THE LITTEN NATURAL BRIDGES AND CLOSELY ASSOCIATED PHENOMENA, EASTERN OWEN COUNTY, INDIANA.

ARCH R. ADDINGTON, Indiana University.

These interesting features of our state are rather remote from the main traveled highway and they are so deftly secluded by their immediate surroundings that the occasional explorer of the region usually fails to hear of their existence. My interest was first aroused in them while on a "cave hunting" trip in eastern Owen County during the summer of 1926. It occurred to me that the bridges and their immediate environment are of rather peculiar interest since they are located near McCormick's Creek Gorge and because the small drainage diversion associated with their development has taken place in a direction that is nearly diametrically opposed to the regional dip of the rock in the locality.

Consequently, during a few days in the summer of 1927 the region was studied more carefully. A few square miles were mapped on basis of a 20-foot contour interval and a smaller area near the bridges was mapped on basis of a 10-foot contour interval. Valuable assistance in completing the topographic mapping was given by Mr. S. T. Clashman, a student of Indiana University.

Location and Description. People of the local community refer to these features as the "Litten Natural Bridges," presumably because the bridges are located on the farm of Mr. Jack Litten.

The bridges, two in number, are situated close together near the upper end of a short, rocky gorge. They are found a few paces south of the by-road that may be noted crossing the northwest ¼ of section 14, township 10 north, range 2 west. (Fig. 1.) The bridges are ¾ mile north and east of McCormick's Creek Gorge and ⅞ mile south and east of White River at the place where it bends to the west in section 11, township 10 north, range 3 west.

In the summer season the location of the bridges is almost obscured by the dense undergrowth of brush and tangling vines that everywhere are prevalent in this region. Most of the large timber has been removed, so that the entire locality is more or less a wild, woolly, thicket.

When dry weather prevails, it is possible for the motorist to drive along the by-road to the point where it is crossed by a small tributary stream to White River. (Fig. 1.) From this place it is only a few paces to the southwest until he will find himself in the small, steep-sided, rocky gorge. Cautiously picking his way around and over rock fragments that litter the rocky bed, it is only a short distance until the first of the natural bridges can be seen.

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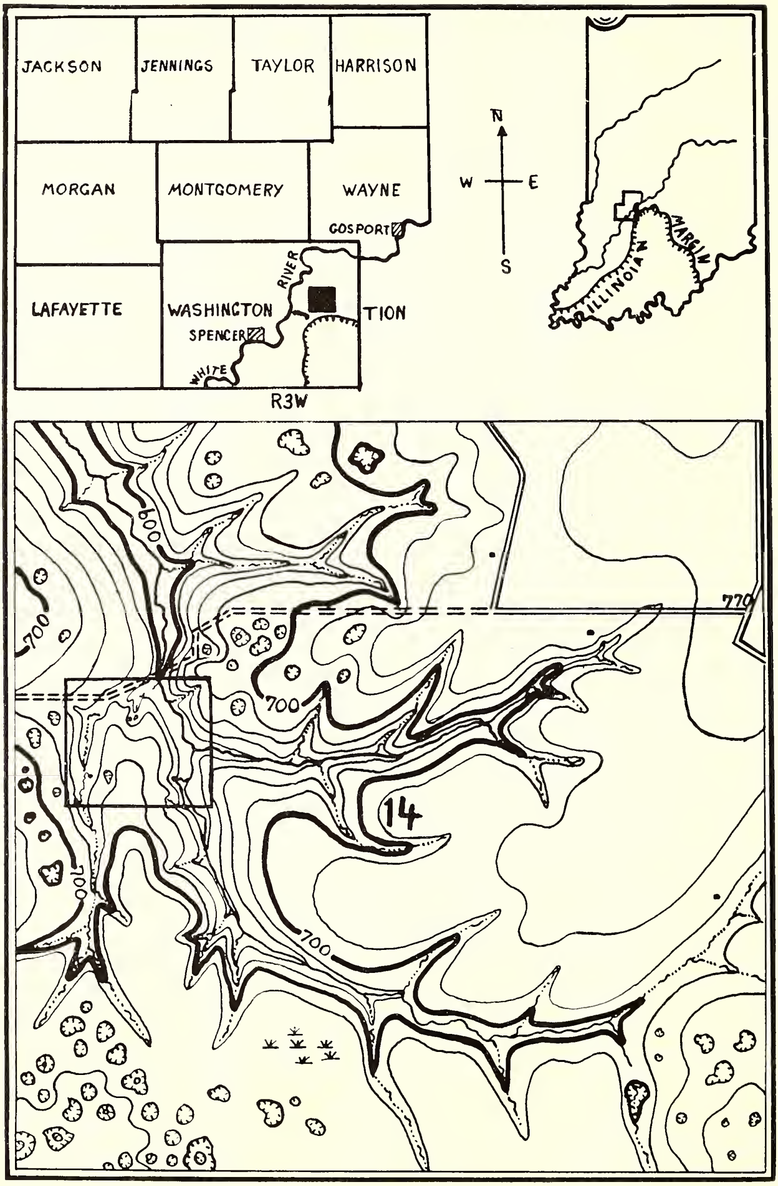

Fig. 1—Topographic map of section 14, township 10 north, range 3 west. The map shows the general topographic condition near the Litten Natural Bridges. The rectangle encloses an area reproduced as figure 2. Contour interval 20 feet.

The insets are maps of Indiana and a part of Owen County which illustrate the general locational relations of the region to the Illinoian Drift and to the principal drainage routes. McCormick's Creek Gorge is illustrated by a short black line in the inset of Owen County. Area topographically mapped indicated by black square.

It is picturesque. A rather massive limestone layer forms the span rock which has a total length of 15 feet. Its vertical thickness is four feet, width 10 feet, and its distance above the bottom of the gorge is 12 feet. The generalized cross section profile of the opening beneath the span is somewhat rectangular in outline but weathering processes and the erosive work of running water have undermined the bridge abutments to a considerable extent. The rock forming the bridge abutments is rather thin layered and somewhat crossbedded.

Immediately beyond the bridge the stream channel bends abruptly to the right. Some slumping of material from the sides of the gorge has occurred here and has partially obstructed the channel. As soon as one passes around the bend the second bridge may be seen. This is no less picturesque than the first although it is less in size. The channel beneath it is littered with rock fragments, some of large size, which seem as if they had only fallen yesterday.

The span rock is formed of the same massive layer as that of the first bridge and it is of the same thickness. The length of the span is 10 feet, the width six feet, and the height above the bottom of the gorge is six feet.

Associated Phenomena: From a vantage point on the rock fragments beneath the bridge one can gaze into a low cavern entrance made to appear lower than it really is because of the collapsed rocks that partly obscure its true dimensions. Just within the entrance there is a shallow pool of limpid water. A short distance farther on the roof becomes lower and cavern darkness prevents any further visibility by natural means.

If the visitor now climbs to the top of the bridge and then proceeds in a general westerly direction across a gently rounded spur of land he comes rather abruptly to a valley-like depression which terminates in a low broadly arched cavern entrance, not greatly dissimilar to the one he saw from his vantage point beneath the bridge. This cavern entrance leads to Wolf Cave and according to traditionary accounts the last wolf of the county met his fate here. It scarcely calls for any stretch of imagination on the part of the observer to see that this entrance leads into the same cave as that at the bridges. In other words, Wolf Cave is simply an irregular limestone tunnel with cavern-like entrances at either end. The distance the entrances are apart is approximately 200 feet.

At times, an intermittent stream flows in the valley, dissappears in Wolf Cave, emerges from the entrance near the bridges, flows beneath the latter, and eventually joins the tributary stream in the valley adjacent. That this has not always been the case is evidenced by the continuance of the valley depression beyond Wolf Cave and the pressence of a low col in the valley. A study of figures 2 and 3 will make clear existing and former conditions of drainage.

Proceeding up the valley in a general southerly direction from Wolf Cave a small spring may be noted issuing from the west side of the valley. The branch thus formed flows a short distance to the north and finally disappears among the rock on the east side of the valley.

The spring is not a large one and its volume diminishes considerably in dry weather. In local phraseology, it would perhaps be called a "wet weather" spring.

Farther south the valley divides into several sharp ravines that head upon a plain modified by numerous steeply funnel-shaped sink-holes. From these sinks it is ¼ mile to the gorge of McCormick's Creek, or more strictly speaking, the gorge is ¼ mile in a southwest direction from the southwest corner of the mapped area shown in figure 1. The property of the state park adjoins the area on the south and west.

It seems most reasonable to believe that the sinks found in this part of the section represent drainage through subterranean routes to the gorge of McCormick's Creek. That the subterranean drainage should follow the normal dip of the rock to the southwest rather than to some eastern point, as is the case farther down the valley, is because there is no deeply entrenched valley adjacent these sinks on the east. If the drainage through the sinks is to McCormick's Creek Gorge it is easy to see that the stream which at times flows through Wolf Cave is robbed of some of the water it otherwise would have. Diversion of surface waters through subterranean channels at the headwater portions of surface streams is not an uncommon phenomenon in limestone countries. A classic example of this is to be found in the Bloomington region where the headwaters of Indian Creek have been diverted through subterranean routes to the valleys of Clear Creek and Richland Creek.[1] Other examples might be mentioned. The general effect is to decrease the volume of the surface stream and thereby decrease the rate at which such stream may lower its valley. Although this is not the only factor involved it is an aid in establishing a difference in valley levels of a tributary to that of a larger stream. The intermittent stream flowing into Wolf Cave is suggestive of this condition. (Fig. 1.)

Attention is now called to the largest valley depression represented in the figure. (Fig. 1.) This valley continues in a generally northwest direction until it joins White River Valley about one-half mile distant. The stream which flows through this valley is fed principally by springs and seepage. It will be noted that the valley floor is considerably lower in elevation than that of the valley leading to Wolf Cave. (Fig. 2, which is mapped on basis of a 10-foot contour interval, illustrates the condition more clearly.)

In the southeast part of the area shown by figure 2, a spring may be noted issuing from the west valley wall. The volume of the spring is comparable to that which may be seen at the spring in the valley to the west. Between the places where the water from the latter spring disappears in the rock and the spring in the valley to the east one may note a steep sink hole that is almost on a line between the places mentioned. The condition just described is suggestive of a subterranean route beneath the spur separating the two valleys. It should be noticed that the distance separating the two places is not great, being approxi-

[1] J. W. Beede. The Cycle of Subterranean Drainage as Illustrated in the Bloomington, Indiana, Quadrangle. Proc. Ind. Acad. Sci. 1910, pp. 81-111.

mately 30 rods. The general direction in which the diversion takes place, however, is to the east, which is opposite to the normal dip of the rock in this locality.

It will be noted with reference to the location of Wolf Cave and the natural bridges that the alignment is similar to that mentioned above and that the general direction of diversion has been to the east. Diversion opposite to the dip of the rock is, perhaps, more unusual than

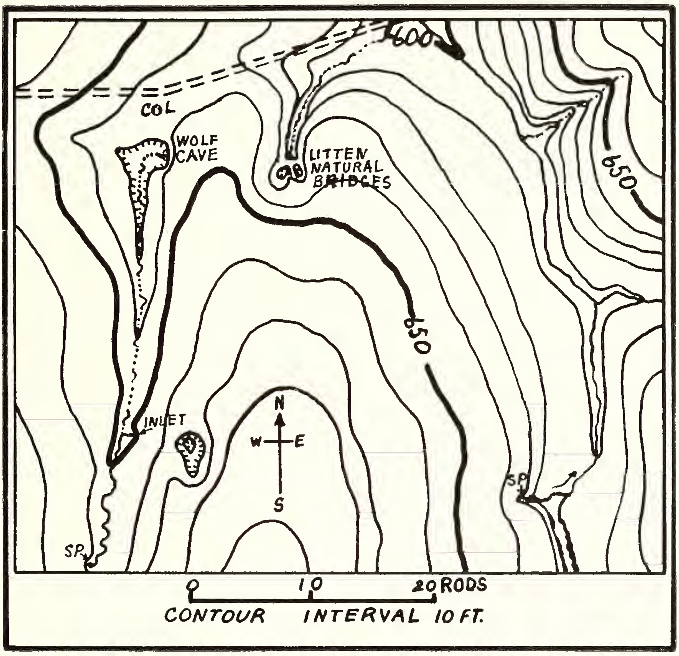

Fig. 2—A reproduction on a larger scale of the rectangle shown in figure 1. The positional relations of the cave, natural bridges, gorge, and abandoned valleys are shown. The figure illustrates successive abandonment of a valley by a surface stream due to subterranean diversion.

usual. Its development here is due to local conditions which will presently be explained. An important factor in bringing about the conditions of drainage shown here is the lithologic characters of the sub-surface rocks.

General Geology. The surface materials of the area are of glacial origin and consist of gravelly loams, silts, and sands such as one might expect about the waning borders of an ice mass. None of the glacial material is of large size and some of it could, perhaps, best be described as outwash. The general relation of the area topographically mapped to the Illinoian Glacial Margin may be observed by noting figure 1.

The bed rocks of the region exposed at the surface are Paleozoic sediments of Mississippian Age. The rock formations having surface outcrop are the Mitchell Limestone and the Salem Limestone. The dip of these formations in this particular locality is toward the west at an average rate of 30 feet per mile.

The Mitchell Limestone forms the sub-surface rock of the higher elevations. Its lower limit in this area as determined by barometer measurement is 650 feet. The formation is one of the most conspicuous lithologic units of the state and its salient characteristics have often been described.[2] The individual layers of the stone are rather dense and their excessively jointed character make the formation most favorable for the circulation of subterranean waters when suitable conditions of topography are present. The sinkholes, previously mentioned, and also the sinkhole between the springs, are developed in this formation.

The Salem Limestone lies beneath the Mitchell Limestone and is the lowest rock formation exposed in the area. Core drillings indicate a thickness of 80 feet. The part used as a quarry stone is a massive bedded, nearly pure carbonate of lime rock. Where streams cut into the formation its massive character is oftentimes excellently represented by the cliff-like exposures along the stream valley. Such exposures are present in this region but the cliffs are not high and so fail to show upon the topographic map.

In many instances the upper part of the Salem, near its point of contact with the overlying Mitchell, is composed of alternate thin and thick beds, sometimes cross-bedded, and presenting more or less of a shaly character. This lithologic phase is usually referred to as "Bastard Rock" or "Rotten Rock" among the quarrymen. It is not uncommon for small springs to appear at this horizon, the water having circulated along the joints and crevices of the overlying Mitchell stone. The influence of this phase is represented by the appearance of the springs illustrated in the figures accompanying this paper. (Figs. 2 and 3.)

The natural bridges also occur in this part of the Salem formation. The span rock representing a relatively thick bed while the bridge abutments are carved from the thinner layers. (See description of bridges, page 143.) This lithologic condition has been favorable to the formation of the bridges and to their preservation.

Joints occur in the Salem Limestone. These are oftentimes of large size. The joints are rather widely spaced, however, and are not nearly so numerous as they are in the Mitchell Limestone. Where joints are present they exert an important control over the direction of flow of subterranean streams and where sufficient difference in adjacent valley levels exist the combination of these conditions may overcome the influence of regional dip of rock in controlling the general direction of sub-surface flow. It is evident these conditions must be present at the natural bridges and at the place farther south where diversion of spring waters is now taking place.

The general situation as regards the geology and topography of the region may be obtained from figure 3. From this figure the general

[2] Hand Book of Indiana Geology, pp. 499-508, Citation E. R. Cumings, for complete description of the Mitchell and Salem limestones.

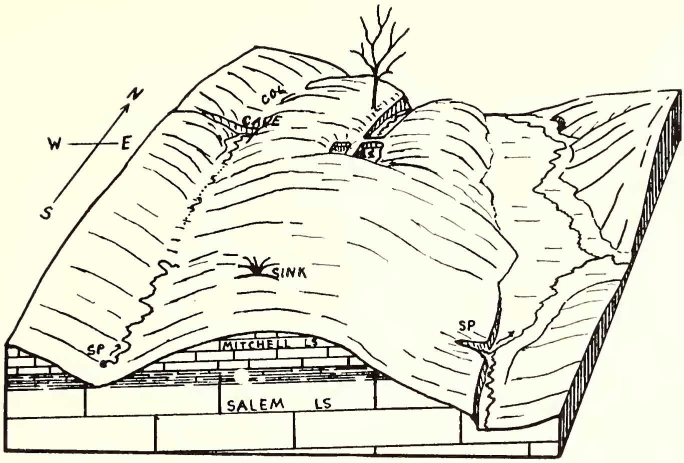

Fig. 3—A generalized block diagram illustrating positional relations of the rock formations and the general topographic condition. The dip of the rock formations and the vertical relief is slightly exaggerrated. The finer divisions represented in the upper part of the Salem Limestone are to illustrate the thin layered and shaly phase of that formation.

positional relations of the rock formations may be observed as well as a bird's-eye view of the positional relations of the gorge, bridges, and cave.

In the immediate vicinity of the bridges the influence of glacial material can practically be neglected since it forms only a very thin veneer over the bed-rock.

It is assumed that the change of drainage associated with the formation of the natural bridges occurred in Post Illinoian Time, perhaps Post Wisconsin, an assumption that is based upon the very youthful stage of development of the gorge and the apparent recency of the drainage change.

The Drainage Diversion: Brief Résumé of Development. As a result of the survey of surface conditions in the area near the Litten Natural Bridges it appears that the intermittent stream, which at times flows into the cave, formerly followed a surface route to its point of junction with the larger stream in the neighboring valley. At this period the valley levels of both streams were at a higher elevation than now and it is probable their place of junction was at an accordant level. A condition of this character would not favor subterranean diversion of the water from the tributary to that of the larger stream because there would be no difference in static head.

The entrenchment of the area by streams was and is primarily dependent upon the entrenchment of White River. Hand in hand with the deepening of the valley of the latter would occur the deepening of its tributary valleys, tributaries to them and so on *ad infinitum*. But if for any cause related to lithologic control, to stream condition as regards volume, velocity, and amount of load, one stream is able to deepen its valley faster than an affluent, it will in time leave the affluent at a higher elevation at their point of junction and as a result a waterfall or cascade may develop at the mouth of the affluent stream. It is not improbable that a waterfall or cascade developed here, but if such were the case, process and time have obliterated all tangible evidence of its former existence. A small valley depression extends in the general direction of the col (fig. 2) and is followed in part by the roadway.

Contemporaneous with the establishment of difference in level of adjacent valleys arises the favorable condition for an active subterranean circulation from the higher valley level to that of the lower valley level, particularly, if such valleys are formed in areas of pervious or well-jointed rock. Under a topographic condition of this sort the presence of joints and bedding planes in the rock mass form routes of least resistance for the circulating waters. Such routes may be rapidly enlarged by the swirling eddies that at times follow them and in time a tubular cavern may result. The water would appear from the lower end of such a tubular cave as a spring.

In time the inlet for the water becomes sufficiently enlarged so that it accommodates all the drainage of the valley above the point of inlet. Along with this enlargement goes, deepening of the inlet by the stream flowing into it and as a result a new and steeper gradient appears in the valley immediately above the inlet. Weathering processes and erosive work of running water cause a gradual recession of the cavern inlet in a general downstream direction. There is some evidence of this migration at Wolf Cave.

Changes also occur about the spring outlet. In many instances the volume of water issuing is able to remove the fragments of weathered material that otherwise would accumulate about the spring orifice and serve as protective covering against weathering agencies. The gradual collapse of material over the subterranean stream due to weathering about the spring outlet and to the erosive and chemical work of the stream in widening its channel and the subsequent removal of this material, in time, forms a gorge which gradually increases in length in an up-stream direction. The natural bridges span a small gorge of this origin. (Fig. 3.)

The cavern, gorge, natural bridges, and the abandoned part of the valley are topographic features that result from the drainage diversion through subterranean routes of the surface stream that intermittently occupies the valley leading to Wolf Cave.

Formation of Litten Natural Bridges. Natural bridges result from divers causes. It is beyond the purpose of this paper to present a résumé of natural bridge formation, which would necessarily demand considerable space and time.[3]

[3] H. F. Cleland. "North American Natural Bridges," Bulletin Geological Society of America. Vol. 21, pp. 313-338. An excellent summary of natural bridge formation.

The Litten Natural Bridges are the direct result of the partial collapse of adjacent portions of a cavern roof. This mode of origin is most evident since the bridges are in such close proximity to the vestige of cavern remaining. To walk beneath the bridges and then almost immediately into a cavern entrance suggests a method of origin too plain to be denied. Primarily, they owe their existence to those conditions which favored differential deepening of adjacent valleys and to the subterranean circulation which was thereby established.

The method of natural bridge formation by collapse of adjacent parts of a cave roof is not unusual. It is a method described in nearly every text book dealing with the origin of land forms. But these bridges are of particular interest because they are so closely associated with the attendant phenomena that furnish undeniable evidence of their method of origin. Such a clear case of this manner of natural bridge formation is perhaps not equalled in very many localities.

Significance of Features and Phenomena Described with Reference to McCormick's Creek Gorge. It will be recalled that the location of the bridges and associated features is within a fraction of a mile of McCormick's Creek Gorge, which is the chief attraction of the McCormick's Creek State Park.

Several theories have been advanced to explain the origin of this well known feature. The most probable of these, according to Mallott is, "that the canyon was begun by underground drainage since the structure and dip of the rock in which the gorge is located are favorable and such drainage would not be unnatural under such favorable circumstances."[4]

Is it not suggestive to find within so short a distance of McCormick's Creek Gorge a smaller feature of similar character whose origin is so clearly demonstrated? Does not the presence of Wolf Cave, the Litten Natural Bridges, and the attendant gorge furnish evidence in corroboration of the subterranean theory of origin of the larger gorge? It may seem to some, perhaps, that the analogy is too far-fetched but the finding of these interesting features so near McCormick's Creek Gorge seemed to the writer a very significant piece of evidence pointing to the subterranean method of origin of the latter.

Although McCormick's Creek Gorge is developed in the Mitchell Limestone (the Salem Limestone is exposed near the lower end of the gorge) and the features herein described are developed in the Salem Limestone, it will be noted that the lithologic character of the material in which these features have been formed is not greatly dissimilar to that of the Mitchell Limestone. Because the features happen to be in different geological formations does not preclude the possibility of similar methods of origin.

[4] C. A. Malott. Hand Book of Indiana Geology, p. 215.