

STATEMAP
Harco-BG

Bedrock Geology of Harco Quadrangle

Saline, Williamson, and Franklin Counties, Illinois

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2015



ILLINOIS STATE
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Stratigraphy

Following are remarks on selected the units named on the stratigraphic column.

Permian age igneous rocks

Ultramafic dikes have been observed throughout southeastern Illinois and northwestern Kentucky. Excellent exposures of these ultramafic bodies have been encountered in underground and surface coal mine workings within the region. These igneous bodies are ultramafic, vertical or nearly vertical dikes that normally trend in a north-northwest direction. Due to the mineralogy of the dikes, we assume they have ascended from the upper portion of the earth's mantle, deep within the earth, intruding upward into the Paleozoic rocks (Denny et al., 2002). The igneous intrusions were emplaced about 270 million years ago or during the Permian (Fifarek et al., 2001), and are interpreted to be ascending very rapidly along the northwesterly-trending joints and fractures within the Precambrian basement. The igneous features contain several percent magnetite, which provides a strong magnetic contrast compared to the surrounding sedimentary host rock. Success locating these dikes has been found using magnetic surveys (Hildenbrand and Ravat, 1997; Silverman et al., 2003).

Mapping of these features indicates that some of these dikes can be traced along strike for several miles. Most dikes are a few feet in width, but a dike encountered in a coal mine at Harrisburg, Illinois was reported to be over 100 feet wide (Denny et al., 2006). The dikes may be associated with faults of small to moderate displacement, but in other instances the dikes split the coal seam without appreciable offset of the coal on either side of the dike. The dikes are usually along very straight linear trends and may intrude through the entire Pennsylvanian units or sill out below the Pennsylvanian coals in lower Paleozoic units. Horizontal sills formed adjacent to the dikes in the Paleozoic units as the velocity of the ascending igneous dike slows (Sparlin and Lewis, 1994). The sills have been mainly documented by oil and gas exploration, where exploration wells intercept a bed of ultramafic rock a few feet to 75 feet thick between horizontal sedimentary layers. In addition to the linear dikes and interconnected horizontal sills, circular pipe shaped features or diatremes are also present that represent venting of the igneous complex to the paleosurface. Diatremes may have formed within the ultramafic magma due to rapid expulsion of volatiles potentially augmented by interaction with groundwater (phreatomagmatic). In some intrusions of this provenance volcanoclastic or diatreme phase features called shatter breccias have been observed. In shatter breccia the primary rock mass is composed clasts of country rock with a lesser amount of igneous material between sedimentary clasts.

Dikes plotted on this quadrangle are based on mine notes, IGS publications, and drill data. The dikes mostly trend

about N 20° W and have an irregular upper surface or top. From previous investigations it appears the dikes in this area are clustered around the Cottage Gove Fault. Along the north side of the Cottage Grove Fault the top surface of the dikes usually dips to the north. In July of 2015 the American Coal Company encountered a shatter breccia dike in their underground workings within their New Future Mine in the Harco Quadrangle. The underground workings south of the dike did not encounter the igneous feature. This suggests this particular dike is rising to the north and emphasizes that the orientation of these igneous features is difficult to predict.

Fairbanks Coal Member. The uppermost coal seam on the column is identified as the Fairbanks Coal Member (Bond Formation), which was named by Shaver et al. (1970) for the village of Fairbanks in Sullivan County, Indiana. The Fairbanks Coal has been widely traced though eastern and southern Illinois on subsurface cross sections (W.J. Nelson, unpublished data).

Stark Shale Member. The black, fissile shale that directly underlies the Carthage Limestone has been correlated with the Stark Shale Member of the Midcontinent on the basis of conodont biostratigraphy (Heckel and Weibel, 1991).

Raben Branch Coal Member. The thin coal seam (locally, two coal layers separated by shale) occurring 20 to 25 feet below the Stark Shale is correlated with the Raben Branch Coal Member, which was originally described in Posey County, Indiana (Shaver et al., 1970). The Raben Branch is distinct from the younger New Haven Coal (Parker Coal in Indiana), which occurs (where present) at the base of the Stark Shale.

Hushpuckney Shale Member. The black, fissile shale associated with the Macoupin Limestone has been correlated with the Hushpuckney Shale of the Midcontinent on the basis of conodont biostratigraphy (Heckel and Weibel, 1991). This unit is present through much of the Illinois Basin.

Womac Coal Member. There is some question as to the correct identity of the Womac Coal in the Harco quadrangle. Cores and mine exposures reveal a very thin coal layer or carbonaceous streak at the base of the Hushpuckney Shale and overlying a thick, well developed underclay (paleosol). At its type locality in Macoupin County, Illinois the Womac Coal occupies the same position (Kosanke et al., 1960). The much thicker coal that was extracted in the Phoenix Mine lies 20 to 37 feet below the Hushpuckney apparently represents an older cycle of deposition. Pending resolution of the question, the older and thicker coal layer has been labeled "Womac Coal".

Mound City Shale Member. The black, fissile shale associated with the Cramer Limestone Member has been correlated with the Mound City Shale of the Midcontinent on the basis

of conodont biostratigraphy (Heckel and Weibel, 1991).

Exline Limestone Member. A thin but widely persistent limestone unit in the study area is correlated with the Exline Limestone of the Midcontinent on the basis of regional subsurface correlation, supported by conodont biostratigraphy (Heckel and Weibel, 1991) and palynology of associated coal layers (Peppers, 1996). Unpublished cross sections by W.J. Nelson confirm that the Exline is directly continuous with the upper bench of the West Franklin Limestone east of the study area. Thus, the top of the Exline is considered to contact between the Patoka and Shelburn Formations. Moreover, the base of the Exline is the regional boundary between the Missourian and Desmoinesian Stages (Heckel et al., 2002).

Athensville Coal Member. This thin but widely persistent unit has been called both Athensville Coal (for a locality in Macoupin County) and Lake Creek Coal (for a site in Williamson County). Physical correlation and palynology (Peppers, 1996) indicates that both are the same unit. Given that Athensville and Lake Creek both were introduced in the same publication (Kosanke et al., 1960), neither name has priority. My arbitrary choice is to use Athensville, because this unit has a well-described type section in a stream cut, whereas the type section for the Lake Creek is in a drill core that no longer exists.

Attila Shale Member. This widespread unit of black, fissile shale was named by Nelson (2007) for the village of Attila in the adjacent Pittsburg quadrangle. The Attila is correlated with the Nuyaka Creek Shale of the Midcontinent on the basis of conodont biostratigraphy (Heckel, 2013).

Rock Branch Coal Member. Like the Athensville, this coal has gone under two names: Rock Branch (from Macoupin County) and Pond Creek (from Williamson County). Again, both names first appeared in the same publication (Kosanke et al., 1960), so neither has clear priority. I select the name Rock Branch to avoid duplication with the Pond Creek coal bed of eastern Kentucky.

Baker Coal Member. The name Allenby Coal Member (Kosanke et al., 1960) previously was used for the thin coal or pair of thin coals that lie a short distance above the Bankston Fork Limestone and below the Danville Coal. However, the Allenby clearly is the same as the Baker coal bed of western Kentucky, and the name Baker has priority (Glenn, 1912).

Survant Coal Member. In the Harco quadrangle, and throughout much of the Illinois Basin, the Survant Coal Member comprises two coal layers that developed in separate cycles of sedimentation. The upper and lower Survant coals probably correspond, respectively, with the Bevier and Wheeler Coal Beds of the Midcontinent.

Dekoven Coal Member. Without explaining the mecha-

nism, Jacobson (1987, 1993) described and mapped the two “benches” as a simple case of the Dekoven Member “splitting”. An alternative proposal is two distinct cycles of sedimentation, corresponding to the Greenbush (older) and Abingdon Coal Members of western Illinois (c.f. Wanless, 1957).

Structure

The map area is situated near the southern margin of the Illinois Basin. Contour lines on the geologic map depict elevation (structure) of the top of the Springfield Coal. These show an average northward dip of approximately 50 feet per mile, which translates to a 1% grade or a dip of ½ degree. A statewide map of Springfield Coal structure (ISGS, unpublished data) reveals that the northward dip markedly diminishes near the northern border of Saline County, and that the Springfield attains its lowest elevation through a broad area extending north-northeast from northeastern Hamilton to southwestern Jasper County. Structure of deeper horizons, including the top of the Mississippian Ste. Genevieve Limestone (Bristol and Howard, 1976), base of the Devonian New Albany Shale (Cluff et al., 1981), and top of the Ordovician Kimmswick (Trenton) Limestone (Bristol and Buschbach, 1973), broadly mirrors that of the coal. These maps show the deepest point in the basin roughly 25 miles north-northeast of the Galatia quadrangle in eastern Hamilton and northwestern White Counties. Also, these maps indicate the northward dip to be somewhat gentler on Mississippian and older horizons than on the coal.

The chief structural feature of the region is the Cottage Grove Fault System, the main part of which crosses the southern part of the quadrangle. The system comprises an east-trending “master fault zone” flanked by a series of smaller faults and igneous dikes that trend northwest. The master fault zone enters the Harco quadrangle from the west as a zone of strongly deformed rocks several hundred feet wide and trending approximately N 70° W. Exposures in ravines and a railroad cut show strata steeply upturned against both sides of the fault zone, producing a sharp-crested anticline. The Bankston Fork and Piasa Limestone crop out within the fault zone, and in one place the Herrin Coal may reach the surface. Near the Williamson-Saline county line the master fault zone bifurcates, one strand continuing eastward in sinuous fashion, and the other bearing southeast as a set of stair-step faults downthrown to the southwest. Just south of the southern border of the quadrangle, the southern strand returns to a due east heading.

The C.E. Brehm No. 1 Edwards oil test hole in NE¼ SE¼ NW¼, Sec. 1, T8S, R4E, Williamson County, penetrated the master fault at a depth of approximately 2,510 feet in the Mississippian Cypress Formation. The electric log indicates approximately 150 feet of repeated section, indicating a reverse fault. Projecting from the well penetrated to the surface trace, the average dip of the fault is approximately

72 degrees southwest.

Between the strands of the master fault and north of the northern strand are numerous northwest-trending faults and several igneous dikes. Most of the faults are high-angle normal, but some may be reverse or oblique-slip. The largest known throw is less than 20 feet. These faults and dikes can be mapped only where they were encountered in underground mines.

Regionally, the Cottage Grove is interpreted as a right-lateral strike-slip fault system. Geophysical data indicate that the zone penetrates basement rocks and may follow a Precambrian crustal boundary (Nelson and Krausse, 1981; Duchek et al., 2004). However, the lack of offset where the Galatia paleochannel crosses the fault zone (in the adjoining Galatia quadrangle) indicates that the strike-slip displacement near the surface is small.

Economic Geology

Coal. Coal is the leading economic resource in the Harco quadrangle. Mining began more than a century ago, and continues today. Most of the earlier mining took place underground in the Springfield Coal, which was 6 feet or thicker across large areas and had unusually low sulfur content for Illinois Basin coal (Hopkins, 1968). After World War II, large-scale surface mining of the Herrin Coal (and in places the younger Danville Coal) commenced in the southern part of the map area. More recently, underground mines operated in the Herrin Coal, the largest producers being the Brushy Creek Mine (now abandoned) and the New Era Mine (currently active). In addition, the Womac Coal Member (Patoka Formation) was mined from open pits at the Phoenix Mine in Secs. 14 and 15, T8S, R4E.

Substantial reserves of Springfield Coal remain in the western and northern part of the map area. Seam thickness varies from about 4 to 7 feet and sulfur content is expected to be low to moderate. The Dykersburg Shale, composed of medium to dark gray silty shale and siltstone, is moderately competent as mine roof. In the past, some mine operators experienced difficulties with moisture sensitivity and horizontal stresses. The Sahara Coal Company coursed incoming air through “conditioning chambers” in worked-out panels to stabilize temperature and humidity before sending air to the working face. This procedure reportedly improved roof stability in active portions of the mine. Just east of the study area at the Galatia Mine, the operator encountered a strong concentration of roof failures in north-south headings. An overcoring study by the U.S. Bureau of Mines confirmed a horizontal stress field having the principal stress three times the least stress and the principal stress axis oriented (average) N 85°E (Ingram and Molinda, 1988). Where possible, the company responded by reorienting entries at 45° to the

stress axis, with a marked improvement in roof conditions. As for the Herrin Coal, thickness in unmined areas is consistently 4.5 to 6.5 feet and sulfur content is expected to be high (3 to 5%). Roof conditions for underground mining in the Herrin are overall good to excellent, because the Anna Shale is moderately competent and the Brereton Limestone highly competent as the main roof. Faults and dikes are the main obstacles to mining, but for the most part their locations are well known. Large masses of coal balls, composed of limestone, have been encountered in the active New Era Mine of American Coal Company just east of the Harco quadrangle. These features are unpredictable and can be a serious impediment to longwall mining.

Coalbed methane. The first commercial coalbed methane project in Illinois is the Delta project, which is largely situated in the southern part of the Harco quadrangle. BPI Industries, an Ohio company, began drilling development wells in 2004 on a tract of 43,000 acres. These wells tap gas from ten coal seams having net thickness of 22 to 55 feet, averaging 33 feet. Target seams range from the Herrin Coal downward to the “New Burnside coal”, a lenticular bed below the Murphysboro Coal. Producing wells are clustered along the Cottage Grove Fault System, which enhances fracture porosity of coal seams and enclosing rocks. As of 2005, the methane was compressed on site and transferred to an existing pipeline (Rodvelt and Oestreich, 2005). Current status of the field and production figures are not available.

Oil. A large portion of the Harco oil field and a few wells of the Harco East oil field lie within the Harco quadrangle. Discovered in 1954, the Harco field originally comprised 145 pumping wells, of which 42 were still producing in 2014. Cumulative production from the field is more than 3.4 million barrels, but output for 2014 was only 9,475 barrels, showing the field to be in old age. Production in the Harco field is chiefly from sandstone reservoirs in the Chesterian (Upper Mississippian) Waltersburg, Tar Springs, and Aux Vases Formations, with the latter accounting for 76 out of 145 wells. Limestone reservoirs in the Ste. Genevieve Formation also produced in 17 wells (Huff, 1989). Given that no structural closure is evident in the field area on the Springfield Coal or deeper mapping horizons, the trapping mechanism at Harco is believed to be primarily stratigraphic.

The Harco East field was discovered in 1955 and formerly hosted wells, but as of 2014 only five were still pumping, yielding 245 barrels. Reservoir rock included Mississippian Cypress and Aux Vases (sandstone) and a little Ste. Genevieve (limestone). Again, the traps are believed to be stratigraphic.

As shown by the above figures, known oil reserves in the Harco quadrangle are nearly depleted. Future hope for production must lie in stratigraphic traps in rocks older than the

Ste. Genevieve.

Current production figures were supplied by Bryan G. Huff of the ISGS.

Acknowledgements

This research was funded in part by the U.S. Geological Survey (USGS) National Cooperative Geologic Mapping Program under USGS STATEMAP award number G14AC00328, 2014. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

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