PRESIDENTIAL ADDRESS

Significant Features of the Indiana Karst

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The pit-marked lands of southern Indiana, where placid streams disappear and riotous storm waters are swallowed up and disgorged from mysterious subterranean routes, constitute a singular geomorphic area of unusual lure and challenging inquiry. During the past 60 years the Indiana Academy of Science has held eleven field meetings in this area and at least 30 papers bearing on the region have appeared in the Academy Proceedings. It has been my pleasure to act as guide on a

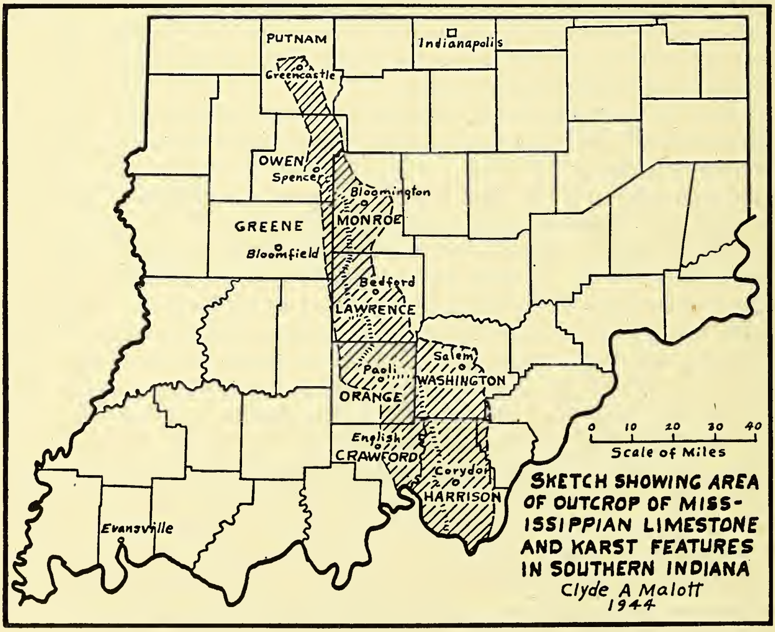


Fig. 1.

number of the Academy field excursions in this unusual Indiana region, which, also, has been the field of my own most interesting researches. I propose to identify and set forth the more significant characteristics of some 35 features peculiar to limestone terrains and well exemplified in the karst region of southern Indiana.

Subterranean drainage with an associated sinkhole topography characterizes a considerable portion of the outcrop belt of the Mississippian limestones of middle southern Indiana. The limestone belt, comprising an area of approximately 2,000 square miles, is an irregular strip of upland of varying width extending south-southeasterly from near Greencastle to the Ohio River. It is a northern extension of a greater area in western Kentucky. It composes the Mitchell plain and the eastern margin of the Crawford upland, two distinct topographic units separated by a much dissected and indented scarp in southern Indiana. (Fig. 1.)

Limestone is an essential underlying bedrock requirement of the underground drainage and the well developed karst topography of the area. The limestone formations are the Harrodsburg (Warsaw), Salem, St. Louis, Ste. Genevieve, and one or more of the Chester limestones at the top. There is much thinning of the limestones on the north in Putman and Owen counties, where the country also becomes partially or wholly covered with glacial drift. Southward the total thickness of the limestones reach a maximum of approximately 575 feet. The limestone formations dip westerly at a rate of about 30 feet to the mile, and accordingly the Harrodsburg is the first to appear on the east and the first to pass below drainage. The other formations appear successively on the west and likewise pass below drainage. The underground drainage of this limestone belt with its innumerable sinkholes and its sinking streams is best developed on the St. Louis and Ste. Genevieve limestones through much of their outcrop area in Monroe, Lawrence, Orange, Washington, and Harrison counties.

While an area of some 2,000 square miles is composed of limestone, not all of it is characterized by underground drainage and karst topography. At least 500 square miles of the upland limestone area possess normal surface drainage. Some of this normal surface drainage area is high upland and is strangely without sinkholes. The upper drainage of Lost River occupies such an area in the very midst of the karst terrain. Sinkholes with little or no stream drainage dominate an aggregate of about 650 square miles, and they are occasionally present and somewhat characteristic of an additional area of about 450 square miles. Minor valleys with limestone floors, usually characterized by sinkholes, lose their drainage to underground routes in the eastern margin of the Crawford upland. These valleys have an aggregate area of about 400 square miles. Hence, karst features are characteristic of some 1,500 square miles of the limestone area.

Karst features, such as sinkholes, small sinking streams, and shallow caverns are present in other limestone areas in Indiana, but they do not dominate the topography. Perhaps as much as 150 square miles of the outcrop area of the Devonian limestone of Clark, Jefferson, and Jennings counties have scattered local areas of karst in which sinkhole drainage is well developed.

The term *karst* is used in the sense of the dominance of landscape features dependent upon subsurface solution and the diversion of surface waters to underground routes. Its most characteristic topographic feature is the sinkhole, though sinking streams, caverns, resurgences, and other features attending underground drainage in limestone areas compose the karst assembly. Many of the features of the karst assembly are not distinctly topographic, or they are only occasionally present in the karst terrain. An enumeration of the many features characteristic of karst areas requires some special terms, but many of the features are characterized by descriptive terms or phrases more or less self-explanatory.

The surface and near-surface solution of limestone by descending percolating waters leaves a residue of surface red clay which mantles the limestone bedrock, masking from view the erose rock surface and filling the widened joints of the irregularly dissolved limestone. This residual red clay is the *terra rossa* which is so characteristic of limestone areas and karst terrains long subject to surface decomposition. Locally, where relief permits or where the *terra rossa* has been washed away, the exposed limestone is etched, pitted, grooved, or otherwise made rugged through differential solution. Such barren, etched and rugged surfaces are designated as *lapies*. Lapies surfaces are small and only occasionally present in the Indiana karst. A good example of such a surface is present along the west side of the Monon Railway a short distance south of White River in Lawrence County, where the surface soil was removed from the Salem limestone to construct the railway grade more than 80 years ago. An area of an acre or more here exhibits barren rock surfaces with characteristic lapies features and patchy terra rossa. In such surfaces and elsewhere in the near surface limestone, joints are occasionally opened and widened by solution into gaping fissures known as *grikes*.

The most common and distinctive feature of the karst terrain is the *sinkhole*. Topographically, it is a depression. It varies in size from a mere dent to expansive depressions of considerable depth. Perhaps the funnel-shaped depression is the ideal form. Sinkholes with gentle, soil-covered sides and flattish bottoms are the most common. This form, largely developed by solution under a soil mantle, may be designated by the European term *doline*. Steep-sided, rocky, and abruptly descending forms are frequently called *collapse sinkholes*, after the manner of their

Fig. 2. View of a collapse sinkhole, entrance to Nicols Çave, Lost River region four miles southwest of Orleans, Orange County.

development. (Fig. 2.) Some of the collapse sinkholes may resemble the abrupt and deep forms of the Yucatan region known as *cenotes*, which are developed probably as much by stopping from below as by collapse. Another form, only occasionally present, is the gaping, deep, well-like form or hole, which may be called *abime*, after the French term.

Some sinkhole depressions, probably originally produced by collapse over an underground stream, have become considerably modified. Occasionally they allow the unroofed portion of a cavern or an underground stream to show. Such specialized depressions may be called *karst windows*. They may have a stream flowing across the bottom either continually or intermittently. Some of the karst windows are entrances to caverns both upstream and downstream, such as the well-known Twin Caves at the Spring Mill State Park. The term may be applied to any specialized sinkhole form which shows evidence of stream or cavern unroofing, whether a mere peephole or one of considerable area. Some of the karst windows may have become greatly enlarged and possess alluviated floors in which waters rise and sink. These are the *uvala* forms of the West Indian karst. In the Lost River region of Orange County, such depressions with steep-sided perimeters and alluviated floors are called *gulfs*, such as the Wesley Chapel Gulf, five miles southwest of Orleans.

It is not uncommon for flat-bottomed sinkhole depressions to become clogged with inwashed clay, so that they hold the waters which drain into them, producing *sinkhole ponds* or karst lakes. (Fig. 3.) In localities

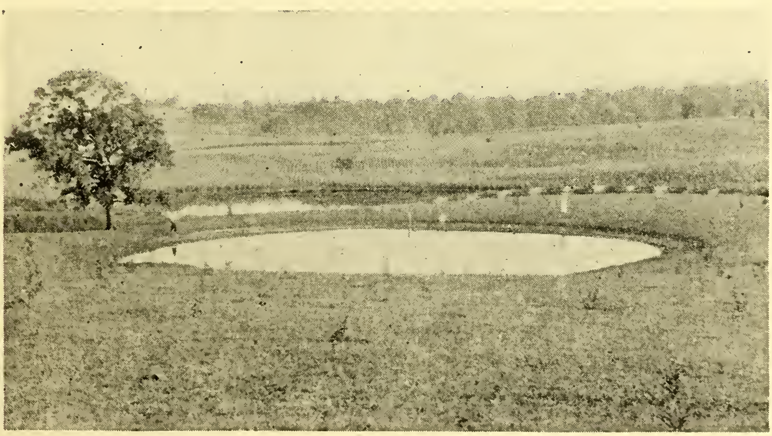
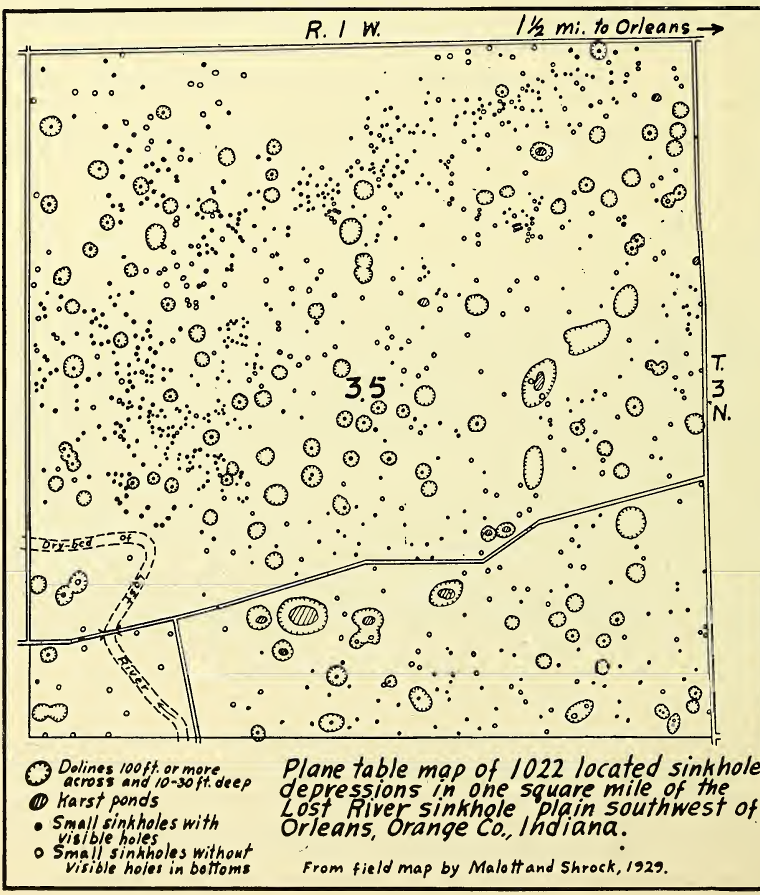


Fig. 3. View of a sinkhole pond in a doline, sinkhole plain four miles southwest of Bloomington, Monroe County.

of poor surface drainage shallow *solution pans* are occasionally developed, These shallow depressions are but slightly below the surrounding surface and may embrace a considerable expanse. One in the upper Lost River region in Washington County, two miles east of Livonia, contains more than 30 acres. Such solution pans frequently are swampy or contain some open water during wet periods, and these may be termed *karst swamps* or karst fens.

Sinkhole depressions are developed in great numbers in much of the upland limestone plain. They form the principal relief of extensive areas between the larger intrenched valleys. They use up nearly all of the upland surface area, and much of the limestone terrain becomes a veritable *sinkhole plain.* They vary in depth from a few feet to a maximum of upwards of 100 feet. The vast majority of them are more or less symmetrical depressions from 10 to 30 feet in depth, and embrace areas of a few square rods to an acre or more. Some of them possess obvious holes in the bottom where the rain-born waters reach into subterranean leads, while others have no visible places of water descent. The larger more expansive sinkhole depressions are frequently compound ones, containing merged depressions. Some of them contain smaller ones on their sides, as if the rain-born waters must descend below into the solution-riddled limestone grid rather than waste time in further surface flow. The sinkhole plain in large areas is a veritable regional sieve with



Plane table map of 1022 located sinkhole depressions in one square mile of the Lost River sinkhole plain southwest of Orleans, Orange Co., Indiana.

From field map by Malott and Shrock, 1929.

Fig. 4.

thousands of surface hoppers which convey the rainfall to underground routes. Large areas in Lawrence, Orange, Washington, and Harrison counties contain hundreds of sinkhole depressions to the square mile which furnish complete drainage to underground routes. An actual count from a plane table map made by the writer and Robert Shrock in 1929 in the Lost River sinkhole plain southwest of Orleans, Orange County, reveals 1,022 sinkholes in one square mile. (Fig. 4.) No surface stream can cross such an area, and Lost River and all its former tributaries are swallowed up in this expansive sinkhole plain. It is quite probable that as much as 400 square miles of the karst terrain contains an average of 500 individual sinkholes each, and it is not unlikely that the whole karst area of southern Indiana has a total number in excess of 300,000 sinkholes.

The sinkhole plain is so effective in absorbing the local rainfall that few streams are able to cross it as surface streams. The larger streams heading beyond it, such as Indian Creek, Blue River, and East White River, cross it in abrupt valleys intrenched 100 feet or more with few or no tributary valleys. The smaller streams and some of considerable size are *sinking streams* which lose their waters to underground routes. They terminate as surface streams. The *sink* of a stream simply denotes the disappearance of a stream at some place, such as the sink of Lost River, the sink of Stampers Creek, etc. The sink of a stream commonly takes place in obvious and occasionally large openings which are called *swallow-holes*. Many of the sinking streams have numerous channel swallow-holes into which their waters are discharged, while others lose their waters in a single terminal swallow-hole.

Sinking streams are expected features in karst areas, and they constitute an important geomorphic aspect of karst terrains. Beede (1911)

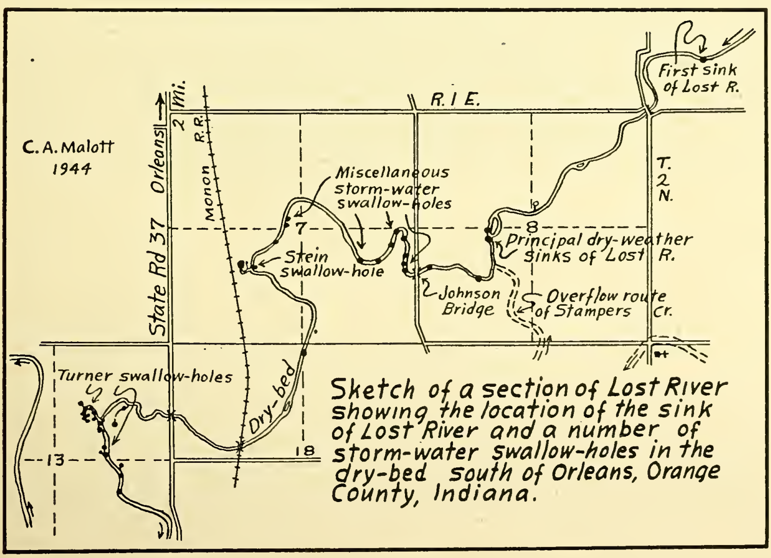


Fig. 5.

described the sinking and diversion of several streams on the upland limestone plain west of Bloomington, Monroe County, where some 15 square miles in area have become lost from the headwaters of Indian Creek and added to the more deeply intrenched valleys on either side. Elrod (1876 and 1899) and Malott (1922 and 1932) have clearly set forth the characteristics of the Lost River drainage of Orange County. Lost River, after gathering its waters from 53 square miles of non-karst limestone upland, sinks in a number of channel swallow-holes, except in times of very low water when the small flow is lost in a single pool without evidence of a swallow-hole. In times of heavy rainfall the swollen stream discharges across the sinkhole plain in a meandering storm-water channel more than 20 miles in length. Such a storm-water channel, normally dry, but kept open, is called a *dry-bed.* Along its dry-bed are many small swallow-holes and a few major ones reached only by muddy storm waters. (Figs. 5 and 6.) The larger ones are characterized by

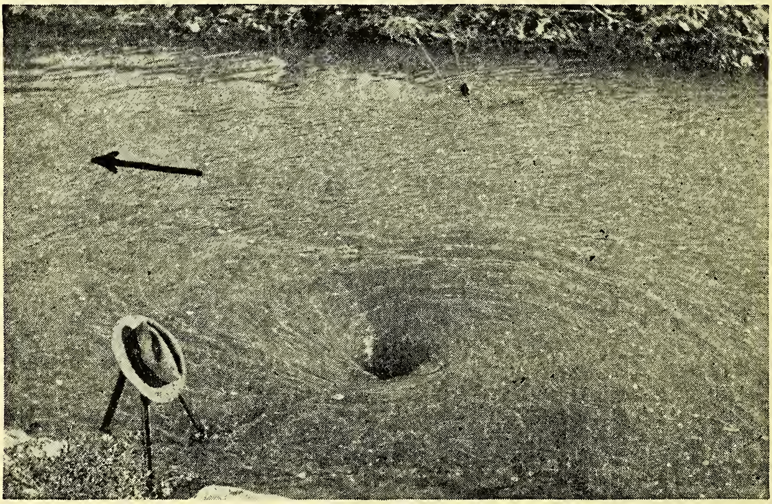


Fig. 6. View of a vortex in the storm waters in the dry-bed of Lost River. About five cubic feet per second are disappearing here in a small swallow-hole about one-half of a mile below the dry-weather sinks of Lost River. Sinking streams rarely disappear in vortices such as the one here pictured.

an accumulation of drift-wood which may be called *swallow-hole rafts.* Stampers Creek, formerly connected with Lost River as a tributary and now draining about 15 square miles, has only one main swallow-hole at the terminous of its surface channel. It does not maintain a dry-bed channel, though on rare occasions an excess of its accumulated storm waters overflow across the country to Lost River.

Some streams have continued to sink in a terminal swallow-hole for such a long time that they have cut their valleys much below the level of the plain or below their former surface courses. Such valleys terminate abruptly, and having no continuation, are known as *blind valleys.* A good example of a blind valley occurs along State Road 37, near Needmore, Lawrence County, where a small stream enters a swallow-hole in a valley cut 60 feet lower than its former surface course. A small blind valley is present on the main campus of Indiana University at Bloomington, and they are present at numerous places where small streams sink in the sinkhole plain. Blind valleys become the sites of temporary lakes when storm waters accumulate about the terminal swallow-holes into which the waters feed more slowly. Stampers Creek valley of the Lost River region is a broad, shallow blind valley in which storm waters accumulate as much as 20 feet deep and spread widely over several hundred acres following continued heavy rains. It takes as long as 23 days for these accumulated waters to completely vacate the valley. Ponded storm waters in some of these broad, shallow blind valleys frequently become a flood menace, such as in the terminal blind valley of Sulphur Creek in the town of Orleans, Orange County.

In contrast to the litter-glutted swallow-holes of many sinking streams, a disappearing stream may flow boldly into a gaping cavern. Such an opening to an underground course may be called a *cave-inlet* instead of a swallow-hole. Cave-inlets are rare in the Indiana karst. Bridge Creek of the American Bottoms region of eastern Greene County enters its underground route through such an opening.

The absorption of surface waters into sinkholes and swallow-holes initiate or furnish waters to *underground streams* which course through conduits or cavernous routes of considerable lengths before being returned to the surface at lower levels in the limestone terrain. The routes of some of these underground streams are known and have been explored in part, such as certain sections of underground Lost River, the lower parts of underground Mosquito Creek in the Donaldson cavern system

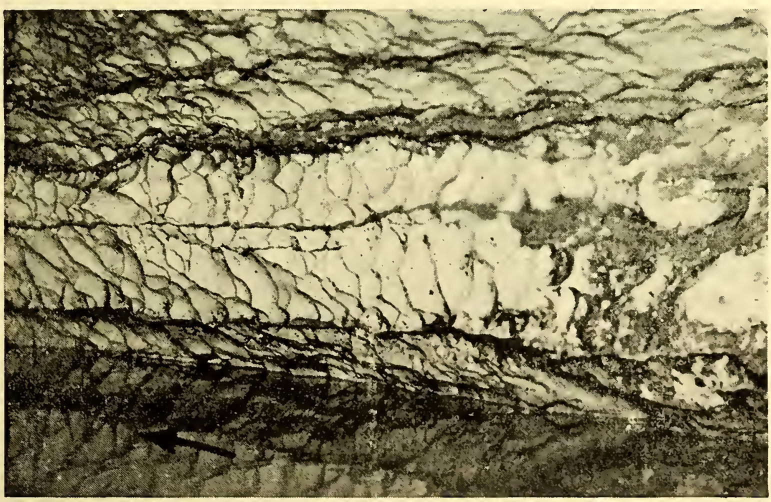


Fig. 7. View of an underground stream and storm-water sculpture in Salts Cavern, one-half of a mile south of Georgia, Lawrence County.

of Spring Mills State Park, and a considerable section of underground Sinking Creek, near Hardinsburg in Washington County. Where underground streams occupy caverns, they may be called *cavern streams.* (Fig. 7.) Untold numbers of underground and cavern streams are not open to exploration. They are sealed to the light of day and their routes are little known. Some of them are at shallow depths, but many of them pass more or less directly underneath high ridges and are deep beneath the surface at such places. The shallow ones frequently may come momentarily to the light of day in karst windows which indicate the courses of their routes here and there.

The return of the waters of the larger underground streams to the surface, either in the lower parts of the same valley or into another valley, produces springs of considerable size and of varying volume, which may in general be called *karst springs.* Many of these resurgences are known to be the reappearances of the waters of sinking streams, and are called *rises* in southern Indiana, such as the rise of Lost River, the rise of Stampers Creek, etc. Many of the rises are attended by moderate flows of clear waters during dry periods, but following heavy rains they send forth great volumes of turbid storm waters and are impressive features along the deep-set valleys of the western margin of the karst area. (Fig. 8.) The larger and more impressive ones are

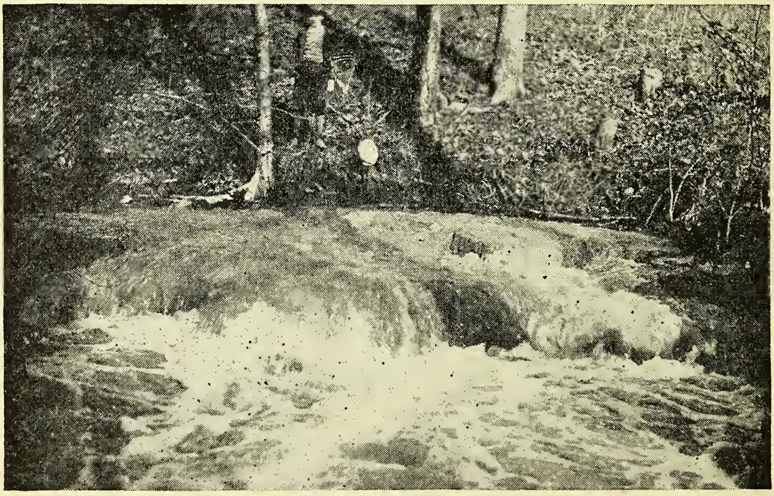


Fig. 8. View of one of the storm-water rises along Caplinger Branch three miles southeast of Paoli, Orange County. This is a storm-water rise only. The waters come from a small tubular cavern.

artesian in character and issue from *rise-pits* of considerable size and depth. (Fig. 9.) The great Harrison karst spring, some six miles west of Corydon in Harrison County, is 80 feet wide, 110 feet long, and at least 35 feet in depth. It is filled with clear waters during dry periods, but following heavy rains it becomes greatly swollen with muddy storm waters which rise vigorously from the bottom of the great rise-pit. A view of the great volumes of storm waters issuing here at such times leaves the observer with little doubt concerning the presence of a large water-filled cavern ending in the great rise-pit below the local drainage level of Blue River valley at this place. The waters come from the higher sinkhole plain and the karst valley areas east and north of the great spring, which in reality is the terminus of a large underground drainage system arising here from its underground route under a forced artesian flow.

Rise-pits are not always water-filled. They may be the sites of *wet-weather rises*, used only during rainy periods, and are *dry rise-pits* during most of the time. Such a rise-pit occurs near the dry-bed of Lost River a short distance north of the well-known Pitcher Cavern, about four miles southwest of Orleans, Orange County. Dry rise-pits occasionally contain worn and polished pebbles which partially clog the

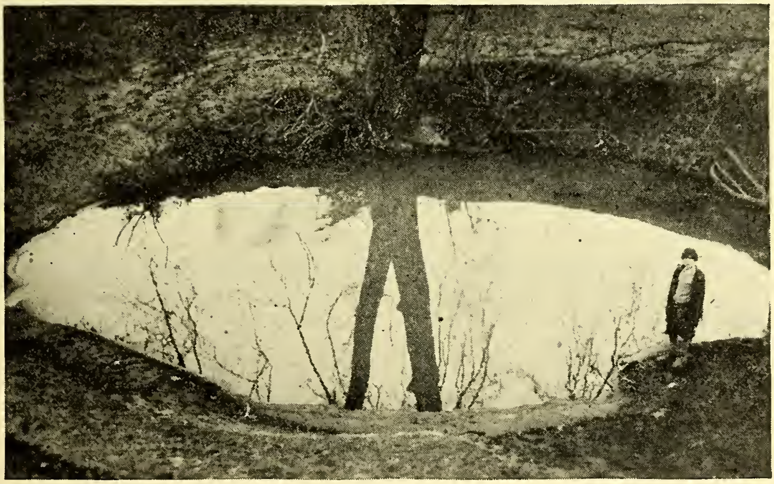


Fig. 9. View of the rise-pit of Lick Creek, locally known as Half Moon Spring, about three miles southeast of Paoli, Orange County.

openings through which the storm waters vigorously rise. They become veritable pebble grinding mills, intermittently active, and indicate the actions probably taking place in the deep rise-pits constantly filled with rising waters.

Not infrequently an underground stream will issue at the head of a valley. The waters may flow directly out of an open cavern which serves as a *cave-outlet* of the underground stream. The mouths of Donaldson and Hamer caverns of the Spring Mills State Park are excellent examples of such cavern outlets of underground streams. Such underground stream outlets are characteristic of the eastern margin of the karst area and are rare on the western margin. Underground streams commonly issue through broken rock or talus which wholly obscures the terminus of the cavernous route from which they flow. Such issuing waters are mere resurgences or karst springs, and no special term is applied to them. Such resurgences in common with those issuing directly from caverns develop steep valley heads of a very striking character, which are under gradual retreat through the sapping action of the issuing waters at their bases. The term *steep-heads* may be applied to them, after the term used for such abrupt valley heads in Florida. The issuing waters at Donaldson and Hamer caves of the Spring Mills State Park have produced such gulch-like steep-heads. Shirley and Leonard springs, four miles southwest of Bloomington, Monroe County, occupy two excellent examples of steep-heads where the waters issue through talus with little evidence of cavern mouths. Occasionally an underground stream issues from the side of the valley near the base of a steep-headed notch, to which the term *spring alcove* may be applied. The short steep-head at Hamer Spring of the Spring Mills State Park may be designated as a spring alcove. The steep notch at the rise of Stampers Creek, three miles southeast of Paoli in Orange County, and the notches at the Avoca and Popcorn springs in Lawrence County, are excellent examples of spring alcoves. Numerous steep-heads and spring alcoves are characteristic of hundreds of springs issuing from the Beech Creek limestone of the Crawford upland area west of the sinkhole plain. The springs issuing at Rays Cave and Sexton Spring in eastern Greene County, and at "The Gorge" southeast of French Lick occupy such spring alcoves made by waters coming from the Beech Creek limestone where massive sandstone is exposed above as a heavy over-hanging brow.

Long continued flowage of waters underground in limestone terrains has developed natural subterranean runway voids known as *caverns.* Some of them are of great size, and, no longer occupied by underground streams, are attractive scenic features within themselves. The smaller caverns usually show very clearly that their development took place along joints and bedding planes in the limestone strata. The joints and bedding planes are systematic, three-dimensional slits which may be occupied by thin films of subsurface water, and which offer opportunity for forced passage under a hydrostatic head. Waters from the surface enter them and selectively enlarge and develop them into initial cavernous routes of discharge, where the waters move through the limestone from higher to lower levels of drainage. Once selected out from the original grid of joints and bedding planes, they offer easy lines of passage of surface rainfall and run-off as underground drainage routes in preference to surface routes of drainage. If these premises are true, large caverns have been hollowed out by the solutional action of large quantities of water which have flowed through them. Some students of cavern development believe that the deep ground waters themselves have developed the caverns of limestone areas, while others believe that in-fed waters from the surface have developed them. Many large caverns are the underground channel routes of water drainage in limestone areas, and in times of heavy rainfall receive and convey great floods of water through their voids. In periods of low water many of these underground drainage conduits may be entered and explored. (Fig. 10.)

Few caverns may be explored great distances, as rock falls and other features obstruct the passages. The Donaldson cavern system of the Spring Mills State Park has been explored and mapped by Scott (1909) for 9,127 feet, which is perhaps only one-third of the underground distance back to the sink of Mosquito Creek where the cavern probably heads. Trinkle Cavern, near Hardinsburg, Washington County, is the

Fig. 10. View in Trinkle Cavern showing a mud bank made by the storm waters of underground Sinking Creek, beneath U. S. Highway 150, one mile southeast of Hardinsburg, Washington County. 9,300 feet of the route of this stream-coursed cavern have been mapped.

route of the lower section of underground sinking Creek. It was mapped by Bates (1932) for a distance of 9,300 feet, which appears to be about one-half of this underground section of Sinking Creek. The writer has entered and mapped (1932) only a small fraction of the many miles of the underground course of Lost River. Addington (1927) was able to explore and map only about 850 feet of the well-known Porters Cavern in northeastern Owen County, though he clearly shows the main cavern to be a relatively simple drainage conduit about 2,000 feet in length. Fidlar (1935) explored and mapped the complete route of Old Town Spring Cavern, near Marengo, Crawford County, from its mouth to its beginnings under a sinking stream, a distance of 3,500 feet. Only primitive, undeveloped tubes, defying exploration, were found to extend beyond the clogged entrance holes of the surface floods from the sinking stream above the explored end of this cavern. Blatchley (1897), in his well-known "Indiana Caves and Their Fauna," gives the characteristics of 17 caverns and the mapped routes of seven of them. The explored routes of only six of them exceed 1,000 feet, and only the famous Wyandotte

Cavern was found to exceed 3,000 feet in length. Many of the caverns explored and mapped are only fragments of far more extensive conduits, but obstructions prevented further exploration in them.

Some caverns are single-route conduits, while others are a complex of routes. Dry caverns very frequently have two or more levels of development, or are *galleried caverns*. The cavern galleries may be directly above or below each other or they may wander away. Three cavern galleries have been commonly noted, and as many as five have been rather vaguely ascertained. The tiered cavern systems appear to be partly dependent upon development at successive levels because of stages of down-cutting of the outside valleys into which the cavern drainage was discharged, but relative ease or opportunity of development in certain layers over others is also a factor in multiple cavern levels.

Many dry caverns still indicate that they were once the courses of underground streams. Marengo Cavern of Crawford County is such. Its silt-covered, current-marked floor clearly indicates the former presence of a free flowing stream. Its floor is now only 25 feet higher than the outlet of an underground stream of considerable size which enters the surface drainage near-by. The great Wyandotte cavern system has long routes of stream deserted channels, the main floors of which are 65 feet above the near-by Blue River. While the deserted stream floors in these magnificant caverns receive little attention from the casual visitor, they are significant aspects of the great routes themselves in which the more attractive decorative features have been formed. These long cavern voids were once the routes of coursing waters which flooded through them in a manner similar to streams in surface channels. They, too, had periods of quiet flow and periods of boisterous flood, dependent upon rainfall and run-off fed into them. Perhaps the waters which formerly coursed through Marengo Cavern came from parts of Cider Fork valley, while Wyandotte carried part of the waters of Blue River itself for a long period before special conditions favored a relatively rapid down-cutting of the surface valley, and the waters were shunted away from the shorter subterranean course which is now high and dry and only partially explored. Little investigation has been made with respect to the drainage condition under which our larger dry caverns have been developed. This fertile field of geomorphic study is a standing challenge to the problem of cavern development in the karst terrain. The long dry caverns certainly once carried surface drainage waters similar to the wet and frequently flooded cavern conduits of which the underground routes of Stampers Creek and Lost River are examples.

Natural bridges are occasionally present in karst regions. They are almost wanting in the Indiana karst. Addington (1928) has described two rather insignificant natural bridges, located a short distance north of McCormicks Canyon State Park in Owen County, as the Litton natural bridges. These small arches are the remnants of the roof rock of a shallow cavern where two small windows have been developed by collapse near the terminous of a small cavern tunnel known as Wolf Cave. I have no knowledge of other natural bridges in the Indiana karst, though a few natural arches or bridges are developed elsewhere.

Subterranean cut-offs form an assembly of underground drainage or karst features of more than usual interest. A subterranean cut-off is an underground diversion of a stream beneath a meander spur. It is composed of a swallow-hole into which a stream sinks, a subterranean tunnel, and a rise or resurgence of the diverted water on the opposite and downstream side of an intrenched meander. No fully completed subterranean cut-offs are known in the Indiana karst, but at least five developing cases are known. Malott (1919) has described a well developed subterranean cut-off along Clifty Creek in the American Bottoms region of eastern Greene County, about one and one-half miles north of the village of Koleen. Another has been described in considerable detail by Malott (1922) along Indian Creek, about nine miles west of Bedford in western Lawrence County. This developing subterranean cut-off involves the sink, the passage, and the resurgence of the low waters of Indian Creek beneath the neck of a large compound meander spur. The subterranean route is only one-fourth of a mile in length, while the meander route of the surface channel is more than three miles in length. The developing subterranean route well illustrates economy of distance.

Thornbury (1931) has described two developing subterranean cut-offs along the deeply intrenched Bogard Creek and Little Blue River in central Crawford County, about three and one-half miles southeast and four and one-half miles south of English, respectively. The one along Little Blue River, known as the Carnes Mill cut-off, is of more than usual interest. The intrenched meander loop is a short one and the neck is very narrow with only 200 feet of separation. The natural tunnel

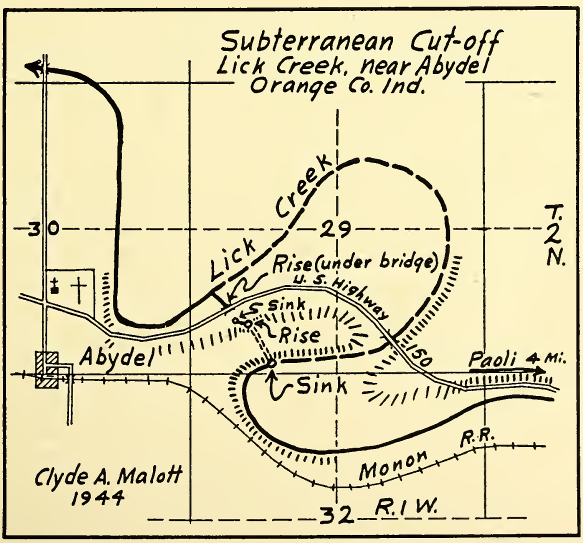


Fig. 11. Sketch showing the location of a developing subterranean cut-off along Lick Creek, about four miles west of Paoli, Orange County. The resurgence of Lick Creek takes place beneath a bridge on U. S. Highway 150.

was formerly used as mill race in the operation of a small mill. It appears that subterranean perforation here is serving as an aid to valley intercision in which a surface diversion will probably take place before total subterranean diversion can be completed.

A more readily available and undescribed subterranean cut-off is developing through a meander neck of Lick Creek on the well known Ballard farm along U. S. Highway 150 between Paoli and West Baden in Orange County. The resurgence of the diverted waters of Lick Creek appears first as a spring-like rise on the north side of the meander spur less than 100 yards from the highway. The waters then sink again in swallow-holes, and again rise under a highway bridge. The bridge, with a considerable stream in a normal channel on one side and no stream or channel of any kind on the other, presents an anomalous situation among highway bridges. (Fig. 11.)

An adequate discussion of the significant aspects of the Indiana karst requires some consideration of the Crawford upland area west of the general sinkhole plain, where rugged sandstone ridges separate deep-set valleys with their floors developed in limestone. Here, shales and heavy bedded sandstones overlie the limestone and compose the rugged ridges. The deeply intrenched valleys, however, penetrate into the soluble limestone and karst features have been developed in them, producing *karst valleys*. The normally developed tributaries with their dendritic arrangements reach from the standstone hills into the karsted valleys where their waters are lost in swallow-holes. The tributary streams are the dismembered distal branches of former trunk streams which once descended the main valley in normal stream alimentation. In the floors of scores of these valleys there are no signs of a trunk stream, the floors being completely characterized by sinkholes and other karst features. Many of them, however, have dry-bed stretches which terminate in swallow-holes or which discharge surface storm waters down the lower sections of the karst valleys. Some of the dismembered side valleys terminate abruptly in deep-sunk individual courses, producing blind valleys. The sinking waters of the karst valleys in many cases are directed through underground routes completely away from the valley into the deeper surface streams adjacent, but commonly the underground drainage comes to the surface in the lower part of the same valley, appearing as a rise or karst spring. Occasionally karst windows reveal short sections of the subterranean streams.

Karst valleys characterize at least 400 square miles of the western hilly margin of the karst terrain in southern Indiana. They occur west of the dissected Chester escarpment and west of the sinkhole plain proper. Some of them are quite broad and present hemmed-in small karst areas west of the main area of the karst plain itself. Caverns are far more abundant and much more readily available in the karst valley areas than in the sinkhole plain proper. Karst valleys are numerous in western Lawrence, Orange, western Washington, northeastern Crawford, and western Harrison counties. Ripperden, Grassy, Walnut, Moberly, Brushy and Hancock valleys of western Harrison County are well developed karst valleys perched above Indian Creek and Blue River into which their underground drainage is discharged through large artesian rises or springs. Cider Fork valley of northeastern Crawford and southeastern Orange counties has many undescribed characteristics of underground drainage awaiting study. Sinking Creek Valley of southwestern Washington County, with the longest mapped single-course cavern in Indiana, has received some study by Bates (1932). Mahan Valley, a partial tributary of Stampers Creek in Orange County, and the Dry Branch system north of Orangeville near the rise of Lost River, possess interesting surface and underground features which as yet have not been published. Beaver Valley, along the B. and O. Railway and State Road 60 and U. S. Highway 50, west from near Mitchell to Huron in southwestern Lawrence County, has had more than 30 square miles of its drainage directed from under it to East White River on the north and to Lost River on the south, both of which are many miles away. It does not recover its own lost waters. At least 100 of its tributary branches have been dismembered and terminate in individual swallow-holes, and finally its beginning trunk, far down its valley, is itself swallowed up one-half mile east of the village of Huron. It contains the unusually interesting Salts Cavern through which waters are conducted to the Lost River system, and Connerly Cavern which carries waters beneath a high ridge from one part of the system to another. The hidden drainage of this remarkable valley is virgin territory awaiting detailed study, like that of much of the Indiana karst.

The features described in this brief survey of the Indiana karst are features dependent upon the solvent action of the waters received from the surface. Systematic solution has so riddled the limestone terrain that the waters of storm and stream are diverted from the surface to underground routes. Sinkholes, sinking streams, underground streams, caverns, great springs, and the like, are co-related phenomena of subterranean drainage, and they compose the significant features of karst terrains wherever they are.

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