ILLINOIS STATE GEOLOGICAL SURVEY
Open-File Series
Illinois State Geological Survey
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Availability of the Herrin Coal for Mining in Illinois

Map Sheet 1, Geology and Mining

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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. Herrin Coal is also the most valuable coal resource in Illinois. It is estimated that nearly more than 10% of the original 80 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 many factors, but the factors that can be natural or 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 in coal mining, and identify those geologic conditions that could cause mining problems and substantially negative impacts on mining costs. This map summary follows a similar map published for a report on the availability of the Springfield Coal, listed below.

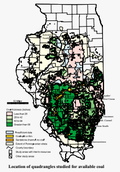
Reports on the Availability of the Springfield Coal

Treworgy, C.G., C.P. Korose, C.A. Chenoweth, and D.L. North, 2000, Availability of the Springfield Coal for Mining in Illinois: Illinois State Geological Survey Illinois Minerals 118, 47 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, 59 p.



Location of quadrangles studied for available coal

Factors used to define Herrin Coal resources available for underground mining

Technological restrictions	
Minimum seam thickness	42 inches
Maximum seam dip	18°
Minimum ratio of bedrock to unconsolidated overburden	1:1
Floodplains	
Minimum distance between mineable seams	40 ft
Minimum size of mineable block (Chain coal)	40 million tons
Faults - width of zone of no mining	
Normal fault System	
Shawnee fault	500 to 1000 ft
Subsidiary faults	100 ft
Wabash Valley Fault System	500 ft
Centralia Fault	500 ft
Wabash Valley Fault System	800 ft
Wash zones - width of mining, within 0.5 mi	
Anvil Rock Channel	no mining within 1000 ft
Energy Shale	no mining within transition zone
Herrin Coal Sandstone within 5 ft of coal	no mining
Partings	**
Land-use restrictions (width of unmineable coal around features)	
Occupied residences	200 ft
Towns	0 ft
Interstate Highways	500 ft
Major roads	100 ft
Railroads	100 ft
Gravel removal of wells	1/7 wells per 40 acres
Available with potential restrictions	
Gravel removal of wells	4.7 wells per 40 acres
Potential land-use conflicts	
All otherwise available underground	
mineable coal in areas where land-use	
use patterns are incompatible with mining	identified
Bedrock cover	minimum bar / 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.

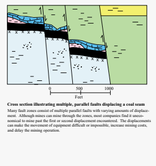
** Partings greater than 4 inches thick were considered unmineable immediately no-thick for mining were identified, but the tonnage of resources restricted from mining was not calculated.

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

Factors used to define Herrin Coal resources available for surface mining

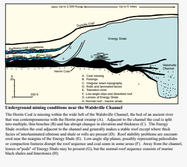
Technological restrictions	
Minimum seam thickness	10 inches
Maximum seam dip	18°
Maximum unconsolidated overburden	100 ft
Stripping ratio (cubic yards of overburden/acre of raw coal, volumes	
Maximum ratio adjusted for swell factors or cleaning losses)	
Shoreline	20:1
Maximum average	20:1
Mine life (minimum acreage (clean coal))	
Cumulative tonnage needed to support	
a mine and preparation plant	10 million tons
Mine life (minimum number of years)	
Less than 50 ft of overburden	150
More than 50 ft of overburden	300
Land-use restrictions (width of unmineable coal around features)*	
State parks & preserves	1000 ft
Railroads	100 ft
Interstate & state highways	500 ft
Major streams	1000 ft
Pipelines	100 ft
Occupied rural homes	300 ft
Towns	0.5 mi
Available with potential restrictions	
Potential land-use conflicts	
All otherwise available surface	
mineable coal in areas where land-use	
use patterns are incompatible with mining	identified

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



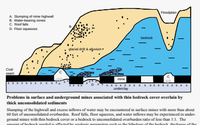
Effect of interburden thickness on underground mining

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.



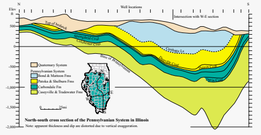
Underground mining conditions associated with the Anvil Rock Sandstone

The Anvil Rock Sandstone has a far 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 channel (B). Factors that affect the degree of roof instability include the width of the channel, subsidence 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 so well above the roof bolting zone (C), but large subsidence 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 100 feet of unconsolidated overburden (A). Roof falls (B) and inflows of water (C) may be encountered 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.



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

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Johnson, D.O., 1972, Stratigraphic Analysis of the Interval Between the Herrin (No. 6) and Springfield (No. 5) Coals in Southeastern Illinois: Ph.D. thesis, University of Illinois at Urbana-Champaign, 197 p.

Nelson, W.J., 1987, The Hemerly District of Low-Sulfur Herrin Coal in Central Illinois (Clinton, Macoupin, Montgomery, and Sangamon Counties), Illinois State Geological Survey Circular 540, 40 p.

Treworgy, C.G., and R.J. Jacobson, 1996, Paleocurvatures and distribution of low-sulfur coal in Illinois, in Jorand T. Cross, editor, Proceedings of the Seventh Annual Conference on Carbonaceous Basins, International Congress of Carboniferous Stratigraphy and Geology, Washington and Champaign-Urbana, May 1979: Southern Illinois University Press, Carbondale, p. 1909-1921.

Treworgy, C.G., S.J. Pearson, M.A. Harlan, C.A. Chenoweth, M.R. Gross, and C.P. Korose, 1999, Coal Resources Data Base and Resource Assessment and Database Development - Final Report: Illinois State Geological Survey Open-File Series 1999-4, 160 p.

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 drift. The Herrin Coal is generally thickest in the southern part of the basin in southeastern Illinois where it reaches a maximum depth in Illinois of about 1,200 feet. More than 10,000 square miles of resources have been mapped in Illinois. The majority of these resources are in Franklin, Jefferson, Perry, and Randolph Counties in an 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 Wabash Valley Fault System in southeastern Illinois and in paleochannels cut by the Anvil Rock (the coal formed Unknown 1972; Treworgy and Jacobson 1996; Nelson 1987). In addition to apparently influencing the coal's thickness, the Wabash Valley Fault System also influences the coal's sulfur content. Coal in the fault zone and in the area immediately to its east has less than 1% sulfur, but because it lies near the surface over a broad area, it has been extensively explored by surface mines. Smaller pockets of Herrin resources have also been identified in northern Illinois (see Northern Illinois).

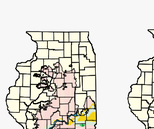
This map is based on a series of studies that examined the availability of coal in Illinois for future mining. These studies assessed the availability of coal in 21 7.5-minute quadrangles in areas where coal resources were considered favorable for underground mining. Parts of the state. Factors that restrict availability of coal were identified through interviews with more than 40 mining engineers, geologists, and other mining specialists employed by companies that own coal resources in Illinois or companies that provide services to 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 below. Because the geologic factors are more complex than land-use factors, they are discussed in the following paragraphs. The land-use factors are divided into two categories: land-use and technological. The land-use factors consist of various land uses that are in some cases specifically protected from mining, but in most cases are simply avoided by coal companies because the costs associated with 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*.

Quality

The Herrin Coal is a high volatile, bituminous coal that ranges from mark A to the southwestern corner of the state to mark C in the northwestern two-thirds of the state. Heat content ranges from about 10,500 Btu/lb (24.4 MJ/kg) in the southwest to 12,500 Btu/lb (29.1 MJ/kg) in the northeast (a difference of 2,000 Btu/lb or more than 10,000 Btu per pound (as-received; as)). Ash is commonly in the range of 7 to 12% (as), slightly lower and content is reported in the southernmost part of the state.

The sulfur content of the coal is commonly more than 2.5 pounds per million Btu, equivalent to 5% sulfur (as) in the southwestern part of the state. Sulfur content decreases to the east and northeast of the normal limestone resource extents of Rock shale and limestones. The Energy Shale is associated with the Wabash-Ste Channel and is believed to be a non-marine or brackish water deposit. Sulfur content of the coal is commonly less than 1% in areas where the Energy Shale is in coming into direct contact with sulfur-bearing marine waters (Ellenburger and Simon 1968). In the northeastern part of the state, the sulfur content of the coal is as low as less than 1 percent of sulfur per million Btu.

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 0.4% in the central part of the basin (Cluff 1981).



Heat content of the Herrin Coal

(from Treworgy et al. 2000)

Sulfur content of the Herrin Coal

Chlorine content of the Herrin Coal

(from Cluff, 1981)

Percent of original resources by heat content

Cross-hatched portion = mined out

Percent of original resources by sulfur content

Cross-hatched portion = mined out

Resources

Approximately 70% of the original Herrin resources (71 billion tons) are available for mining. Available means that the surface land use and geologic conditions related to mining costs are favorable. Only 15% of the available resources (11 billion tons of overburden) are comparable to those for other states currently mined in the state. Of these resources, 23 billion tons are in seams 42 to 60 inches thick, and 39 billion tons are in seams 28 to 42 inches thick. Only 9 billion tons of the 79 billion tons of resources are available but have geologic or land use conditions that may make them more costly to mine. Only 1% of the resources are unavailable because of the mining parameters such as size of reserve block(s) restrict mining of 24% of the original resources. Of the 79 billion tons, surface, highway/city restrictions mining of 4% and 1171 have been removed from 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 0.6 and 1.7 pounds of sulfur per million Btu (0.3 to 0.7 lbs/MBtu). Approximately 2 billion tons of low-sulfur resources are available are available with potential restrictions. Technological factors, such as geologic conditions associated with faults and channels, are the primary restrictions on mining these low-sulfur deposits.

Only about 15 billion tons of the original Herrin resources are less than 200 feet deep and potentially available for surface mining. Approximately 4 billion tons (5% of the original) and 170 (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 79 billion tons remaining, only 11 billion tons (17%) 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 same land-use factors listed in the table to the right that are not considered in 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 the presence of channels cut by the Anvil Rock Sandstone that underlying coals. Land use restricts underground mining of 5% of the resources, and 11% have already been mined or lost to mining.

The resources that remain after considering the coastal and southern portions of the state and non-coal-related for high-efficiency longwall mining. The resources are relatively flat lying with a consistent seam thickness over large areas, relatively free of faults and channels, and with favorable roof conditions. Underground mining of these favorable resources will affect surface development, and occur in relatively blocks of hundreds of millions of tons. Whether or not the resources are inherently mined depends on a number of factors, but the most important are the ability of the coal company and 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

Numbers in parentheses are percent of original resources. Note: surface and underground resources do not add to total because coal 42 to 60in but dep is included in both categories.

	Surface (surface mining methods)		Underground (underground mining methods)	
	Coal 42 to 60 inches thick	Coal 28 to 42 inches thick	Coal 42 to 60 inches thick	Coal 28 to 42 inches thick
Original	23 (29)	39 (49)	23 (29)	39 (49)
Mined	9.4 (11)	11 (13)	8.6 (10)	2.7 (3)
Unavailable	10 (13)	17 (21)	3.7 (5)	6.1 (8)
Available	11 (14)	11 (13)	10.5 (13)	30.1 (38)
Available with potential restrictions	1.1 (1)	0.7 (1)	1.1 (1)	0.7 (1)
Technological restrictions	0.4 (1)	0.9 (1)	0.3 (1)	0.7 (1)
Land-use restrictions	0.8 (1)	0.6 (1)	0.1 (1)	0.1 (1)

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

	Surface	Underground	Unavailable
Bond	1,000	1,000	1,000
Brown	1,000	1,000	1,000
Champaign	101	10	91
Christian	1,000	1,000	1,000
Clay	2,000	2,000	2,000
Clinton	2,000	2,000	2,000
Coles	1,000	1,000	1,000
Crawford	1,000	1,000	1,000
Cumberland	1,700	1,000	1,000
Edgar	1,000	1,000	1,000
Edwards	1,000	1,000	1,000
Effingham	933	879	879
Fayette	1,000	1,000	1,000
Franklin	2,000	2,000	2,000
Gallatin	1,000	1,000	1,000
Hamilton	1,000	1,000	1,000
Jackson	1,000	1,000	1,000
Jasper	1,000	1,000	1,000
Jefferson	2,000	2,000	2,000
Marion	1,000	1,000	1,000
Perry	2,000	2,000	2,000
Randolph	1,000	1,000	1,000
Richland	1,000	1,000	1,000
Saline	1,000	1,000	1,000
Shelby	1,000	1,000	1,000
Union	1,000	1,000	1,000
Wabash	1,000	1,000	1,000
Washington	1,000	1,000	1,000
Wayne	1,000	1,000	1,000
White	1,000	1,000	1,000
Williamson	1,000	1,000	1,000
Total	79,000	71,000	71,000

Availability for mining - billions of tons and percent of original resources

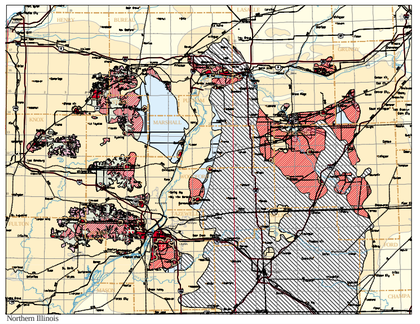
Availability of the Herrin Coal for Mining in Illinois

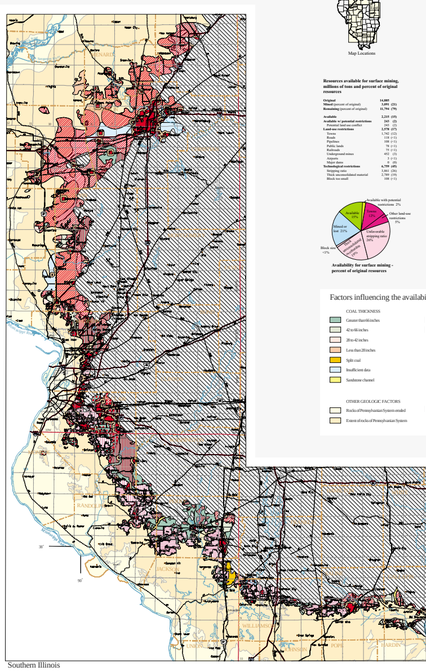
Map Sheet 2, Surface Mining

Colin G. Treworgy, Christopher P. Korose, and Christine L. Wiscombe

Map Summary of Illinois Minerals 120

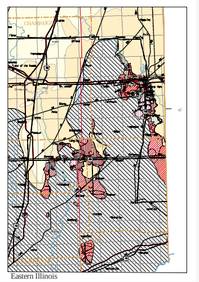
2000

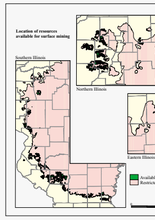




Surface Mining

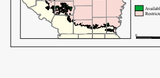
Areas of available surface mineable coal are limited to strategic and areal extent. Towns, high stripping ratios, and thick unconsolidated overburden restrict mining of significant quantities of resources. Future surface mining operations will be smaller in size and production relative to past operations and will use mobile equipment that can be easily moved to another site. This map sheet depicts the location, quantity, and availability of surface mineable resources of the Herrin Coal.





Resources available for surface mining, millions of tons and percent of original resources

	>2.5/MBtu	<2.5/MBtu
Original	3,164	(100)
Mined (percent of original)	1,497	(55)
Remaining (percent of original)	16,794	(79)
Available	3,164	(49)
Available w/ potential restrictions	1,171	(18)
Potential land-use conflicts	205	(2)
Land-use restrictions	1,170	(17)
Towns	1,170	(17)
Roads	110	(11)
Railroads	110	(11)
Public lands	70	(11)
Cemeteries	70	(11)
Unmapped mines	491	(7)
Airports	5	(1)
Water bodies	5	(1)
Technological restrictions	**4,350**	**(68)**
Stripping ratio	2,961	(46)
Unconsolidated material	1,389	(22)
Block too small	100	(1)



Availability for surface mining - percent of original resources

Factors influencing the availability of coal for surface mining

COAL THICKNESS
- Greater than 60 inches
- 42 to 60 inches
- 28 to 42 inches
- Less than 28 inches
- Split coal
- Insufficient data
- Sandstone channel

COAL DEPTH
- 200 feet

OTHER GEOLOGIC FACTORS
- Rocks of Pennsylvanian System eroded
- Extent of rocks of Pennsylvanian System
- Low- to medium- sulfur coal area, boundary is one half township north and west of Herrin Coal Sandstone, Energy Shale and Shelby Shale Thickness Lineations

MINED AREAS
- Mined area - surface
- Mined area - underground
- Active mine

SURFACE FEATURES
- Stream or small river
- Large river, lake
- U.S. Highway
- Railroad
- Pipeline

POTENTIAL RESTRICTIONS
- Potential land-use conflict

LAND-USE RESTRICTIONS
- U.S. Highway
- Interstate
- Railroad
- Pipeline
- Town
- Other land-use restrictions (see table above)

TECHNOLOGICAL RESTRICTIONS
- Unconsolidated bedrock to unconsolidated overburden ratio of less than 1:1
- Unconsolidated overburden thickness greater than 60 feet
- Mining block too small

Base map modified at the Illinois State Geological Survey from digital data provided by the U.S. Geological Survey and the Illinois Department of Transportation, 1997. North American Datum 1983.
Lambert conformal conic projection based on standard parallels 33° and 45°, central meridian 89°.
Mined areas updated to December 1999.

Availability of the Herrin Coal for Mining in Illinois

Map Sheet 3, Underground Mining

Colin G. Treworgy, Christopher P. Korose, and Christine L. Wiscombe

Map Summary of Illinois Minerals 120

2000

Underground Mining

Most of the resources of Herrin Coal will have to be mined by underground methods. The available resources are primarily located in the central and southern parts of the state where the coal is relatively thick and relatively flat lying. The coal is also relatively flat lying, have a consistent seam thickness over large areas, are relatively free of faults, channels, or other geologic anomalies, are located predominantly in rural areas where land-use conflicts are minimal, and are relatively large contiguous blocks of hundreds of millions of tons. To avoid high mining costs resulting from undesirable geologic conditions, mining companies should avoid areas with: thick drift and thin bedrock, abandoned mines, and faults and folds. Because of the geologic complexity of the Energy Shale deposits, Anvil Rock Sandstone in the immediate roof, and faults.

Acknowledgments

We especially appreciate the information given to us by mining experts on criteria that limit the availability of coal. Interviews were conducted with AMAX Coal Company, Arch Minerals, Archer Coal Company, Black Beauty Coal Company, Consolidation Coal Company, Kerr-McGee Coal Corporation, Knight Hawk Coal Company, Lee-Marlin Coal Company, MAPCO Coal Inc., Midwest Coal Company, Monterey Coal Company, Old Ben Coal Company, Peabody Coal Company, Sahara Coal Company, Sunrise Coal Company, Tri-County Coal Company, and Zeigler Coal Company. Consultants, and Illinois Office of Mines and Minerals.

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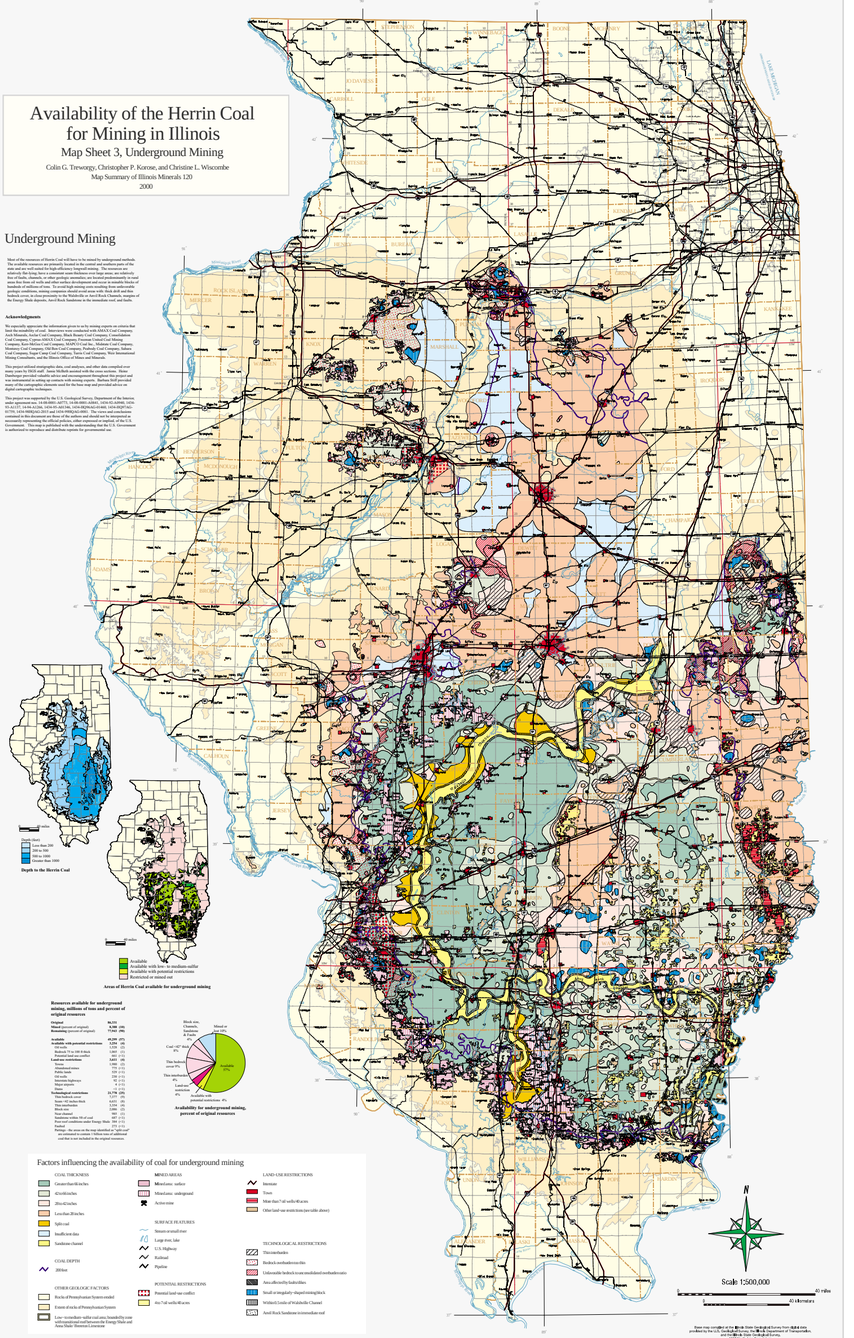

Resources available for underground mining, millions of tons and percent of original resources

	>2.5/MBtu	<2.5/MBtu
Original	46,161	
Mined (percent of original)	8,600	(19)
Remaining (percent of original)	71,042	(89)
Available	**19,104**	**(27)**
Available with potential restrictions	**1,256**	**(4)**
Potential land-use conflicts	1,256	(4)
Bedrock 75 to 100 ft thick	9,997	(21)
Unconsolidated overburden	1,256	(4)
Land-use restrictions	9,997	(21)
Towns	9,997	(21)
Occupied homes	1,256	(4)
Subdivisions	1,256	(4)
Oil wells	1,256	(4)
Interstate highways	1,256	(4)
Major streets	9,997	(21)
Technological restrictions	**21,778**	**(47)**
Bedrock 0 to 75 ft thick	9,997	(21)
Seam <42 inches thick	9,997	(21)
Thin interburden	9,997	(21)
Roof hazard	9,997	(21)
Sandstone within 5ft of coal	9,997	(21)
Thick unconsolidated Energy Shale	9,997	(21)
Faulted	9,997	(21)

* Because of the nature of the map, identified "Towns" are estimated to contain 2 billion tons of additional coal that is not included in the original resources.

Availability for underground mining, percent of original resources

Factors influencing the availability of coal for underground mining

COAL THICKNESS
- Greater than 60 inches
- 42 to 60 inches
- 28 to 42 inches
- Less than 28 inches
- Split coal
- Insufficient data
- Sandstone channel

COAL DEPTH
- 200 feet

OTHER GEOLOGIC FACTORS
- Rocks of Pennsylvanian System eroded
- Extent of rocks of Pennsylvanian System
- Low- to medium- sulfur coal area, boundary is one half township north and west of Herrin Coal Sandstone, Energy Shale and Shelby Shale Thickness Lineations

MINED AREAS
- Mined area - surface
- Mined area - underground
- Active mine

SURFACE FEATURES
- Stream or small river
- Large river, lake
- U.S. Highway
- Railroad
- Pipeline

POTENTIAL RESTRICTIONS
- Potential land-use conflict
- 4to 7 ft thick coal

LAND-USE RESTRICTIONS
- Interstate
- Town
- More than 1 ft of soil to 40 acres
- Other land-use restrictions (see table above)

TECHNOLOGICAL RESTRICTIONS
- Thin interburden
- Bedrock-unconsolidated overburden
- Unconsolidated bedrock to unconsolidated overburden ratio of less than 1:1
- Area affected by faults/folds
- Small or irregularly-shaped mining block
- Wabash Lowlands of Wabash Ste Channel
- Anvil Rock Sandstone in immediate roof

Base map modified at the Illinois State Geological Survey from digital data provided by the U.S. Geological Survey and the Illinois Department of Transportation, 1997. North American Datum 1983.
Lambert conformal conic projection based on standard parallels 33° and 45°, central meridian 89°.
Mined areas updated to December 1999.