BEDROCK GEOLOGY OF JOHNSTON CITY QUADRANGLE
WILLIAMSON AND FRANKLIN COUNTIES, ILLINOIS

Illinois Department of Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY
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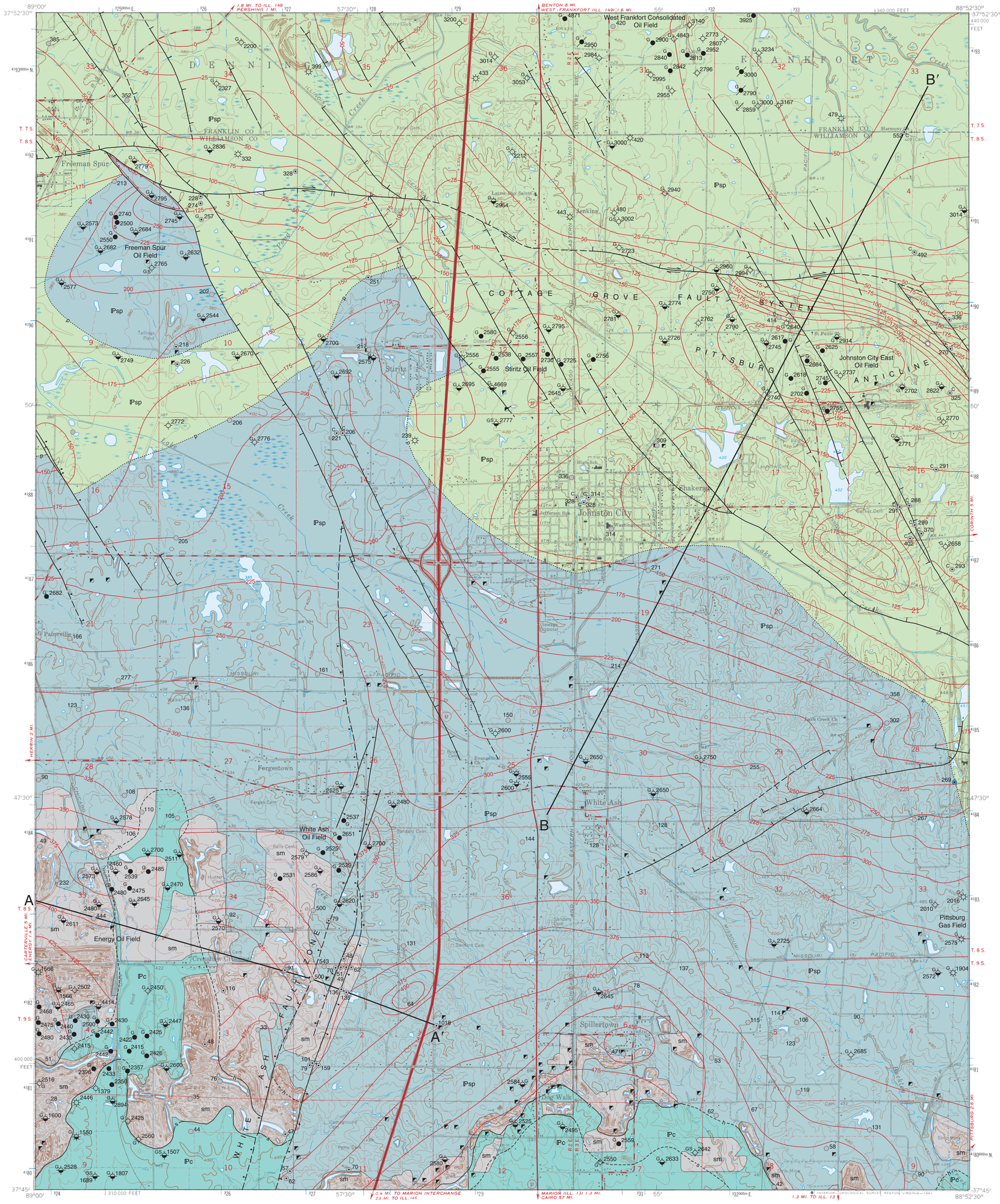
2007

Illinois Geologic Quadrangle Map
IGQ Johnston City-BG



EXPLANATION

- sm — Surface mine
- Pennsylvanian / Desmoinesian
  - IPsp — Shelburn and Patoka Formations undivided (p, Piasa Limestone Member)
  - IPc — Carbondale Formation (h, Herrin Coal Member; s, Springfield Coal Member)

Symbols

- Drift mine
- Shaft mine
- Slope mine

Drill Holes
From which subsurface data were obtained

- Water well
- Coal boring
- Oil well
- Dry hole
- Dry hole - show of oil
- Dry hole - show of oil and gas
- Gas well
- Gas well - show of oil
- Oil well - abandoned
- Water injection well

CSG 2620 — Numeric label indicates total depth of boring in feet.
Boring with samples (s), geophysical log (g), or core (c)
Dot indicates location accurate within 100 feet.

Line Symbols
dashed where inferred, dotted where concealed
All faults are shown where they intersect the Herrin Coal.

- Contact or bed subcrop
- Fault, direction of throw unknown
- Normal fault: bar and ball on downthrown side
- Fault, type unknown: ticks on downthrown side
- High-angle reverse fault: sawteeth on upthrown block
- Strike-slip fault
- 425 — Elevation of top of Herrin Coal, contour interval 25 feet
- A—A′ — Line of cross section

Note: This subcrop map shows the bedrock surface with all Quaternary deposits removed. Geology shown as it was prior to surface mining. Except for the southern edge of the White Ash Fault Zone, faults are shown where they intersect Herrin Coal. Well and boring records are on file at the ISGS Geological Records Unit and are available online from the ISGS Web site.

Base map compiled by Illinois State Geological Survey from digital data provided by the United States Geological Survey. Topography by photogrammetric methods from aerial photographs taken 1959. Field checked 1963. Photoinspected 1976; no major changes.

North American Datum of 1927 (NAD 27)
Projection: Transverse Mercator
10,000-foot ticks: Illinois State Plane Coordinate system, east zone (Transverse Mercator)
1,000-meter ticks: Universal Transverse Mercator grid system, zone 16

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SCALE 1:24,000

1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 KILOMETER

BASE MAP CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Released by the authority of the State of Illinois: 2007

Geology based on field work and data analysis by W.J. Nelson, 2001–2003.

Digital cartography and graphics by J. Domier, T. Goeppinger, M. Bentley, L. Verhelst, and M. Widener, Illinois State Geological Survey.

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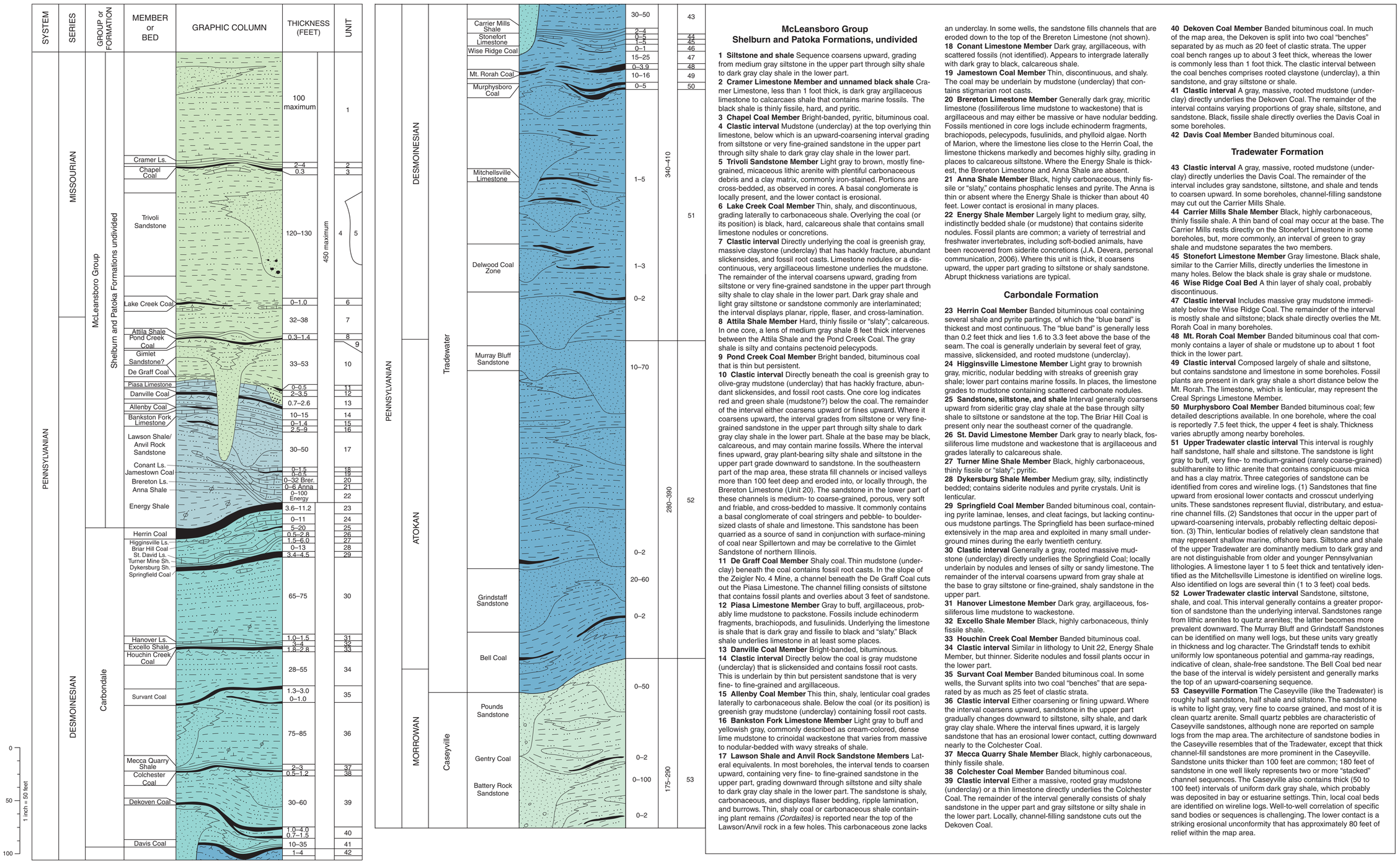
ADJOINING QUADRANGLES
1 Christopher
2 West Frankfort
3 Thompsonville
4 Herrin
5 Pittsburg
6 Crab Orchard Lake
7 Marion
8 Crab Orchard

APPROXIMATE MEAN DECLINATION, 2007

ROAD CLASSIFICATION

- Primary highway, hard surface
- Secondary highway, hard surface
- Light-duty road, hard or improved surface
- Unimproved road
- Interstate Route
- State Route



McLeansboro Group
Shelburn and Patoka Formations, undivided

1 Siltstone and shale Sequence coarsens upward, grading from medium gray siltstone in the upper part through silty shale to dark gray clay shale in the lower part.

2 Cramer Limestone Member and unnamed black shale Cramer Limestone, less than 1 foot thick, is dark gray argillaceous limestone to calcarcaes shale that contains marine fossils. The black shale is thinly fissile, hard, and pyritic.

3 Chapel Coal Member Bright-banded, pyritic, bituminous coal.

4 Clastic interval Mudstone (underclay) at the top overlying thin limestone, below which is an upward-coarsening interval grading from siltstone or very fine-grained sandstone in the upper part through silty shale to dark gray clay shale in the lower part.

5 Trivoli Sandstone Member Light gray to brown, mostly fine-grained, micaceous lithic arenite with plentiful carbonaceous debris and a clay matrix, commonly iron-stained. Portions are cross-bedded, as observed in cores. A basal conglomerate is locally present, and the lower contact is erosional.

6 Lake Creek Coal Member Thin, shaly, and discontinuous, grading laterally to carbonaceous shale. Overlying the coal (or its position) is black, hard, calcareous shale that contains small limestone nodules or concretions.

7 Clastic interval Directly underlying the coal is greenish gray, massive claystone (underclay) that has hackly fracture, abundant slickensides, and fossil root casts. Limestone nodules or a discontinuous, very argillaceous limestone underlies the mudstone. The remainder of the interval coarsens upward, grading from siltstone or very fine-grained sandstone in the upper part through silty shale to clay shale in the lower part. Dark gray shale and light gray siltstone or sandstone commonly are interlaminated; the interval displays planar, ripple, flaser, and cross-lamination.

8 Attila Shale Member Hard, thinly fissile or "slaty"; calcareous. In one core, a lens of medium gray shale 8 feet thick intervenes between the Attila Shale and the Pond Creek Coal. The gray shale is silty and contains pectenoid pelecypods.

9 Pond Creek Coal Member Bright banded, bituminous coal that is thin but persistent.

10 Clastic interval Directly beneath the coal is greenish gray to olive-gray mudstone (underclay) that has hackly fracture, abundant slickensides, and fossil root casts. One core log indicates red and green shale (mudstone?) below the coal. The remainder of the interval either coarsens upward or fines upward. Where it coarsens upward, the interval grades from siltstone or very fine-grained sandstone in the upper part through silty shale to dark gray clay shale in the lower part. Shale at the base may be black, calcareous, and may contain marine fossils. Where the interval fines upward, gray plant-bearing silty shale and siltstone in the upper part grade downward to sandstone. In the southeastern part of the map area, these strata fill channels or incised valleys more than 100 feet deep and eroded into, or locally through, the Brereton Limestone (Unit 20). The sandstone in the lower part of these channels is medium- to coarse-grained, porous, very soft and friable, and cross-bedded to massive. It commonly contains a basal conglomerate of coal stringers and pebble- to boulder-sized clasts of shale and limestone. This sandstone has been quarried as a source of sand in conjunction with surface-mining of coal near Spillertown and may be correlative to the Gimlet Sandstone of northern Illinois.

11 De Graff Coal Member Shaly coal. Thin mudstone (underclay) beneath the coal contains fossil root casts. In the slope of the Zeigler No. 4 Mine, a channel beneath the De Graff Coal cuts out the Piasa Limestone. The channel filling consists of siltstone that contains fossil plants and overlies about 3 feet of sandstone.

12 Piasa Limestone Member Gray to buff, argillaceous, probably lime mudstone to packstone. Fossils include echinoderm fragments, brachiopods, and fusulinids. Underlying the limestone is shale that is dark gray and fissile to black and "slaty." Black shale underlies limestone in at least some places.

13 Danville Coal Member Bright-banded, bituminous.

14 Clastic interval Directly below the coal is gray mudstone (underclay) that is slickensided and contains fossil root casts. This is underlain by thin but persistent sandstone that is very fine- to fine-grained and argillaceous.

15 Allenby Coal Member This thin, shaly, lenticular coal grades laterally to carbonaceous shale. Below the coal (or its position) is greenish gray mudstone (underclay) containing fossil root casts.

16 Bankston Fork Limestone Member Light gray to buff and yellowish gray, commonly described as cream-colored, dense lime mudstone to crinoidal wackestone that varies from massive to nodular-bedded with wavy streaks of shale.

17 Lawson Shale and Anvil Rock Sandstone Members Lateral equivalents. In most boreholes, the interval tends to coarsen upward, containing very fine- to fine-grained sandstone in the upper part, grading downward through siltstone and silty shale to dark gray clay shale in the lower part. The sandstone is shaly, carbonaceous, and displays flaser bedding, ripple lamination, and burrows. Thin, shaly coal or carbonaceous shale containing plant remains *(Cordaites)* is reported near the top of the Lawson/Anvil rock in a few holes. This carbonaceous zone lacks an underclay. In some wells, the sandstone fills channels that are eroded down to the top of the Brereton Limestone (not shown).

18 Conant Limestone Member Dark gray, argillaceous, with scattered fossils (not identified). Appears to intergrade laterally with dark gray to black, calcareous shale.

19 Jamestown Coal Member Thin, discontinuous, and shaly. The coal may be underlain by mudstone (underclay) that contains stigmarian root casts.

20 Brereton Limestone Member Generally dark gray, micritic limestone (fossiliferous lime mudstone to wackestone) that is argillaceous and may either be massive or have nodular bedding. Fossils mentioned in core logs include echinoderm fragments, brachiopods, pelecypods, fusulinids, and phylloid algae. North of Marion, where the limestone lies close to the Herrin Coal, the limestone thickens markedly and becomes highly silty, grading in places to calcareous siltstone. Where the Energy Shale is thickest, the Brereton Limestone and Anna Shale are absent.

21 Anna Shale Member Black, highly carbonaceous, thinly fissile or "slaty," contains phosphatic lenses and pyrite. The Anna is thin or absent where the Energy Shale is thicker than about 40 feet. Lower contact is erosional in many places.

22 Energy Shale Member Largely light to medium gray, silty, indistinctly bedded shale (or mudstone) that contains siderite nodules. Fossil plants are common; a variety of terrestrial and freshwater invertebrates, including soft-bodied animals, have been recovered from siderite concretions (J.A. Devera, personal communication, 2006). Where this unit is thick, it coarsens upward, the upper part grading to siltstone or shaly sandstone. Abrupt thickness variations are typical.

Carbondale Formation

23 Herrin Coal Member Banded bituminous coal containing several shale and pyrite partings, of which the "blue band" is thickest and most continuous. The "blue band" is generally less than 0.2 feet thick and lies 1.6 to 3.3 feet above the base of the seam. The coal is generally underlain by several feet of gray, massive, slickensided, and rooted mudstone (underclay).

24 Higginsville Limestone Member Light gray to brownish gray, micritic, nodular bedding with streaks of greenish gray shale; lower part contains marine fossils. In places, the limestone grades to mudstone containing scattered carbonate nodules.

25 Sandstone, siltstone, and shale Interval generally coarsens upward from sideritic gray clay shale at the base through silty shale to siltstone or sandstone at the top. The Briar Hill Coal is present only near the southeast corner of the quadrangle.

26 St. David Limestone Member Dark gray to nearly black, fossiliferous lime mudstone and wackestone that is argillaceous and grades laterally to calcareous shale.

27 Turner Mine Shale Member Black, highly carbonaceous, thinly fissile or "slaty"; pyritic.

28 Dykersburg Shale Member Medium gray, silty, indistinctly bedded; contains siderite nodules and pyrite crystals. Unit is lenticular.

29 Springfield Coal Member Banded bituminous coal, containing pyrite laminae, lenses, and cleat facings, but lacking continuous mudstone partings. The Springfield has been surface-mined extensively in the map area and exploited in many small underground mines during the early twentieth century.

30 Clastic interval Generally a gray, rooted massive mudstone (underclay) directly underlies the Springfield Coal; locally underlain by nodules and lenses of silty or sandy limestone. The remainder of the interval coarsens upward from gray shale at the base to gray siltstone or fine-grained, shaly sandstone in the upper part.

31 Hanover Limestone Member Dark gray, argillaceous, fossiliferous lime mudstone to wackestone.

32 Excello Shale Member Black, highly carbonaceous, thinly fissile shale.

33 Houchin Creek Coal Member Banded bituminous coal.

34 Clastic interval Similar in lithology to Unit 22, Energy Shale Member, but thinner. Siderite nodules and fossil plants occur in the lower part.

35 Survant Coal Member Banded bituminous coal. In some wells, the Survant splits into two coal "benches" that are separated by as much as 25 feet of clastic strata.

36 Clastic interval Either coarsening or fining upward. Where the interval coarsens upward, sandstone in the upper part gradually changes downward to siltstone, silty shale, and dark gray clay shale. Where the interval fines upward, it is largely sandstone that has an erosional lower contact, cutting downward nearly to the Colchester Coal.

37 Mecca Quarry Shale Member Black, highly carbonaceous, thinly fissile shale.

38 Colchester Coal Member Banded bituminous coal.

39 Clastic interval Either a massive, rooted gray mudstone (underclay) or a thin limestone directly underlies the Colchester Coal. The remainder of the interval generally consists of shaly sandstone in the upper part and gray siltstone or silty shale in the lower part. Locally, channel-filling sandstone cuts out the Dekoven Coal.

40 Dekoven Coal Member Banded bituminous coal. In much of the map area, the Dekoven is split into two coal "benches" separated by as much as 20 feet of clastic strata. The upper coal bench ranges up to about 3 feet thick, whereas the lower is commonly less than 1 foot thick. The clastic interval between the coal benches comprises rooted claystone (underclay), a thin sandstone, and gray siltstone or shale.

41 Clastic interval A gray, massive, rooted mudstone (underclay) directly underlies the Dekoven Coal. The remainder of the interval contains varying proportions of gray shale, siltstone, and sandstone. Black, fissile shale directly overlies the Davis Coal in some boreholes.

42 Davis Coal Member Banded bituminous coal.

Tradewater Formation

43 Clastic interval A gray, massive, rooted mudstone (underclay) directly underlies the Davis Coal. The remainder of the interval includes gray sandstone, siltstone, and shale and tends to coarsen upward. In some boreholes, channel-filling sandstone may cut out the Carrier Mills Shale.

44 Carrier Mills Shale Member Black, highly carbonaceous, thinly fissile shale. A thin band of coal may occur at the base. The Carrier Mills rests directly on the Stonefort Limestone in some boreholes, but, more commonly, an interval of green to gray shale and mudstone separates the two members.

45 Stonefort Limestone Member Gray limestone. Black shale, similar to the Carrier Mills, directly underlies the limestone in many holes. Below the black shale is gray shale or mudstone.

46 Wise Ridge Coal Bed A thin layer of shaly coal, probably discontinuous.

47 Clastic interval Includes massive gray mudstone immediately below the Wise Ridge Coal. The remainder of the interval is mostly shale and siltstone; black shale directly overlies the Mt. Rorah Coal in many boreholes.

48 Mt. Rorah Coal Member Banded bituminous coal that commonly contains a layer of shale or mudstone up to about 1 foot thick in the lower part.

49 Clastic interval Composed largely of shale and siltstone, but contains sandstone and limestone in some boreholes. Fossil plants are present in dark gray shale a short distance below the Mt. Rorah. The limestone, which is lenticular, may represent the Creal Springs Limestone Member.

50 Murphysboro Coal Member Banded bituminous coal; few detailed descriptions available. In one borehole, where the coal is reportedly 7.5 feet thick, the upper 4 feet is shaly. Thickness varies abruptly among nearby boreholes.

51 Upper Tradewater clastic interval This interval is roughly half sandstone, half shale and siltstone. The sandstone is light gray to buff, very fine- to medium-grained (rarely coarse-grained) sublitharenite to lithic arenite that contains conspicuous mica and has a clay matrix. Three categories of sandstone can be identified from cores and wireline logs. (1) Sandstones that fine upward from erosional lower contacts and crosscut underlying units. These sandstones represent fluvial, distributary, and estuarine channel fills. (2) Sandstones that occur in the upper part of upward-coarsening intervals, probably reflecting deltaic deposition. (3) Thin, lenticular bodies of relatively clean sandstone that may represent shallow marine, offshore bars. Siltstone and shale of the upper Tradewater are dominantly medium to dark gray and are not distinguishable from older and younger Pennsylvanian lithologies. A limestone layer 1 to 5 feet thick and tentatively identified as the Mitchellsville Limestone is identified on wireline logs. Also identified on logs are several thin (1 to 3 feet) coal beds.

52 Lower Tradewater clastic interval Sandstone, siltstone, shale, and coal. This interval generally contains a greater proportion of sandstone than the underlying interval. Sandstones range from lithic arenites to quartz arenites; the latter becomes more prevalent downward. The Murray Bluff and Grindstaff Sandstones can be identified on many well logs, but these units vary greatly in thickness and log character. The Grindstaff tends to exhibit uniformly low spontaneous potential and gamma-ray readings, indicative of clean, shale-free sandstone. The Bell Coal bed near the base of the interval is widely persistent and generally marks the top of an upward-coarsening sequence.

53 Caseyville Formation The Caseyville (like the Tradewater) is roughly half sandstone, half shale and siltstone. The sandstone is white to light gray, very fine to coarse grained, and most of it is clean quartz arenite. Small quartz pebbles are characteristic of Caseyville sandstones, although none are reported on sample logs from the map area. The architecture of sandstone bodies in the Caseyville resembles that of the Tradewater, except that thick channel-fill sandstones are more prominent in the Caseyville. Sandstone units thicker than 100 feet are common; 180 feet of sandstone in one well likely represents two or more "stacked" channel sequences. The Caseyville also contains thick (50 to 100 feet) intervals of uniform dark gray shale, which probably was deposited in bay or estuarine settings. Thin, local coal beds are identified on wireline logs. Well-to-well correlation of specific sand bodies or sequences is challenging. The lower contact is a striking erosional unconformity that has approximately 80 feet of relief within the map area.

Introduction

This map depicts the bedrock formations of the Johnston City Quadrangle as they would appear if all surficial deposits were removed. The entire map area is blanketed with Quaternary sediments, including Illinoian glacial drift, Wisconsinan lake sediments, Illinoian and Wisconsinan wind-blown silt (loess), and Holocene stream deposits. The only rock exposures are in abandoned surface mines, and these are badly weathered, heavily vegetated, and difficult to access.

Information for making this map came from several sources. I visited several surface and underground coal mines in this quadrangle while they were active. Notes and sketches made in mines by other Illinois State Geological Survey (ISGS) geologists are archived in the ISGS library. Coal mine maps, preserved on microfilm and as paper copies in the ISGS library and at the courthouse in Marion, record faults and, in many cases, include surveyed elevations of the coal seam. All borehole records on file at the ISGS were consulted. Electric logs and other geophysical logs and/or sample studies are available for most of the petroleum exploration holes. Coal-test holes generally yield drillers' logs and, in many cases, core descriptions made by geologists. The overall density and quality of drill-hole information in this quadrangle is excellent.

Stratigraphy

McLeansboro Group
Pennsylvanian strata overlying the Herrin Coal on this map are assigned to the McLeansboro Group. According to the Tri-State Committee (2001), the McLeansboro constitutes the Shelburn (oldest), Patoka, Bond, and Mattoon Formations throughout the Illinois Basin (Illinois, Indiana, and western Kentucky). These formations are essentially similar in overall lithology; their boundaries are based on widely traceable limestone members. The Shelburn-Patoka contact is defined as the top of the West Franklin Limestone Member or its equivalent, the top of the Exline (Scottville) Limestone (Tri-State Committee 2001, p. 16).

Geologic Structure

The Johnston City Quadrangle lies near the southern margin of the Illinois Basin. As shown by contour lines on the map, the Herrin Coal dips northward at an average rate of about 62 feet per mile or 1 foot in 85 feet, which amounts to a dip of 0.7°. Regional dip is obscured by local folding and faulting.

The White Ash Fault Zone lies west of and parallel to Interstate 57 in the southwestern part of the quadrangle. As encountered in underground and surface coal mines, the zone comprises mainly high-angle normal faults, but one small reverse fault was observed. In the southern part of the zone, the easternmost fault has displacement as much as 80 feet down to the east. To the north, the overall displacement is down to the west.

All other faults in the map area belong to the Cottage Grove Fault System. The master fault of the system follows a gently sinuous course eastward from Freeman Spur, just south of the county line. Along most of its length the north side is downthrown, but in one place the south side is down. This fault is thought to have a large component of right-lateral strike-slip movement, meaning that the rocks north of the fault were displaced horizontally eastward relative to rocks south of the fault (Nelson and Krausse 1981).

A sharply upthrown slice of rock surrounded by high-angle reverse faults lies on the south side of the master fault just east of Freeman Spur. The slice is lens-shaped and oriented northwest-southeast in map view. Data from the Old Ben Coal Company indicate that the Herrin Coal is upthrown as much as 250 feet compared with adjacent areas. The upthrown slice occurs where the master fault intersects a large northwest-trending fault. The map pattern suggests that the latter is younger and offsets the master fault with right lateral slip. The slice could be called a "positive flower structure" or "pop-up structure" and is evidence for a strong component of horizontal compression along the master fault (Duchek et al. 2004).

Northeast of Johnston City, the Pittsburg Anticline is on the south side of the master fault. The anticline provides the structural trap for the Johnston City East Oil Field. The Herrin Coal drops 200 feet in elevation within half a mile on the north flank of the fold. A smaller anticline, oriented northwest, is about 1 mile south of the Pittsburg Anticline.

A multitude of subsidiary faults accompany the master fault of the Cottage Grove Fault System. The majority strike northwest; all dip steeply. Normal faults are most common, but some subsidiary faults are reverse, and others show evidence (as viewed in underground mines) of strike-slip or oblique-slip motion. Some faults exhibit "scissoring" in which the downthrown side changes from one side of the fault to the other, pivoting through a hinge point of no apparent offset.

Economic Geology

Coal
Coal mining was the main industry in the Johnston City area for more than a century. The thickest coal seam, the Herrin Coal, is almost entirely mined out within the map area. The coal was surface-mined where it outcropped and exploited in underground mines to the north where depth increases. Peabody Coal Company's initial mining venture commenced in 1905 when it bought an existing mine that had opened in 1895. The interconnected workings of Peabody's No. 1, 2, and 3 Mines underlies Interstate 57 near the southern edge of the quadrangle. Other industry leaders that operated in the Johnston City Quadrangle include the Freeman United, Old Ben, and Zeigler Coal Companies.

The Springfield Coal has been mined far less extensively than the Herrin Coal in this area. Workings are confined to surface mines and a few shallow underground mines. The Springfield Coal is consistently close to 4 feet thick throughout the map area, and it probably has a high (3 to 5%) sulfur content.

Several deeper coal seams, the Dekoven, Davis, Mt. Rorah, and Murphysboro, all attain thickness of 4 feet at least locally. None of these seams have been mined within the map area, and the likelihood of mining under current economic conditions is low. All of these seams are lenticular, and the Murphysboro consists of isolated pods of thick coal.

Coal Bed Methane
Four wells are producing methane from abandoned coal mines in the northern part of the quadrangle. The wells are located in Secs. 1, 3, and 14 of T8S, R2E and Sec. 6, T8S, R3E. Initial gas production was reported as 908 million cubic feet per day from the well in Sec. 3 and 1,123 million cubic feet per day from the well in Sec. 1. Production figures from the other two wells is not reported. The Johnston City Quadrangle provides ample opportunities for recovering methane from abandoned mines, as nearly the entire map area has been undermined.

Commercial production of methane from wells drilled into virgin coal recently has commenced in western Saline County just east of this mapping area. Not counting the Herrin Coal, the Johnston City Quadrangle contains 20 feet or more of net coal seam thickness. Faults, a negative factor in mining, enhance methane production by providing fracture pathways. Most of the methane wells in Saline County have been drilled intentionally into or close to faults of the Cottage Grove Fault System.

Oil and Gas
Six oil fields and one gas field have been developed within the Johnston City Quadrangle. The largest in Williamson County is Johnston City East, northeast of its namesake city and extending beyond the map area. This field contains 21 wells, of which 14 were producing in 2004. Cumulative output is 1,228,600 barrels of oil (2004), which is about 36% of oil from Williamson County. Pay zones are sandstone reservoirs in the Cypress, Bethel, and Aux Vases Formations and limestone reservoirs in the Ste. Genevieve Limestone. In addition, a little gas has been recovered from the Tar Springs Formation. All producing formations are of Chesterian (Upper Mississippian) age. The Pittsburg Anticline provides the trap for the resevoirs.

The Energy Oil Field in the southwestern part of the map area is the third largest in Williamson County. Discovered in 1968, the field contains 23 producing oil wells and 6 gas wells, of which 20 oil wells are still pumping. The reservoir rock is Aux Vases Formation at a depth of approximately 2,400 feet. Huff (1993) reported reservoirs are lenses of permeable sandstone encased in impermeable shale, limestone, and tightly cemented sandstone. Based on fossils and sedimentary structures observed in cores, Huff interpreted the reservoir facies as tidal sand ridges or bars. The trapping mechanism is primarily stratigraphic, although the field lies along a north-trending structural nose. Initial production of oil wells in the Energy Oil Field varied from 25 to 135 barrels per day. Huff estimated the original in-place reserves at slightly over 4 million barrels, of which approximately 21%, or 500,000 barrels, is recoverable. At the end of 2004, cumulative production was 406,600 barrels. The field is currently undergoing secondary recovery. Gas production in the Energy Oil Field came from the Palestine Sandstone, but most of the gas wells have been shut in.

The southern end of the West Frankfort Consolidated oil field is at the northern edge of the map area. Discovered in 1941, the field contains 187 wells; 75 of those are still working. Cumulative production is nearly 9 million barrels from multiple Mississippian pay zones: Tar Springs, Aux Vases, Ste. Genevieve, St. Louis, and Salem.

The Stiritz Oil Field, which lies mostly in Sec. 12, T8S, R2E, contained seven oil wells, of which five were completed in the Aux Vases Formation and two in the Bethel Sandstone. One gas well was completed in the Tar Springs Formation. All are currently shut in, having yielded 278,687 barrels of oil and 68 million cubic feet of gas. As at Johnston City East, the trap is a faulted anticline within the Cottage Grove Fault System. The White Ash Oil Field in the southwestern part of T8S, R2E consists of five wells completed in the Aux Vases and "Ohara" pay zones in the Karnak Member of the Ste. Genevieve Limestone. None of the wells exceeded 25 barrels of oil per day initial production, but three were still pumping in 2004, when cumulative output stood at 36,700 barrels. The trap is apparently stratigraphic, although the White Ash Fault Zone may have played a role in migration and trapping of oil.

The Freeman Spur Oil Field in Sec. 4, T8S, R2E comprises three wells completed in the Aux Vases Formation. The field was discovered in 1968 and abandoned in 1979, having yielded fewer than 4,000 barrels. The reservoir is a lens of permeable sandstone on the flank of a small, faulted anticline; dry holes were drilled structurally higher than producers. The Herrin oil field is a single well (Sec. 21, T8S, R2E), which produced 1,971 barrels from a "bar" sand at the top of the Cypress Formation between 1965 and 1972.

The Pittsburg gas field includes four wells; three of those are within the map area (Sec. 33, T8S, R3E and Sec. 4, T9S, R3E). Cumulative production amounted to 170 million cubic feet and came from stratigraphic traps in lenticular sandstone bodies of the Tar Springs Formation.

Only two holes have tested petroleum possibilities below the Ste. Genevieve Limestone. In the Energy Oil Field, the Vaughn 5 Eovaldi-Fairchild test was drilled to a depth of 4,419 feet in the Lower Devonian Clear Creek Formation. The operator reported a small show of oil in the Mississippian Salem Limestone and a show of gas in the Upper Devonian New Albany Shale. No drill-stem tests were performed, and the hole was plugged and abandoned. In the Stiritz field, the C.E. Brehm 3B Littlefair was drilled to 4,669 feet, also in the Clear Creek Formation. Oil shows were encountered in the Mississippian "Warsaw" (Ullin) Limestone, and a little gas was recovered during a test. A drill-stem test in Middle Devonian limestone recovered oil, but not in paying quantities; the hole was plugged and abandoned.

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