Geologic Structures in the Coal City and Switz City Area of Indiana

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Introduction

Coal beds and the adjacent associated strata, such as are exposed in the Coal City and Switz City area, exhibit an unusual diversity of structural features and sedimentary unconformity. Recognition and interpretation of the structures are of economic benefit in the exploration and mining of coal, in the search for oil and gas, and in the quarrying of sandstones, limestones, shales, and clays within the coal-bearing formations.

The Coal City and Switz City area is on the eastern edge of the coal fields of southwestern Indiana and is about 30 miles southeast of Terre Haute (Fig. 1). The area lies within two physiographic divisions of Indiana, the western part in the Wabash Lowland and the eastern part a fringe of the Crawford Upland. Narrow ridges separated by wide expanses of alluvial bottomlands are characteristic of the topography.

The field work in the area was done during 1949 and 1950 for the Coal Section of the Indiana Geological Survey. This paper is published with permission of the State Geologist, Dr. Charles Deiss, and has been reviewed by Charles E. Weir, head of the Coal Section.

Stratigraphy

The rocks exposed in the Coal City and Switz City quadrangles are Lower Pennsylvanian and Quaternary in age. The upper part of the Mansfield formation, the Brazil and Staunton formations, and the lower part of the Linton formation crop out (Fig. 2). The nearest Mississippian rocks, of the Chester series, crop out below Mansfield sandstone beds four miles east of the quadrangles. Quaternary sediments are Illinoian till and Wisconsin proglacial deposits that overlie the bedrock and so blanket the area that outcrops of the Pennsylvanian rocks are limited to strip pits, road cuts, and deeply eroded stream valleys.

The basal Pennsylvanian Mansfield formation overlies Mississippian rocks with a pronounced erosional unconformity east of Switz City but only the upper 30 to 45 feet of the formation crops out in the mapped area. The formation in drillings ranges from 152 to 266 feet in thickness, averaging 210 feet. The beds are characteristically light-gray to gray, cross-laminated, ripple-marked sandstones that weather to rust-brown honeycombed bluffs. The upper one-fifth of the formation is locally a blue-gray shale. A thin dark-gray limestone and associated black shales occur in places near the top of the Mansfield formation and are probably correlative with the Ferdinand limestone of southern Indiana (2). Lenses of minable coal are locally present at several horizons within the Mansfield formation.

The Brazil formation is divisible into eight units, from base upward, as follows: (1) the Lower Block coal, which averages about 2 feet thick, (2) blue-gray to gray shale with thin sandstone laminae, 9 to 36 feet thick, (3) the Upper Block coal and its underclay, 3 to 7 feet thick, (4) a hard gray sandstone overlain by a gray sandy concretionary shale, 15 to 36 feet thick, (5) the Minshall coal and its underclay, several feet thick, (6) black to dark-gray shales and the Minshall limestone; the lower shales are 5 to 16 feet thick, the limestone 2 to 14 feet thick, (7) gray sandy shale and light-gray sandstone, about 12 feet thick, (8) Coal II, about 6 inches thick.

In many places the upper beds of the Brazil formation were removed

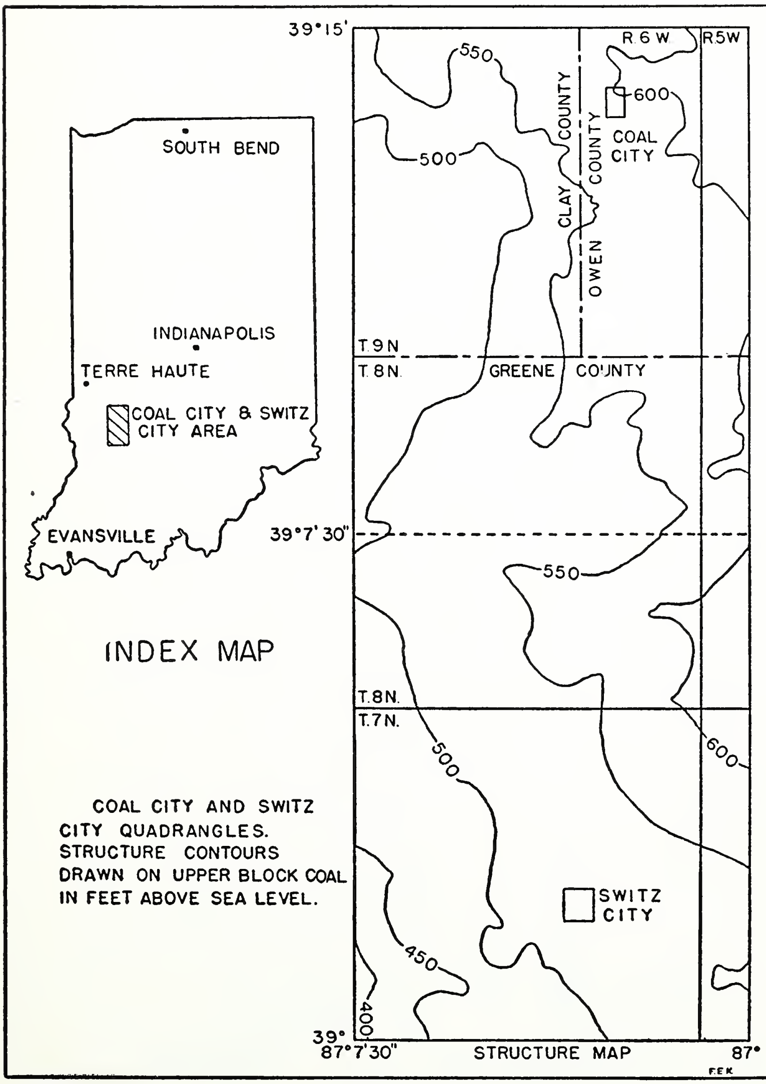

FIGURE 1.

by erosion, and the basal sandstone of the Staunton formation rests on the Minshall limestone or lower horizons.

The Minshall coal and limestone are named after the small village of Minshall in south central Parke County, Indiana. The limestone and coal crop out in the bluffs and ravines near Minshall, but no connected section is exposed, therefore the type section is taken partly from mining information. A section near Minshall is as follows, from outcrops and from Ashley (1):

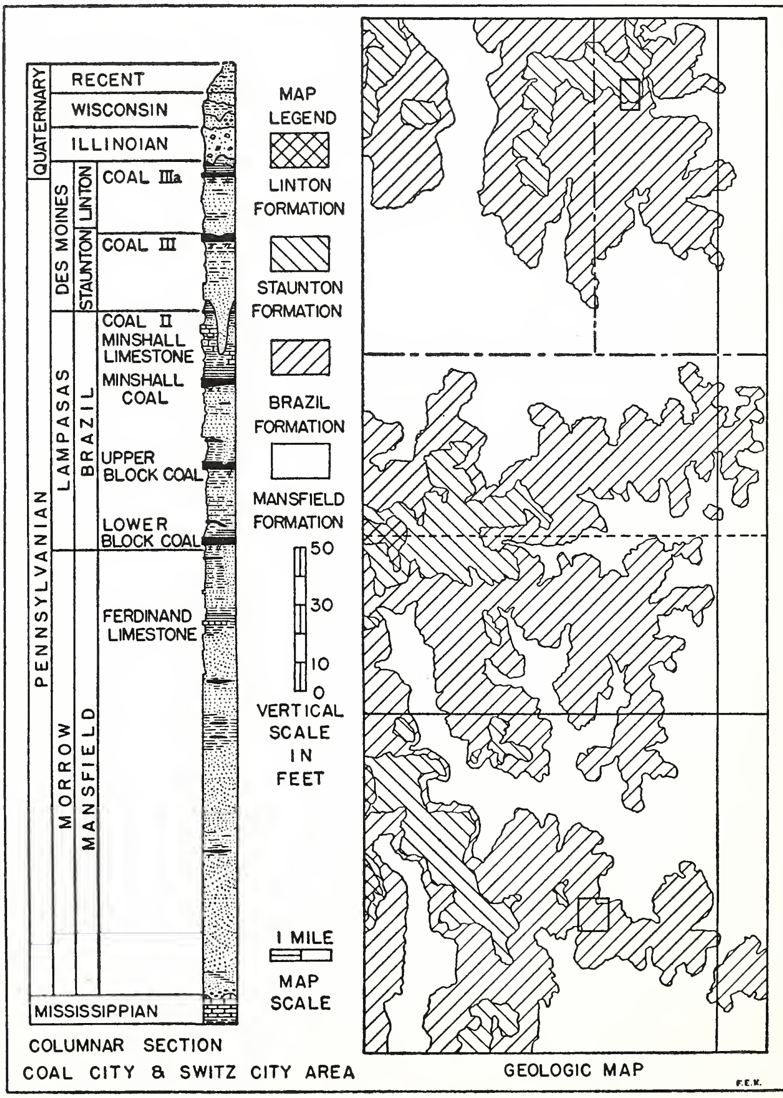

FIGURE 2

NW¼ sec. 17, T. 14 N., R. 7 W.:	Feet
8. Shale, sandy; locally shaly fossiliferous limestone lenses near base	30 plus
7. Upper Minshall coal, or Coal II, semi-block	1.0–3.2
6. Clay, light-gray	2
5. Shale, blue	8–18
4. Minshall limestone, blue-gray, thick-bedded, cherty, fossiliferous	2–3
3. Shale, black, sheety	3–14
2. Minshall coal, semi-block, dull, some pyrites	3.7-5.5
1. Underclay, gray to dark-gray	4–5
NW¼ sec. 35, T. 14 N., R. 7 W., Superior No. 2 Shaft:	Feet
6. Shale, dark gray, beneath underclay	6–2
5. Upper Block coal	4.3–5.1
4. Fireclay, lower part concretionary	4–5
3. Shale, sandy, brownish-gray	16
2. Shale, brown, blocky	10–12
1. Lower Block coal	2.0-4.5

The fauna of the Minshall limestone near Coal City is characterized by the brachiopods *Marginifera haydenensis, M. wabashensis* and by *Fusulinella* sp. therefore appears to be of Lampasas age. The Minshall limestone correlates with the Seville limestone in western Illinois and the lower Mercer limestone in Ohio.

The Staunton formation is 19 to 55 feet thick in the Coal City and Switz City quadrangles where it can be differentiated. The basal member is a light-gray, cross-laminated, micaceous, massive sandstone which varies greatly in thickness as it fills channels and depressions on a pre-Staunton surface. The sandstone is overlain by blue-gray sandy shale which underlies the underclay of Coal III. Coal III is 2 to 5 feet thick in the areas where it has not been cut out below the erosional surface at the base of the Linton formation.

The Linton formation is about 65 feet thick to the west but only the basal 30 feet occurs in the Coal City and Switz City quadrangles beneath the Quaternary glacial deposits. The basal bed is a light-gray micaceous sandstone, about 20 feet thick, overlain by gray clay shale that underlies Coal IIIa. Coal IIIa averages less than one foot thick and is overlain by 2 to 4 feet of marine black shale. To the west the black shale grades up into the thin Oak Grove limestone, and the limestone is overlain by a sequence of sandy shales capped by Coal IV.

The Pennsylvanian bedrock is covered by a blanket of Illinoian glacial till 4 to 82 feet thick. Till fills a buried pre-glacial valley in the northwestern part of the Coal City quadrangle, as indicated on the geological bedrock map (Fig. 2) by the thin strip of the Mansfield formation 2 to 3 miles west of Coal City. Valley train and lake sediments were deposited in the valleys during early Wisconsin time, and eolian sands and silts were blown onto adjoining uplands.

Figure 2, the geologic map of the bedrock in the Coal City and Switz City quadrangles, reflects: (1) the west-southwest dip of the Pennsylvanian beds, (2) the topography, (3) the distribution of glacial deposits and of pre-glacial valleys.

Regional Structure

The quadrangles are on the eastern edge of the Eastern Interior Coal Basin. The sedimentary beds dip west-southwest to west 15 to 40 feet per mile (Fig. 1). Small, irregularly distributed folds of the plains type interrupt the regional dip at many places. These anticlines, domes, noses, and basins increase in steepness downward, typically occupy less than one square mile, and have vertical closures ranging from 30 to 100 feet. Sandstone lenses in the coal-bearing rocks caused many small anticlines by differential compaction. The vertical closures above these lenses are rarely more than 20 feet.

The northern part of the Indiana coal field, from Vermillion County to Sullivan and Greene counties, is in a minor shallow syncline which is separated from the rest of the Eastern Interior Basin by the LaSalle anticline. The Block coals, Coal III, and Coal IV are thicker and more persistent in this syncline than anywhere else in the basin. The syncline was a controlling factor in the deposition of these older coals as is indicated by their areal extent.

Local Structures

Local structures include two types: (1) primary structures, (2) secondary structures. Primary structures are those due to deposition or erosion during Pennsylvanian time contemporaneous with sedimentation. These are called inorganic mechanical structures by Pettijohn (6). Secondary structures are those due to tectonic movements after lithification of the rocks and are usually of post-Pennsylvanian age in the area.

Primary Structures—Structures due to deposition or erosion during Pennsylvanian time are widespread in the mapped area. Southwestern Indiana was part of a low, uneven, coastal plain during most of Pennsylvanian time, and in depressions on this surface coal swamps formed. The lenticular character of the Lower Pennsylvanian coals suggests that most of the persistent coal swamps during the time were relatively local. Thin, impure limestones and associated black shales were deposited when the coastal plain sank below sea level, with thicker deposits being formed in the deeper coal basins. Post-Staunton coals, such as Coal V, are at least 3 to 5 feet thick over hundreds of square miles because they were deposited in larger shallow depressions.

An analogous situation might be the present-day Dismal Swamp in North Carolina and Virginia, a fresh-water swamp, which lies on the Atlantic Coastal plain with its surface only 5 to 25 feet above sea level (7). It covers an area of 2,200 square miles, and contains an average of 7 feet of peat. The lenses of thick Brazil coals in Indiana cover much smaller areas and their distribution indicates a more or less continuous swamp in southwestern Indiana with the thicker lenses deposited in the deeper depressions. The block coals contain more durain and cannel coal than later coals, therefore are composed of the smaller and more resistant fragments of plants. These resistant vegetal portions collect in open water (5) and would tend to be concentrated in local deeper basins.

Pennsylvanian rocks in the Eastern Interior Basin record the rhythmic advance and retreat of shallow sea waters in which thin limestones and marine shales were deposited. Absence of the sea was marked by the spreading of terrestrial sandstones and shales, by the establishment of large coal swamps, by the development of underclays which in most cases were poorly drained soils, and by the deposition of freshwater limestones. Widespread unconformities mark the pronounced changes in sea level in contrast to local unconformities which occur at the base of most Pennsylvanian sandstones and are produced by the streams that deposited the sandstones.

The coals were originally deposited as masses of vegetation in swamps, the plant material was compacted to peat, and the peat under pressure of superimposed sediments lost water and gases until coal was formed. The plant material is compressed ⅛ to 1/20 of its thickness to form coal. Before compaction the swamp basin is filled by peat to a level surface. After compaction the top of the coal bed in the center of the swamp is lower than the top of the coal bed around the margins of the basin. The margins of the coal basins, therefore, are indicated by coal beds that dip upward away from the lower parts of the basin and that thin away from the center of the basin. The margin of an Upper Block coal basin is exposed in the west highwall of the strip pit in the NW¼ sec. 23, T. 9 N., R. 6 W. where the coal bed dips steeply south and thins to the north.

Locally sand bars were deposited by streams in the pre-swamp basins. These sandbars were only partly buried by plant material and were preserved as ridges over which the coal is thin or absent. Many of these ridges, called horsebacks by the miners, occur in the small mines southeast of Coal City in Sec. 24, T. 9 N., R. 6 W. A typical horseback is exposed in the Commadore strip mine beneath the Minshall coal north of Coal City.

Local partings are common in the coals of the Brazil formation. Splitting of the coals into benches separated by thick clay, shale, or even sandstone partings has caused much confusion in correlation and locally has made mining costly. Many of the younger and more extensive coals, such as Coals III, IV, and VI, have clay partings that are present throughout most of the Indiana coal field. The partings in the Brazil coals are local lenticular beds of shale or sandstone deposited by streams during a brief pause in the deposition of plant material in the coal swamps. A 0.4 to 1.1 foot shale bed that grades laterally into sandstone is present in the middle of the Lower Block coal in outcrops along the ravine in NW¼ sec. 13, T. 9 N., R. 6 W. Two thick shale partings occur in outcrops of the Upper Block coal in the west bank of the ravine in NE¼ sec. 10, T. 8 N., R. 6 W. A thick sandstone and shale wedge splits Coal II into two thin beds near the east end of the well-exposed outcrops in the Illinois Central Railroad cut, Sec. 21, T. 7 N., R. 6 W.

Rock fillings of channels cut into coal beds are called rolls and crop out in the highwalls of almost all strip pits mining the Block coals. The channels either were cut after deposition and lithification of the coal bed or by open water currents during the deposition of the plant material in the coal swamp. Channel fillings contemporaneous with coal deposition are characterized by: (1) coal laminae that extend from the coal bed into the sandstone fill rock as discontinuous fingers, (2) the coal's usual roof extends over the channel fill, (3) the upper coal laminae in the sandstone fill bend upward from the coal bed. A contemporaneous channel fill of sandstone crops out in the east highway of the strip pit in SE¼ sec. 4, T. 9 N., R. 6 W.

Sandstones that fill channels cut after coal deposition are abundant. A large channel cut through and almost 15 feet below the Upper Block coal and is filled by sandstone in sec. 9, T. 9 N., R. 6 W. in the Commadore strip pit. Near the north end of the same pit small channels are filled by a bright reddish-brown, coarse breccia containing fragments of coal and carbonized plant imprints in a matrix of hematite-impregnated sand and clay. A channel sandstone is well exposed in the west highwall of the strip pit in NW¼ sec. 23, T. 9 N., R. 6 W. where the channel was almost 500 feet wide. Many smaller channel sandstones crop out in the highwall of the strip pit in SW¼ sec. 12, T. 8 N., R. 6 W. One side of the channel in many places is a steep bluff of shale against which the sandstone abuts.

Secondary Structure—Structures due to tectonic movements are not pronounced in the mapped area. A small reverse fault crops out in the southeast highwall of the strip pit in the SE¼ sec. 4, T. 9 N., R. 6 W. The Upper Block coal in the western footwall is dragged upward along the fault plane and in the eastern hanging wall is intimately shattered and thrust relatively westward 7 feet. The throw of the fault is 8 feet. A similar shallow Pleistocene overthrust was reported by Wier (9) southwest of Linton. A normal fault is exposed in the Illinois Central Railroad cut in sec. 21, T. 7 N., R. 6 W. Here Coal II is faulted as a result of differential compaction under a sandstone lense.

The gentle west or west-southwest dip of the Pennsylvanian beds in the area is interrupted by small domes, noses, and basins. Some of these structures are due to differences in deposition during Pennsylvanian time but in many places they reflect deeper structures. The most pronounced structural feature in the Switz City area is the terrace several miles west and southwest of Switz City (Fig. 1). The structure is partly concealed by unconsolidated deposits south of Switz City but two noses and a small dome are indicated by detailed structure contours (3). The steep dip west of the terrace is based on relatively sparse information. The low narrow structural ridge in the northern part of the Switz City quadrangle parallels a similar ridge in the southern part of the Coal City quadrangle (Fig. 1). The broad, irregular terrace near Coal City and the southward plunging nose in the northwest corner of the quadrangle are the chief structural units in the northern part of the mapped area.

The larger secondary structures are indicated by the contours on the structure map (Fig. 1) which are drawn on the top of the Upper Block coal because less error is introduced in calculating to its horizon from data on other coals. Actually none of the three main coals (Lower Block, Upper Block, Minshall) are too reliable as structural horizons as their elevations are partly controlled by sandstone lenses, by thickness variations of the rocks between the coal beds, and by the thickness variations of the underlying Mansfield formation. Shallow drillings to the Mississippian Chester formations, which are 125 to 325 feet deep, would give satisfactory structural control and would reflect structures in the petroleum-bearing Devonian formations.

To the west the younger more persistent coal beds reflect, in general, structures beneath the Pennsylvanian rocks, and are a valuable guide to petroleum-producing highs. The Wilfred pool in the Hymera quadrangle (10) and the Heien and Marts pools in the Shelburn quadrangle (8) are outlined by and were discovered from coal domes. Some of the folds, however, are the result of differential compaction around and over sandstone lenses within the Pennsylvanian rocks, such as the structural ridge in the northwestern part of the Dugger quadrangle (4) which is almost entirely due to a thickening of sandstones between Coal IV and Coal V.

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