STATEMAP
Herod-BG

Bedrock Geology of Herod Quadrangle

Pope, Saline, and Hardin Counties, Illinois

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Introduction

The Herod 7.5 Minute quadrangle covers portions of northeastern Pope, northwestern Hardin, southeastern Saline, and extreme southwestern Gallatin County in southern Illinois. Geology of this area previously was mapped by Butts (1917 and 1925), Weller et al. (1920), Weller (1940), and Baxter et al. (1967). Further reports on the Illinois-Kentucky Fluorite District and its mines and minerals include Heyl et al. (1974), Goldstein (1997), and Denny et al. (2008).

The map area lies in the southern part of the Illinois Basin and near the western end of the Rough Creek Graben, a late Precambrian to Middle Cambrian failed rift structure. Recurrent tectonism combined with Permian ultramafic igneous activity and Permian(?) and younger mineralization render this one of the most complex areas, in terms of geologic structure, in the North American Midcontinent. The Illinois-Kentucky district contains the largest fluorite deposits in the United States and until recently laid idle due to depressed markets, was the nation's leading producer of fluorite, along with substantial quantities of lead, zinc, barite, and other minerals.

The oldest rocks that crop out in the quadrangle are Devonian at the apex of Hicks Dome, an uplift that resulted from Permian igneous activity. Faults radiate from the dome and surround it in concentric fashion. Hicks Dome lies along a larger, broad northwest-trending arch named the Tolu or Kutawa Arch (Baxter et al. 1967). Mississippian and Lower Pennsylvanian sedimentary rocks that surround Hicks Dome are faulted by northeast-striking extensional normal faults, which outline horsts and grabens and comprise the Fluorspar Area Fault Complex (Treworgy 1981).

Mapping methods

Readers who compare our map with that of Baxter et al. (1967) will observe that our map appears less detailed than theirs in many areas. We mapped fewer faults and a smaller number of stratigraphic map units, especially in the Pennsylvanian. The reason for the differences is that we believe, after careful consideration, that many features and units mapped by Baxter et al. cannot be supported by the available data. For example, we could find no field evidence for several faults that Baxter et al. portrayed in the northern part of the quadrangle, although we went into the field aware of their interpretation and looking for the evidence. Abrupt pinch-out or thickness changes of Pennsylvanian sandstone bodies seem to explain some of the apparent offsets previously interpreted as faults. Other faults on the map of Baxter et al. pass through valleys, where alluvium, slope wash, and other surficial deposits conceal any possible evidence for structure.

We have opted to combined a number of stratigraphic units that Baxter et al. mapped separately because the scarcity of outcrops does not permit drawing their contacts with any confidence. Several of the units that Baxter et al. classified as formations are less than 30 feet thick, and cannot honestly be projected between their widely scattered exposures. In the Pennsylvanian System, the ledge- and cliff-forming sandstone bodies that comprise the vast majority of outcrops are channel- and valley-fill units that undergo abrupt and dramatic changes of thickness. The various sandstone lentils are so much alike in lithology that they cannot be defined as members, especially in faulted areas. We have mapped major sandstone bodies wherever possible, but in most cases they are left nameless. We also have not mapped any of the Quaternary deposits along modern stream valleys.

Structural Geology

Recurrent tectonic activity from at least Cambrian through Cretaceous time (Nelson 1995) produced complex geologic structure that is difficult to accurately plot at a scale of 1:24,000, especially given the paucity of outcrops. The dominant structural trend is northeast, with tensional radial and concentric faults near the apex of Hicks Dome. A few northwest- trending faults may be related to the Tolu/Kutawa Arch.

The Herod Fault Zone, in the northwest part of the quadrangle, is a northeast extension of the Lusk Creek Fault Zone (Nelson 1995). The zone consists of vertical or steeply dipping faults, none of which are well exposed. Overall displacement is down to the southeast along the southwestern portion of the fault zone, and down to the northwest along the northeastern part. Displacement is nearly 300 feet at the southern edge of the quadrangle, decreasing to the northeast. The Herod Fault Zone continues only 1½ miles north of the Herod quadrangle (Nelson and Lumm 1986). Two diatremes or explosion-breccia features have been mapped along the zone.

Geometry and kinematics of the Herod Fault Zone are poorly known due to lack of exposure. The Herod lacks the narrow, upthrown slices of older rocks that characterize the Lusk Creek and Shawneetown Fault Zones, and which have been interpreted as the result of reversals in the direction of slip (Nelson and Lumm 1984, Nelson 1995). However, zones of breccia several hundred feet wide along a fault zone having relatively small net displacement, suggest that multiple episodes of movement have taken place. The lack of strong folding along the margins of the Herod Fault Zone suggests that the faulting was tensional. Presence of diatremes, presumably of Permian age, implies that faulting was under way by early Permian time.

The Shawneetown Fault Zone curves across the northwestern corner of the Herod Quadrangle. On the southwest the Shawneetown merges with the Herod Fault Zone to form the Lusk

Creek Fault Zone (Baxter et al. 1967). North of the map area, the Shawneetown curves to the east and merges with the Rough Creek Fault System. Within the Herod quadrangle the net throw is relatively small, a maximum of 300 to 500 feet down to the northwest. Width of the fault zone varies, but is as great as 2,000 feet in places. The zone contains rocks that are vertical to steeply dipping, sharply folded, and brecciated.

A peculiar feature of the Lusk Creek, Shawneetown, and Rough Creek Fault Systems is presence of narrow slices of older rocks surrounded by younger rocks. Two such slices have been identified in the Herod quadrangle. Both consist of Chesterian (Upper Mississippian) shale and limestone, including limestone diagnostic of the Clore Formation; sandwiched between sandstone of the Lower Pennsylvanian Caseyville Formation. Existence of such slices suggest dip-slip faulting with reversals in the direction of slip. Regional evidence presented by Nelson and Lumm (1984) and Nelson (1991) theorizes the southeastern block being uplifted under regional compression, then downdropped under extension, leaving slices of older rock wedged within the zone. Alternatively, the slight curvature in map view of the Shawneetown Fault Zone conforms to the concentric outcrop pattern at Hicks Dome, suggesting that uplift of the dome influenced the fault zone.

The Hamp Fault is an arcuate fault that crosses the north flank of Hicks Dome. The south side is downthrown; however, near its western end the north side is down. The change in throw probably relates to the effects of cross-cutting smaller faults. (Baxter et al. 1967). Several fluorite mines have operated along the Hamp Fault.

The Hobbs Creek Fault Zone comprises high-angle normal faults that trends northeast, bounding the southeastern edge of the Dixon Springs Graben (Baxter et al. 1967). Baxter et al. (1967) mapped zone completely across the quadrangle, but we could not substantiate the northeastern portion and show the zone dying out southwest of Hicks Dome.

The Empire Fault is a normal fault dipping steeply to the southeast. The stratigraphic offset is about 15 feet down to the southeast. Several mines have operated on the Empire Fault and the nearby Pierce Fault.

The Horton Hill Anticline (Baxter 1967) is a north-northeast trending structure between the Shawneetown and Herod Fault Zones. It has a broad, flat crest more than a mile wide where erosion has breached the resistant Caseyville sandstone, creating a broad valley in underlying Chesterian shale and limestone and leaving Wamble Mountain and Horton Hill as outliers. The nearly level crest gives way abruptly to the southeast flank, where bedding dips 18° to 38° and local strike-faults occur. Farther southeast, bedding dips gradually diminish, reaching horizontal along the margin of the Herod Fault Zone. This geometry suggests that a high-angle reverse fault antithetic to the Shawneetown Fault Zone underlies the steep southeast limb, but only barely reached the present ground surface. The Horton Hill Anticline is also in line with the projected trend of the McCormick Anticline (Nelson and Lumm 1990). It is possible the Horton Hill anticline is the extension of the McCormick Anticline but later faulting along the Lusk Creek and Shawneetown-Rough Creek fault zone has offset this structure.

Igneous Activity

Igneous rocks in the region are ultramafic and have intruded into the Paleozoic section from a great depth. They occur as narrow dikes, pipes, sills, and diatremes. Dark-colored rocks that form dikes and sills are composed of olivine (usually altered to serpentine), phlogopite, pyroxene, apatite, magnetite, sphene, chlorite, and calcite. Alteration makes classification difficult, but most have been classed as mica peridotite, monticellite-alnöite (Sparlin and Lewis 1994), and lamprophyre. Light gray, fine-grained igneous rock of the region has been classified as lamprophyre. Diatremes and breccias incorporate clasts of country rock (autolithic breccia).

Structural uplift at Hicks Dome appears to be related to a crypto-volcanic event that produced pipe- shaped diatremes which vented gases to the surface (Brown et al. 1954; Heyl and Brock 1961). Radiometric dating indicates early Permian age, about 270 Ma. years ago (Fifarek et al. 2001, Zartman et al. 1967). This ultramafic igneous activity is part of a regional northwesterly trending structure that underlies the Illinois Kentucky Fluorite District from northwestern Kentucky into southeastern Illinois called the Tolu Arch (Baxter 1967).

Four igneous bodies were observed and sampled during this study: the Grants Intrusive, Sec. 6, T12S, R8E (1200 ft. NL, 200 ft. WL); Chamberlain diatreme, Sec. 19, T11S, R7E (3500 ft. NL, 3300 ft. WL); unnamed diatreme, Sec. 16, T11S, R7E (1800 ft. NL, 3000 ft. WL); and another unnamed diatreme in Sec. 1, T11S, R7E (2200 ft NL, 1100 ft. WL). A fifth dike is suspected along the northwest corner of Hicks Dome; Sec. 24, 11S, 7E (400 ft SL, 1200 ft EL), where large flakes of phlogopite and several pieces of gravel spar were collected from a roadside ditch. Several other igneous dikes mapped by Baxter et al (1967) were not relocated during current mapping.

Economic Geology

Fluorite, zinc, lead, and barite have been mined at several surface pits and underground mines in this quadrangle. Mineralization within the Illinois-Kentucky Fluorite District probably results from an acidic brine, charged with fluorine and carbon dioxide gases derived from alkaline magma (Plumlee et al. 1995). As these complex fluids migrated, they were probably concentrated along the crest of the northwesterly trending Tolu Arch-much like a structural oil trap (Denny et al. 2008). Most fluorite mineralization is in contact with carbonate units. Therefore it is likely that when these complex acidic mineral rich fluids came in contact with carbonates they were buffered and precipitation occurred. The mineral deposits have been commonly called Mississippi Valley Type deposits, but they may be better classified as a fluoritic subtype of the Mississippi Valley–type deposit. At one of the igneous bodies in Sec. 16, T11S, R7E (1800 ft. NL, 3000 ft. WL) fluorite was identified within the igneous rock. This observation strongly suggests that the mineralization is genetically related to the igneous activity.

Mines are located along faults of moderate displacement and ore is a result of fracture and fissure filling, horizontal bedding replacement of carbonate, and weathered residual or gravel spar. Geologists have noted replacement of carbonate wall rock adjacent to veins in several mines. The Hamp Mines mined residual ore “gravel spar” produced by weathering of veins at the surface. It is reported that some gravel deposits extend to depths of over 200 feet (Thurston, Hardin, and Klepser 1954), but most are much shallower. More than a dozen mines or prospects were opened in the Empire District (Sections 27 and 34, T11S, R7E). Some of these workings were started at the surface; a few shafts were sunk along veins.

Barite deposits were observed in several places. The Rock Candy Mountain Mine is located along the Herod\Lusk Creek Fault Zone, where a vein of barite was observed in a prospect pit (Sec. 34, 11S, 7E) along this fault. The Hamp mines are located along the north flank of Hicks Dome along concentric and radial faults. The Rose Creek Mine (Sec. 11, T11S, R7E) is located along a concentric fault northwest of Hicks Dome. Many prospect pits have been opened along several of the fault zones in this quadrangle. Barite was observed in several of these pits and small scale mining of barite was undertaken at a small surface pit (Sec. 34, T10S, R7E).

Chert gravel has been obtained from weathered outcrops of the Fort Payne Formation and used for road aggregate. An abandoned quarry is located in Sec. 25, 11S, 7E.

Extensive limestone deposits are present in lower Chesterian and Valmeyeran formations in the southern part of the quadrangle. The section from the Downeys Bluff Limestone through the Salem Limestone is close to 1,000 feet thick and almost entirely limestone, with minor dolomite and sandstone. Large quarries are presently active in these formations along the Ohio River at Cave in Rock, about 15 miles southeast of the present map area. Proximity to highway and river transportation is the main advantage for Cave in Rock.

Several oil and gas borings have been made in this quadrangle along the crest of the Horton Hill Anticline. All of these holes were dry and abandoned. The nearest producing wells are in the Mitchellsville area of southern Saline County, about 5 miles northwest of the map area. Prospects for oil and gas in the Herod quadrangle are not favorable, because potential oil and gas accumulations likely escaped along faults and fractures (Baxter et al. 1967).

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References

Baxter, J.W., G.A. Desborough, and E.W. Shaw, 1967, Areal geology of the Illinois fluorspar district, Part III, Herod and Shetlerville quadrangles: Illinois State Geological Survey, Circular 413, 41 p. and 1 plate, 1:24,000.

Brown, J.S., J.A. Emery, and P.A. Meyer, Jr., 1954, Explosion pipe in test well on Hicks Dome, Hardin County, Illinois: Economic Geology, v. 49, no. 8, p. 891–902.

Butts, C., 1925, Geology and mineral resources of the Equality-Shawneetown area: Illinois State Geological Survey, Bulletin 47, 76 p.

Denny, F.B., A. Goldstein, J.A. Devera, D.A. Williams, Z. Lasemi, and W.J. Nelson, 2008, The Illinois-Kentucky Fluorite District, Hicks Dome, and Garden of the Gods in southeastern Illinois and northwestern Kentucky, in A.H. Maria and R.C. Counts, eds., From the Cincinnati Arch to the Illinois Basin: Geological field excursions along the Ohio River valley: Geological Society of America, North-Central Section, Field Guide 12, p. 11–24.

Fifarek, R.H., F.B. Denny, L.W. Snee, and D.P. Miggins, 2001, Permian igneous activity in southeastern Illinois and Western Kentucky: implications for tectonism and economic resources: Geological Society of America Abstracts with Programs, v. 33, no. 6, p. A–420.

Goldstein, A., 1997, The Illinois-Kentucky fluorite district: The Mineralogical Record, v. 28, p. 3–49.

Gutschick, R.C., 1965, Pterotocrinus from the Kinkaid Limestone (Chester, Mississippian) of Illinois and Kentucky: Journal of Paleontology, v 39, p. 636–646, pl. 79–80.

Nelson, W.J., 1991, Structural styles of the Illinois Basin: in M.W. Leighton, D.R. Kolata, D.F. Oltz and J.J. Eidel, editors, Interior Cratonic Basins, American Association of Petroleum Geologists, Memoir 51, p. 209–243.

Nelson, W.J., 1995, Structural features in Illinois: Illinois State Geological Survey, Bulletin 100, 144 p.

Nelson, W.J. and D.K. Lumm, 1984, Structural geology of southeastern Illinois and vicinity: Illinois State Geological Survey, Contract/Grant Report 1984-2, 127 p.

Nelson, W.J. and D.K. Lumm, 1986, Geologic map of the Rudement quadrangle: Illinois State Geological Survey, Illinois Geologic Quadrangle Map IGQ-3, 1 sheet, 1:24,000.

Nelson, W.J. and D.K. Lumm, 1990, Geologic map of the Eddyville quadrangle: Illinois State Geological Survey, Illinois Geologic Quadrangle Map IGQ-5, 1 sheet, 1:24,000.

Sparlin, M.A., and R.D. Lewis, 1994, Interpretation of the magnetic anomaly over the Omaha Oil Field, Gallatin County, Illinois: Geophysics, v. 59, no. 7, p. 1092–1099.

Thurston, W.R., G.C. Hardin, Jr., and H.J. Klepser, 1954, Fluorspar deposits in western Kentucky-Part 3: U.S. Geological Survey Bulletin 1012-E and F, 130 p.

Treworgy, J.D., Structural features in Illinois—a compendium: Illinois State Geological Survey, Circular 519, 22p.

Weller, J. M., 1940, Geology and oil possibilities of extreme southern Illinois-Union, Johnson, Pope, Hardin, Alexander, Pulaski, and Massac Counties: Illinois Geological Survey Report Investigation 71, 71 p.

Weller, J. M., R.M. Grogan, and F.E. Tippie, 1952, Geology of the fluorspar deposits of Illinois: Illinois State Geological Survey, Bulletin 76, 147 p.

Weller, Stuart, Butts, Charles, L.W. Currier, and R.D. Salisbury, 1920, The geology of Hardin County and the adjoining part of Pope County: Illinois State Geological Survey, Bulletin 41, 416 p.