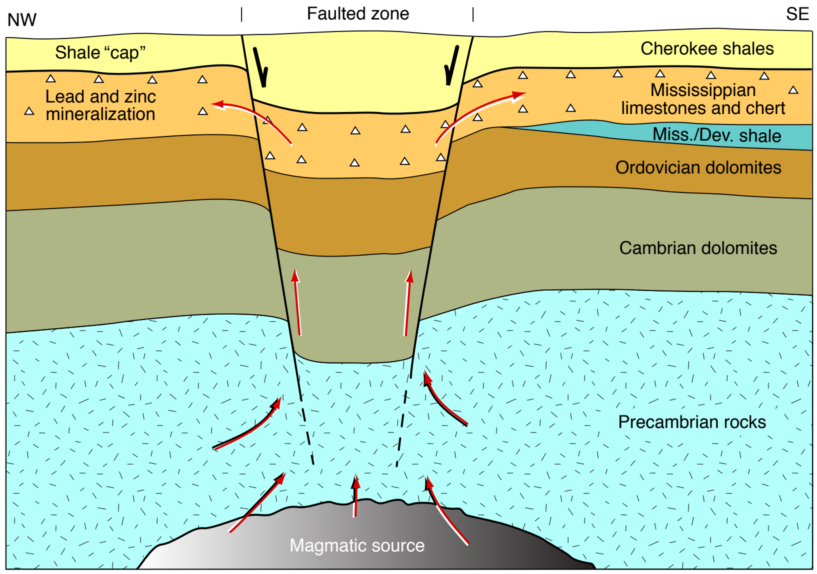

Figure 2: Hot fluids from a magma source rose along faults into the Mississippian limestones and chert. The fluids then spread laterally when they hit the Cherokee shales.

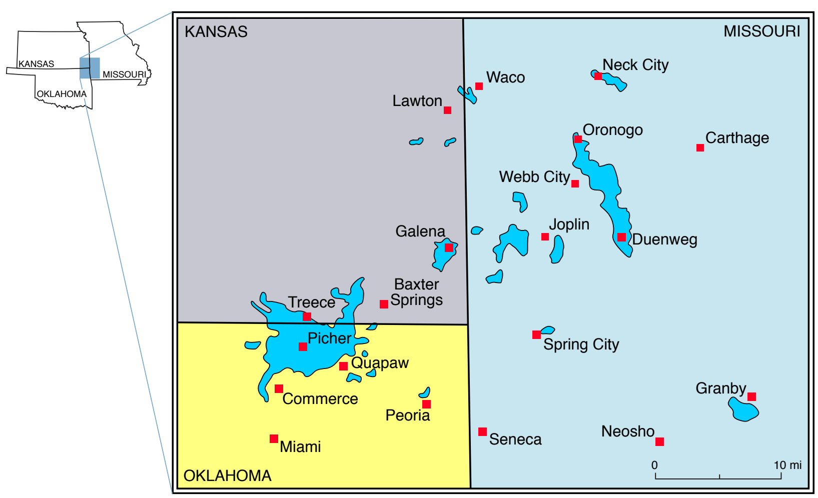

Figure 3: The Tri-State mining district in Kansas, Missouri, and Oklahoma. Dark blue represents mined areas.

The rise and fall of Galena mining

Upon discovering the lead source on his land, Egidius Moll began working with the nearby Joplin, Missouri Mining Companies. Later that year, two more mining companies built their own town sites in the area: Empire City and Galena.[2] Within just a few months, it is estimated that the population of Galena had reached almost 3,000. In 1879, two railroads — the Missouri River, Fort Scott & Gulf Railroad and the St. Louis and San Francisco Railroad — extended their lines to Galena. In 1926, Route 66 was established along Galena's main street, bringing in more people and business[2] (figs. 4–5).

The lead mined in the Tri-State district (fig. 6) was used to produce ammunition, paints, ceramic glazes, and more. In addition to the lead, mining companies found the mineral sphalerite, a source of zinc, in the district. Zinc is used to prevent rusting of other metals

Figure 4. Kennedy Auto Company was located on the northwest corner of Joplin and Seventh Streets in Galena. (Photo courtesy of Galena Mining and Historical Museum.)

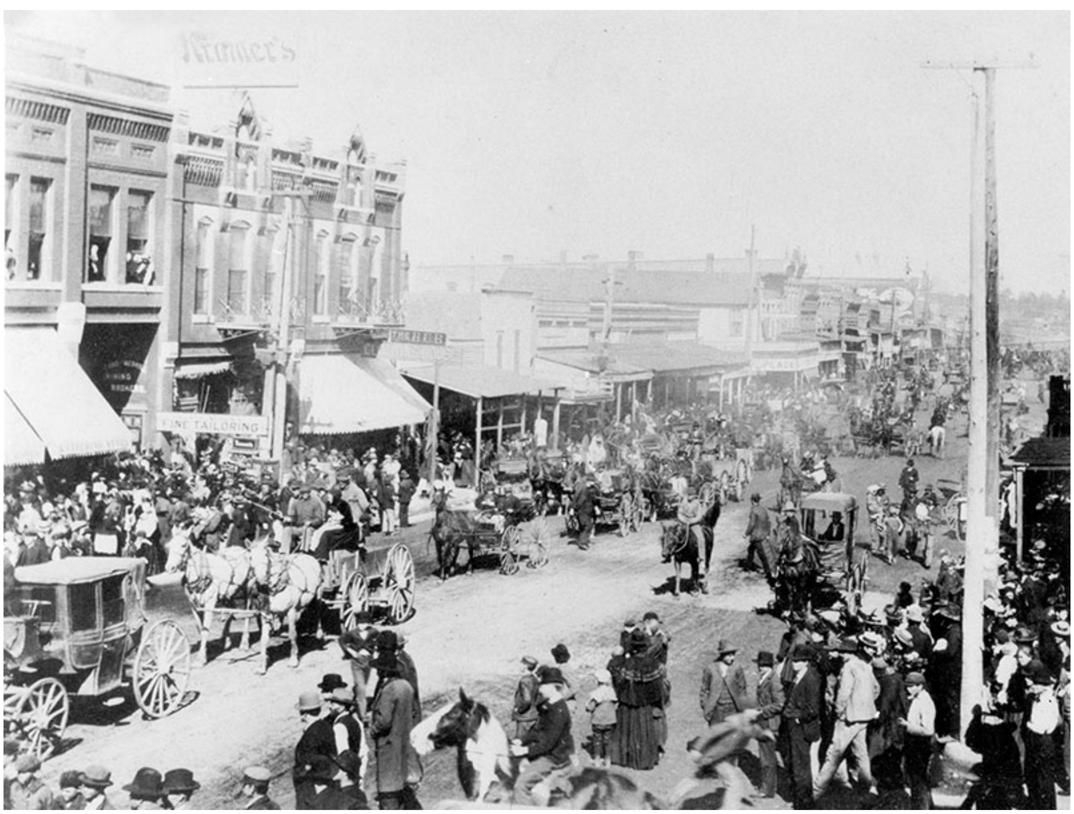

Figure 5. Pay day in Galena, 1897. (Photo courtesy of the Galena Mining and Historical Museum.)

> 21st Galena is the liveliest town we saw on the road. The mining excitement is higher here than elsewhere. There were at least a thousand people on the street last evening and a great many had gone over to Missouri to spend their Sunday. The piles of rock are more conspicuous here than at Joplin so many of the mines being on the town site. There was a smelter here but it burnt down was a great loss to the town. At this place as at all others mining is a very uncertain business. A few men have got rich while the majority have lost money, a great many have lost all they had. From here we travelled west to Shoal Creek a fine rock bottomed stream. The roads are rocky and very rough. There is very little nice road for driving buggies over like there is a hundred and fifty miles further west. Still, we saw a great many bicycles here, many more than there are with us in a better country to run a bicycle in…
>
> -Thomas Butcher journal account, 1896[5]

and as an alloy with other metals to develop materials used to make a variety of products, such as automobiles and electrical components. Smelters constructed in Weir City in 1873 and Pittsburg in 1878 processed the zinc ores mined in the Tri-State area.[2] The smelters were the final step to transform the zinc ore into pure zinc or zinc oxide so that it could be used in products.

Galena's importance peaked from 1918 to 1941 in conjunction with the two world wars. The entire Tri-State mining area was a significant producer of zinc and lead ores used for wartime production. In the 1920s, an estimated 11,000 miners worked in the area. Disruption of the industry occurred in 1935, though, when miners went on strike in the district. Strikes led to multiple incidents of unrest over the next two years, and the Tri-State mining district never fully recovered. As the importance of the district declined, so did Galena's population. The zinc and lead mines closed in the 1970s, and the new interstate 44 that was constructed nearby bypassed Galena.

Figure 6. Postcard sent from Galena between 1890 and 1910 showing active mining scene. (Photo courtesy of Kansas Historical Society.[3])

By this point, the Kansas part of the Tri-State district had produced more than 2.9 million tons of zinc, with an estimated value of $436 million, and 650,000 tons of lead worth nearly $91 million.[4]

Figure 7. Galena Mining and Historical Museum (top) and train outside the museum (bottom).

The Galena Mining and Historical Museum

Howard "Pappy" Litch, born in Galena in 1906, served as the town's local historian. Over the course of his lifetime, he collected artifacts that are now displayed in the Galena Mining and Historical Museum[6] (fig. 7). The museum is housed in the old Missouri-Kansas-Texas train depot. The railroad, better known as the "Katy," maintained a north-south route that connected St. Louis, Kansas City, Dallas, San Antonio, and Houston (fig. 8).

The museum contains memorabilia from the mining and railroad industries as well an extensive mineral collection, vintage Model T vehicles, and more. Displays also describe efforts, completed in 2007, to clean up more than 1,200 acres of mining wastes. Outside displays include Army tanks, train engines, helicopters, and mining equipment. Half a mile around the corner from the museum is "Cars on the Route," a display of famous Pixar characters from the Cars animated series. Exhibits in the museum describe how the animators took a series of road trips to this area of Kansas to help them design one of the most famous characters from the movie series: Mater.[6]

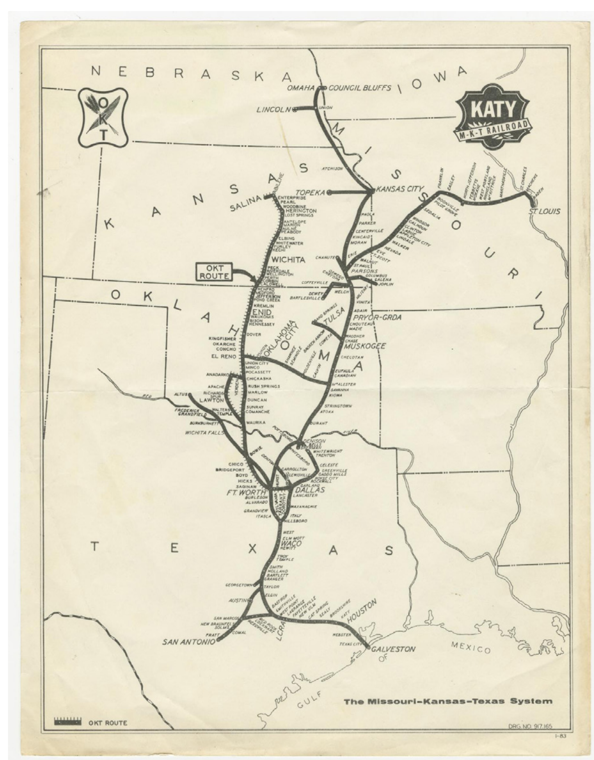

Figure 8. Map of the MKT route.[7]

Resources

[1]**Kansas Route 66 Historic District – East Galena**
National Park Service
https://www.nps.gov/nr/travel/route66/east_galena_historic_district.html

[2]**Galena, Kansas – A Lead Mining Maven: Legends of America**
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https://www.kansasmemory.org/item/220645

[4]**Lead and Zinc Mining in Kansas**
L. Brosius and R. Sawin, 2001, Public Information Circular (PIC) 17, Kansas Geological Survey
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https://galenamuseum.org/

[7]**Missouri-Kansas-Texas Railroad**
Missouri-Kansas-Texas System, map, 1983; Saint Louis, Missouri
University of North Texas Libraries, The Portal to Texas History (https://texashistory.unt.edu), crediting Midwestern State University
https://texashistory.unt.edu/ark:/67531/metapth117410/

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Thursday, June 23, 2022

7 a.m. Breakfast at the La Quinta Inn, Pittsburg

7:50 a.m. Meet at bus in La Quinta Inn parking lot

8 a.m. Bus to Midwest Minerals

Bus Talk: Governor's Mined Land Reclamation Award Program
Andrew Lyon, Director of Conservation, Kansas Department of Agriculture

8:30 a.m. **Stop 2: Midwest Minerals**
Steve Sloan, President, Midwest Minerals

9 a.m. Bus to Mined Land Wildlife Area #1, Frontenac

Bus Talk: Southeast Kansas Aggregate Production and Use
Kyle Halverson, Chief Geologist, Kansas Department of Transportation

9:30 a.m. **Stop 3: Mined Land Wildlife Area #1, Frontenac**
David Jenkins, Wildlife Manager III, Kansas Department of Wildlife, Parks and Tourism
Marlene Spence, Unit Manager, Kansas Department of Health and Environment
Rolfe Mandel, Director, Kansas Geological Survey

Restroom break at Casey's gas station, Girard

10:15 a.m. Bus to Jayhawk Wind Energy Center, Fort Scott

Bus Talk: Breaking Ground for the New Jayhawk Wind Energy Center in Bourbon and Crawford Counties
Josh Svaty, Senior Advisor, Gencur Svaty Public Affairs

11:15 p.m. **Stop 4: Jayhawk Wind Energy Center, Fort Scott**
Josh Svaty, Senior Advisor, Gencur Svaty Public Affairs

12:15 p.m.	Bus to Hepler Community Center Building for lunch
12:30 p.m.	Lunch at Hepler Community Center Building Ron Grusenmeyer, Farmers Relations Kansas Representative, Midwest Dairy Food catered by Chicken Annie's Dessert provided by Midwest Dairy Restroom break
2 p.m.	Bus to Foster Dairy Farms, Fort Scott
2:15 p.m.	**Stop 5: Foster Dairy Farms, Fort Scott** Lynda Foster, Owner, Foster Dairy Farms Mike Beam, Secretary, Kansas Department of Agriculture
3:30 p.m.	Bus to Fort Scott National Historic Site, Fort Scott **Bus Talk: Mine Creek Battlefield Site** Rolfe Mandel, Director, Kansas Geological Survey
4 p.m.	**Stop 6: Fort Scott National Historic Site, Fort Scott** Guided tour by park personnel Restroom break
5:30 p.m.	Bus to T&C Wildlife, Arcadia
6 p.m.	**Stop 7: Critical Minerals Research Presentation and Dinner at T&C Wildlife, Arcadia** **Welcome** Scott Ishman, Associate Director for Research, Kansas Geological Survey **Dinner and Presentation** Franek Hasiuk, Associate Scientist, Kansas Geological Survey Social
8 p.m.	Bus to La Quinta Inn, Pittsburg

Midwest Minerals

Prepared by Blair Schneider

KEY FACTS

- The USGS classifies Kansas as a principal state for the production of crude gypsum, crude and Grade-A helium, and pumice.
- Kansas maintains records of more than 8,800 quarries and mines across the state; 139 mines and quarries are currently active.
- Industrial minerals in Kansas are produced in both surface mines and underground mines. The majority of aggregates are produced in surface mining operations.
- The Surface Mining Land Conservation and Reclamation Act moved the regulatory oversight of all non-fuel mining in Kansas to the KDA in 1994, with the exception of river dredging, which is overseen by the U.S. Army Corps of Engineers.
- After mining operations have stopped, mining operators work with the KDA Division of Conservation to complete reclamation and ensure reclamation requirements have been met. Mining operators have up to three years to complete the reclamation process.

Overview

Coal, lead, and zinc are the most well-known products mined in southeast Kansas. Though lead and zinc production ended in the 1970s and coal production ceased in 2017, mining in this region continues. Active mines in Kansas number 139, and 28 of these are in the southeastern region (Cherokee, Crawford, Bourbon, Labette, Allen, Montgomery, Wilson, Woodson, and Neosho counties).[1] The majority of these active mines (84%) produce sand, gravel, crushed stone, and clay or shale, which are used in construction and referred to as aggregate materials.

Production of aggregate materials provides significant economic benefit to the state of Kansas. In 2017, Kansas sold $217 million dollars in aggregates, which is estimated to support more than 2,000 jobs in the industry. The USGS classifies the state of Kansas as a principal state for the production of crude gypsum, crude and Grade-A helium, and pumice.[2]

The process of mining aggregates can have adverse effects for the natural environment. In 1994, the Kansas Department of Agriculture, Division of Conservation, began administering the Surface Mining Land Conservation and Reclamation Act (K.S.A. 49-601-624), which ensures that any land disturbed for mining purposes, except for coal and gas, will be reclaimed.[3] Coal surface mines are regulated under an earlier statute (K.S.A. 49-401), established in 1969.

This stop will provide an opportunity to see mining activities up close as well as an example of a successful reclamation project by Midwest Minerals (fig. 1) that transformed a previously mined area back to its natural environment.

Industrial minerals in Kansas

The KGS maintains records of more than 8,800 quarries and mines[4] that have produced a variety of industrial minerals (fig. 2), including sand, gravel, clay, gypsum, limestone, dolomite, sandstone, salt, and volcanic ash. An industrial mineral is any rock or mineral that has economic value, except for metallic rocks or ores and fuels such as coal, oil, and natural gas. The term aggregate refers specifically to construction materials that are hard and do not react chemically with materials around them. Aggregate materials include sand, gravel, crushed stone, and clay or shale. Crushed stone is made up of limestone, dolomite, and sandstone. Clay and shale are used to manufacture lightweight aggregate.[5]

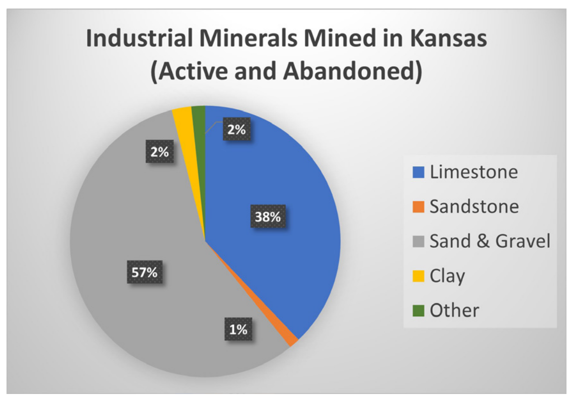
Figure 1. Entrance to the Midwest Minerals plant.

Aggregate materials are used to make concrete, mortar, asphalt, and other similar products. Concrete or asphalt roads are constructed using sand and crushed stone. Buildings are constructed using concrete and mortar. Unprocessed aggregate is used to maintain unpaved country roads across the state.[6]

The mining process

Industrial minerals in Kansas (fig. 3) are produced from both surface and underground mines. Underground mines use methods such as drilling, blasting, and crushing to extract the desired mineral. In Kansas, underground mines include gypsum mines in Barber and Marshall counties; salt mines in Rice, Reno, and Ellsworth counties; and limestone mines in northeast Kansas. Most Kansas mining sites, however, are surface mines (fig. 4). These mining operations range in size and method, depending on the type of aggregate and size of the deposit.

Sand and gravel are mined primarily across the central and western portions of the state using three main methods. In western Kansas, small sand and gravel pits are excavated using a front-end loader to fill trucks. In the rest of



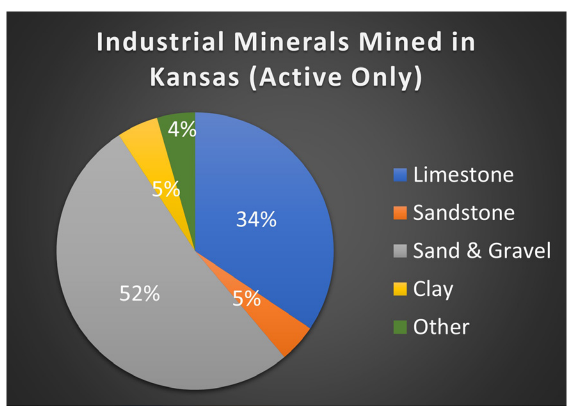


Figure 2: Breakdown by percentage of the types of industrial minerals that have been or are actively being mined in Kansas. Pie chart on the top shows the percentages for all active and abandoned quarries. Pie chart on the bottom shows the percentages for active quarries only.

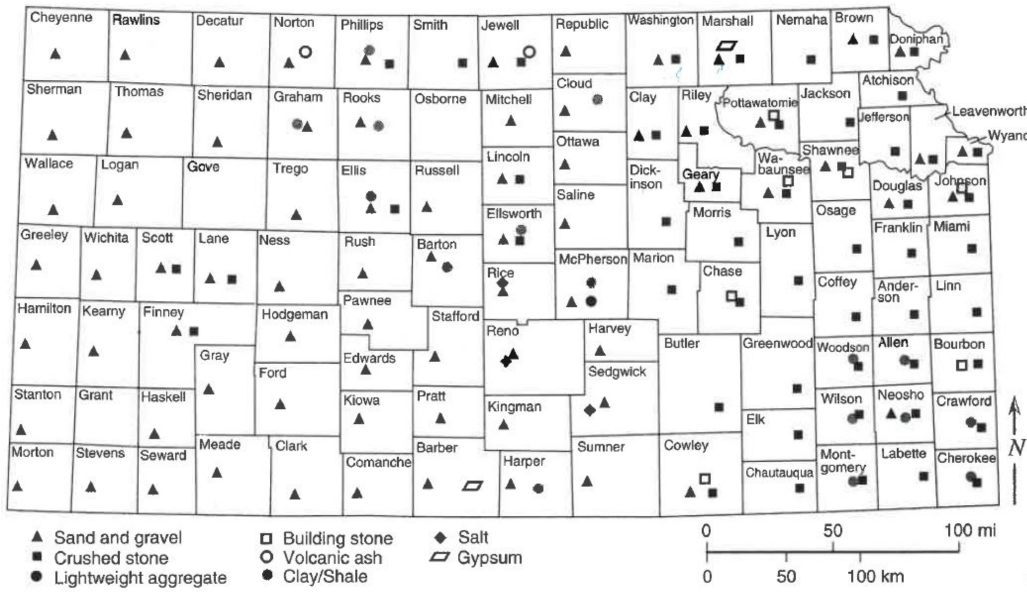


Figure 3. Industrial minerals produced in each county in Kansas.

the state, most sand and gravel comes from river dredging in the Kansas and Arkansas rivers.[5] A river dredge sits in the middle of a river and sucks out the sand and gravel from the bottom of the riverbed. Reclamation is not needed after the dredging because the river is constantly transporting new material downstream that will fill in the hole left behind by the dredge. A final method used in Kansas for sand and gravel surface mining is floodplain dredging. This method is the same as the river dredge, except the pit dredges sit within the floodplain instead of directly in the river. Two disadvantages to this method are that a significant amount of overburden — overlying soil and rock — must be removed from the floodplain to reach the water table and the pit that remains after the dredge is removed requires reclamation efforts to restore it to its original condition. After the material is dredged, it is sent to a plant for processing to separate out the materials by grain size (fig. 5).

The mining process for crushed rock requires more intense methods, include drilling, blasting, and crushing. The majority of crushed rock is mined in the eastern half of the state; however, Ellis, Rooks, and Osborne counties in northwest and north-central Kansas also have a large number of crushed stone quarries. Clays and shales are soft enough that they can be mined like the sand and gravels in western Kansas using a front-end loader to fill trucks. Clay and shale mining operations take place in portions of northwest Kansas (Graham, Rooks, and Phillips counties), south-central Kansas (Harper County), and southeast Kansas (Montgomery, Crawford, and Cherokee counties).

Environmental considerations

Prior to the Surface Mining Land Conservation and Reclamation Act, individual counties in Kansas regulated aggregate operations within their borders. The act moved the regulatory oversight of all non-fuel mining in Kansas to the Kansas Department of Agriculture (KDA), except for river dredging, which is overseen by the U.S. Army Corps of Engineers.[6] Under this act, mining operations are required to submit a reclamation plan and a reclamation bond to apply for a license and register a site. In addition, mining operators must submit an annual report and site registration renewal that outlines how many tons of material have been produced so far and the number of acres that have been affected at their site. After mining operations have stopped, mining operators work with the KDA Division of Conservation

Figure 4. Heavy machinery breaking ground at a Pittsburg quarry. (Photo courtesy of Midwest Minerals.)

Figure 5. Rock segregation, or variation in size within aggregate materials, lowers the quality of the aggregate. Machines called stackers, like the one pictured here, keep rock segregation to a minimum. (Photo courtesy of Midwest Minerals.)

to complete the reclamation and ensure that reclamation requirements have been met (fig. 6). Mining operators have up to three years to complete the reclamation process. Once those requirements are met, the reclamation bond is released.

Midwest Minerals

Midwest Minerals has provided crushed limestone aggregates and agricultural lime throughout southeast Kansas, northeast Oklahoma, and southwest Missouri since 1947. It was founded by John and Mary Stark, who moved to Kansas from Tennessee and began producing agricultural lime, a material used by farmers to boost crop growth.[7] Over the next few decades, the Starks transitioned the company into the production of aggregate materials. The company incorporated under the name of Midwest Minerals, Inc. in 1968.

Midwest Minerals operates five separate portable crushing machines that can be moved to different quarries depending on need and can crush rock into 20 different sizes depending on the intended use (fig. 7). The company and its 95 employees also continue to produce agricultural lime.[7]

In 2008, Midwest Minerals received the Kansas Governor's Mined Land Reclamation Award, given annually since 2002 to "raise the awareness and standards of reclaiming mined land and to recognize excellence in reclamation, restoration, beautification, community relations, and environmental enhancement."[3] In 2009, the company received the National Association of State Land Reclamationists Non-Coal Award for its efforts to reclaim a quarry in Pittsburg. The association noted the company's work in this area as "*a positive example of how quarry pits can be reclaimed to blend in with the surrounding area, while providing valuable water resources and wildlife habitat.*"

Today, Steve Sloan serves as president and CEO. The company's corporate office is in Pittsburg, and it operates under the leadership of Summit Materials, a nationwide construction materials company, and Cornejo & Sons, a Wichita-based construction and aggregates company.

Figure 6. Before and after comparison of the Buildex lightweight aggregate quarry near Ottawa. Left: The quarry in 2012 after mining had stopped. Right: The quarry in 2019 after the area was reclaimed. (Photos provided by Scott Carlson, Kansas Department of Agriculture.)

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[1]**Active mines and mineral plants in the US**
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[2]**USGS Minerals Yearbook 2017**
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[3]**Surface Mining Reclamation**
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[4]**KGS Directory of Kansas Industrial Mineral Producers**
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D. A. Grisafe, 1999, Kansas Geological Survey Educational Series 13
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[7]**Midwest Minerals**
https://midwestminerals.com/about/

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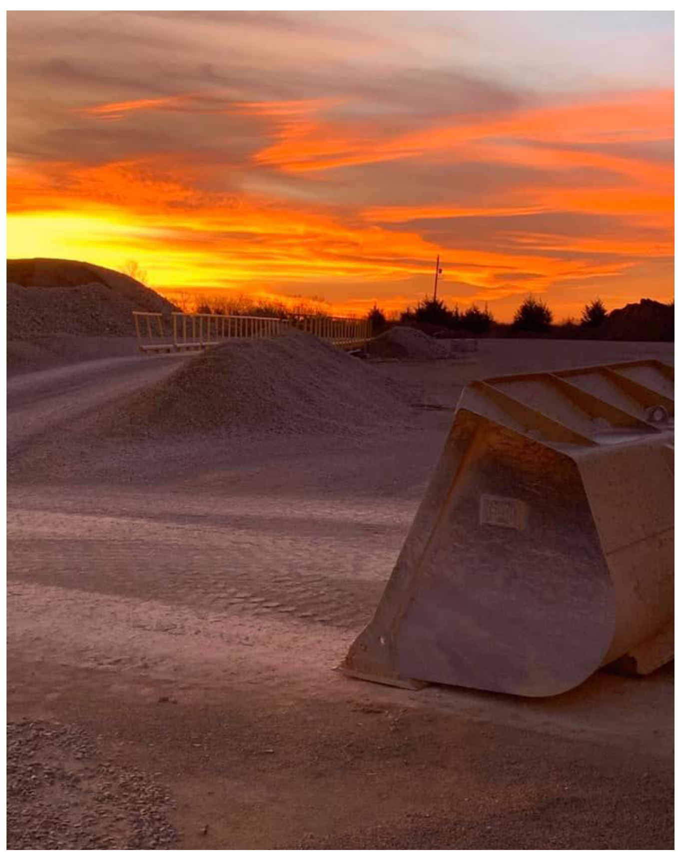

Figure 7. Sunrise over the Fort Scott quarry, Christmas Eve 2019. (Photo courtesy of Midwest Minerals.)

Mined Land Wildlife Area

Prepared by Blair Schneider

STOP 3

KEY FACTS

- The coal mined in this region formed from swamp muck during the Pennsylvanian Subperiod, sometimes called the "Great Coal Age."
- The Mined Land Wildlife Area encompasses 14,500 acres – 1,500 acres of that is water and the rest is land.
- Between 1920 and 1974, 86% of this property was surface mined; more than 1,000 strip-mine lakes remain.
- Restoration of native grasses has led to an increase in the biodiversity of the region.
- More than 200 of the lakes are stocked with fish, and fishing is a popular tourist activity in the area.

Overview

The impacts of mining in the Tri-State district in the southeast corner of Kansas extend beyond the areas mined for lead and zinc. Another important industrial mineral actively mined at the same time was coal. This stop will highlight the transformation of strip-mined land into restored habitat that offers hunting, hiking, camping, and wildlife viewing for the local community and tourists visiting the area (fig. 1).

Beginning in the 1870s, people arrived in Crawford, Cherokee, and Bourbon counties to dig for coal, a firm, brittle, and easily combustible sedimentary rock derived mainly from compacted plant debris, including ferns and club mosses. Depending on its quality, coal is divided into three main categories: anthracite (highest quality), bituminous (medium quality), and lignite (lowest quality). Bituminous coal is the most common type in Kansas and is the type of coal that workers found in this southeastern corner of the state (fig. 2). It breaks into irregularly shaped blocks, has a luster varying from dull to fairly bright,

Figure 1. An abandoned strip-mined trench filled with water in Cherokee County. The area was reclaimed and is now maintained by the Kansas Department of Wildlife, Parks and Tourism.

and burns with a yellow flame. This coal formed from swamp muck during the Pennsylvanian Subperiod, sometimes called the "Great Coal Age." At that time, widespread freshwater swamps in eastern Kansas covered low-lying areas thick with ferns as tall as trees and other primitive plants. Layers of dead and decaying plants accumulated on the bottom of the swamps and were eventually covered by layers of mud and sand. The weight of the overlying layers compressed the plant debris. Over time, the decaying plant material formed into peat — a soil-like partially decayed mineral matter — then lignite, then bituminous coal. Geologists estimate that it took about 10 feet of leaves, tree trunks, and other organic matter to produce a one-foot layer of coal.

The majority of the coal mining operations in eastern Kansas peaked during WWI but decreased since due to the availability of other cheaper alternatives, such as oil, gas, and renewable energy resources (fig. 3). All coal

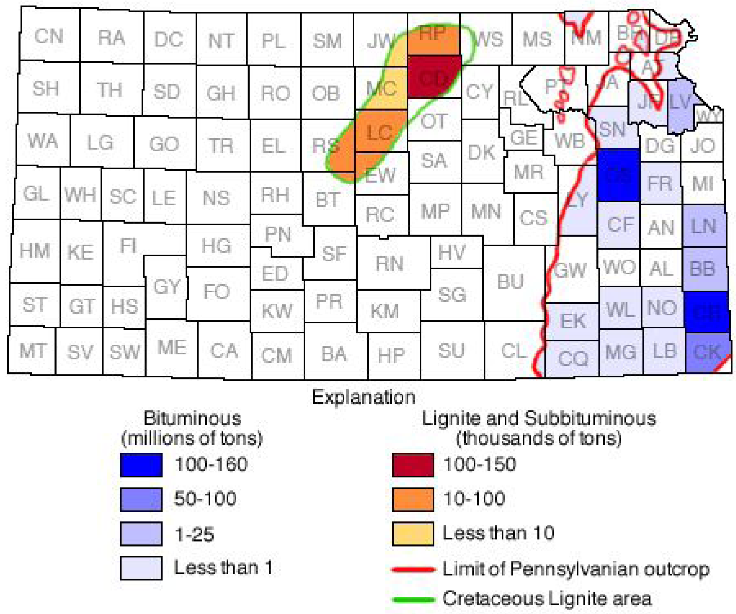

Figure 2: Primary areas of coal production in Kansas since 1869. Medium-grade coal (bituminous) is primarily located in the eastern third of the state. Low-grade coal (lignite) is produced in the north-central portion of the state2.

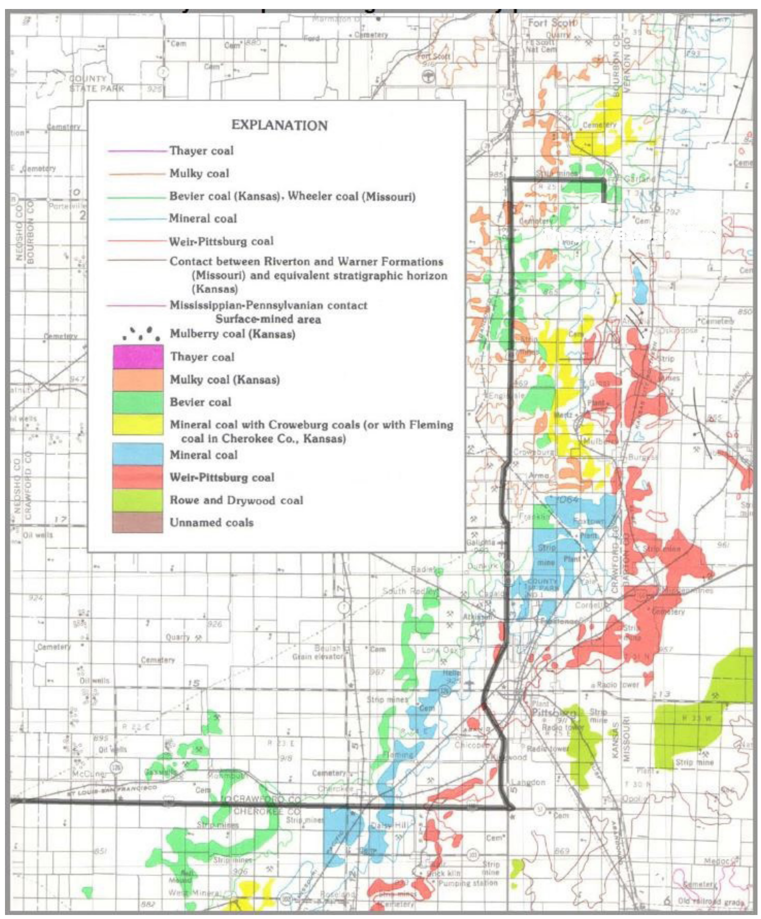

Figure 3: Distribution of coal deposits in Cherokee, Crawford, and Bourbon counties.3 Four coal beds identified on this map (Mineral, Bevier, Mulberry, and Nodaway) represented the largest amount of coal resources available in 2005 (nearly 1.3 billion tons).

mines in Kansas were closed by 2017.[1] During the several decades of strip mining, excavators dug large holes in the ground to remove the coal. In 1969, the Kansas Legislature passed regulations requiring coal companies to reclaim mined land and make it productive again. More stringent federal regulations followed. Today, strip mines must be converted into useful productive land. Once an area has been mined, companies must smooth out the ditches, replace the topsoil, and plant grass or crops similar to those present before mining. Once the land is leveled, it can be used for farming or grazing. These regulations, however, apply only to mines closed after 1969. Strip mines that had ceased operation before 1969 remained a problem. The state of Kansas stepped in to address this through the development of the Mined Land Wildlife Area.

Mined Land Wildlife Area

Most of the Mined Land Wildlife Area property (fig. 4) was acquired through donations, beginning in 1926. The largest donation of land came from the Pittsburg and Midway Coal Company to the Kansas Department of Wildlife, Parks and Tourism (KDWPT) in 1981, when a total of 8,208 acres was signed over to the state.[4] The property now encompasses 14,500 acres – 1,500 acres of that is water and the rest is land. Between 1920 and 1974, 86% of this property was surface mined (fig. 5). More than 1,000 strip-mine lakes remain, ranging in size from one-quarter of an acre to 50 acres, with depths up to 60 feet.

Ecology and biodiversity activities

Native grass and some cool-season grasses dominate almost 28% of the property. Bur oak, pin oak, walnut, hickory, and hackberry with a thick understory of dogwood, green briar, honeysuckle, poison ivy, and blackberry cover the remaining land. The restoration of native grasses has led to an increase in the biodiversity of the region. From the Mined Land Wildlife Area brochure: *"Cottontail*

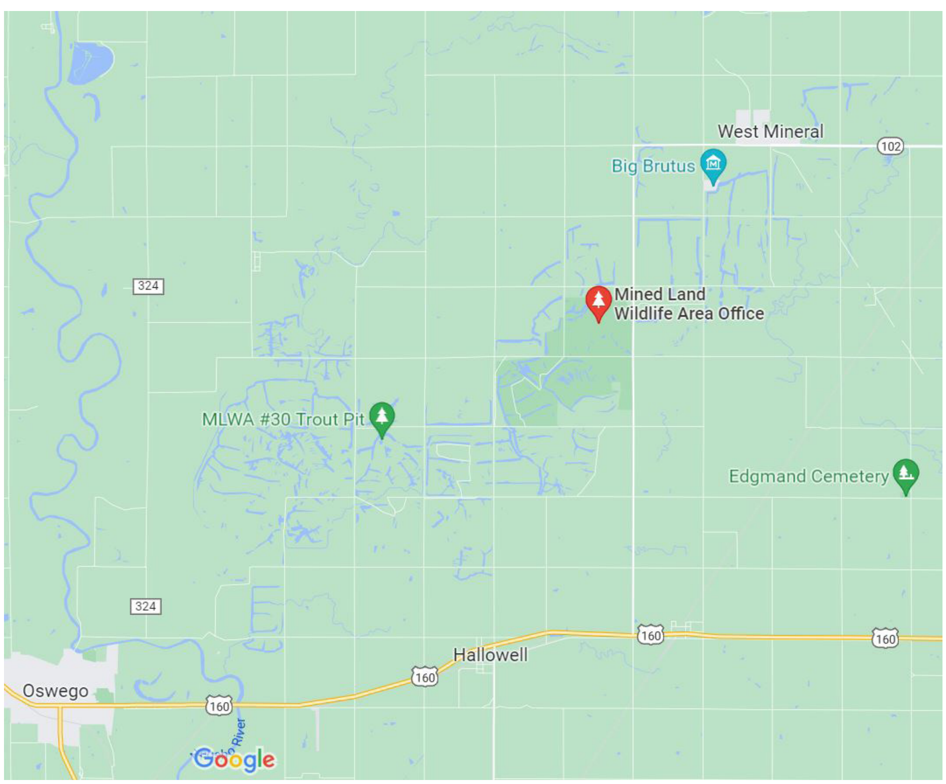

Figure 4: Google maps image of a portion of the KDWPT Mined Land Wildlife Area. Blue represents water and green represents land. Remains of strip mines can be seen running as parallel and perpendicular lakes across the map.

Figure 5. Unreclaimed strip-mined land in Linn County.

rabbits and fox squirrels are abundant. Several large food plots are managed specifically to attract doves in September. Doves can be abundant and offer good opportunities for all ages. Waterfowl hunting can also be good on the area. Several marshes have been constructed to attract ducks. A waterfowl refuge often holds several hundred Canada geese in the area. The woodlands areas of the property hold good populations of white-tailed deer and eastern turkey. The area supports good numbers of raccoons, muskrats, bobcats, beavers, and coyotes. Other furbearers, including mink, and fox are also common."

KDWPT employs several management practices to protect and restore the land. Prescribed burns are used to maintain the health of prairies, control invasive species, and reduce the risk of wildfires.[5] Other management practices include wildlife plantings, planting of more native grasses, and water-level management. Federal wildlife restoration money, fees collected from the state wildlife fee fund, and income generated by agricultural activities on the property fund these management practices.

Popular tourist attractions of the Mined Land Wildlife Area

The Mined Land Wildlife Area is a popular spot for hunting, with whitetail deer, eastern turkey, mourning dove, bobwhite quail, fox squirrel, and cottontails among the game species on the property. Waterfowl hunting is especially popular after property managers constructed several marshes to attract them.

The strip-mine lakes (fig. 6) in southeastern Kansas also offer numerous opportunities for fishing. More than 200 of the lakes are stocked with fish, including largemouth bass, rainbow trout, walleye, and channel catfish.[4] Canoeing is allowed in all lakes, but motorized boats may only be used for fishing and hunting. Swimming is not allowed. Trout Lake (fig. 7), a 28-acre strip-mine lake located within the Mined Land Wildlife Area, is stocked with rainbow and brown trout. Recently, KDWPT constructed two cabins in the wildlife area

Figure 6. Reclaimed strip-mine lakes, such as this one in Cherokee County, are popular for fishing.

Figure 7. Dock at Trout Lake in Mined Land Wildlife Area #30 (see fig. 4 map).

overlooking Trout Lake (fig. 8). The cabins are named Coal Ridge and Mine 19 to represent the coal mining era that once dominated this landscape.

Another popular tourist attraction at the MLWA is the Bob Grant Bison Herd, which is located on Unit 1 in Frontenac. The herd is named after state legislator Bob Grant, who advocated for the maintenance of this local bison herd for several decades. The Pittsburg Area Chamber of Commerce held a ribbon-cutting dedication in April 2018 to commemorate the site.

Figure 8. Newly constructed cabin available at Trout Lake. The cabins are available for rent year round and can accommodate up to six guests.

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Renewable Energy Development in Kansas: Jayhawk Wind Energy Center

By Kimberly Gencur Svaty and Blair Schneider

Overview

Kansas has a long history with renewable energy, wind energy in particular (fig. 1). Kansas residents, especially those in the central and western portions of the state, are acutely aware of Kansas's robust wind. Nearly a hundred years ago, as rural areas began to electrify, many family farms turned first to wind generators installed on their property to power lights inside the home.[1] In the 1990s, when wind power re-emerged in the United States, meteorological towers that had collected years' worth of wind speed data confirmed what Kansans already knew: Kansas has a lot of wind. Constant and powerful wind speeds mean that generating wind power could become a new cash crop for Kansas farmers, ranchers, and surrounding communities. At this stop, we will visit the Jayhawk Wind Energy Center, a 190-megawatt wind facility in Crawford and Bourbon counties established in December 2021.

Figure 2, developed by the Kansas Corporation Commission, highlights the mean range of annual wind speeds across the state of Kansas.[2] Areas in western and southwestern Kansas have the highest mean annual wind speeds. The first commercial wind farm constructed in Kansas was a 110-megawatt facility in Gray County built in 2001, a partnership between Florida Power and Light (FP&L) and Aquila. Since then, more than 40 wind farms have been built across Kansas, representing more than $14 billion in private capital investment into the state, creating more than 20,000 direct and indirect jobs, bringing in more than $48 million in annual landowner payments, and generating just under 45% of all electricity produced in the state.[3] Because wind energy requires no water to operate, it also provides significant water saving benefits compared to other forms of energy like oil and gas (fig. 3).

In 2020, Kansas ranked first in the country for wind energy as a share of electricity generation and fourth for installed wind capacity[5] (fig. 4). Kansas wind power is some of the most productive in the country, meaning the costs associated with generating wind power are

STOP 4

KEY FACTS

- Kansas wind power is some of the most productive in the country, meaning the costs associated with generating wind power are lower than those associated with other forms of power generation.
- More than 40 wind farms have been built across Kansas, representing more than $14 billion in private capital investment in the state, creating 20,000 direct and indirect jobs, bringing more than $36 million in annual landowner payments, saving more than 4.4 billion gallons of water annually, and generating just under 45% of all electricity produced in the state.
- Each wind farm requires four elements to be successful: a quality wind resource, landowners willing to lease their ground, access to the transmission system, and a power purchaser.
- At the state level, wind developers work most frequently with KDHE, KDWPT, KDOT, the Kansas Historical Society, and, to a lesser extent, the Kansas Corporation Commission. At the federal level, wind farms undergo extensive federal regulatory reviews before construction, including reviews associated with the National Environmental Policy Act, the Endangered Species Act, the Federal Aviation Administration, and archaeological and historically sensitive sites within the footprint of the project.
- In addition to wind, solar and battery storage industries are beginning to see growth in Kansas.

Figure 1. Wind turbines in Kansas. (Photo by Tim Nauman.)

lower than those associated with other forms of power generation. Specifically, in Kansas, wind power costs the least to generate. The fuel (wind) is free, operation and maintenance costs are lower than other forms of generation, and power purchase contracts can be "locked in" for a long period of time — 5, 10, 20, 25 years. Utilities and power purchasers use the ability to lock in long-term power contracts as a hedge against future price volatility in the market. Kansas wind power generates enough electricity to power nearly 2.5 million Kansas homes, but it also powers the operations of a broad suite of local, national, and international businesses.

Basics of project development

Each wind farm requires four elements to be successful: a quality wind resource, landowners willing to lease their ground, access to the transmission system, and a power purchaser. Wind farms connect their power to the Southwest Power Pool (SPP), the regional transmission organization of which Kansas is a member. Access to transmission must be extensively studied by SPP before a project is built. The project developer assumes the costs of interconnecting the project to the grid. Further, before SPP undertakes a study, it requires a developer to have extensive land leased for the project. Wind farms are not public utilities and cannot be built using eminent domain, nor can they use eminent domain at any point during the lifecycle of a project.[6] Therefore, wind farms must find locations where landowners are willing to lease their land for development.

Regulatory roles in siting

In 2004, Governor Kathleen Sebelius convened the Kansas Wind and Prairie Task Force to explore appropriate development of wind sites specifically in the Flint Hills region. Out of that effort came a voluntary area referred to as the Heart of the Flint Hills where wind power was not to be developed. That agreement with industry was expanded during Governor Sam Brownback's administration to include all or part of 18 counties that constitute the Flint Hills in Kansas as defined by the

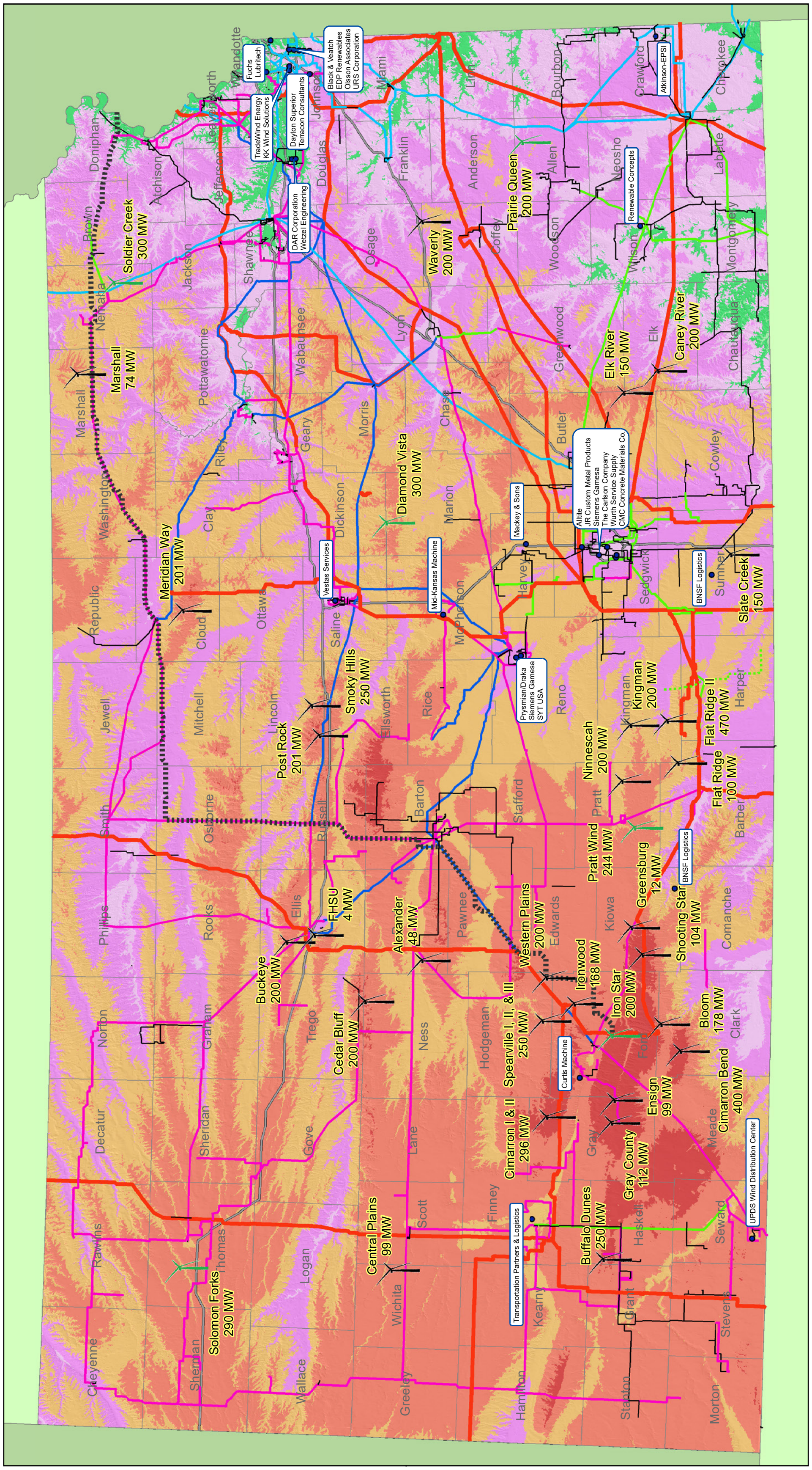

Figure 2. Wind resources of Kansas.

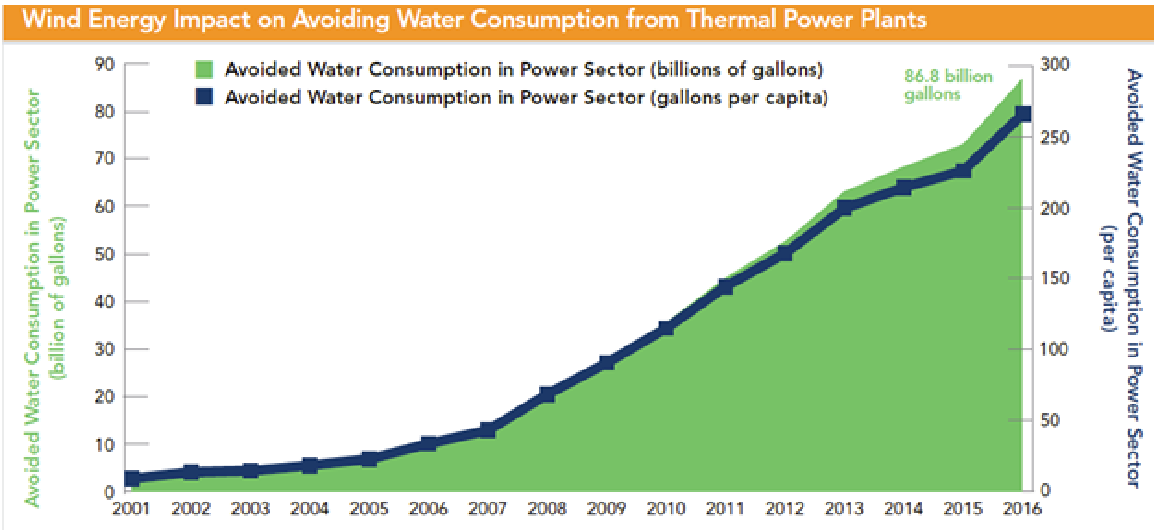

Figure 3. Amount of water saved (not consumed by thermal power plants) using wind energy, 2001 to 2016.[4]

U.S. Department of Wildlife and Parks. The Tallgrass Heartland, as the 2011 expanded zone is known, was reaffirmed by Governor Laura Kelly in 2020.[7]

In addition to the Tallgrass Heartland zone, the state has a robust role in siting wind farms. Scores of local, state, and federal permits must be applied for and approved for a project to move into construction. At the state level, wind developers work most frequently with the Kansas Department of Health and Environment (KDHE), Kansas Department of Wildlife, Parks and Tourism (KDWPT), Kansas Department of Transportation (KDOT), Kansas Historical Society, and, to a lesser extent, the Kansas Corporation Commission.

The Kansas Supreme Court affirmed the role of county commissions in wind farm siting in its 2010 ruling in Zimmerman vs. Wabaunsee County.[9] Counties in Kansas are diverse in terms of population density, topography, and other factors, so project considerations are better served on a county-by-county basis rather than a one-size-fits-all standard. County commissions and wind power developers conduct extensive negotiations, including decommissioning agreements that specify developers are responsible for returning the land to its original or better-than-original condition; road maintenance agreements, in which developers assume responsibility for the cost of upgrading or rebuilding roads and bridges to handle heavy equipment associated with construction and maintenance of the wind farm; and community contribution agreements, which are negotiated payments made to the counties for the first 10 years of the project to account for the 10-year project tax exemption granted to all electric generating and transmission infrastructure by the Kansas Legislature. In zoned counties, developers must receive a conditional or special use permit to construct and operate wind farms.

Natural resource considerations in siting

Like all major construction projects, wind farms undergo extensive federal regulatory reviews before construction. Those include, but are not limited to, reviews associated with the National Environmental Policy Act (NEPA), the Endangered Species Act (ESA), Federal Aviation Administration (FAA), archaeological and historically sensitive sites within the footprint of the project, and other associated regulatory permitting processes. Wildlife assessments are undertaken in consultation with the KDWPT. Water considerations are a critical component as are the wind farm's potential effects on all wildlife species. Each individual wind turbine in a project is studied

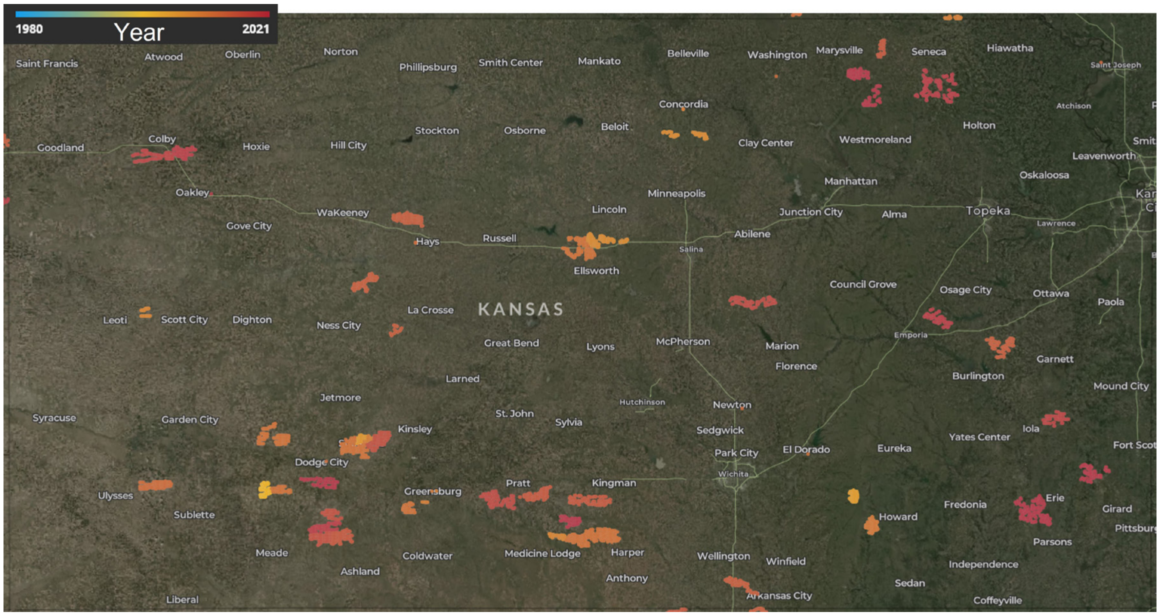

Figure 4. Wind farm locations in Kansas. Color bar represents the year the turbines were first used. (Image modified from the U.S. Geological Survey's U.S. Wind Turbine Database Interactive Mapper.[8])

by the Federal Aviation Administration (FAA) in consultation with the Department of Defense (DOD) to ensure air safety. State and federal transportation agencies are highly involved in project siting as well. Cultural, historical, and extensive environmental permitting is required by state and federal agencies.

If conflicts related to natural resources arise during a review, wind developers typically have three options: 1) use mitigation tools to limit negative impacts, 2) propose an adjusted or new location, or 3) cease project development. Other critical considerations, such as FAA and DOD approval, also could prompt a change in turbine siting or cessation of project development. During construction, wind farms are required to abide by all Clean Water Act rules for large construction sites, including those related to stormwater runoff. Construction components are nearly all concrete, steel, and gravel, which means they can be specifically designed to make stormwater runoff manageable by diverting or directing it.

Natural resource considerations

Though a leased wind farm may encompass tens of thousands of acres, the actual disturbed area is less than one percent of the leased land. Wind tower base depth is determined by the specific geology of the site but is typically 12 feet deep with a concrete and steel lattice structure (fig. 5–6). Wind easements specify the reclamation of any turbine upon the end of the useful life of the project, with most turbines being removed and the ground restored to original condition down to three to five feet below the surface.

All wind farms continue avian and wildlife studies during the operational life of a project as part of federal compliance and in keeping with agreements with local, state, or regional environmental organizations. Among the concerns raised by wildlife advocates since the advent of wind power is whether turbines pose a danger to birds, particularly during migration.[10] Documented instances of birds coming into contact with wind turbines have occurred, but those numbers are low. When dealing with protected species such as the whooping crane, steps are taken to minimize the risks posed by turbines, including ceasing wind farm production during migration.

An additional consideration with respect to natural resources is the environmental impact of waste. Approximately 85% of wind turbine

Figure 5. Steel lattice foundation of a new wind turbine at Jayhawk Wind Energy Center.

Figure 6. Invenergy worker securing the base of the turbine to the surface pad. (Photo by Tim Nauman.)

components are fully recyclable. The blades, however, are not and can end up in landfills if companies don't find ways to reuse them.[12] To address this, companies are partnering with academic institutions to convert old blades into transmission poles. For the future, Siemens Gamesa recently announced the launch of the first recyclable wind turbine blade.[13]

Future considerations

Renewable energy, specifically wind power, has seen enormous growth over the last 20 years, and the new energy economy is only beginning. Growth in electric vehicles (EVs) will continue to drive new electricity demands, and those demands will largely be met by renewable or carbon-free technology. In addition to wind, solar and battery storage industries are beginning to see growth in Kansas.

Solar developments are different from wind farms. Unlike wind, which may have a 20,000-acre leased "footprint" but use only 200 acres, a solar farm needs 5–6 acres per megawatt and will take that land out of production for other uses (fig. 7). As a guide, it would take roughly one section (640 acres) of land for a 100-megawatt solar facility. In

In 2017, the KDWPT issued several recommendations to prevent potentially detrimental effects of wind energy production, including bat and avian collisions, grassland fragmentation, and avoidance by sensitive species.[11] These guidelines include:

(1) That wind power facilities should be sited on previously altered landscapes, such as areas of extensive cultivation or urban and industrial development, and outside of the "Tallgrass Heartland" wind moratorium area as well as other areas of large intact native prairie, important wildlife migration corridors, and migration staging areas.

(2) That projects should adhere to the Siting Guidelines for Windpower Projects in Kansas, produced by the Kansas Renewable Energy Working Group3, or the U.S. Fish and Wildlife Service's Land Based Wind Energy Guidelines4.

(3) That the study and establishment of standards for adequate inventory of plant and animal communities is conducted before wind development site selection, during construction, and after development is completed. The resultant improvement in available knowledge of wind power and wildlife interactions obtained through research and monitoring should be used to periodically update guidelines regarding the siting of wind power facilities.

(4) That the Department recommends avoidance of native prairie and other crucial habitats as opposed to compensatory offsite mitigation.

(5) That mitigation is appropriate if significant ecological harm from wind power facilities cannot be adequately addressed through proper siting and avoidance of crucial habitats. The Department requests that, when possible, project developers utilize established mitigation programs to offset unavoidable impacts (examples include established conservation banks and the WAFWA Range Wide Plan for Lesser Prairie-Chicken Conservation).

(6) That the Department manages public wildlife areas to optimize habitat for native wildlife species especially game species and migratory birds. This work tends to concentrate wildlife in those areas. To avoid adverse impacts to those species and the users of the wildlife areas, the Department recommends that turbines not be sited within three (3) miles of a KDWPT-managed property.

(7) That Environmental Reviews, which investigate possible impacts to native wildlife and habitats, should be conducted by Department staff to assist in the determination of possible adverse impacts to wildlife and support the establishment of processes to ensure a comprehensive and consistent method in addressing proposed wind power developments.

contrast to wind turbines, which can reach heights of 400–450 feet, the overall height of solar projects is less than 15 feet.

Battery storage is an up-and-coming technology often designed to be part of new power generating facilities or added to existing facilities. Battery units the size of shipping containers allow excess capacity (power usually generated at night from wind farms) to be stored until the grid needs the power (in the middle of a hot afternoon, for example). The technology may allow energy producers to minimize price spikes during peak times and enhance the stability of the grid by allowing stored power to be deployed when needed.

Figure 7. Kansas's newest large-scale solar project, Sunflower Solar, in southwest Kansas. (Photo by Tim Nauman.)

Hydrogen technology is also a critical area receiving a great deal of attention domestically and internationally. The Kansas Geological Survey is conducting extensive work in this area to help address the challenge of intermittent production from renewable sources by storing excess energy generated by coal-fired power plants, in the form of hydrogen, in underground salt caverns for future use.

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NOTES

A New Future in Dairy Farming: Robotic Milking Systems at Foster Dairy

Prepared by Lynda Foster and Blair Schneider

STOP 5

KEY FACTS

- Kansas is ranked 16th among states for milk production, with more than 200 dairy farms and 170,000 dairy cows.
- Foster Dairy Farm, in operation since the 1940s, is the last remaining dairy farm in Bourbon County.
- The benefits of robotic milkers are consistency in the milking process for the cows, increased milk output, reduced stress on the cow, and data that help farmers identify illness or injury.
- Since switching to robots, the Fosters have seen an increase in milk production. Their cows are milked an average 2.6 times a day and produce an average of 10 gallons of milk per cow each day.
- Foster Dairy is a member of the U.S. Dairy Net Zero Initiative (NZI), which is committed to conserving natural resources and making progress toward adopting sustainable practices by 2050.

Dairy farms play a vital role in the Kansas economy, contributing $4.2 billion in 2018.[1] Kansas is the 16th-ranked state for milk production, with more than 200 dairy farms and 170,000 cows.[2] Dairy farms have evolved in a variety of ways over the past few decades, particularly with respect to minimizing water use, enhancing cow care and nutrition, and advancing technology. Foster Dairy Farms (fig. 1) is an example of a family-owned dairy farm that is voluntarily taking actions to sustain the environment through decreased water consumption and optimized use of cow manure. Foster Dairy has been in operation since the late 1940s and is the last remaining dairy in Bourbon County. The dairy is owned by Lynda and Gary Foster and their eldest son and his wife, David and Addi Foster. Since September 2016, the dairy's cows have had access to a robotic milking system 24 hours a day, seven days a week.

Robotic dairy farming has been touted as one of the most important inventions of the 20th century for dairy farmers, but the history of automatic milking systems goes back to 1819, when catheter milking machines first

Figure 1. Foster Dairy Farm.

appeared. The technology evolved over the next 170 years, and in 1985, for the first time, a milking cup was attached to a cow using a robotic arm in an experimental setting.[3] Since then, the number of dairy farms using automatic milking machines skyrocketed. Today, more than 35,000 robotic milking systems operate on dairy farms around the world.

Foster Dairy uses a Lely Astronaut A4 automatic milking system with a total of three robots for its 165 cows. The first Lely milking robot to go into operation was the Lely Astronaut milking robot in 1992 (fig. 2). The newer generation Lely Astronaut A4 looks like a large box with metal bars on the outside and is big enough for a cow to walk through. Each cow wears a transponder on her collar that matches the cow to a computerized record of her milk production history, including rumination and activity information. Once the cow enters the A4 system, the system scans her transponder (fig. 3). If sufficient time has passed since her last milking, the system gives the cow a measured amount of food as a treat and then uses lasers to determine her exact standing position. Disinfected brushes wash and massage the teats on the udder to clean them and to stimulate milk let-down. They also dry the teat ends. The robot then uses lasers to scan the position of the teats and attaches the milking cups. The milk is collected in a glass container and is weighed and analyzed for quality. When the cow is done milking, a teat dip is sprayed on her udder to help prevent potential infections until she is milked again. The cow is then allowed to leave the system. Both before and after each milking, the robot arm cleans the teat cups with heated steam, followed by a short rinse with water.

There are many advantages of a robotic milking system (fig. 4). The robots eliminate some labor for the farmer, freeing up time that can be redirected to other aspects of the dairy

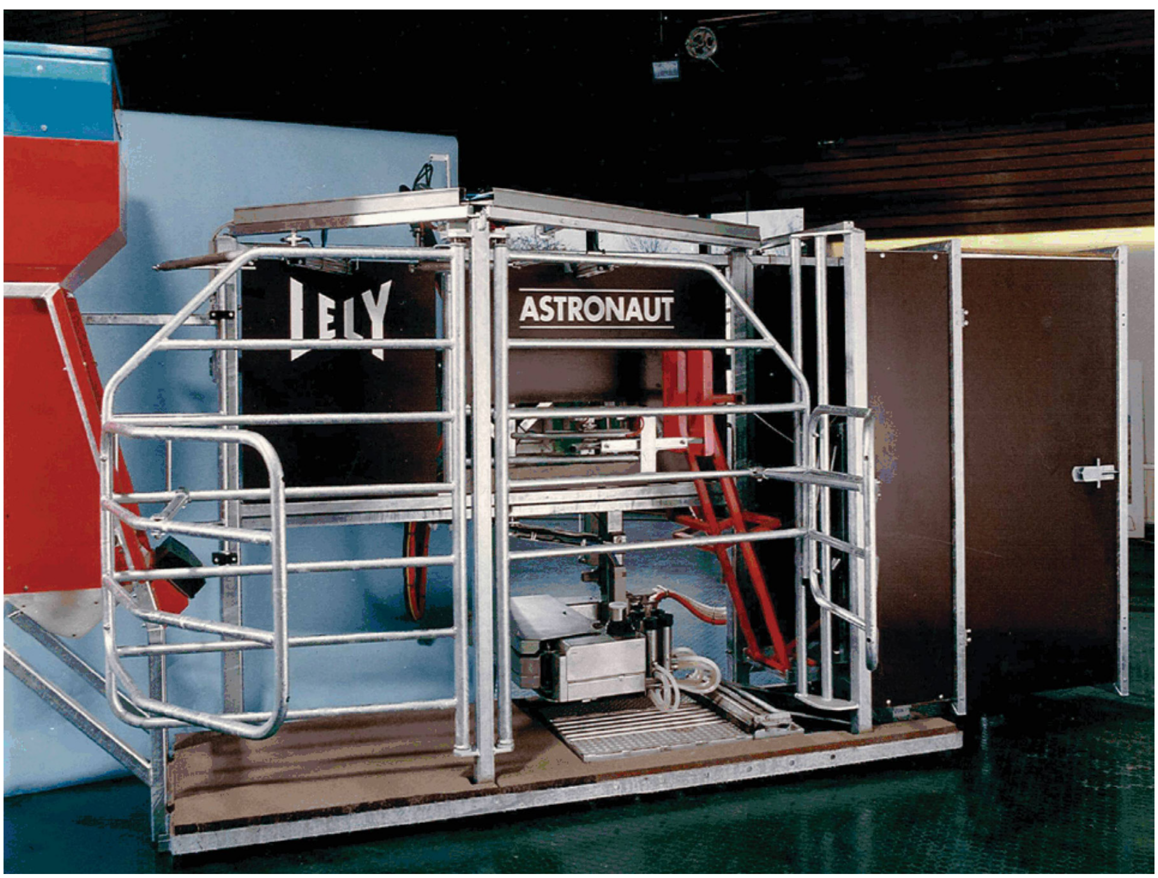

Figure 2. Prototype of the Lely Astronaut milking robot introduced in 1992. (Source: Lely.[4])

Figure 3. First milking in September 2016 after the robots were installed. (Photo courtesy of Lynda Foster.)

Figure 4. Lynda and Gary Foster's grandson helps out by reading the cows' numbers as they enter the machine. (Photo courtesy of Lynda Foster.)

operation. They also provide consistency in the milking process for the cows — the system milks the cow the same way every time — and may reduce stress on the cow, which in turn may allow for increased milk production and milking frequency. Finally, the robotic milking system collects information that allows farmers to examine individual cow histories and provides indications of unusual changes in a cow's production that may indicate illness or injury.[5] Since switching to robots, the Fosters have seen an increase in milk production. Their cows are milked an average 2.6 times a day and produce an average of 10 gallons of milk per cow each day. Their milk is sold to Dairy Farmers of America, and the majority goes to a Hiland processing plant.

Foster Dairy, as part of the overall U.S. dairy industry, is a member of the U.S. Dairy Net Zero Initiative (NZI) (fig. 5). Through this initiative, the dairy community is committed to conserving natural resources and making progress toward adopting sustainable practices. The initiative has set three goals, with a target date for achieving them of 2050:

- Become carbon neutral or better.
- Optimize water use while maximizing recycling.
- Improve water quality by optimizing use of manure and nutrients.

Led by the Innovation Center for U.S. Dairy, NZI promotes research, pilot projects, new technology, and improved dairy management practices in support of these goals. Its four areas of focus are feed production, manure handling and nutrient management, cow care and efficiency, and on-farm energy efficiency and renewable energy use.[6]

Foster Dairy has worked toward these goals for several years. Some examples of the changes they have implemented:

- The dairy installed new fans in the free-stall barn (a large open barn where cows move about freely) that help keep the cows cooler and save on electricity over the older style they replaced (fig. 6).

Figure 5. Summary of the U.S. Dairy Net Zero Initiative strategy to bring dairy farmers together across the United States and commit to achieving carbon neutral status, maximizing water use and recycling, and improving water quality by 2050. (Source: Midwest Dairy.[7])

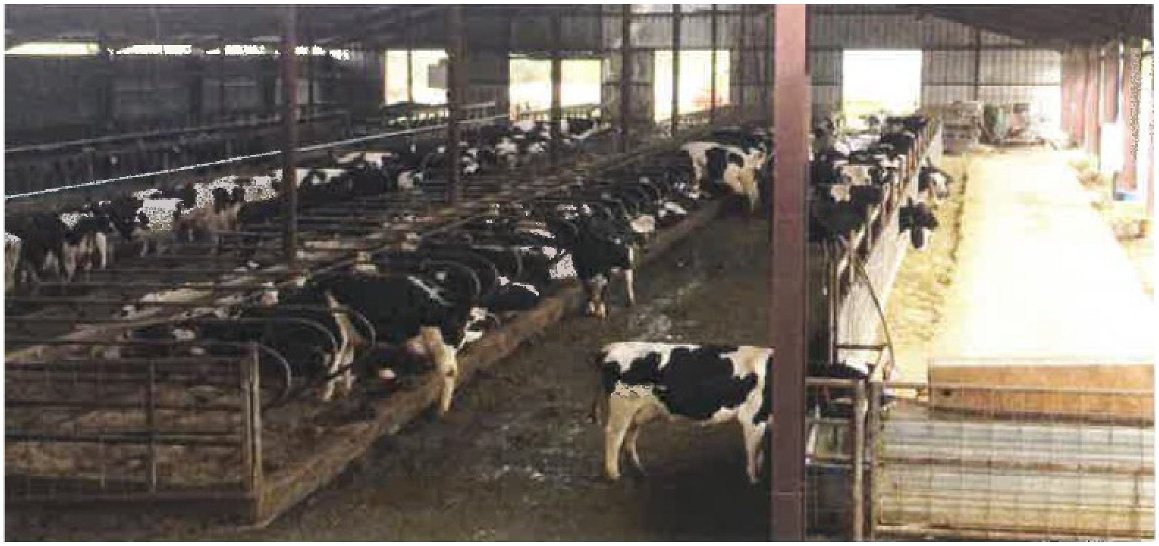

Figure 6. Inside the barn at Foster Dairy. (Photo courtesy of Lynda Foster.)

- They converted to more economical LED lighting.
- They recycle cow manure and spread it on crop ground and pastures as needed.
- They rotate crops and sample the soil for more efficient use of fertilizer applications.

The dairy has also taken several steps toward recycling and optimizing water use. In the milk barn, they have invested in a heat exchange system that cools the milk before it enters the milk tank. Called a plate cooler, the system uses cold water, separated from the milk by metal plates, to absorb heat from the milk. This reduces the run time of the refrigeration system after the milk enters it, providing additional cost savings. The dairy then recycles the water as it is directed from the plate cooler to water tanks for the cows to drink. In addition, they installed a sprinkler system in the free-stall barn that helps cool the cows in the summer. Sprinkler water is recaptured in a lagoon, and the top water off the lagoon is used to irrigate nearby pastures and crop ground.

Future endeavors for the dairy farm include replacing the divider loops in the free-stall barns, which ensure that each cow has enough space to enter, exit, and rest inside. The Fosters are also exploring the feasibility and economics of installing a methane digestor in their lagoon. These anaerobic digesters help decrease greenhouse gas emissions by installing a cover to trap the methane gases at the surface of the lagoon. These gases can then be used for other purposes, such as vehicle fuel or renewable electricity.[8] Finally, family leadership will be transitioning to the next generation in the next 10 years. Even though labor is always an issue on any dairy farm, the robots have significantly eased the family's worries about getting the cows milked. As Lynda Foster puts it, "a robot doesn't call in sick and always shows up on time."

> "Basically, the NZI is really just pointing out the different methods that farms have been using for years to be sustainable. By calling it an initiative, it highlights to the general public how the dairy community is helping to be more sustainable. Plus the NZI helps point out to dairy farmers some of the new advances and technologies available that they can use on their own farms."
>
> —Lynda Foster

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STOP 6

Fort Scott National Historic Site

Prepared by Blair Schneider

A piece of Kansas History: Fort Scott in the mid-19th century

Sitting atop coal-bearing rocks in Bourbon County is a fort that represents the history of westward expansion into Kansas as well as the fight for a free state during the Civil War. Fort Scott (fig. 1), established in 1842, was named after General Winfield Scott, who served as commander during the War of 1812 and the Mexican-American War.[1] The fort's original purpose was to maintain peace between native tribes and white settlers who were migrating and settling westward. From 1843 to 1845, Fort Scott soldiers participated in military expeditions, provided armed escorts along the Santa Fe and Oregon trails, surveyed previously unmapped portions of the country, and maintained contact with native tribes.[2]

Later, soldiers from Fort Scott were sent to fight in the Mexican-American War, which began in 1846 and lasted for two years. In 1853, the military abandoned the

KEY FACTS

- Fort Scott was established in 1842 to maintain peace between native tribes and white settlers who were migrating and settling westward.
- The military abandoned the fort after the Mexican-American War, and the buildings were auctioned to the public.
- During the Civil War, Fort Scott was the largest Union stronghold south of Fort Leavenworth.
- After the Civil War, the town used the fort's remaining buildings until 1978, when the fort officially became a national historic site under the supervision of the National Park Service.
- Fort Scott sits atop the Fort Scott Limestone, which was named for the town in 1866.

Figure 1. The Fort Scott National Historic Site in Bourbon County.

fort, and the buildings were auctioned to the public. Because of this, the original fort buildings became a part of the town of Fort Scott (figs. 2–3). The fort's officer's quarters, for example, were transformed into a prominent hotel called the Free State Hotel,[3] its name a nod to the turbulent political climate of the period just before the beginning of the Civil War. Kansas entered the Union as a free state on January 29, 1861.

The Union Army re-established Fort Scott after the Civil War began. They used some of their former buildings but also constructed new buildings and fortifications around the site. During the war, Fort Scott was the largest Union stronghold south of Fort Leavenworth.[6] After the Civil War ended in 1865, the Army sold off its buildings and left town. The town used the fort's remaining buildings until 1978, when the fort officially became a national historic site under the supervision of the National Park Service.

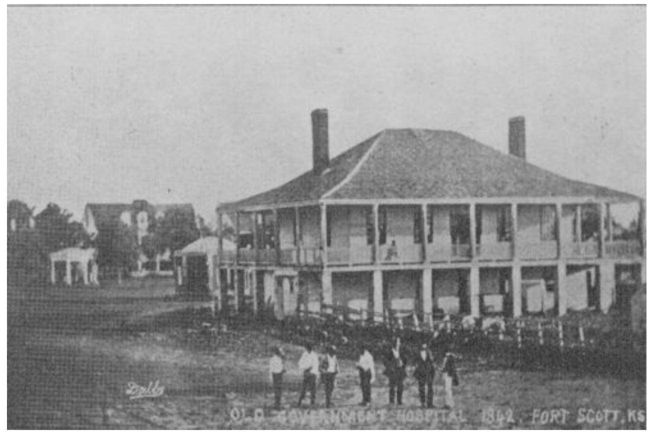

Figure 2. Government hospital at Fort Scott, 1842. (Photo courtesy of the Kansas Historical Society.[4])

Figure 3. Main Street in Fort Scott, 1865. (Photo courtesy of the Kansas Historical Society.[5])

The Fort Scott railroad

The Army returned once more in the 1870s to settle disputes between railroad workers and the local community. Fort Scott had become an active trade center in the region during the Civil War, and the town sought to add a railroad line to continue that tradition. In 1869, the town of Fort Scott invested in the Missouri River, Fort Scott and Gulf Railroad, which provided a connection from Fort Scott to the east[7] (fig. 4). Within Kansas, the railroad stretched almost 160 miles and was in operation in summer 1870. It continued to expand and was eventually sold to the St. Louis and San Francisco Railway Company in 1928.[8]

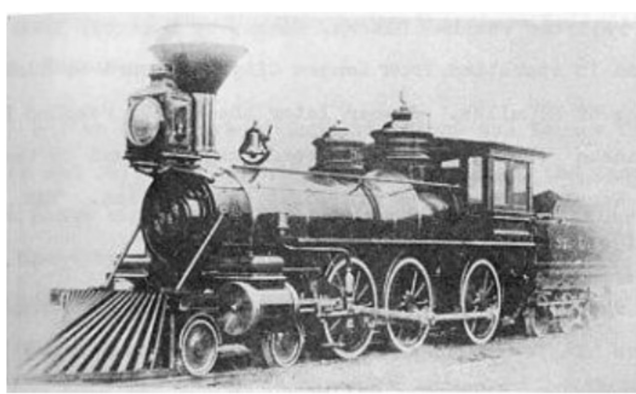

Figure 4. Wood-burner locomotive, used by the Missouri River, Fort Scott and Gulf Railroad. (Photo courtesy of Kansas Historical Society.[8])

Fort Scott – A geologic namesake

The Fort Scott Town Company prospered in part because of the coal deposits that lay below residents' feet (fig. 5). Fort Scott sits atop the Fort Scott Limestone, which was named for the town in 1866[9] (fig. 6). The Fort Scott Limestone comprises three members: the Higginsville Limestone Member, the Little Osage Shale Member, and the Blackjack Creek Limestone Member. At the base of the Blackjack Creek is a deposit of coal, called the Mulky coal, that was mined in Bourbon County.[10] The Mulky coal is red in color and is often referred to as the "Fort Scott Coal." It ranged in thickness from 8 to 12 inches and was strip mined at the surface.[11]

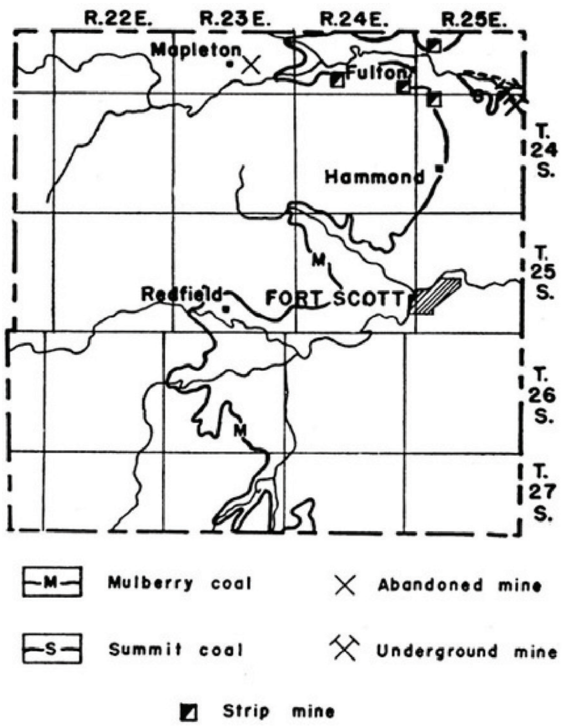

Figure 5: Extent of coal deposits around Fort Scott in 1940.[12]

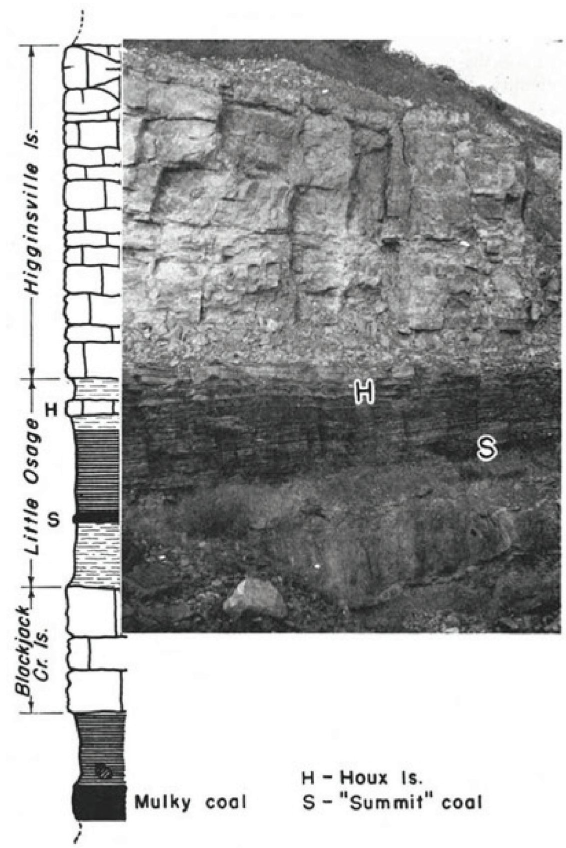

Figure 6: Representative section of the Fort Scott Limestone, illustrating its three members — the Higginsville Limestone Member, the Little Osage Shale Member, and the Blackjack Creek Limestone Member — as well as the Mulky coal at the base of the Blackjack Creek.

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[12]**Coal Resources of Kansas: Post-Cherokee Deposits**
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CONTACTS

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The Potential for Critical Mineral Resources in Kansas

Prepared by Julie Tollefson

STOP 7

KEY FACTS

- The KGS has been awarded $1.5 million to study the feasibility of recovering rare earth elements and critical minerals from coal deposits and associated layers of rock in the Cherokee-Forest City basin.
- Critical minerals are defined as raw materials that are vital for our economic or national security and come predominantly from foreign sources that are prone to disruption.
- The project will pilot a new methodology that could revolutionize and expedite exploration for critical mineral distribution.
- The project will assess the potential for critical mineral production from waste piles and tailings from past mining operations, coal-fired power plants, electronic recycling facilities, and other industrial recyclers.

The Kansas Geological Survey has been awarded $1.5 million for a two-year project to study the feasibility of recovering minerals critical to advanced and defense manufacturing as well as the clean energy industry from coal deposits, related resources, and even legacy mining wastes found in Kansas and neighboring states. Critical minerals are defined as raw materials that are vital for our economic or national security and come predominantly from foreign sources that are prone to disruption. The Kansas economy relies heavily on critical minerals today.

The grant is one of 13 funded by the U.S. Department of Energy across the country to support the production of rare earth elements (REE) and critical minerals used to produce magnets in wind turbines, advanced batteries in electric and conventional vehicles, and other components important to advanced and defense manufacturing as well as clean energy technology (fig. 1).

The project supports the DOE's goal of expanding and transforming coal from a resource that is burned into a source for critical minerals, rare earth elements, and other carbon-based products that are in short global supply. This project has the potential to not only spark new mining activity across a broad swath of the U.S. Midwest but also to identify sources of vital raw materials to support advanced, defense, and clean energy manufacturing. It also may

Figure 1. Some of the major Kansas industries that rely on critical minerals.

result in new funding sources to remediate legacy mining wastes.

The KGS and its collaborators in the project — the state geological surveys of Iowa, Oklahoma, Missouri, and Nebraska and the Osage Nation Minerals Council — will study the potential of recovering minerals from an area known as the Cherokee-Forest City basin, which stretches from northeast Oklahoma through the Osage Nation, eastern Kansas, northwest Missouri, and southeast Nebraska into southwest Iowa (fig. 2).

Kansas and its neighbors have a long history of producing coal and other rocks and minerals of economic value. Coal was mined in northeastern Kansas as early as 1827. In the late 1800s, mines in Osage, Bourbon, Cherokee, and Crawford counties supplied fuel for railroads. In 1889, Osage County had 118 coal mines that employed more than 2,200 people. In addition to coal, the era saw thriving zinc and lead mines in far southeastern Kansas. The Tri-State mining district was once one of the major zinc and lead mining areas in the world.

The last coal mining company in Kansas, at least for now, ceased operations several years ago, but the coal deposits and associated strata — nearby layers of rocks — might contain valuable critical minerals (fig 3).

KGS scientists note that there is a world-class deposit of niobium, scandium, titanium, and rare-earth elements within the critical minerals project's area of investigation in southeast Nebraska. One avenue of inquiry is whether these minerals weathered into the Cherokee-Forest City basin during intervals of coal formation and as a result increased the mineral content of these coals.

The KGS-led project will analyze available information — including drill cores from coal-bearing rocks housed

Figure 2. Carbon ore, rare earth element, and critical minerals basins in the United States. The KGS will explore the potential of recovering minerals from the Cherokee-Forest City basin (number 12 on map).

Figure 3. Stephan Oborny of the KGS inspects an outcrop of Pennsylvanian-aged rock layers in eastern Kansas. These strata may host critical mineral deposits.

at each of the state geological surveys involved in the study — to model and calculate the concentration and distribution of critical minerals across the basin (fig. 4). Team members will pilot the use of a new methodology that has the potential to revolutionize and expedite exploration for and modeling of critical mineral distribution in the future. The innovative technology can measure the chemistry of rocks through well logging, or lowering sensors down oil and water wells. This will allow the project team

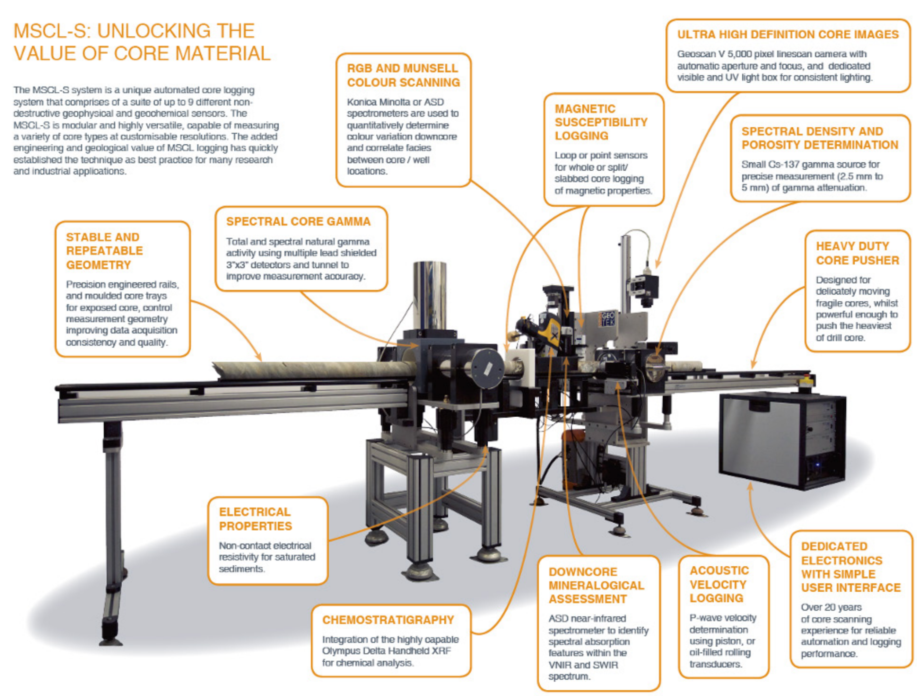

Figure 4. Diorama of the new core scanner recently funded by a National Science Foundation EPSCoR (Established Program to Stimulate Competitive Research) project.

to unlock data that has been collected from thousands of other wells.

In addition to studying coals and associated rock layers, the team will identify waste piles and tailings from past mining operations as well as from coal-fired power plants, electronic recycling facilities, and other industrial recyclers and will assess whether these sources can be recycled for critical mineral production (fig. 5).

The team envisions establishing a technology innovation center, dubbed "CritiMinTic," ideally located in KU's Innovation Park, to serve as a center for teaching industry how to identify and produce these deposits in an environmentally friendly manner.

An advisory committee includes representatives of the coal, aggregate, and REE industries as well as retired academics with expert knowledge of the historical mining operations and stratigraphy of the Cherokee-Forest City basin.

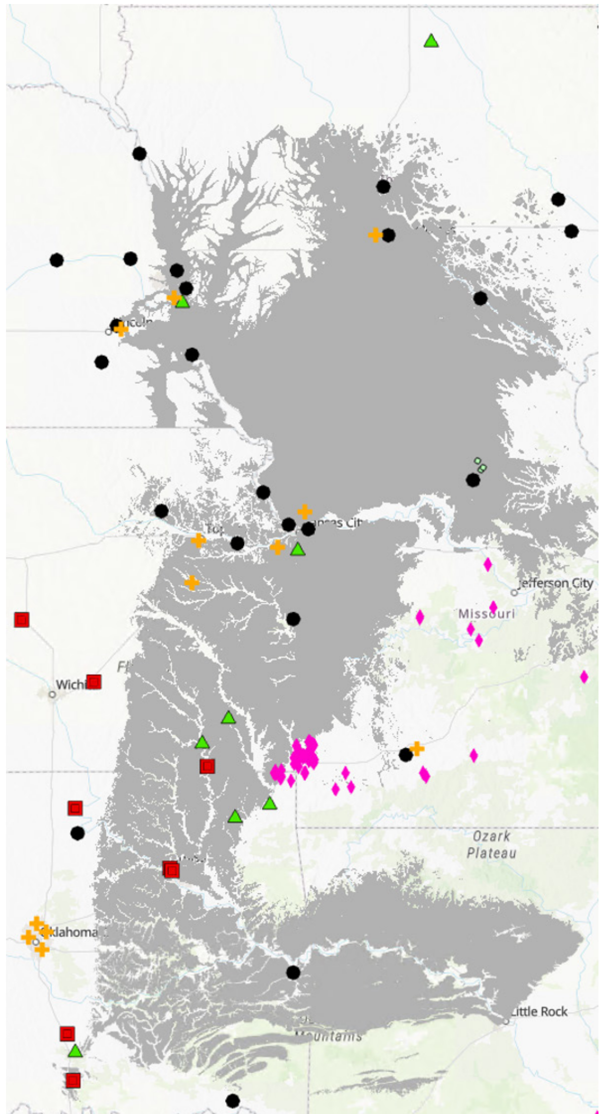

Figure 5. Waste streams that may contain critical minerals. Pink diamonds: lead-zinc tailing piles; black circles: coal-fired power plants; green triangles: cement plants; red squares: refineries; and orange crosses: computer/electronics recycling centers.

CONTACT

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The U.S. Geological Survey List of Critical Minerals 2022

https://www.usgs.gov/news/national-news-release/us-geological-survey-releases-2022-list-critical-minerals

Aluminum, used in almost all sectors of the economy

Antimony, used in lead-acid batteries and flame retardants

Arsenic, used in semi-conductors

Barite, used in hydrocarbon production.

Beryllium, used as an alloying agent in aerospace and defense industries

Bismuth, used in medical and atomic research

Cerium, used in catalytic converters, ceramics, glass, metallurgy, and polishing compounds

Cesium, used in research and development

Chromium, used primarily in stainless steel and other alloys

Cobalt, used in rechargeable batteries and superalloys

Dysprosium, used in permanent magnets, data storage devices, and lasers

Erbium, used in fiber optics, optical amplifiers, lasers, and glass colorants

Europium, used in phosphors and nuclear control rods

Fluorspar, used in the manufacture of aluminum, cement, steel, gasoline, and fluorine chemicals

Gadolinium, used in medical imaging, permanent magnets, and steelmaking

Gallium, used for integrated circuits and optical devices like LEDs

Germanium, used for fiber optics and night vision applications

Graphite, used for lubricants, batteries, and fuel cells

Hafnium, used for nuclear control rods, alloys, and high-temperature ceramics

Holmium, used in permanent magnets, nuclear control rods, and lasers

Indium, used in liquid crystal display screens

Iridium, used as coating of anodes for electrochemical processes and as a chemical catalyst

Lanthanum, used to produce catalysts, ceramics, glass, polishing compounds, metallurgy, and batteries

Lithium, used for rechargeable batteries

Lutetium, used in scintillators for medical imaging, electronics, and some cancer therapies

Magnesium, used as an alloy and for reducing metals

Manganese, used in steelmaking and batteries

Neodymium, used in permanent magnets, rubber catalysts, and in medical and industrial lasers

Nickel, used to make stainless steel, superalloys, and rechargeable batteries

Niobium, used mostly in steel and superalloys

Palladium, used in catalytic converters and as a catalyst agent

Platinum, used in catalytic converters

Praseodymium, used in permanent magnets, batteries, aerospace alloys, ceramics, and colorants

Rhodium, used in catalytic converters, electrical components, and as a catalyst

Rubidium, used for research and development in electronics

Ruthenium, used as catalysts, as well as electrical contacts and chip resistors in computers

Samarium, used in permanent magnets, as an absorber in nuclear reactors, and in cancer treatments

Scandium, used for alloys, ceramics, and fuel cells

Tantalum, used in electronic components, mostly capacitors and in superalloys

Tellurium, used in solar cells, thermoelectric devices, and as alloying additive

Terbium, used in permanent magnets, fiber optics, lasers, and solid-state devices

Thulium, used in various metal alloys and in lasers

Tin, used as protective coatings and alloys for steel

Titanium, used as a white pigment or metal alloys

Tungsten, primarily used to make wear-resistant metals

Vanadium, primarily used as alloying agent for iron and steel

Ytterbium, used for catalysts, scintillometers, lasers, and metallurgy

Yttrium, used for ceramic, catalysts, lasers, metallurgy, and phosphors

Zinc, primarily used in metallurgy to produce galvanized steel

Zirconium, used in the high-temperature ceramics and corrosion-resistant alloys.

NOTES

Friday, June 24, 2022

7 a.m. Breakfast at La Quinta Inn

8 a.m. Load luggage and check out of room

8:30 a.m. Bus to Big Brutus Museum, West Mineral

9 a.m. **Stop 8: Big Brutus Museum, West Mineral**
Joe Manns, Manager, Big Brutus, Inc.

Restroom break

10:30 a.m. Bus to Treece, Kansas

Bus Talk: Reclamation Efforts in the Tri-State Mining District
Leo Henning, Deputy Secretary and Director of Environment, Kansas Department of Health and Environment

11 a.m. **Stop 9: Treece, Kansas**
Leo Henning, Deputy Secretary and Director of Environment, Kansas Department of Health and Environment
Rolfe Mandel, Director, Kansas Geological Survey
Kyle Halverson, Chief Geologist, Kansas Department of Transportation
Rick Miller, Senior Scientist, Kansas Geological Survey

12:15 p.m. Bus to Southeast Kansas Nature Center, Galena

Restroom break at Southeast Kansas Nature Center

12:45 p.m. Lunch at Southeast Kansas Nature Center, Galena
Brad Loveless, Secretary, Kansas Department of Wildlife, Parks and Tourism
Food catered by Red Onion Expressoria, Galena

2 p.m. **Stop 10: Schermerhorn Park and Shoal Creek**

Southeast Kansas Nature Center
Jennifer Rader, Director, Southeast Kansas Nature Center

Shoal Creek
Connie Owen, Director, Kansas Water Office

Schermerhorn Cave
Blair Schneider, Outreach Manager, Kansas Geological Survey

3:30 p.m. Bus to La Quinta Inn Hotel, Pittsburg

4 p.m. Approximate arrival a La Quinta Inn Hotel, Pittsburg

STOP 8

Big Brutus: A History of Strip Mining in Southeast Kansas

Prepared by Blair Schneider

KEY FACTS

- The KGS has records of 147 coal mines or pits in the state. These coal deposits were mined either at the surface or in underground mines.
- In 1931, the number of surface strip mines exceeded the number of deep coal mines in production, a gap that continued to increase until 1964 when the last deep coal mine closed.
- Overall, an estimated 300 million short tons of coal have been produced in Kansas.
- Big Brutus is one of the world's largest power shovels and operated 24 hours a day, seven days a week in Cherokee County from 1963 to 1974.
- Big Brutus was placed on the National Register of Historic Places in 2018.

Overview

Mining companies employed two types of mining in southeast Kansas: strip mining and underground mining. Each leaves different marks on the environment decades after the mines have shut down. At this stop, we will learn more about strip mining and see how a community of volunteers transformed a piece of its history into a well-known tourist attraction called Big Brutus, featuring an enormous power shovel dubbed a "coal monster" in newspapers at the time (fig. 1).

A brief history of coal mining targets in Kansas

The eastern third of Kansas sits within the western region of the Interior Coal Province, which also includes parts of Iowa, Missouri, Nebraska, Oklahoma, and Arkansas (fig. 2). Within Kansas, five stratigraphic groups are known to contain coal deposits[1] (fig. 3). Three of these are exposed in the southeastern half of the province, and two are exposed in the northeastern half of the province. The Kansas Geological Survey has records of 147 coal mines or pits in the state. Table 1 identifies the number of abandoned mines by county.

Coal mining is estimated to have begun in Kansas as early as 1847 when Fort Leavenworth was established

Figure 1. One of the world's largest power shovels, Big Brutus was operated 24 hours a day, seven days a week to strip mine coal in Cherokee County from 1963 to 1974. It is now the centerpiece of a museum featuring the southeast Kansas coal mining industry.

Figure 2: Western and eastern regions of the Interior Coal Province.[1]

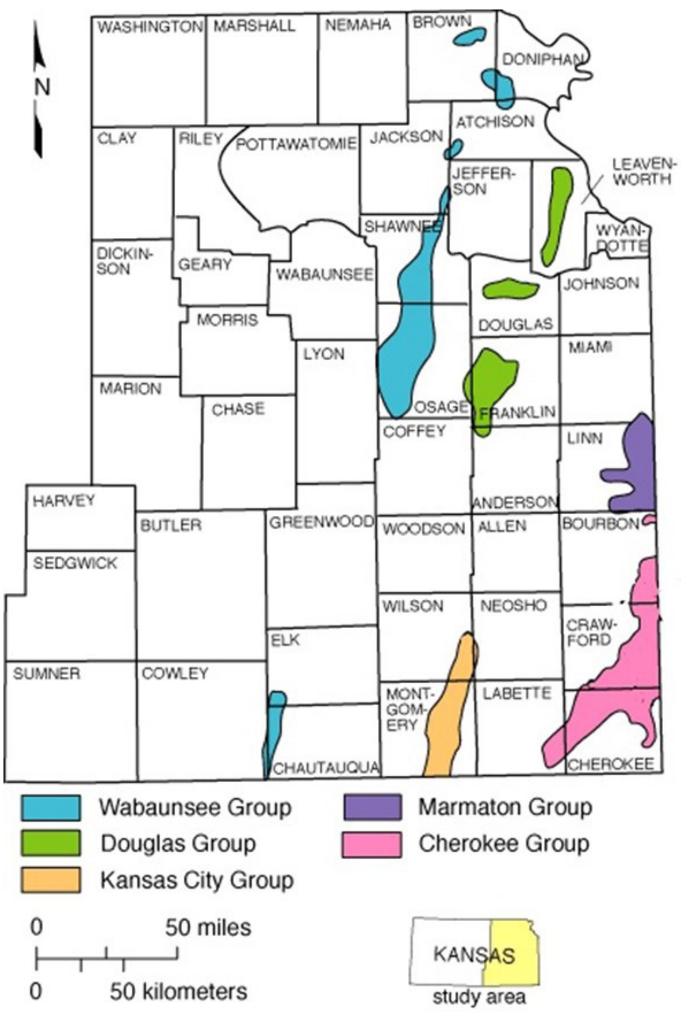

Figure 3: The five stratigraphic units that contain coal seams in eastern Kansas. Modified from Brady and Hatch.[1]

in northeast Kansas. By the late 1850s, Missourians were mining coal for use by blacksmiths near what is now Weir, in southeastern Kansas. Just before and after the Civil War, coal production became central to the expansion of railroads because it burned hotter and was less bulky than wood. To meet the demands of the railroads, strip mines were opened during the 1870s in Bourbon, Cherokee, and Crawford counties (fig. 4). In 1931, the number of strip mines exceeded the number of deep coal mines in production, a gap that continued to increase until 1964, when the last deep coal mine closed.

Coal was also mined in Osage County in east-central Kansas from 1885 to 1969. In 1889, Osage County had 118 coal mines that employed more than 2,200 people and produced almost 400,000 tons of coal. For many years, this was the main source of fuel for the Santa Fe railroad, whose main line passes through Osage County. Overall, an estimated 300 million short tons of coal have been produced in Kansas before coal production ended in 2017.

The strip mining method

When surface mining first began, the only process available to extract the mineral from the earth was to hook up plows to teams of guided mules and horses. Once the animals removed the unwanted rock and soil layers (termed "overburden") above the coal seam, the exposed coal was excavated by hand.[2] This mining technique worked for very shallow layers of coal, but was not sufficient to reach deeper layers. In 1877, power equipment — including electric shovels and draglines — was introduced in southeast Kansas (fig. 5). A dragline is "a large bucket

Table 1. Number of abandoned coal mines by county, 1998.

County	Number of Abandoned Mines
Atchison	13
Bourbon	25
Coffey	1
Crawford	47
Douglas	1
Franklin	4
Jackson	1
Jefferson	3
Labette	8
Leavenworth	4
Linn	11
Lyon	1
Nemaha	2
Osage	8
Pottawatomie	1
Shawnee	4
Wabaunsee	1

excavator that is controlled by a system of pulleys, chains, and ropes that hoist a bucket."[3] The machines can move tons of overburden and allow miners to dig up to 100 feet below the surface.

The coal monster

One of the world's largest power shovels, Big Brutus, operated 24 hours a day, seven days a week in Cherokee County from 1963 to 1974 (fig. 6). It is now the centerpiece of a museum in West Mineral and is designated as one of the "8 Wonders of Kansas Overall" by the Kansas Sampler Foundation.[4] Big Brutus was the second-largest shovel of its type when it was in operation during the 1960s and 1970s, standing 16 stories high and weighing in at 5,500 tons (11 million pounds).

Big Brutus cost a total of $6.5 million in 1962, purchased from the Bucyrus-Erie Company in Milwaukee.[5] Because of its size, the shovel had to be shipped in pieces and constructed on site. In total, 150 railroad cars were required to transport the pieces, and it took a full year to complete construction. The

Figure 4. Clemens Coal Company strip mine in Crawford County.

Figure 5. Coal strip mine in Crawford County using an electric shovel and dragline.

coal monster moved at a speed of 0.22 miles per hour, required a three-man crew and the additional support of electricians and roller operators, and needed 6,900 volts of electricity just to start. Its 90-cubic-yard shovel could move 150 tons of overburden in one scoop.[4]

Big Brutus was designed to last for 25 years but was shut down after only 10 when a combination of circumstances, including depleted coal beds, made operating it unprofitable.[4] Its parts were stripped, but because of its size, its owners left the bulk of the machine in place. A decade later, community volunteers formed a non-profit corporation dedicated to preserving the mining heritage of southeast Kansas and turned Big Brutus into a museum. The Pittsburg & Midway Coal Company donated the shovel, 16 surrounding acres, and $100,000 to the project, and the museum opened in 1985.[5] Two years after that, the American Society of Mechanical Engineers (ASME) designated Big Brutus a Regional Historic Mechanical Engineering Landmark. In 2018, Big Brutus was placed on the National Register of Historic Places.[6]

The museum has grown since its opening in 1985. The Wilkinson Coal Company donated a dragline to the Big Brutus museum in 1991. Inside the museum you will see the "Little Giant," the world's smallest working replica of an early electric mining shovel.[6] Built by a hobbyist in the 1930s and 1940s, the Little Giant is constructed using a scale of one inch to one foot. The Big Brutus museum is open year round to visitors, with the exception of Christmas and Thanksgiving Day.

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[6]**Big Brutus Inc.**
https://www.bigbrutus.org/index.html

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joe@bigbrutus.org

Figure 6. Big Brutus scooping a load. (Photo courtesy of Kansas Historical Society.[4])

NOTES

Treece: An Example of the Consequences of Underground Mining

Prepared by Blair Schneider

STOP 9

Overview

Previous stops at Big Brutus and the Mined Land Wildlife Area revealed the effects surface strip mining can have on the environment. The ghost town of Treece (fig. 1) provides another perspective: the environmental consequences of underground coal, lead, and zinc mining in the region. At this stop, we will learn about two programs our state sponsors have undertaken to address these environmental issues. The first program, run by the Kansas Department of Health and Environment (KDHE), is addressing the environmental remediation of a U.S. Environmental Protection Agency (EPA) Superfund site in Cherokee County. In the second program, the Kansas Department of Transportation (KDOT) is working with the Kansas Geological Survey (KGS) to identify areas of potential sinkhole development. Previous sinkholes have caused damage to homes, roads, and businesses.

The underground mining process

The Kansas Corporation Commission has recorded 239 abandoned underground mines in Crawford and Cherokee counties (fig. 2). In the early 1980s, a project sponsored by the U.S. Department of the Interior's Office of Surface Mining mapped the abandoned mine areas within a 110-square-mile area in those counties. Its report addressed

Figure 1. Memorial marker erected at the intersection of US-69 and State Line Road to commemorate the residents of Treece.

KEY FACTS

- Until 1931, underground mining was the dominant form of coal extraction, and the Weir-Pittsburg coal bed in southeast Kansas was the most extensively mined coal bed in state history.
- After the mines closed and the pumping stopped, abandoned tunnels filled with water, which became contaminated with iron sulfide and other metallic sulfides in the mines. Water seeping and flowing from the mines, in turn, contaminated local streams, springs, and groundwater resources.
- In addition to surface water contamination, the soils around chat piles contain maximum concentrations of several thousand parts per million (ppm) of lead and zinc.
- In 2009, the EPA allocated $3.5 million to the Kansas Department of Health and Environment to buy out and relocate the more than 100 remaining residents of Treece. Treece was officially removed from the state map in 2012, and its land was auctioned off in 2015.
- The U.S. Bureau of Mines identified more than 1,500 open shafts and nearly 500 subsidence collapse features in the Tri-State area, including 599 mine hazards in and around Galena.
- The Kansas Department of Environment and the Kansas Geological Survey have successfully used boreholes and seismic methods to identify mined areas below K-7 and US-69.

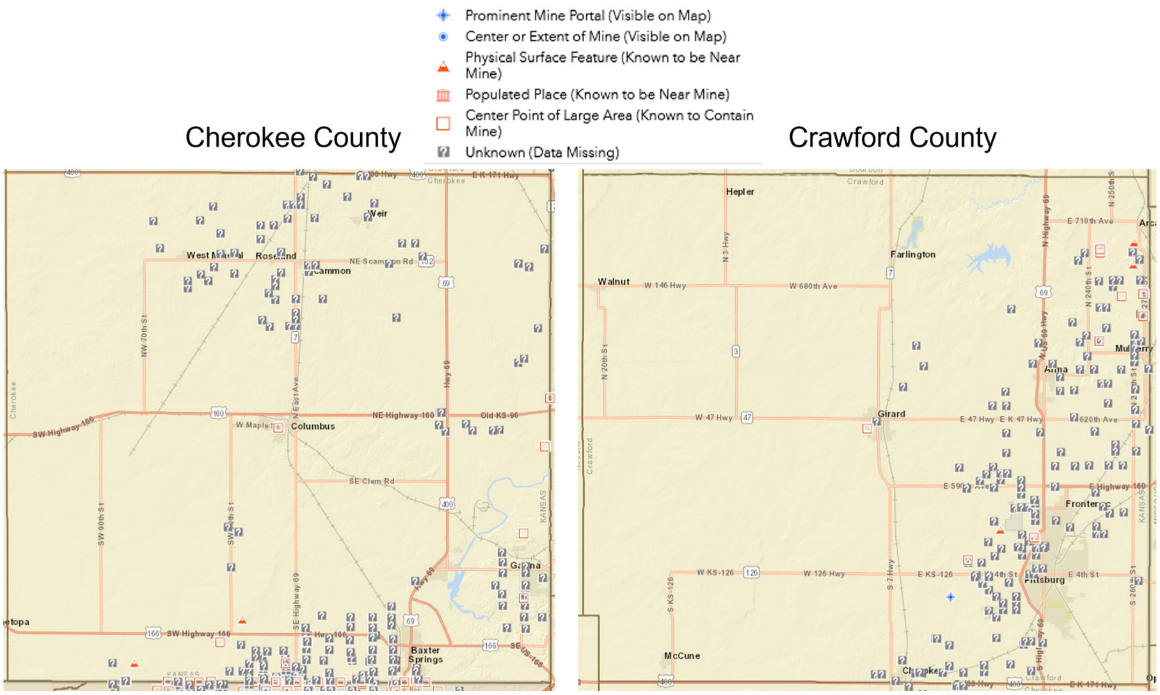

Figure 2: Locations of underground mines in Cherokee and Crawford counties. Figure developed using imagery from the National Mining Map Repository Interactive Mapper sponsored by the U.S. Department of the Interior Office of Surface Mining Reclamation and Enforcement. Each point represents the location of a mine. The question marks represent an area where a mine exists, but the exact location of the mine entrance is unknown.

the social, economic, and environmental impacts of the abandoned mine lands that remained.[1] The results of the investigation contributed to the National Mine Map Repository, sponsored by the U.S. Department of the Interior Office of Surface Mining Reclamation and Enforcement. This mine map repository was a significant project because 40,000 acres of abandoned or orphaned mines that were not addressed by the 1969 Kansas Mined Land Reclamation and Conservation Act still remained in the state (fig 3).

Underground mining of coal or ore deposits often used a room-and-pillar method, in which

Figure 3. Aerial view of open mines and asphalt lake near Galena in Cherokee County. The discovery of zinc ore near Galena in 1870 marked the beginning of a century of lead and zinc mining in the area. In the early 1980s, studies identified nearly 600 open shafts and collapsed mines in and around the town. In 1994 and 1995, the U.S. Environmental Protection Agency and local citizens filled in the hazards.

miners excavated room-shaped areas but left large pillars of rock in place to support overlying rock (fig. 4). Underground rooms had walls 25 to 100 feet high and pillars 20 to 50 feet thick. In 1874, the first mineshaft in Cherokee County was dug and coal was excavated using the room-and-pillar system. Until 1931, underground mining was the dominant form of coal extraction, and the Weir-Pittsburg coal bed in southeast Kansas was the most extensively mined coal bed in state history.

Contamination sources from underground mining

After the mines closed and the pumping stopped, the abandoned tunnels filled with water, which became contaminated with iron sulfide (from pyrite and marcasite) and other metallic sulfides in the mines. Water seeping and flowing from the mines, in turn, contaminated local streams, springs, and groundwater resources (fig. 5). Gob piles, the piles of discarded coal waste and fractured rock outside of the mines, are a second source of contamination associated with abandoned coal mines. These gob piles also contained iron pyrite. When exposed to water and oxygen, pyrite undergoes a chemical reaction that produces sulfuric acid, iron oxides, and hydroxides. Sulfuric acid pollutes both the water and soil around the mines.

Lead and zinc production involved crushing and grinding the mined rock to standard sizes and separating the ore.[1] The remaining rocks were dumped into piles on the surface, called tailings or chat (fig. 6). Chat piles covered approximately 4,000 acres in Cherokee County[1] and, even though the ore had been separated out, still contained significant amounts of lead, zinc, and cadmium. These metal contaminants leached into groundwater and contaminated nearby streams and rivers from runoff after rain. Dust from the chat piles contributed to the spread of contamination. Wind picked up and carried chat dust to nearby areas. Soils around the piles still contain maximum concentrations of several thousand parts per million (ppm) of lead and zinc.[3]

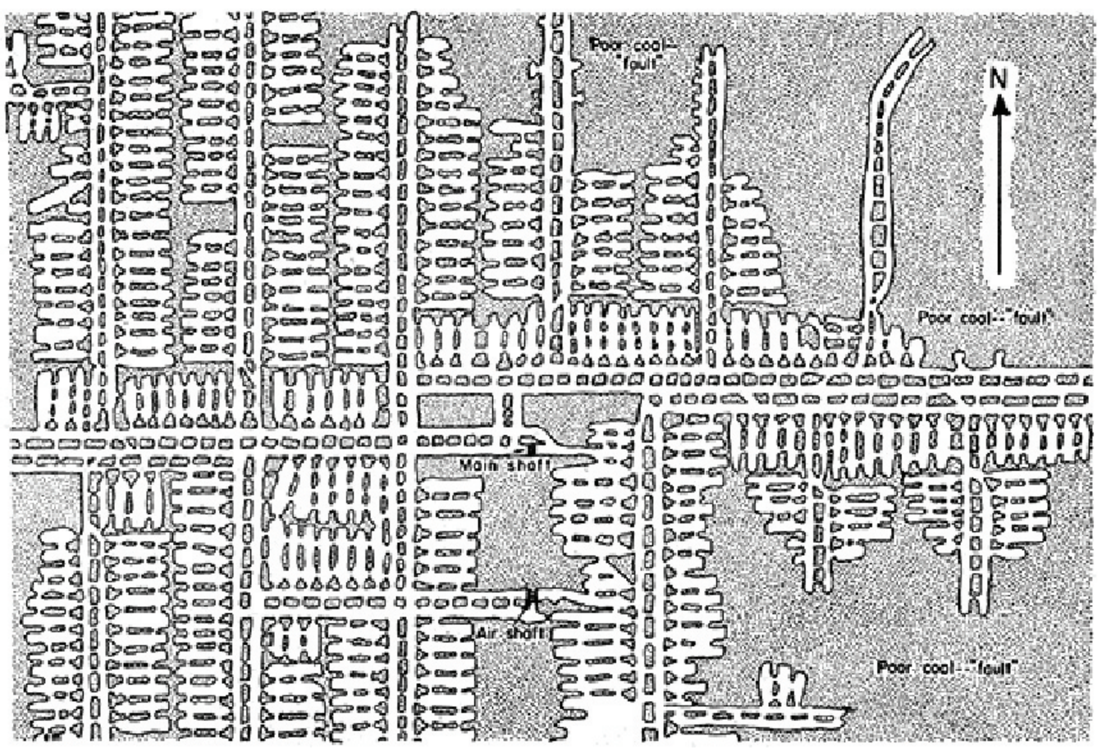

Figure 4. Section of a mine map showing the room-and-pillar system of mining.[2]

Figure 5. Copper-colored water runoff from the remaining chat piles in Picher, Oklahoma, 2021.

Figure 6. View toward Picher, Oklahoma, from atop the chat piles at the Blue Mound EPA Superfund subsite in Treece, Kansas. (Source: Kansas Department of Health and Environment Superfund program.)

Remediation efforts to address contamination sources

Much of the cleanup effort was funded through the EPA Superfund. The Cherokee County Superfund site was listed on the EPA's National Priorities List in 1983.[3] Because the area in and around Galena had some of the worst contamination, early cleanup efforts were centered there. Chief among them was the provision of a safe water supply for rural residents whose wells had been contaminated. The EPA designated six sites, including Galena, within the Spring River basin for remediation efforts (fig. 7–9).

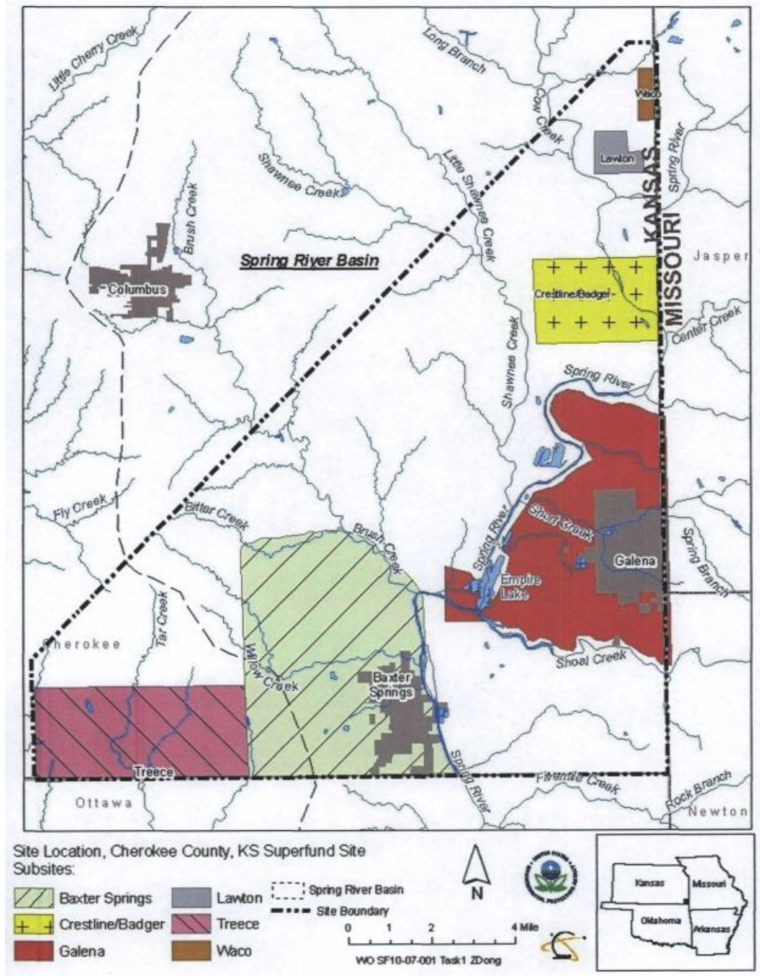

Figure 7. Six site locations within the Cherokee County Superfund site boundary. (Source: U.S. Environmental Protection Agency Sixth Five-Year Review Report for Cherokee County Superfund Site, Cherokee County, Kansas.[3])

In 2008, the EPA provided $8 million, mostly Superfund money, to buy out and relocate about 1,600 residents of Picher, Oklahoma, just south of the Kansas state line. Mountains of chat towered above the town, and water and soil contamination was excessively high. In 2009, the EPA allocated $3.5 million to the Kansas Department of Health and Environment to buy out and relocate the more than 100 remaining residents of Treece. Treece was officially removed from the Kansas state map in 2012, and its land was auctioned off by the EPA in 2015.[5]

Remediation efforts have varied at each subsite within the Cherokee County Superfund site[3] and have included

- drilling new wells or connecting residents to existing water supply lines in rural water districts to replace contaminated wells;
- closing poorly constructed deep water wells to protect the deeper aquifer;
- excavating, relocating, regrading, capping, and replanting areas such as chat piles, enclosed ponds that contain contaminated tailings, and outwash deposits where contaminated sediments were transported during storms or floods;
- reducing the amounts of chat through reuse of the materials, following criteria mandated by the EPA in 2007 to ensure that chat use does not increase the threat to human health and the environment;[6]
- stream re-channelization by redirecting natural streams into modified or constructed stream beds and construction of stream diversion/control structures;

Figure 8. Galena in 1980 (top) before remediation began and in 1999 (bottom) after reclamation was completed.

- preventing discharge of water from mines by filling the abandoned mines with sediment so that water does not seep in;
- preventing future damage to remediated areas through land-use and deed restrictions.

Nine operable units have been established within the Cherokee County Superfund site. An operable unit is a division of the greater Superfund site that focuses on a specific geographic area, problem, or action. Examples in Cherokee County include operable units targeting surface water contamination at Galena and the prevention of human ingestion of metal contaminants found in the water and soil at Treece.[7] Remedial actions have been completed for three of the nine operable units, and those units have moved into an "operation and maintenance" long-term monitoring phase. Remedial activities are underway in three more operable units, and the final three are in the remedial design or investigation phase to determine the best remedy for the targeted issue.

Figure 9. View of what used to be Blue Mound mine after cleanup. (Source: Environmental Protection Agency.[7])

At Treece, we will view three stages of remediation efforts (fig. 10). On the eastern side of US-69 lies the Freeman & Suman and the Blue Mound Superfund subsites. These sites have completed remediation, which included providing alternate water sources for the landowner and capping chat piles with grass. These sites are now used for cattle grazing. On the west side of US-69, just north of the Treece memorial marker, is the Webber subsite. This site is under construction for remediation. Plans are to consolidate the chat waste into a single repository and then cap the landscape with vegetation, similar to the Blue Mound remediation efforts across the highway. A final subsite, the WDM construction materials site, sits between the Treece memorial marker and the Webber subsite. WDM is using chat from Oklahoma for construction projects, including road construction. Using chat with other construction materials is safe because concrete or asphalt will bind with the chat and prevent metals from leaching out. In addition, the chat is processed by washing it with water to remove some of the metals before it is transported for construction use.

Sinkhole development from underground mining

The final phase of mining, known as "robbing the pillars," has led to episodes of subsidence. In that process, the pillars of rock that had been left standing to support a mine roof are removed. Without supports, a roof eventually collapses and the surface subsides into the resulting void (fig. 11).

In the early 1980s, the U.S. Bureau of Mines, in cooperation with state geological surveys, conducted detailed studies of the physical hazards associated with the Tri-State mining area, which includes the southeast tip of Kansas and parts of Oklahoma and Missouri. The studies identified more than 1,500 open shafts and nearly 500 subsidence collapse features in the Tri-State area, including 599 mine hazards in and around Galena (fig. 12).

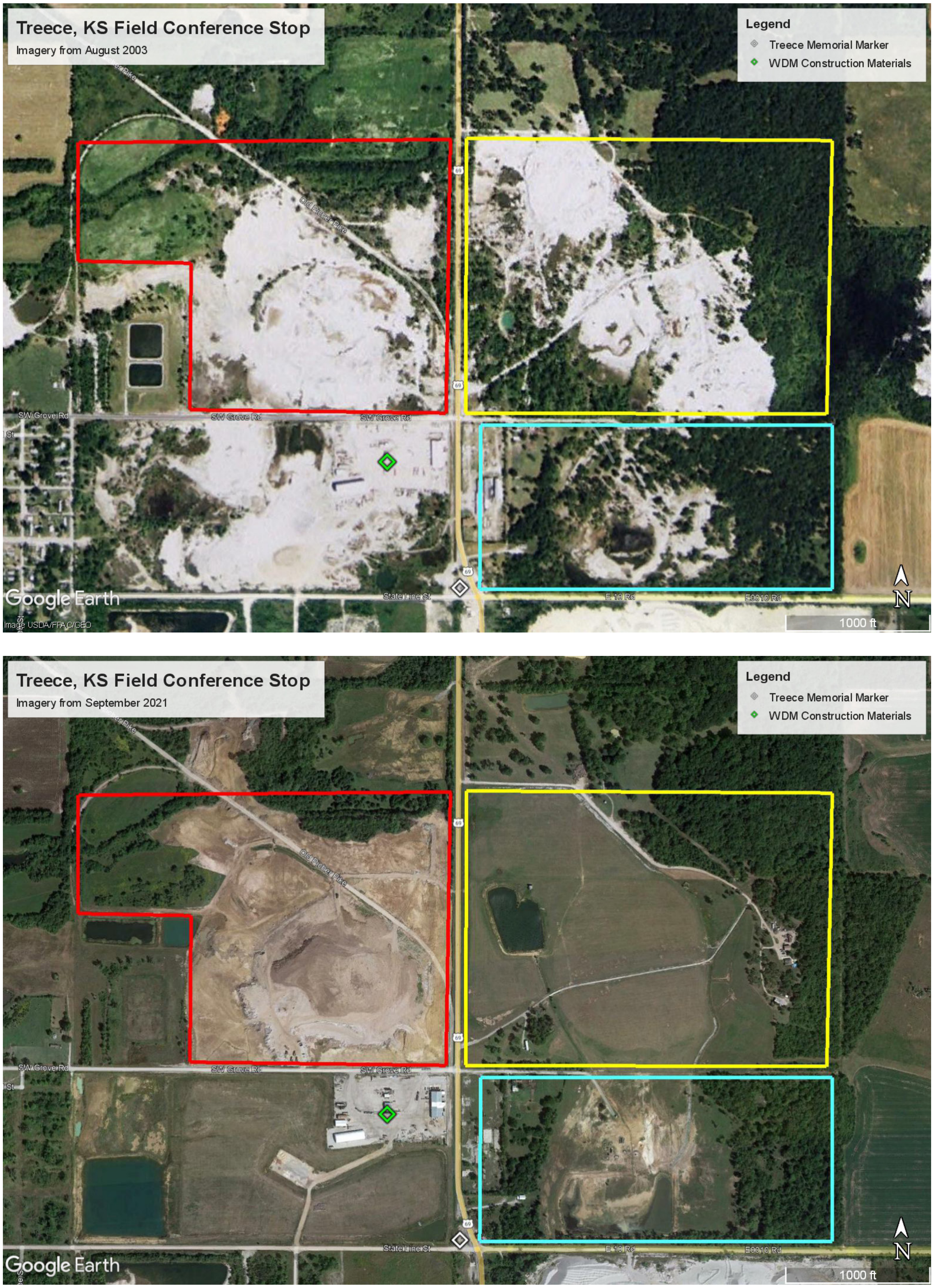

Figure 10. Google Earth maps highlighting two views of the three subsites at the Treece field conference stop: August 2003 (top) and September 2021 (bottom). The blue polygon outlines the Blue Mound subsite, the yellow polygon outlines the Freeman & Suman subsite, and the red polygon outlines the Webber subsite. The green diamond shows the location of the WDM construction materials site. The white diamond shows the location of the Treece memorial marker. Note in the 2003 photo that the pond directly north of the Webber site is discolored. This is a result of acid mine drainage.

> Then there's the water. The local Tar Creek is the color of orange juice, and it smells like vinegar. This is because when the mining companies left, they shut off the pumps that kept abandoned shafts from filling with groundwater. Once water flooded the tunnels, it picked up all the trace minerals underground — iron, lead and zinc — and flushed them into rivers and streams. Fish and fowl fled or went belly-up… A local couple, Dennis and Ella Johnston, agreed to give me the pollution tour. In Dennis's blue Chevy truck, we drove through downtown — a church, trailers, a one-room City Hall with a pair of its windows boarded up — and then went down a dirt road to a pool formed by a caved-in mine. "Local kids used to skinny-dip here all the time," Dennis said, grinning and pointing at the glassy water. "We'd see kids with sunburns all over their bodies." But it turns out the kids hadn't been burned by the sun, he said; they had been chemically burned by all the acids in the water.
>
> —Last Ones Left in a Toxic Kansas Town: The New York Times Magazine[4]

Figure 11. Sinkhole that developed from a mine collapse in Treece. (Source: Kansas Department of Health and Environment Superfund Program.)

Open and collapsed mine shafts and areas of surface subsidence have claimed lives and caused property damage. In 2009, an apartment building in Galena partially collapsed after the ceiling of a mine dug under the town gave way (fig. 13). More recently, a 15-foot diameter sinkhole from a mining prospect hole opened in February 2022 in Joplin, Missouri.[8]

Sinkhole monitoring along K-7 and US-69

Areas of mine collapse in this region have resulted in roadway damage and related challenges for the Kansas Department of Transportation. Starting in the 1980s, roadway damage began to appear along an 11.1-mile section of Kansas highway 7 between Columbus and Cherokee (fig.

Figure 12. Open mine shafts in Treece in 2004. (Source: Kansas Department of Health and Environment Superfund Program.)

Figure 13. Sinkhole that opened in Galena in 2009. Damage to apartment building (top), and interior view of sinkhole (bottom). (Source: Kansas Department of Health and Environment Superfund Program.)

14). The cause of the damage was traced to significant underground mining operations that had occurred prior to the placement of the highway; the state had discovered the potential problem in the 1960s.[10] To address the issue, KDOT completed an investigation in 2012 to determine the overall extent of the mined areas so that remediation could be completed prior to new construction and realignment of portions of the highway. KDOT bored holes every 25 feet along the edge of the pavement and center line of the highway to determine the depth to the tops of mines or to coal (no mine) (fig. 15). Using these results, the agency was able to remediate the mined areas by building barrier walls underground in the mined spaces and filling the space between the walls with concrete. Remediation efforts have proven successful to date.

A second area of concern for KDOT is along U.S. highway 69 directly north of the state line in Treece (fig. 14). Hundreds of lead and zinc mines have collapsed and caused sinkholes at the surface in southeastern Kansas, including 17 sinkholes that have been documented in and around Treece. Knowing this, KDOT and the KGS have collaborated to monitor the condition of roof material and rock lying atop the roof in areas that are known to be mined. Specifically, this portion of the highway passes over the Webber-Barr and Foley mines (fig. 16). The KGS used a

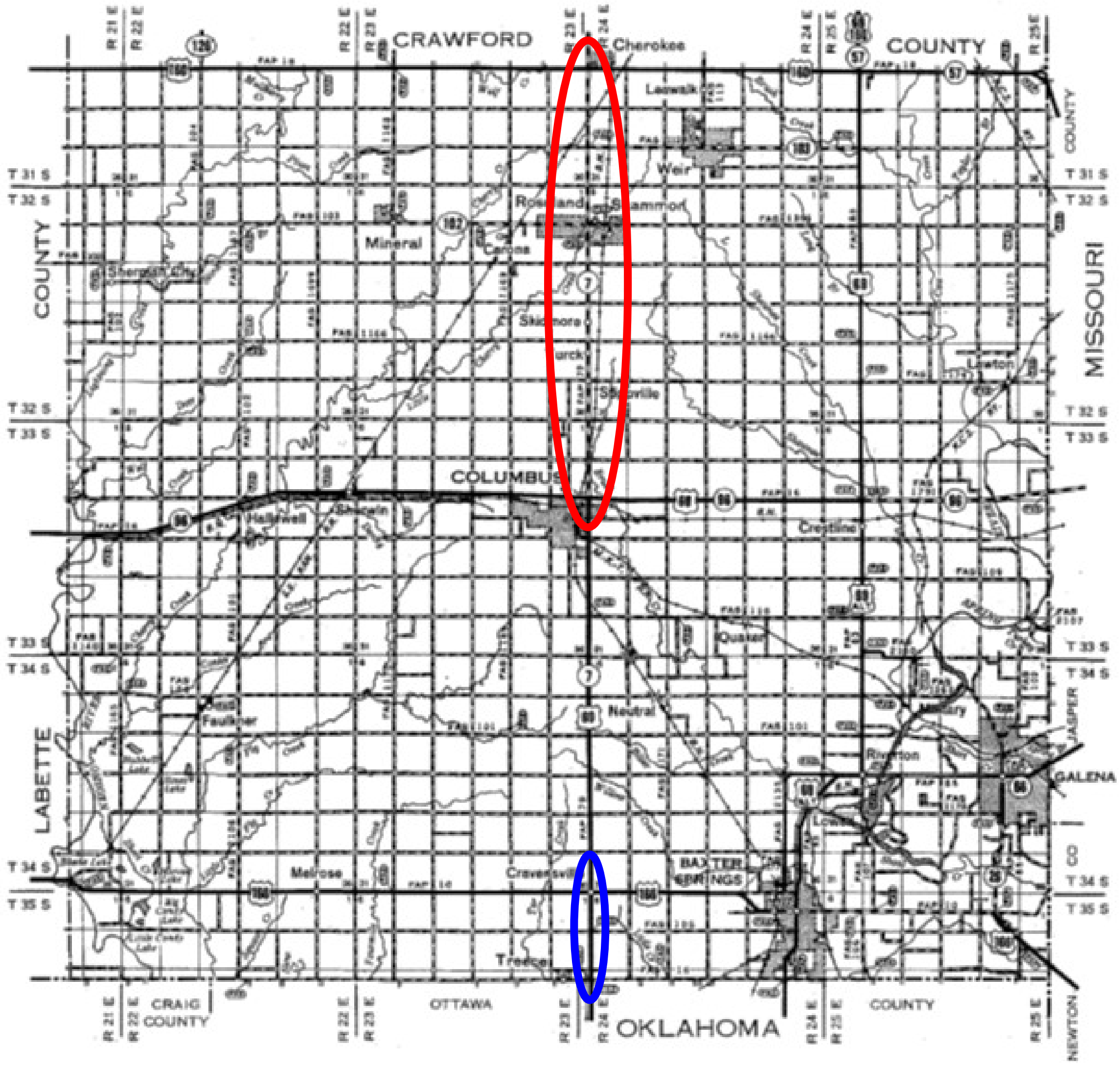

Figure 14. Locations of KDOT's K-7 highway realignment project (red) and the KGS seismic survey investigations on US-69 (blue). (Figure modified from Halverson.[10])

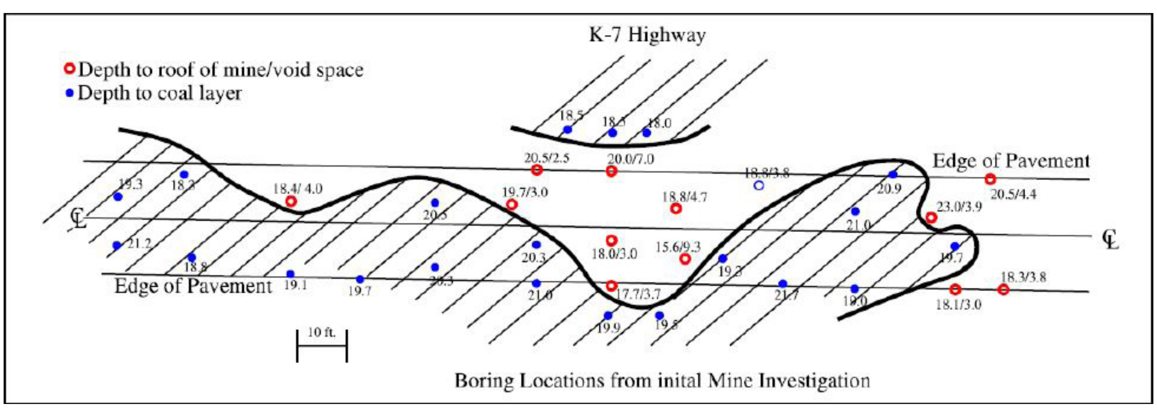

Figure 15. Boring locations along K-7. Red circles indicate boreholes that encountered the roof of a mine or void space and the corresponding depth. Blue circles indicate boreholes that encountered a coal layer (that is, no mine at that location) and the corresponding depth.

combination of seismic methods and boreholes to identify zones of structural weakness along the highway. Seismic methods use sound waves to measure the mechanical properties of the subsurface. The speed of the waves is recorded as the waves move through the subsurface and reflect back to receivers as they encounter changes in rock type. The velocity of sound waves in rock is related to other properties, such as the density of the rock, how much pore space is present in the rock, and whether the pore space is filled with air or fluid. Using this information, scientists can determine whether there are void spaces in the subsurface as well as identify zones of weakness within a rock layer. Figure 17 shows a sample of interpreted results of a seismic reflection survey.[10] Figure 18 shows the results of a velocity profile for a portion of a line along US-69 where seismic data were collected.[11]

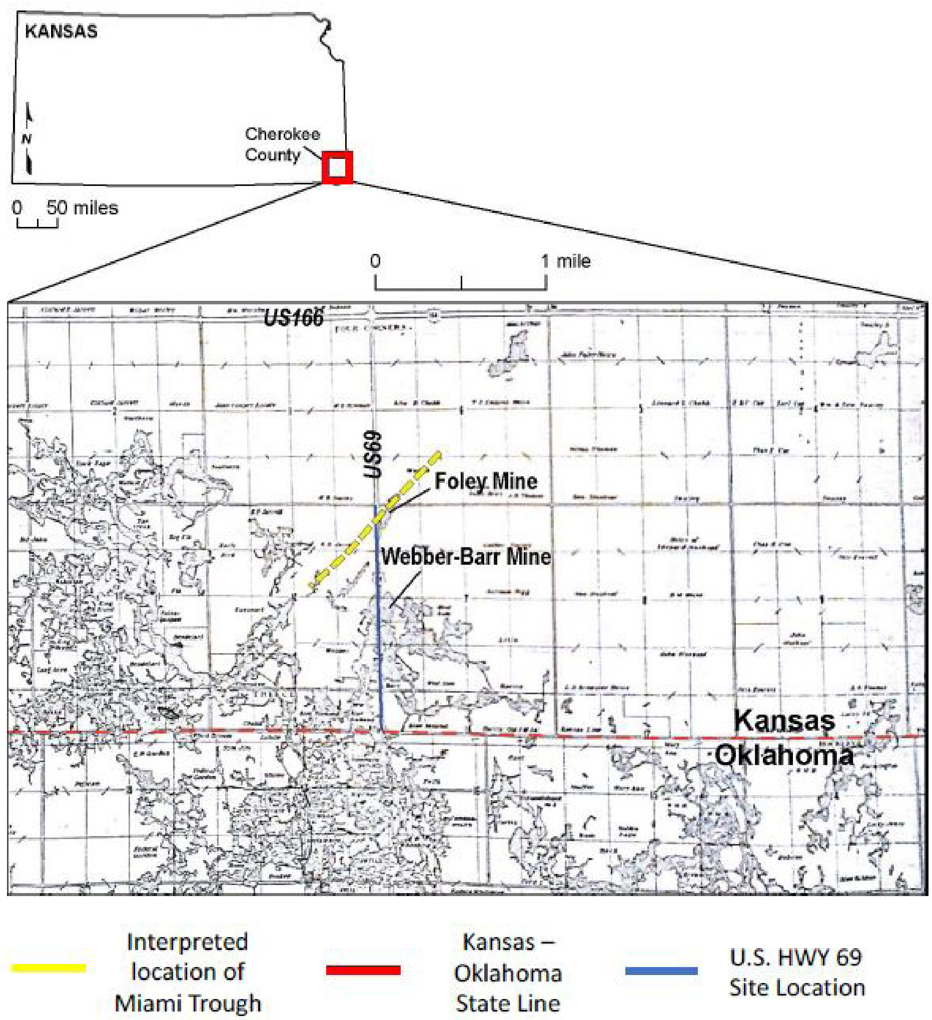

Figure 16. Locations of the previously identified Foley and Webber-Barr mines relative to the Kansas-Oklahoma border and US-69. The blue line along the highway represents the location of the KGS seismic survey investigations. (Source: Fontana.[11])

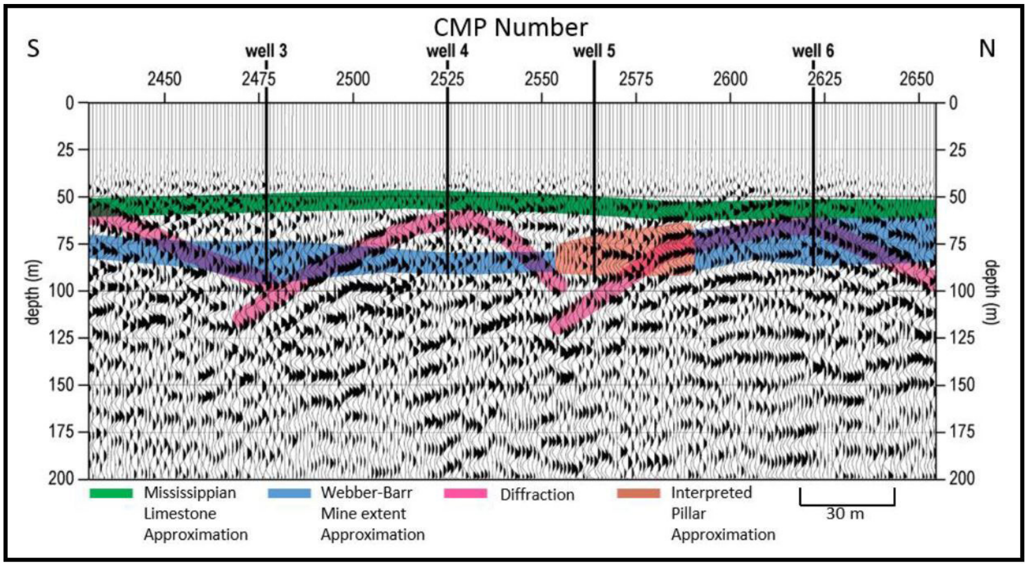

Figure 17. Portion of seismic reflection data results over the Webber-Barr mine along US-69 (highlighted in blue). The pink highlights are called diffractions, which look like arches and occur when sound waves reflect back to the receiver after encountering a buried object. These diffractions are created when the seismic waves encountered air voids from the mine. The section highlighted in orange is interpreted to be a remnant pillar structure (no void encountered).

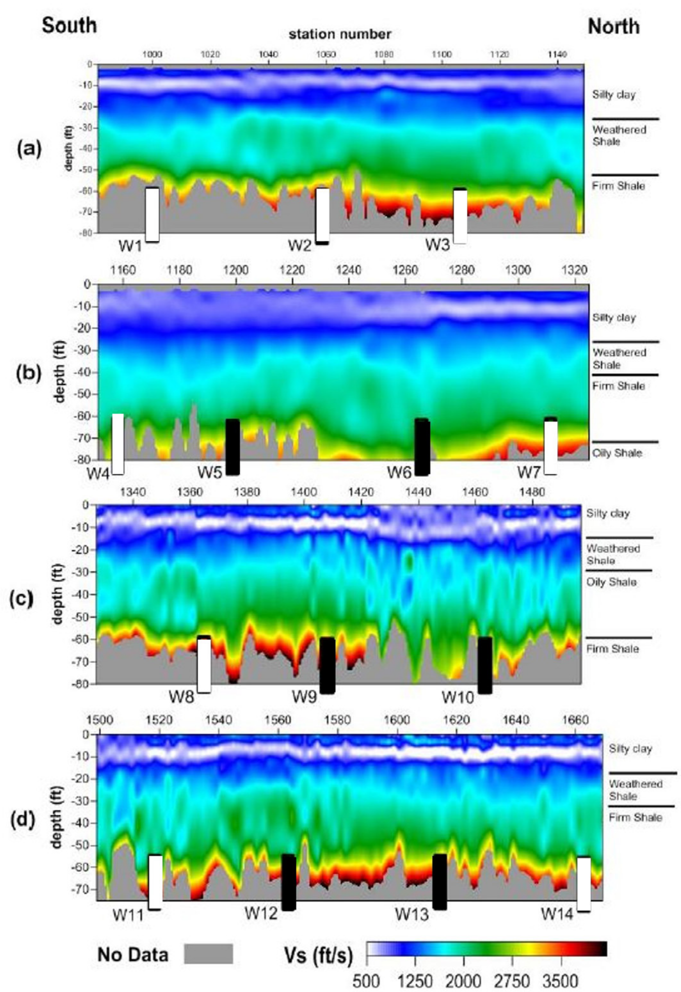

Figure 18. Results of velocity profiles that correspond to 14 borehole locations. Black well segments represent a well that did not encounter a mine. White well segments represent a well that did encounter a mine void space. Overall, velocities remain consistent across the entire length of the line. This suggests that there were not any areas along this section of the highway experiencing a weakening mine-roof structure at the time of data collection. (Modified from Miller et al.[12])

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Ancient Rocks, Rare Species, and Water Quality Reclamation Efforts in Southeast Kansas

STOP 10

KEY FACTS

- The oldest rocks at the surface in Kansas formed during the Mississippian Subperiod about 345 million years ago and are found only in extreme southeast Kansas.
- The Ozark Plateau receives more average annual precipitation than any other region in the state.
- In the 1980s, this part of the Tri-State mining district was considered one of the most environmentally blighted regions in the country.
- Shoal Creek, one of the major tributaries to the Spring River, is home to more than 80 species of fish, some of which are found nowhere else in Kansas.
- The Shoal Creek watershed is home to several “species of conservation concern,” including the Rabbitsfoot mussel and the Neosho mucket.

Overview

Schermerhorn Park offers insight into some of the oldest geologic formations found at the surface in Kansas today. In this area, issues related to geology and ecology intersect. This stop provides participants an opportunity to reflect on how human activities can have significant effects on the environment and the future of our natural resources, such as water.

The Ozark Plateau, at 55 square miles the smallest physiographic region in Kansas, encompasses the far southeastern tip of Cherokee County and the state. Though tiny, it’s part of the much larger Ozark Plateau that extends into Missouri, Oklahoma, and Arkansas (fig. 1).

This part of Kansas receives an average of more than 40 inches of precipitation a year, the highest average in the state. Its wetter conditions support a wider variety of plant and animal life than elsewhere in the state, including some species that are not found anywhere else in Kansas.

Figure 1. Ozark Plateau physiographic region, which extends across Kansas, Missouri, Oklahoma, and Arkansas. (Source: Ozarks Studies Institute, Missouri State University.[1])

Schermerhorn Park, a mile south of Galena, offers a firsthand look at the features typical of the Ozark Plateau physiographic region, including outcrops of ancient rocks and a hilly oak-hickory forested landscape. The park offers easy access to Shoal Creek, a spring-fed stream that played a significant role in shaping the hills and steep bluffs in the region.

The limestones at Schermerhorn Park formed from deposits in a shallow sea that covered the area during the Mississippian Subperiod about 345 million years ago. These limestones, the oldest rocks found at the surface in Kansas, are only visible in the Ozark Plateau region in the southeastern tip of the state.

A short uphill pathway on the north side of the road along Shoal Creek passes through outcrops of Keokuk Limestone, a thick, cherty rock of the Osagian Stage (fig. 2). Skip the uphill climb and see fossils of animals that lived in the Mississippian sea — including crinoids, brachiopods, and bivalves — in rocks across the road from the creek.

Figure 2. Keokuk Limestone sample, including a fossil crinoid specimen, along the trail to Schermerhorn Cave.

Schermerhorn Cave

Schermerhorn Cave, within the park boundaries, is one of numerous caves formed in the region over the ages when slightly acidic water worked its way along fractures in the Mississippian limestone, dissolving rock over hundreds of thousands of years to form larger and larger cavities.

At 2,566 feet long, Schermerhorn Cave is the largest cave in Cherokee County (figs. 3–4). Past its large mouth, though, the cave's two-foot-high passageway is mainly a low streambed.[2] The spring that flows from it is home to grotto salamanders, long-tailed salamanders, and cave salamanders.[3] When conditions are cool and damp, the cave and long-tailed salamanders forage for food outside the cave. The grotto salamander is nonpigmented and blind as an adult and cannot survive outside the cave. Other animals in the cave include southern leopard frogs and a couple of bat species. Only the cave's large mouth is open to the public.

Shoal Creek

Shoal Creek, one of the major tributaries to the Spring River, is home to more than 80 species of fish, some of which are found nowhere else in Kansas, as well as several species of turtle, including the common map turtle and the eastern musk turtle.[3] The Shoal Creek watershed drains about 450 square miles in Missouri and Kansas (fig. 5). Several "species of conservation concern" depend on the health of the creek for survival,[4] including two species of mussel, the Rabbitsfoot mussel and the Neosho mucket.[5]

Southeast Kansas Nature Center

A restored Scout cabin, constructed in the early 20th century, houses the Southeast Kansas Nature Center in Schermerhorn Park (fig. 6). The center offers hands-on activities for all ages, educational displays about the flora and fauna of the region, and collections of rocks, minerals, fossils, and Native American artifacts. Live animal exhibits include reptiles, amphibians,

Figure 3. Entrance to Schermerhorn Cave.

Figure 4. Inside Schermerhorn Cave.

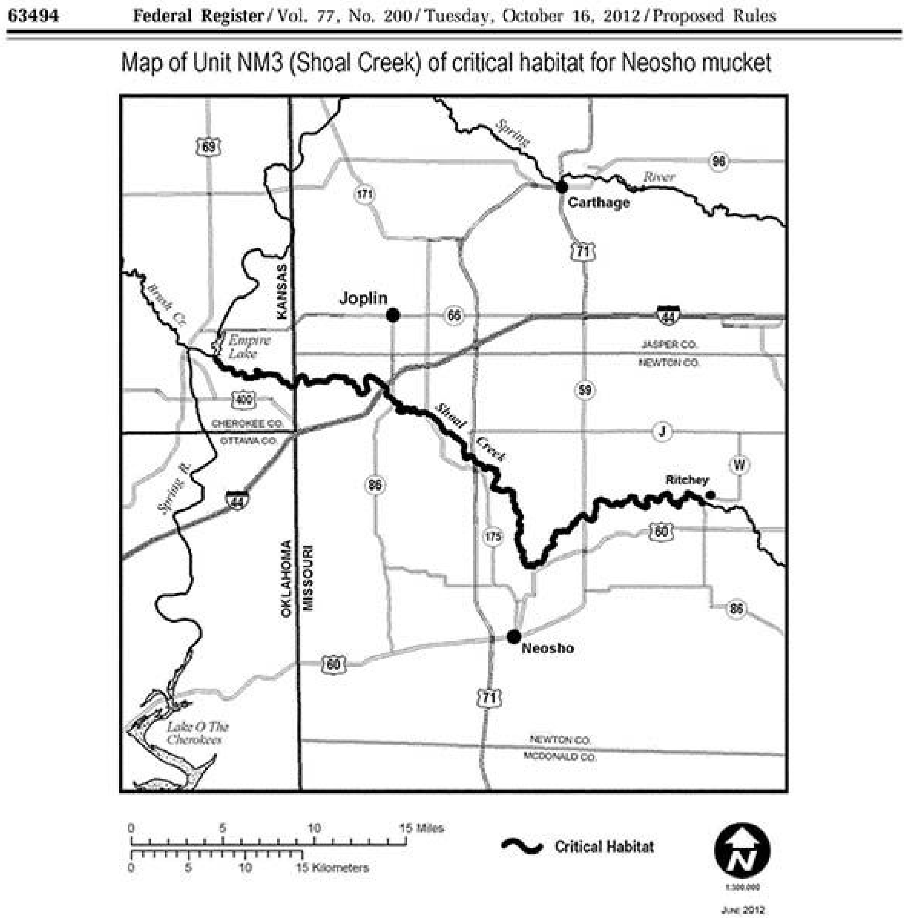

Figure 5. Shoal Creek from Ritchey, Missouri, to Lowell Reservoir in Kansas. This area of Shoal Creek is considered a critical habitat for the Neosho mucket. (Source: U.S. Fish and Wildlife Service.[6])

Figure 6. Southeast Kansas Nature Center. (Photo by Tommy Noe, courtesy of Southeast Kansas Nature Center.)

fish, invertebrates, and a honeybee hive. A one-way window allows visitors to observe birds and other local wildlife outside the center.

Mining's legacy of environmental damage

When a hundred years of lead and zinc mining ended in the Tri-State area, which includes extreme southeast Kansas and parts of Oklahoma and Missouri, the abandoned tunnels and piles of tailings left behind posed serious environmental problems. Water filled the tunnels and became contaminated with iron sulfide and other metallic sulfides that remained in the mines. The contamination spread when the water — very acidic and containing dissolved metals, some of which were toxic — entered local streams, springs, and groundwater.[7]

Tailings — piles of crushed rock left after ore has been separated — contributed to the contamination, too, as water leached lead, zinc, and cadmium from the piles into groundwater and contaminated wells (fig. 7).

In the 1980s, this part of the Tri-State mining district was considered one of the most environmentally blighted regions in the country.

Figure 7. Water, contaminated by iron sulfide, flowing from tailing piles into Tar Creek near Picher, Oklahoma. The iron sulfide turns the water orange.

Reclamation efforts

The U.S. Environmental Protection Agency began working in the area in the early 1980s. EPA Superfund money funded a massive cleanup effort in and around Galena, with one of the main goals to provide a safe water supply for rural residents whose wells had been contaminated.

Cleanup work continues in the area, including in Shoal Creek (fig. 8), where mining practices resulted in significant damage to mussel populations. Mussels are an important indicator of a stream's health. They thrive in clean water, they are vulnerable to sedimentation, and they rely on a healthy fish population because in their larval stage, mussels catch rides to other locations in the watershed by attaching themselves to specific species of fish.[4] In adverse conditions, their populations decline. Nationally, the U.S. Fish and Wildlife Service estimates 70% of freshwater mussels are extinct, endangered, or in need of special protection.[4]

In 2021, the U.S. Fish and Wildlife Service and the Missouri Department of Natural Resources released the Draft Shoal Creek Watershed Restoration Plan, which names the Neosho mucket, a type of mussel, as a focal species for restoration efforts in Shoal Creek.[4] This plan proposes to use a combination of methods that are known to improve watershed health: restoring and enhancing riparian corridors and using non-endangered Plain pocketbook mussels to assess the water quality of Shoal Creek. Plain pocketbook mussels would be introduced in silos for six months at a time to monitor survival rates and growth. The results of the study will help determine whether it is safe to introduce the endangered Neosho mucket back into the watershed. This project is anticipated to take five years, but benefits are anticipated within the first year or two of the project.

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Figure 8. Shoal Creek.