Geologic Contrasts in Indiana State Parks

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The state parks of Indiana, with sites selected largely for scenic and historic reasons but partly with the intent to secure wide geographical distribution for recreational purposes, contain a fairly complete sequence of the geological formations outcropping in the state, besides providing examples for a large majority of the physiographic principles. Evidence of vulcanism is one of the chief things missing, since all of the exposed bedrock in Indiana is of sedimentary origin. Even so, many types of igneous and metamorphic rocks can be picked up among the glacial boulders in the northern part of the state.

The oldest exposed rocks are those of the Ordovician period. Excellent outcrops for the study of the Ordovician strata occur in southeastern Indiana on the west flank of the Cincinnati Arch. The beds are highly fossiliferous and one of the famous collecting grounds for the life forms of this period is near Madison.

Clifty Falls State Park includes strata classified in the upper Ordovician, the Silurian and base of the Devonian periods. The Silurian rocks occupy the hill slopes above the falls and inner gorges in the park with the Devonian capping the higher hills.

The Ordovician formations in the park area from the base upward, begin with 25 feet of the Bellevue, followed by 115 feet of the Arnheim, 55 feet of the Waynesville, 50 feet of the Liberty, about 32 feet of the Saluda and possibly 6 feet of Whitewater. Shale predominates from the Bellevue through the Liberty and is interbedded with thin layers and lenses of limestone, and in contrast the Saluda is a thick bedded limestone with reef corals occuring near its base. The Saluda resists erosion so that being underlain by the crumbly Liberty beds, the limestone forms a waterfall ledge in the streams that flow across it. Clifty, Little Clifty, Hoffman, Tunnel and other falls all have developed at the outcrop of the Saluda in the streambeds. Hanging Rock on Highway No. 7 near Madison is another good example of the ledge forming qualities of the Saluda limestone.

Clifty Falls has a vertical drop of about 50 feet in a total descent of 70 feet. It is easy to walk back of the falls and observe how the splashing and spray from the falling water along with other factors cause the weak Liberty formation to weather and erode thus creating a considerable niche. This process undermines the Saluda limestone and at intervals, perhaps of many years, a block breaks off. Since the first plunge developed from the cliffs at the edge of the Ohio Valley, the falls have retreated upstream leaving a steep, narrow gorge downstream. In all Clifty Falls has retreated about 11,000 feet and, separating from Clifty Creek, the various tributaries each have worn a gorge that ends in a waterfall. In addition to the work by running water and weather-

ing that largely account for the talus accumulations at the base of the cliffs, the work of ground water is shown through the presence of seeps, springs and small landslides.[1]

In 1897 Professor Glenn Culbertson of Hanover College described[2] preliminary work that he hoped would permit the approximate determination of the time required for the erosion of Clifty Falls. In 1911[3] he noted that in 14 years between 1897 and 1911 the undermining at Clifty Falls amounted to four and one-fourth inches. His son, J. A. Culbertson, found in 1927,[4] 30 years after the spike used for measurement was driven into the rocks behind the falls, that the mists had caused a total sapping equal to seven and one-eighth inches. This is about one-fourth of an inch per year for the 30 years. Assuming that the volume of water and rate of recession has been continuously at this rate, about half a million years would have elapsed since the falls began early in the Glacial epoch. Further studies here will be of interest.

The newly established state park near Versailles and the projected Whitewater Park southwest of Liberty in Union county are underlain by the shales of the Richmond (Upper Ordovician) group. However, the strata are not so well exposed or so extensive as in Clifty Falls State Park although including much the same beds. In part the rock outcrops are masked by superficial glacial deposits.

The next park in stratigraphical sequence is Muscatatuck State Park near Vernon. Here the surface formation is the New Albany shale of Devonian age. Below these beds, near the ruins of the Vinegar mill are around 60 feet of Devonian limestones (Beechwood, Jeffersonville, and Geneva), with the Louisville and shows of Waldron shale of Silurian age appearing near the banks of the river. Thus the base of the strata at Muscatatuck State Park coincides with the top beds at Clifty Falls State Park.

Tippecanoe State Park is primarily of historical interest, but, for the record, it may be mentioned that beneath a cover of glacial drift the bedrock of the area is the New Albany shale of Devonian age.

The older school of Indiana geologists called the sandstones and shales of lower Mississippian age, the Knobstone, naming the formation from the rounded hills that are developed from it by erosion. This formation extends from opposite Louisville northward through Lloyd, Washington, Jackson, Brown and eastern Monroe counties. The name Knobstone has been superseded by the name Borden, but anyone who has seen the peculiar looking conical knobs that erosion has developed from this formation will recognize how good a descriptive term Knobstone was. Stockdale[5] estimated that the Borden in southern Indiana has an areal extent of 1,880 square miles, and to vary in thickness from 400

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[1] More about the geology of Clifty Falls State Park is given by the author in Outdoor Indiana, **12**, July, 1945, 10-11.

[2] Proc. Ind. Acad. Sci. 1897, 242-243.

[3] Proc. Ind. Acad. Sci. 1911, 169-170.

[4] Proc. Ind. Acad. Sci. 1927, **37**:118.

[5] Stockdale, Paris B., *The Borden Rocks of Southern Indiana*, Pub. No. 98, Dep't of Conservation, Indianapolis, 1931, p. 5.

feet at the Ohio River to double that in Brown County.[6] In central Indiana the Borden consists of sandstone and shale with occasional lenticular limestone beds. The famous Brown County scenery is all developed upon the Borden.

The Brown County State Park contains rocks of the Borden formation only. Erosion has not been deep enough to expose the underlying New Albany shale, and the overlying Harrodsburg limestone does not occur anywhere in Brown County. Stockdale reports 760 feet of Borden,[7] including subsurface, at Nashville close to the park. Sandstone members of the Borden are fairly resistant and account for the flatish summits of some of the ridges. Narrow ravines are common, and slumping by weak shales that lie under the sandstones help to maintain steep slopes to the hills. Numerous quartz geodes occur in certain horizons of the Borden strata. Some of the beds are quite fossiliferous. Bioherms, composed largely of crinoid stems, occur in the upper Borden. All of these features, along with examples of weathering and the work of water erosion can be seen in Brown County State Park. Although the State Park area was not invaded by glaciers, melt water from the ice sheet crossed Brown County and deposited gravel and silt. From the fire tower there is a superior view of the pre-Pleistocene dissected peneplain, correlated with the Highland Rim Peneplain of Kentucky and Tennessee, preserved in southern Indiana chiefly on the harder rock formations. The base of the fire tower is 1,060 feet in elevation above sea level and Salt Creek is 600 feet, giving a maximum difference in relief of 460 feet. The north lookout is 290 feet above the creek and Abe Martin Lodge is 160 feet.

Four Mississippian limestone formations lie above the Borden and have been named the Harrodsburg, Salem, St. Louis and St. Genevieve. Throughout south-central Indiana these limestones have been affected by solution from ground water that has resulted in numerous caves, sinkholes, lost rivers and other features of karst topography.[8] Among the caverns, Wyandotte and Marengo are best known, being famous for their curious stalactites and other deposits. Although privately owned, these caves are seen by thousands of visitors each year. Water-coursed caverns of considerable size are found in Spring Mill State Park, and the work of underground water is also important at McCormick's Creek State Park. The strata in both these parks that are especially subject to the formation of caves are the St. Louis and St. Genevieve limestones. The Salem limestone occurs below the St. Genevieve in both parks but is nearly devoid of bedding planes, is fairly soft and quite porous. These characteristics permit ground water to percolate through it easily so that the Salem is less readily dissolved to form caves. The Salem is the source of the Indiana limestone for building purposes, and in McCormick's Creek State Park near the White River is an old quarry which provided some of the stone used in constructing the state

[6] Stockdale, op. cit., pp. 56-62.

[7] Stockdale, op. cit., p. 62.

[8] Malott, C. A., Significant Features of the Indiana Karst, Proc. Ind. Acad. Sci., vol. 54:8-24, 1945.

capitol. In contrast, the Harrodsburg, St. Louis and St. Genevieve are rather dense and have many fractures, joints and bedding planes along which the water dissolves the limestone. Hence caves are scarce in the Salem and common in the other limestones mentioned.

An underground river flows through the caves in Spring Mill State Park, and the presence of blind fish in the cave water and the chance of a boat ride underground always interest visitors. The Spring Mill caves appear rather youthful as they are still in process of formation by solution and erosion. The deposition of calcite by dripping ground water, apt to occur in a mature stage in the life history of caves, has not yet been attained.

At McCormick's Creek State Park numerous sinkholes and springs, with some of the springs carrying the outflow from cavernous drainage, provide evidence of the work of ground water. As mentioned previously, the underground drainage is characteristic of the St. Louis and St. Genevieve limestones only. The maximum difference in relief in the park is 220 feet between White River and near Camp Friendly. The most spectacular feature of the park is the narrow gorge of McCormick's Creek that terminates with a drop of 65 feet between just above and just below the falls. The total drop of McCormick's Creek in its lower course is 160 feet in about two miles. Most of the gorge is believed to have been worn in post-glacial time. While the limestone bedrock has been an important factor in the development of the park scenery, the surface features of the area that includes the park, called the Flatwoods, have been modified by the continental glacier.

Siebenthal[9] and Malott[10] agree that the continental glacier crossed the White River and invaded the Mitchel Plain about two miles east of Spencer. The ice dammed the drainage into White River and formed a temporary lake in the Flatwoods area. A similar ponding occured in the valley of Bean Blossom Creek, and the water from these combined glacial marginal lakes overflowed southward to the west of Ellettsville and into Raccoon Creek according to Malott. With the disappearance of the ice the considerable descent of McCormick's Creek permitted that stream to secure most of the surplus water from the Flatwoods. This was favored by the underground drainage channels in the St. Louis limestone that helped to feed McCormick's Creek. In a way this capture of drainage is an example of underground piracy. The two mile long gorge in the State Park is considered by Malott to be largely post-glacial although he thinks the canyon may have been begun by underground drainage. The deep gorge seemingly was the result of the combined action of solution and possible collapse of the cave roof and of stream erosion, the latter being probably the more important factor.

The Chester formations, of upper Mississippian age, are composed of interbedded layers of sandstone, limestone and shale. Areally the Chester lies just west of the exposures of the cavernous Mississippian limestones just discussed. Erosion of the Chester has resulted in in-

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[9] Siebenthal, C. E., 21st Ann. Rept., Ind. Geol. Surv., 1896, p. 302.
[10] Malott, C. A., 39th Ann. Rept., Ind. Geol. Surv., 1914, pp. 217-222.

teresting gorges, picturesque cliffs, wooded hills and sparkling waterfalls, fully as great in scenic interest as in some of the established state parks, but no park area includes any of the Chester formations. Perhaps in the future this will be changed, since the Chester possesses a zone of mineral springs, such as French Lick and West Baden in western Orange County, and Trinity and Indian springs in Martin County.

Two popular state parks are located where the surface bedrock belongs to the Pennsylvanian system, which contains the coal deposits of Indiana. Turkey Run State Park and the nearby Shades, a private recreational area, contain gorges carved from the Mansfield formation at the base of the Pennsylvanian. Shakamak State Park is located on strata belonging to the Petersburg formation, about 300 feet above the Mansfield stratigraphically.

The Mansfield consists mostly of a coarse and often cross-bedded sandstone but includes some beds of shale and generally a thin seam of coal toward its base. Cross-bedding is considered proof of the deposition of the Mansfield near or above sea level where shifting current's operated. The Mansfield is massive and resistant. Wherever the streams have cut valleys into bedrock, cliffs of sandstone rise almost vertically for 50 feet or more. In places Turkey Run gorge is not half as wide as it is deep. Numerous potholes, waterfalls, eratic boulders and fallen rocks are features of interest in addition to the wooded, overhanging cliffs. A fine virgin forest delights the nature lover. Springs at the base of the sandstone above a layer of impervious shale illustrate a common cause for this phenomena.[11]

Shakamak State Park is situated in a rather flat area with a difference of elevation within its boundaries of 85 feet, perhaps more than might appear to the visitor. Two artificial lakes occupy much of the principal valleys and cover some of the outcrops so that exposures of bedrock are uncommon. However, in one place a coal bed is exposed as an exhibit. In the vicinity of the park are some of the largest coal mines in the state. Some of the mines are operated through shafts, others are strip mines.

Northern Indiana is deeply covered by glacial drift and the surface features of the state parks there are of Pleistocene or Recent age. The kind and age of the bedrock under the glacial debris has no significance. Pokagon and Indiana Dunes are the most popular parks in this part of the state, but Tippecanoe, Mounds and Bass Lake Beach are also attractive.

Pokagon State Park on Lake James is a good example of a region deeply covered by drift, in places 500 feet thick, where lakes of glacial origin are abundant. Moraines, kames, kettleholes, outwash deposits, erratic boulders and other evidences of glaciation are everywhere. Both Lake James and Bass Lake are examples of glacial lakes.

In northern Indiana are three abandoned beaches and associated deposits formed by prehistoric, glacial Lake Chicago when it stood at

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[11] Freeman, O. W., *Geology and Turkey Run State Park,* Outdoor Indiana, 12, 12-13, August, 1945.

55, 35 and 20 feet above the present level of Lake Michigan. Sand dunes often are associated with the old beaches. The dunes of Indiana Dunes State Park are being formed at the present time, the needed sand being derived from glacial deposits eroded by the waves from the shores of Illinois and southern Wisconsin and Michigan. Currents carry the sand to the south end of Lake Michigan where it is washed on to the beach. After drying, the prevailing winds blow the sand inland and the process of dune formation begins. The dunes are of two principal types: fore dunes and blowout dunes. The fore dunes form at the edge of broad beaches on which sand is accumulating and are usually 20-50 feet high, but occasionally attain a height of 100 feet. Blowout dunes result when, after vegetation has stabilized the fore dunes, the cover is destroyed in some way and the wind blows the sand away to cut trenches through the older dunes and dump the sand to leeward. The resulting big active tongues of sand are the most spectacular feature of the park. Blowout dunes are the highest hills in the park, Mount Tom reaching 193 feet above the lake with Mount Holden and Mount Jackson rising nearly as high. In their advance the blowout dunes invade the forest and kill the tress, cross marshes and may bury buildings or cover highways.[12]

The mounds in Mounds State Park near Anderson were built by Indians many centuries ago. Beneath a cover of glacial debris in a stream valley are exposures of the Niagara formation of Silurian age, but the outcrops of bedrock are of less interest than the constructions by prehistoric man.

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[12] For further information about the Indiana dunes consult: Cressey, George B., *The Indiana Sand Dunes and Shore Lines of the Lake Michigan Basin*, Geog. Soc. of Chicago, Bull. 8, 1928. Freeman, O. W. *Outdoor Indiana*, **12**, Sept. 1945, 12-13 and 16.