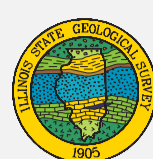




For further information about this map contact:
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Availability of the Herrin Coal for Mining in Illinois

Map Sheet 1, Geology and Mining

Colin G. Treworgy, Christopher P. Korose, and Christine L. Wiscombe
Map Summary of Illinois Minerals 120
2000

Introduction

The 79 billion tons of Herrin Coal remaining in Illinois are the largest coal resource in the state. Although the Herrin has been actively mined since the early 1800s, only slightly more than 10% of the original 89 billion tons of resources have been mined out or left as pillars. The degree to which this remaining resource is utilized in the future depends on the availability of deposits that can be mined at a cost that is competitive with other coals and alternative fuels.

These map sheets are a summary of the Illinois State Geological Survey report *Illinois Minerals 120*. These map sheets identify those Herrin Coal resources that have the most favorable geologic and land-use characteristics for mining, show the probable future trends for mining of these resources, and alert mining companies to geologic conditions that have a potentially negative impact on mining costs. This map summary follows a similar map published for a report on the availability of the Springfield Coal, listed below.

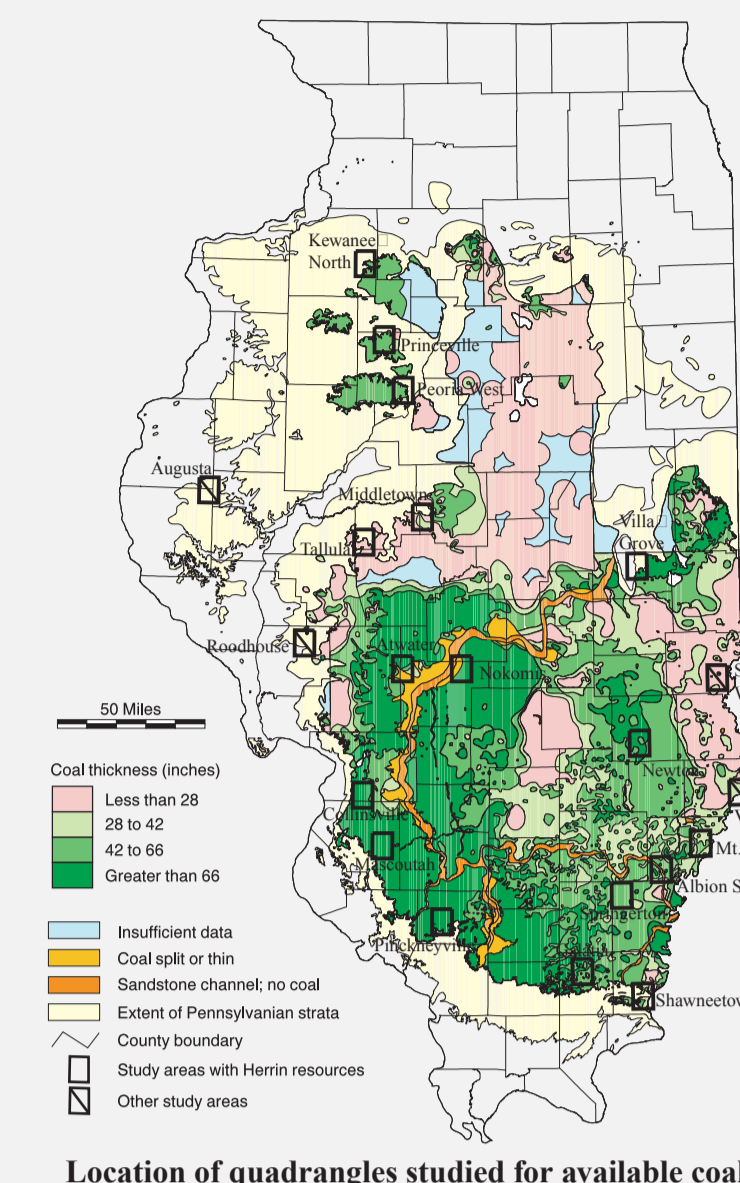
Reports on the Availability of the Springfield Coal

Treworgy, C.G., C.P. Korose, C.A. Chenoweth, and D.L. North, 1999, Availability of the Springfield Coal for Mining in Illinois: Illinois State Geological Survey Illinois Minerals 118, 43 p.

Treworgy, C.G., C.P. Korose, C.A. Chenoweth, and D.L. North, 2000, Map Summary of Illinois Minerals 118, Illinois State Geological Survey Open File Series 2000-1, 2 sheets.

Report on the Availability of the Herrin Coal

Treworgy, C.G., C.P. Korose, and C.L. Wiscombe, 2000, Availability of the Herrin Coal for Mining in Illinois: Illinois State Geological Survey, Illinois Minerals 120, 54 p.

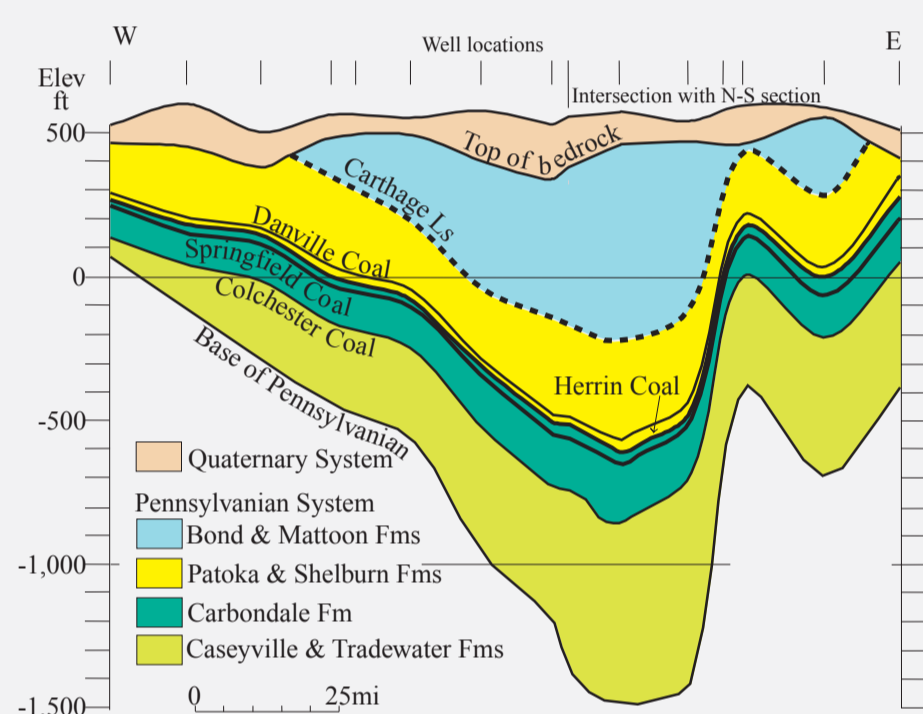


Location of quadrangles studied for available coal

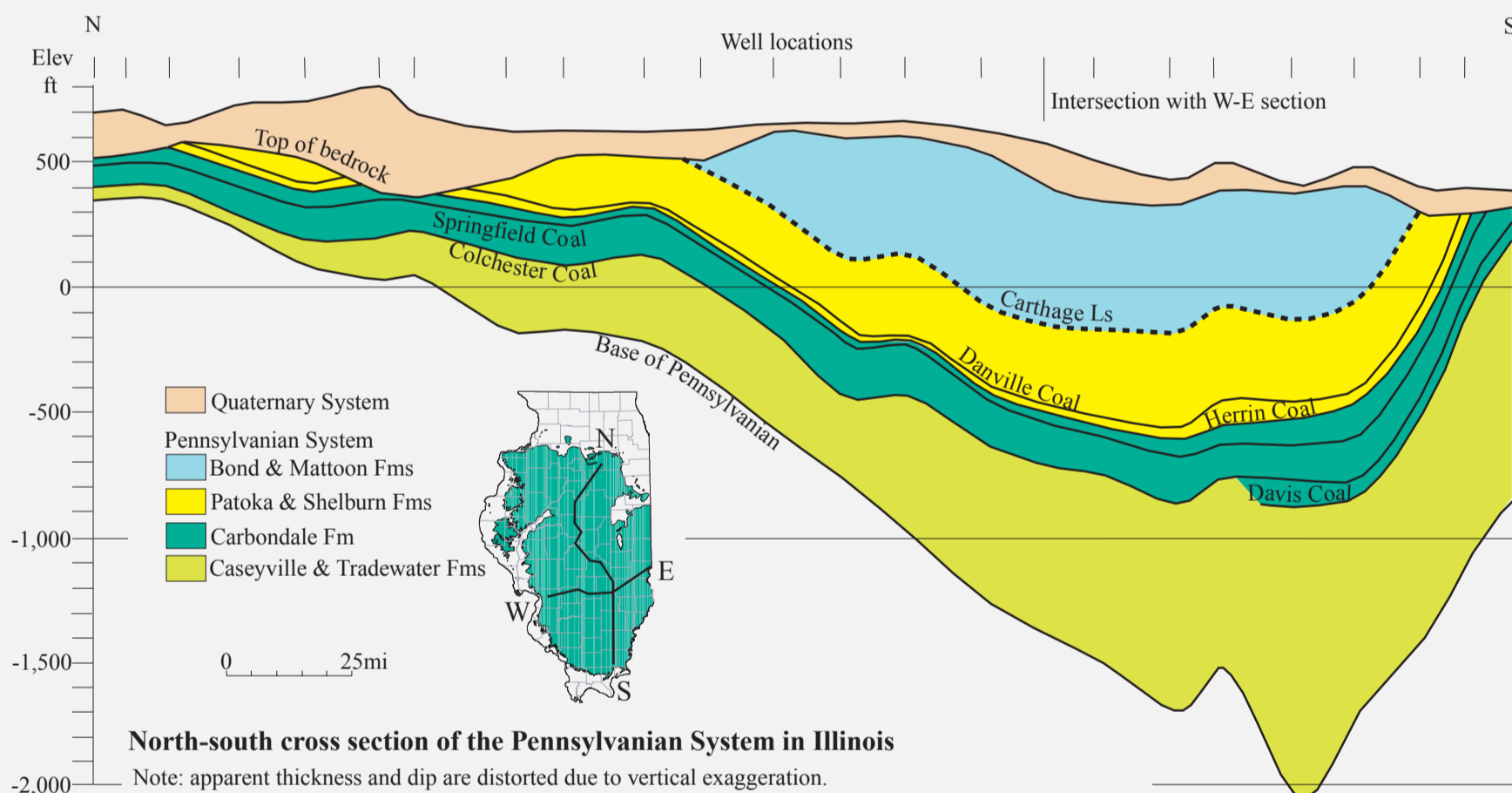
Geology and Minability

The Herrin Coal underlies about two-thirds of Illinois as well as portions of western Indiana and Kentucky. The coal crops out along the margins of the Illinois Basin, but in most of the northern two-thirds of the state, this outcrop is buried by tens to hundreds of feet of glacial and alluvial deposits. The coal dips gently towards the center of the basin in southeastern Illinois where it reaches a maximum depth in Illinois of about 1,300 feet. More than 14,000 square miles of resources have been mapped in Illinois. The majority of the resources are found throughout the southern half of the state in a nearly continuous area lying south of a line from the cities of Springfield to Danville. The thickest resources (up to 14 feet thick) commonly occur along and within several miles of the Washville Channel, a river system that was contemporaneous with the ancient peat swamp in which the coal formed (Johnson 1972, Treworgy and Jacobson 1986, Nelson 1987). In addition to apparently influencing the coal's thickness, the Washville Channel affected the sulfur content and mining conditions of the coal. West of the Illinois River, the coal is commonly less than 5 feet thick, but because it lies near the surface over a broad area, it has been extensively exploited by surface mines. Smaller pockets of Herrin resources have also been mined in northern Illinois around Streator and LaSalle.

This map is based on a series of studies that examined the availability of coal in Illinois for future mining. These studies assessed the availability of coal in 21 7.5-minute quadrangles that were considered to be representative of mining conditions found in various parts of the state. Factors that restrict availability of coal were identified through interviews with more than 40 mining engineers, geologists, and other mining specialists representing 17 mining companies, consulting firms, and government agencies active in the Illinois mining industry. The major geologic and land-use factors that were found to limit surface and underground mining of the Herrin Coal are listed in the tables to the right and their effects on the availability of the coal are shown in these map sheets. These factors are divided into two categories: land use and technology. The land-use factors consist of various land uses that are in some cases specifically protected from mining, but in most cases are simply uneconomic to mine. The technological factors consist of geologic conditions that are likely to raise mining costs to uneconomic levels. A few of these factors are illustrated to the right. A complete explanation of all factors is given in *Illinois Minerals 120*.



East-west cross section of the Pennsylvanian System in Illinois
Note: thickness and dip are distorted due to vertical exaggeration.



North-south cross section of the Pennsylvanian System in Illinois
Note: apparent thickness and dip are distorted due to vertical exaggeration.

Individual Quadrangle Reports on Available Coal Resources

Jacobson, R.J., C.G. Treworgy, and C. Chenoweth, 1996, Availability of Coal Resources for Mining in Illinois: Galatia Quadrangle, Southeastern Illinois: Illinois State Geological Survey Minerals 114, 39 p.

Treworgy, C.G., 1999, Coal Resources Map and Availability of Coal for Mining, Villa Grove Quadrangle, Douglas County, IL: Illinois State Geological Survey IGQ Villa Grove-CR.

Treworgy, C.G., C.A. Chenoweth, and M.H. Bargh, 1995, Availability of Coal Resources for Mining in Illinois: Galatia Quadrangle, Saline and Hamilton Counties, Southern Illinois: Illinois State Geological Survey Illinois Minerals 113, 38 p.

Treworgy, C.G., C.A. Chenoweth, and R.J. Jacobson, 1996, Availability of Coal Resources for Mining in Illinois, Newton and Princeton Quadrangles, Jasper, Peoria, and Stark Counties: Illinois State Geological Survey Open File Series 1996-3, 47 p.

Treworgy, C.G., C.A. Chenoweth, and M.A. Justice, 1996, Availability of Coal Resources for Mining in Illinois, Atwater, Collinsville, and Nokomis Quadrangles, Christian, Macoupin, Madison, Montgomery, and St. Clair Counties: Illinois State Geological Survey Open File Series 1996-2, 33 p.

Treworgy, C.G., C.A. Chenoweth, J.L. McBeth, and C.P. Korose, 1997, Availability of Coal Resources for Mining in Illinois, Augusta, Kewanee North, Macoupin, Pinckneyville, and Roadhouse East Quadrangles, Adams, Brown, Greene, Henry, Perry, Schuyler, and St. Clair Counties: Illinois State Geological Survey Open File Series 1997-10, 72 p.

Treworgy, C.G., G.K. Coats, and M.H. Bargh, 1994, Availability of Coal Resources for Mining in Illinois, Middletown Quadrangle, Central Illinois: Illinois State Geological Survey Circular 554, 48 p.

Treworgy, C.G., J.L. McBeth, C.A. Chenoweth, C.P. Korose, and D.L. North, 1998, Availability of Coal Resources for Mining in Illinois, Albion South, Peoria West, Snyder-West Union, Springfield, and Tallula Quadrangles, Clark, Edwards, Hamilton, Menard, Peoria, Sangamon, and White Counties: Illinois State Geological Survey Open File Series 1998-1, 92 p.

Treworgy, C.G. and D.L. North, 1999, Availability of Coal Resources for Mining in Illinois, Shawneetown Quadrangle, Gallatin County, Illinois and Union County, Kentucky: Illinois State Geological Survey Open File Series 1999-7, 35 p.

Treworgy, C.G., D.L. North, C.L. Conolly, and L.C. Furer, 1999, Resources Maps and Availability for Mining of the Danville, Jamestown/Hymers, Springfield, Survant, and Seelyville Coals: Illinois State Geological Survey IGQ Vincennes-CR.

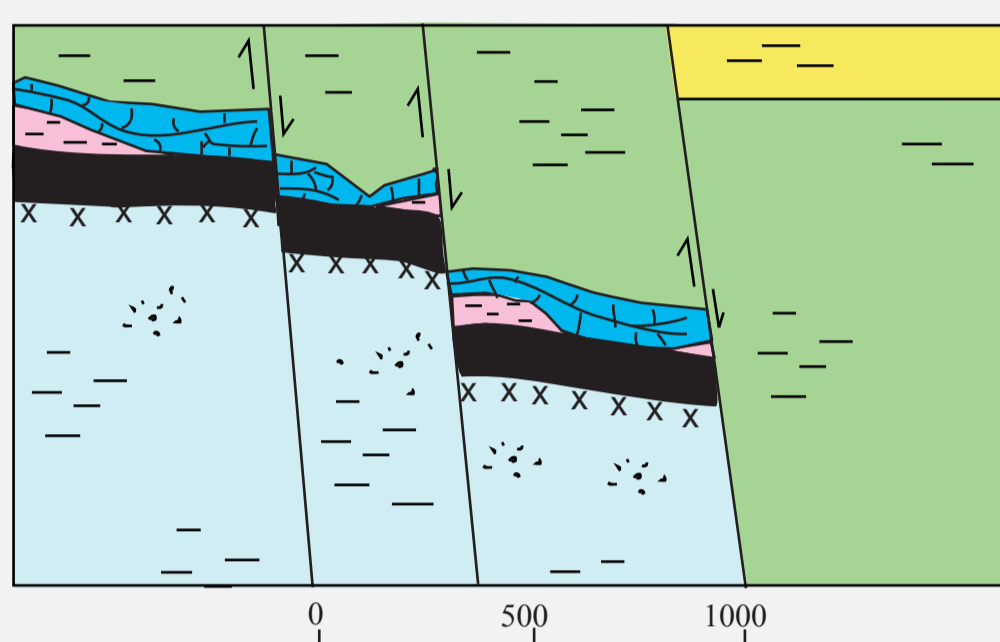
Factors used to define Herrin Coal resources available for underground mining

Technological restrictions	
Minimum seam thickness:	42 inches
Minimum bedrock cover:	variable
Minimum ratio of bedrock to unconsolidated overburden:	1:1
Floodplains	+
Minimum interburden between minable seams:	40 ft
Minimum size of mining block (Clean coal):	400 ft
Faults - width of zone of no mining	40 million tons
Cottage Grove Fault System	
Master fault:	500 to 1000 ft
Subsidiary faults	100 ft
Rend Lake Fault System	200 ft
Centuria Fault	300 ft
Wabash Valley Fault System	800 ft
Walshville Channel	no mining within 0.5 mi
Anvil Rock Channel	no mining within 1800 ft
Energy Shale	no mining within transition zone
Anvil Rock Sandstone within 5 ft of coal	no mining
Partings	++
Land-use restrictions (width of unminable coal around feature)*	
Surface and underground mines	200 ft
Towns	0 ft
Interstate Highways	100 ft
Major airports	100 ft
Dams	100 ft
Closely-spaced oil wells	>7 wells per 40 acres
Available with potential restrictions	
Closely-spaced oil wells	4-7 wells per 40 acres
Potential land-use conflicts:	
All otherwise available underground minable coal within areas where land-use patterns are incompatible with mining	identified
Bedrock cover	> minimum but <100 ft

* Floodplains were considered a restriction in areas where bedrock was less than 100 feet thick. See Illinois Minerals 120 for a complete explanation.

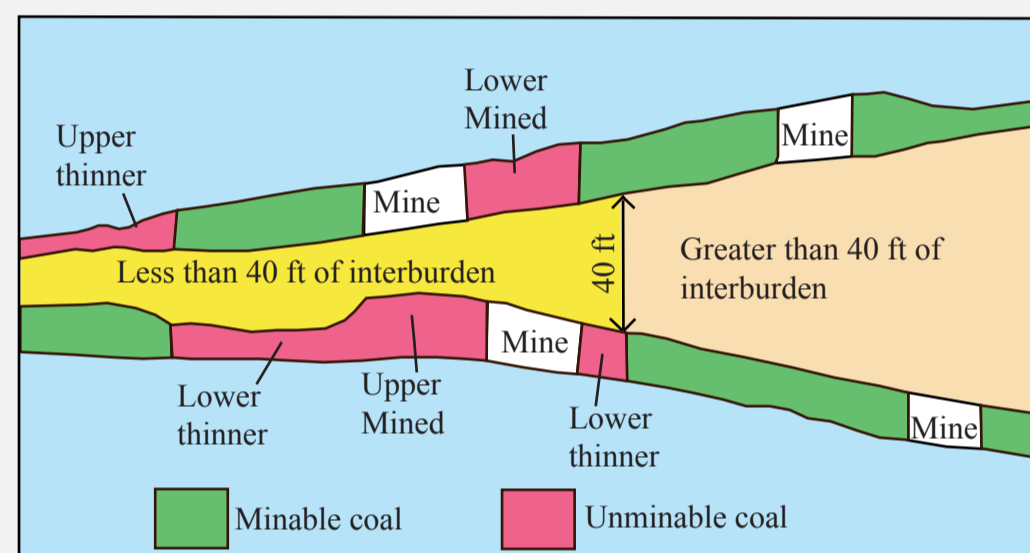
** Areas where partings are likely to be individually or cumulatively too thick for mining were identified, but the tonnage of resources restricted from mining was not calculated.

*** Quadrangle studies also considered subdivisions, churches, schools, high voltage transmission lines, and cemeteries. These were not found to be significant for purposes of a statewide assessment.



Cross section illustrating multiple, parallel faults displacing a coal seam

Many fault zones consist of multiple parallel faults with varying amounts of displacement. Although mines can mine through the zones, most companies find it unconomical to mine past the first or second displacement encountered. The displacements can make the movement of equipment difficult or impossible, increase mining costs, and delay the mining operation.



Effect of interburden thickness on underground mining

In areas where the interburden between two seams is less than 40 feet thick, only one of the two seams can be mined. The thinner of the two seams is considered unminable.

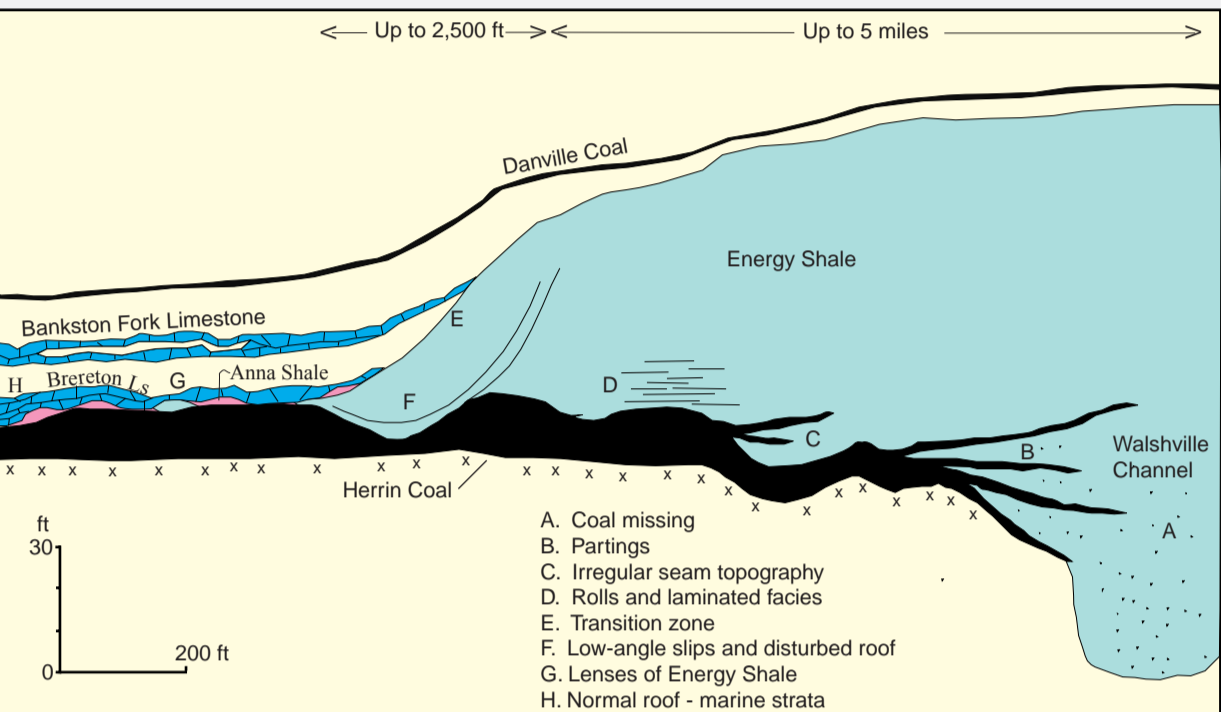
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- Gluskoter, H.J., and J.A. Simon, 1968, Sulfur in Illinois Coals: Illinois State Geological Survey Circular 432, 28 p.
- Johnson, D.O., 1972, Stratigraphic Analysis of the Interval Between the Herrin (No. 6) Coal and the Piasa Limestone in Southwestern Illinois, Ph.D. thesis, University of Illinois at Urbana-Champaign, 105 p.
- Nelson, W.J., 1987, The Hornsby District of Low-Sulfur Herrin Coal in Central Illinois (Christian, Macoupin, Montgomery, and Sangamon Counties), Illinois State Geological Survey Circular 540, 40 p.
- Treworgy, C.G., and R.J. Jacobson, 1986, Paleoenvironments and distribution of low-sulfur coal in Illinois, in Annual T. Cross, editor, Economic Geology-Coil, Oil and Gas, Complete Rendu, v. 4, Ninth International Congress of Carboniferous Stratigraphy and Geology, Washington and Champaign-Urbana, May 1979. Southern Illinois University Press, Carbondale, p. 349-359.
- Treworgy, C.G., E.I. Prussen, M.A. Justice, C.A. Chenoweth, M.H. Bargh, R.J. Jacobson, and H.H. Danberg, 1997, Illinois Coal Reserve Assessment and Database Development: Final Report, Illinois State Geological Survey Open File Series 1997-4, 105 p.

Factors used to define Herrin Coal resources available for surface mining

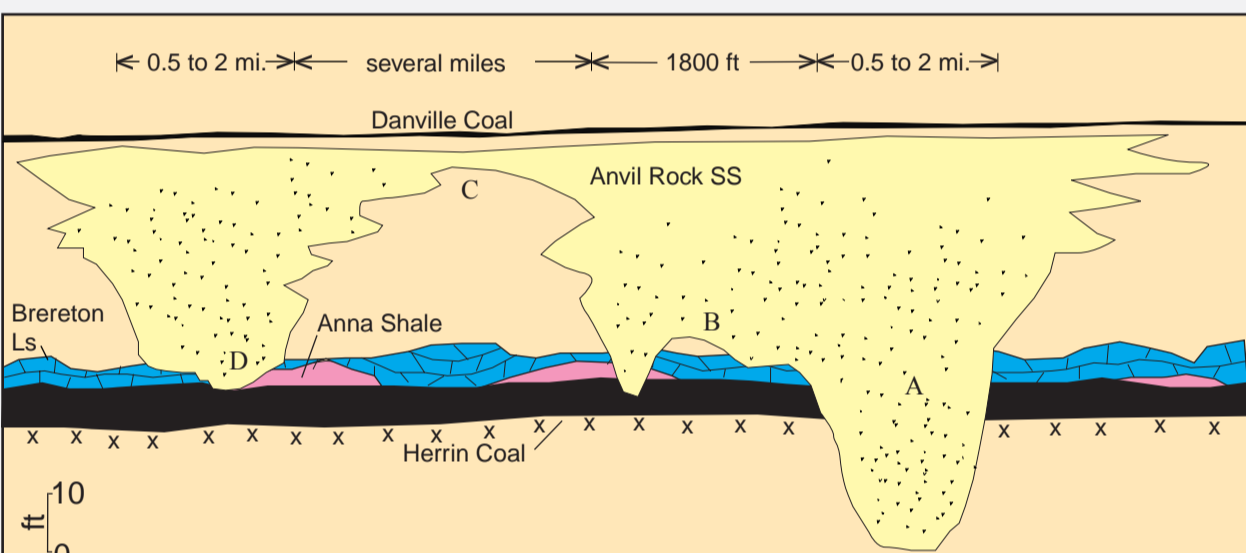
Technological restrictions	
Minimum seam thickness	18 inches
Cumulative tonnage needed to support a mine and preparation plant	200 ft
Maximum depth	60 ft
Stripping ratio (cubic yards of overburden/ton of raw coal; volumes and weights not adjusted for swell factors or cleaning losses)	25:1
Maximum average	20:1
Minimum size of mine reserve (clean coal)	
Cumulative tonnage needed to support a mine and preparation plant	10 million tons
Individual block size (thousands of tons):	
Less than 50 ft of overburden	150
More than 50 ft of overburden	500
Land-use restrictions (width of unminable coal around feature)*	
State parks & preserves	100 ft
Railroads	100 ft
Federal & state highways	100 ft
Major airports	100 ft
Pipelines	100 ft
Underground mines	200 ft
Towns	0.5 mi
Available with potential restrictions	
Potential land-use conflicts	
All otherwise available surface minable coal in areas where land-use patterns are incompatible with mining	identified

* Quadrangle studies also used cemeteries, other paved roads (in some areas), high voltage transmission towers, and rural subdivisions, but these were considered insignificant for purposes of a statewide assessment.



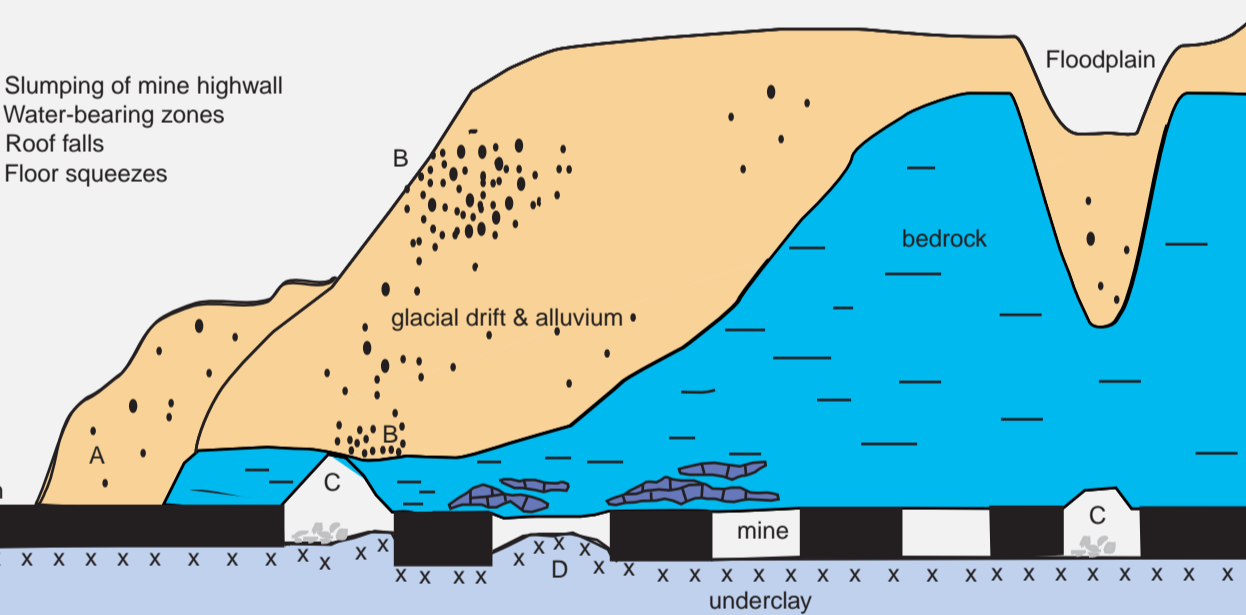
Underground mining conditions near the Washville Channel

The Herrin Coal is missing within the wide belt of the Washville Channel, the bed of an ancient river that was contemporaneous with the Herrin peat swamp (A). Adjacent to the channel the coal is split into multiple, thin benches (B) and has abrupt changes in elevation and thickness (C). The Energy Shale overlies the coal adjacent to the channel and generally makes a stable roof except where thick, low-angle slips and disturbed roof (D). Roof stability problems are encountered near the margins of the Energy Shale (E). Low-angle slip planes, possibly representing paleosols or compaction features disrupt the roof sequence and coal seam in some areas (F). Away from the channel, lenses or "pods" of Energy Shale may be present (G), but the normal roof sequence consists of marine black shales and limestones (H).



Underground mining conditions associated with the Anvil Rock Sandstone

The Anvil Rock Sandstone has its greatest effect on mining where it occupies large channels that have cut through and eroded the Herrin Coal (A). Unstable roof conditions may be found within a zone adjacent to the main channel due to the partial or complete erosion of the Breerton Limestone, the presence of subsidiary channels, and the presence of water-bearing sandstone within the zone penetrated by mine roof bolts (B). Further from the main channel, the Anvil Rock may be thin and/or well above the roof-bolting zone (C), but large subsidiary channels from the main channel have eroded the roof strata and possibly parts of the coal (D).



Problems in surface and underground mines associated with thin bedrock cover overlain by thick unconsolidated sediments

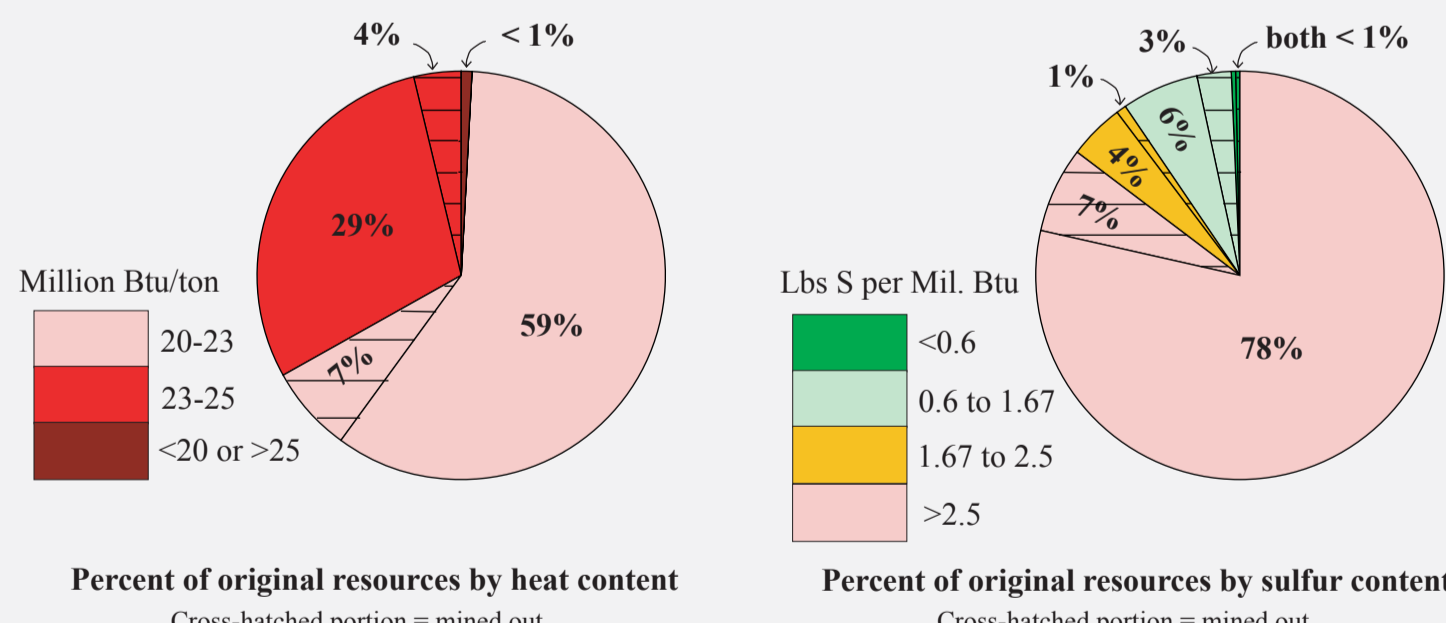
Slumping of the highwall and excess inflows of water may be encountered in surface mines with more than about 60 feet of unconsolidated overburden. Roof falls, floor squeezes, and water inflows may be experienced in underground mines with thin bedrock cover or a bedrock to unconsolidated overburden ratio of less than 1:1. The amount of bedrock needed is affected by geologic parameters such as the lithology of the bedrock, thickness of the unconsolidated sediments, and the presence of bedrock valleys as well as mine design parameters such as the width of rooms and pillars.

Quality

The Herrin Coal is a high volatile, bituminous coal that ranges from rank A in the southeastern corner of the state to rank C in the northwestern two-thirds of the state. Heat content ranges over the same area from more than 25 million Btu per ton to less than 20 million Btu per ton, equivalent to more than 12,500 to less than 10,000 Btu per pound (as-received, ar). Ash is commonly in the range of 9 to 12% (ar), slightly lower ash content is reported in the southeastern part of the state.

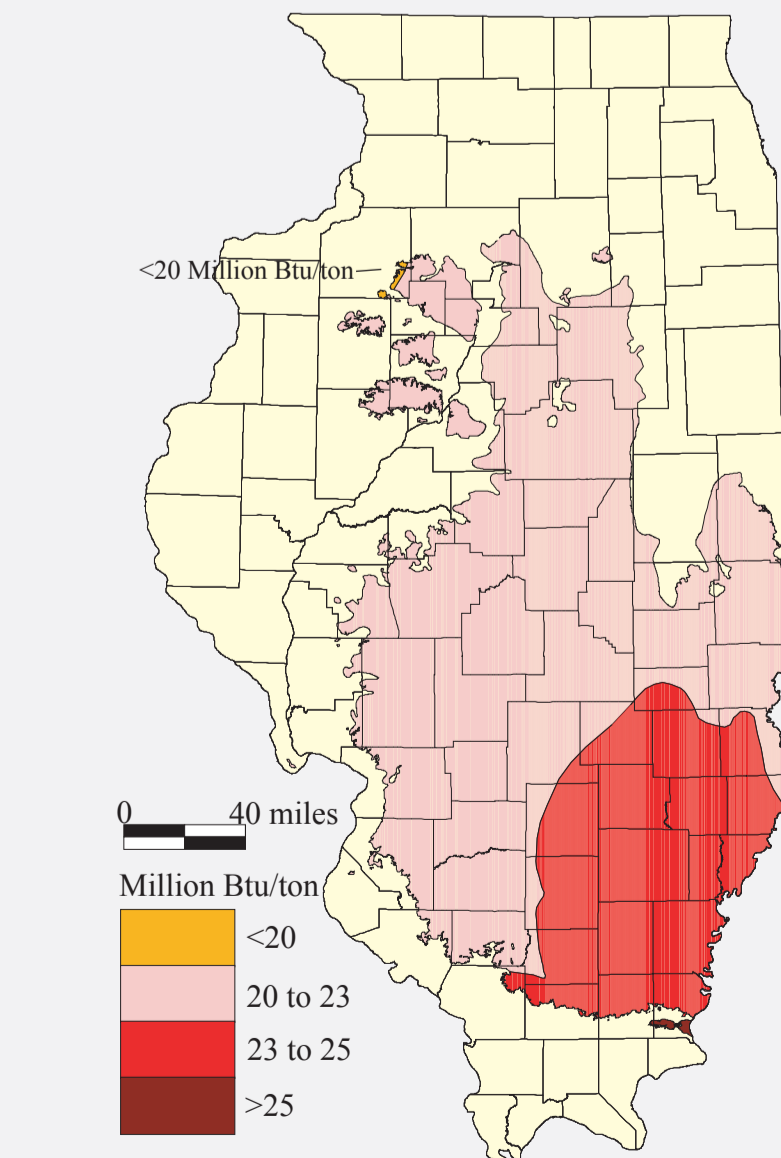
The sulfur content of the coal is commonly more than 2.5 pounds per million Btu, equivalent to 3 to 5% (dry basis) except for areas where the Energy Shale Member directly overlies the coal instead of the normal marine sequence of black shale and limestones. The Energy Shale is associated with the Washville Channel and is believed to be a non-marine or brackish water deposit (such as a crevasse splay) that covered the peat sediments and prevented them from coming into direct contact with sulfur-bearing marine waters (Gluskoter and Simon 1968). In the areas overlain by the Energy Shale, the sulfur content of the coal is as low as less than 1 pound of sulfur per million Btu (about 1%).

Chlorine content of the coal is loosely correlated to depth and increases from less than 0.1% (dry basis) at shallow depths along the margins of the basin to greater than 0.6% in the central part of the basin (Chou 1991).

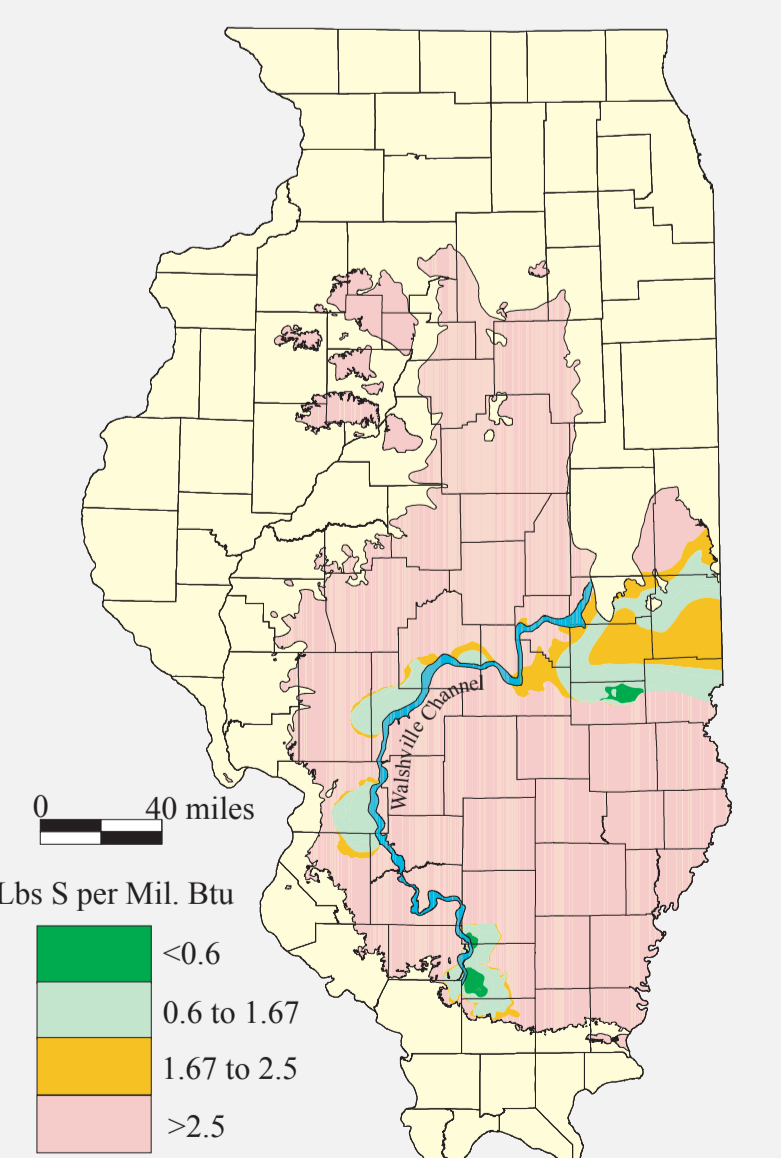


Percent of original resources by heat content
Cross-hatched portion = mined out

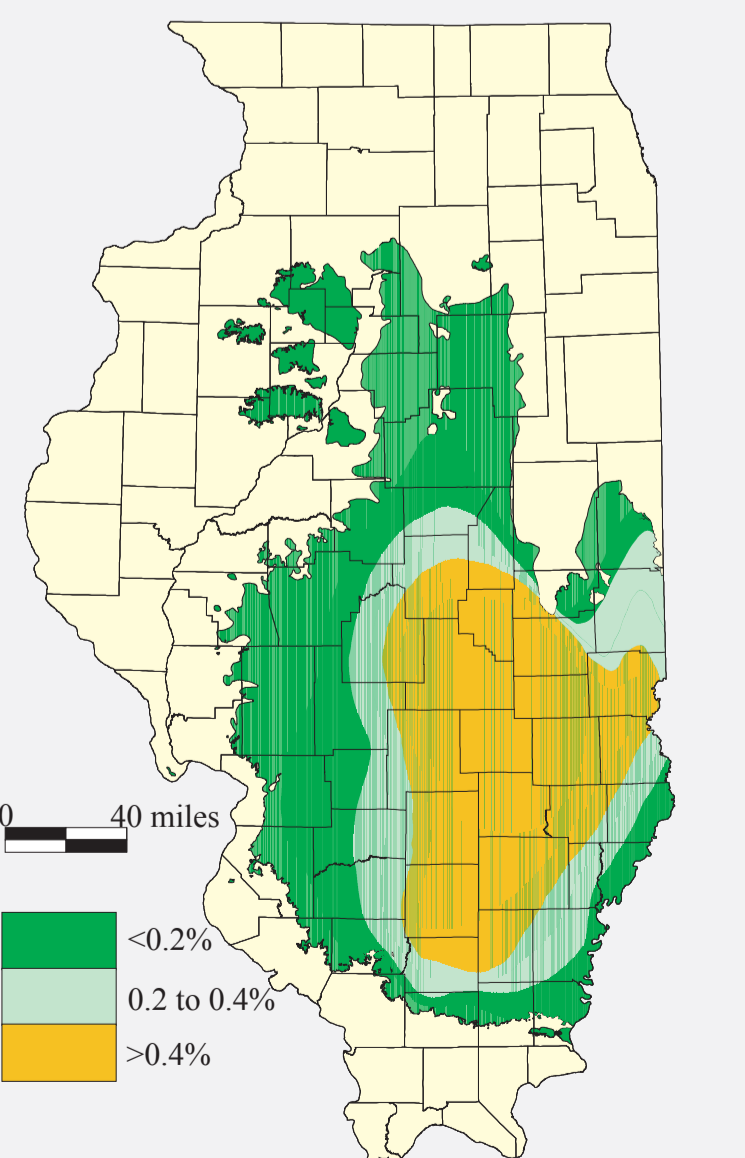
Percent of original resources by sulfur content
Cross-hatched portion = mined out



Heat content of the Herrin Coal
(from Treworgy et al. 1997)



Sulfur content of the Herrin Coal



Chlorine content of the Herrin Coal
(from Chou 1991)

Resources

Approximately 58% of the original Herrin resources (51 billion tons) are available for mining. Available means that the surface land use and geologic conditions related to mining of the deposit (e.g. thickness, depth, in-place tonnage, stability of bedrock) are comparable to those for other coals currently mined in the state. Of these resources, 21 billion tons are in seams 42 to 66 inches thick, and 30 billion tons are in seams greater than 66 inches thick. An additional 3 billion tons of the Herrin resources are available but have geologic or land-use conditions that may make them less favorable for mining. Technological factors (geologic conditions and engineering parameters such as size of reserve block) restrict mining of 24% of the original resources, land use (e.g., towns, highways) restricts mining of 4% and 11% have been mined or lost in mining.

Most of the Herrin Coal resources have greater than 1.67 pounds of sulfur per million Btu and are only suited for the high-sulfur coal market. Only 6 billion tons of the remaining Herrin resources have a sulfur content between 0.4 and 1.7 pounds of sulfur per million Btu. About half of these medium- to low-sulfur resources are classified as available or available with potential restrictions. Technological factors, such as geologic conditions associated with faults and channels, are the primary restrictions on mining these lower sulfur deposits.

Only about 15 billion tons of the original Herrin resources are less than 200 feet deep and potentially minable by surface methods. Of these resources, 21% have already been mined and 15% (2 billion tons) are available for surface mining. Land use, primarily towns, restricts 17% of the resources. Technological factors, primarily stripping ratio and thick unconsolidated material, restrict 45% of the resources.

Future mining of the available Herrin resources will for the most part be by underground methods. Of the original resources that are at least 40 feet deep, 57% are available for underground mining. An additional 4% are available but with potential restrictions that make the resources less desirable. These potential restrictions are the presence of closely spaced oil wells, less stable roof strata, or close proximity to developing urban areas. The major technological factors that restrict mining are unfavorable thicknesses of bedrock and unconsolidated overburden, coal less than 42 inches thick, and thin interburden between the Herrin Coal and an overlying or underlying seam. Land use restricts underground mining of 5% of the resources, and 10% have already been mined or lost in mining.

The available resources are primarily located in the central and southern portions of the state and are well suited for high-efficiency longwall mining. The resources are relatively flat-lying with a consistent seam thickness over large areas, relatively free of faults, channels, or other geologic anomalies, located predominantly in rural areas free from oil wells and other surface development, and occur in minable blocks of hundreds of millions of tons. Whether or not the resources are ultimately mined depends on a variety of other factors that have not been assessed, including willingness of local landowners to lease the coal, demand for a particular quality of coal, transportation infrastructure, proximity of the deposit to markets, and cost and availability of competing fuels.

Availability of the Herrin Coal for mining, billions of tons

	Original	Mined	Remaining	Available	Available with potential restrictions	Land-use restrictions
Total	88.5	86.5	78.1	51.0	2.2	2.6
Surface	8.4	8.1	7.8	4.9	0.2	0.3
Underground	80.1	78.4	70.3	46.1	2.0	2.3
Unminable	8.4	8.1	7.8	4.9	0.2	0.3
Available with potential restrictions	3.1	0.2	0.2	0.2	0.2	0.2
Land-use restrictions	3.8	0.4	0.4	0.4	0.4	0.4

Remaining resources by county and availability by mining method (millions of tons)

mining method (millions of tons)					
	Remaining resources	Total available	Available by mining method		
			Surface	Underground	
Bond	2,517	2,386	-	-	2,386
Bureau	688	21	21	-	-
Champaign	201	33	-	-	33
Christian	3,414	2,972	-	-	2,972
Clark	419	281	-	-	281
Clay	2,054	1,140	-	-	1,140
Clinton	3,186	2,788	-	-	2,788
Coles	1,108	281	-	-	281
Crawford	366	89	-	-	89
Cumberland	1,786	1,593	-	-	1,583
Douglas	1,195	296	-	-	296
Edgar	1,533	406	-	-	406
Edwards	925	479	-	-	479
Effingham	1,334	989	-	-	989
Fayette	3,637	3,348	-	-	3,348
Franklin	1,395	1,184	-	-	1,184
Fulton	246	109	99	10	254
Gallatin	930	357	72	24	204
Greene	96	23	23	-	-
Grundy	45	-	-	-	-
Hamilton	2,597	2,278	-	-	2,278
Henry	244	74	74	-	-
Jackson	78	36	33	-	-
Jasper	2,904	2,718	-	-	2,718
Jefferson	2,614	1,808	-	-	1,808
Jersey	60	28	28	-	-
Knock	212	85	85	-	-
LaSalle	290	23	41	-	-
Lawrence	822	79	23	-	79
Livingston	199	41	41	-	-
Logan	863	305	-	-	305
Macoupin	75	-	-	-	-
Macon	342	102	-	-	102
Madison	3,941	2,487	-	-	2,427
Marion	2,216	966	45	921	-
Marion	1,875	671	-	-	671
Marshall	71	-	-	-	-
Menard	13	-	62	-	-
Monroe	71	-	-	-	-
Montgomery	3,720	3,392	-	-	3,392
Morgan	466	151	-	-	151
Moultrie	1,063	422	-	-	422
Peoria	1,128	513	403	-	113
Perry	1,831	1,521	529	1,240	-
Pitt	38	-	-	-	-
Putnam	87	-	-	-	-
Randolph	248	107	75	-	-
Richland	1,813	1,621	-	-	1,621
St. Clair	2,292	454	86	-	397
St. James	1,277	882	70	-	817
St. Louis	1,147	1,616	109	-	1,616
Scott	1	-	-	-	-
Shelby	3,333	2,644	-	-	2,644
Shelby	466	145	145	-	-
Tazewell	216	-	-	-	-
Vermilion	1,886	551	71	-	488
Washington	897	290	-	-	290
Washington	2,794	1,341	66	-	3,229
Wayne	2,981	2,435	-	-	1,435
Wayne	2,390	1,485	-	-	1,485
Williamson	561	335	57	291	-
Woodford	-	-	-	-	-
	79,043	51,027	2,715	49	29,999