Karst Development in Calcareous Tufa Deposits Along Flint Creek, Tippecanoe County, Indiana

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Abstract

Karst landforms are common in Mississippian limestones of the Mitchell Plain in southern Indiana, and are not rare in older Paleozoic carbonate rocks in the southeastern part of the state. However, they are also well-developed in post-glacial calcareous tufa deposits along Flint Creek, in southwestern Tippecanoe County. This karst development includes caves, sinkholes, and associated calcite cavern deposits.

Pop's Cave, the largest cavern studied, is essentially a single large room with an estimated volume of 1,350 cubic feet, formed by solution and breakdown along a contact between tufa and fine-grained, silty shale of the Borden Group that crops out along the valley walls of Flint Creek. Cavern development on two, or possibly three levels along the valley sides may be related to terrace development on Flint Creek that resulted from alternating episodes of stability and stream downcutting. The tufa provides a protective "cap" that retards erosion of the shales of the valley walls. The tufa deposits and the caves are currently being destroyed by lateral planation and valley wall slumping.

Introduction

The study area described in this report is contained within an area known locally as Burnett's Reserve. The area is of some historical significance in that it was settled by John Burnett before the Land Act of 1784 (3). Therefore, it is the only land in Tippecanoe County which is not laid out in the rectangular coordinate system of land survey. The projected location to the rectangular coordinate system places the location as along Flint Creek, 2 miles west of Westpoint, Indiana, in Sec. 15, T22N, R6W, Wayne Township, Tippecanoe County (Fig. 1).

General Geology

Our interest in the Flint Creek area centers on the presence of certain unusual characteristics of karst development and differing lithologies as compared to other Indiana karst areas. The Flint Creek locality is at least 40 miles north of the terminus of the Mitchell Plain physiographic subprovince defined by Malott (1). The Mitchell Plain is the predominant karst area in Indiana (2), although karst landforms are not rare in Ordovician, Silurian, and Devonian carbonate rocks in southeastern Indiana, and some small caves occur in Silurian age klintar of the upper Wabash Valley.

Unlike karst developed in the Mitchell Plain Mississippian-limestones, Pop's Cave and associated karst features have developed in massive, calcareous, post-glacial tufa. These tufa deposits indirectly result from glaciation of the area. As the Wisconsinan glacier retreated, it deposited a thin veneer of carbonate-bearing glacial till over the silty shales of the Borden Group. The shale acted as an aquatard to downward percolating ground waters, which were saturated with $CaCo_3$ dissolved from the till (Fig. 2A). The ground water thus moved laterally toward Flint Creek, where it reissued as numerous seeps and springs. Upon reaching the valley wall, a change in the partial pressure of CO_2 occurred, and the calcium carbonate was precipitated as tufa.

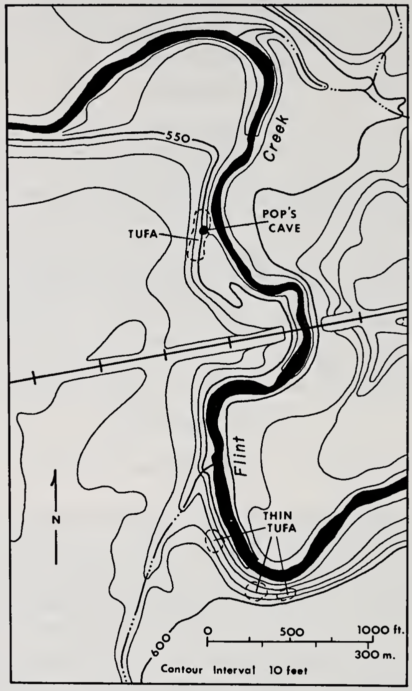

FIGURE 1. *Location map showing topography and tufa deposits of the Pop's Cave area along Flint Creek, Tippecanoe County.*

The tufa is light brown to light gray, and lacks true bedding. It is an accumulation of calcified leaves, sticks, and moss cemented to gastropods and cave material such as broken stalacite straws, etc., forming a very porous and permeable rock. Some relict bedding is observed, but is evidently owing to the bed-like accumulation of leaves, sticks, and other debris that was later calcified.

The shale probably belongs to the upper portion of the Borden Group. It is flaggy, silty, light blue shale that weathers to a light gray color. Quartz, calcite, and sphalerite-filled geodes occur within the shale.

Flint Creek itself is a small, joint-controlled bedrock valley which is probably of pre-Wisconsinan age. After deglaciation, however, it re-excavated its old channel. Field examination indicates that the channel is cut in bedrock locally thinly veneered by alluvial gravels. Flint Creek valley is bounded by rock walls and is 1,000 to 1,500 feet wide at a distance of 1 1/2 miles upstream from the point of issuance of the creek onto the Wabash River floodplain. Compared to other rock-walled streams in the area, for example Grindstone Creek, the drainage pattern and valley form of Flint Creek is much more mature, in the classic descriptive terminology relating to age of valleys. A stream developing during deglaciation would tend to take the path of least resistance, which in this area of thin till cover would be excavation of an old channel rather than cutting of a new one in bedrock. This process would also explain the presence of the deep, wide, well-developed valley of Flint Creek in a geologically relatively youthful area. Furthermore, had the bedrock valley formed since Wisconsinan time, the tufa probably would have been eroded by the stream as fast as it was deposited on the valley walls.

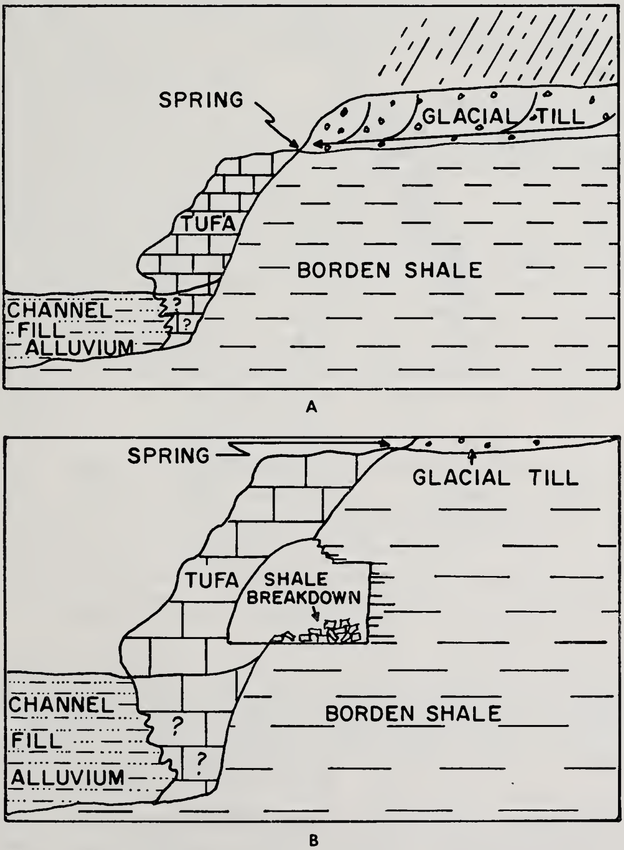

FIGURE 2. *Schematic cross-section of till, shale, and tufa relationships (A) prior to cave development and (B) subsequent to solution of tufa and breakdown of shale.*

Karst Features

The main karst features of the area are several caves in the tufa. The largest of these is Pop's Cave (Fig. 3). This cave is essentially one large alcove 30 feet long, ranging from 5 to 15 feet wide, and 5 feet high. Assuming an average width of 9 feet, the volume is approximately 1,350 cubic feet. It was formed on the shale-tufa contact with enlargement of the passage resulting from two processes: 1) weathering and breakdown of the shale wall and ceiling, and 2) dissolving of calcium carbonate from the tufa (Fig. 2B).

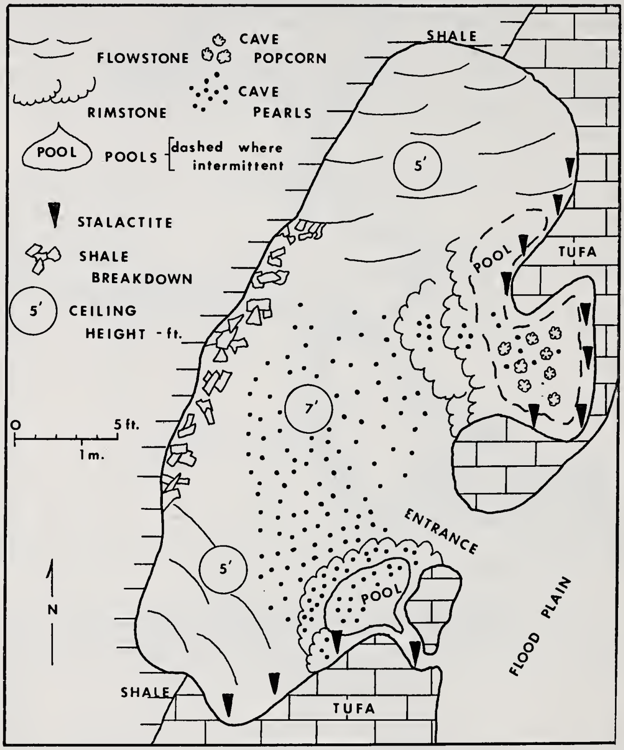

FIGURE 3. *Plan view of Pop's Cave. Entrance is at same level as the cave floor, and is approximately 8 feet above level of adjacent flood plain.*

Other, smaller caves nearby occur on two distinct levels, and a third level may exist. Only Pop's Cave was studied in detail, as the other caves are too small to allow access and, therefore, only the passage trends were noted as being parallel to the valley walls. The multilevel structuring suggests that there were distinct pauses in downcutting during excavation of the valley in post-glacial time. Three terraces, of moderate areal extent but slight vertical separation, are present both upstream and downstream on the flood plain of Flint Creek in the vicinity of Pop's Cave, and tend to further substantiate this conclusion. However, additional study of the terrace-cave level relationship is warranted.

Initial solution apparently began at or near the tufa-shale contact. This is especially apparent in the numerous small caves of the area, where cross-sections suggest that cave development is always nearly symmetrical and parallel to this contact (Fig. 2B). As the caves increase in size, continued enlargement from the contact into both the tufa and shale becomes evident. In all cases, the long dimension of the caves is parallel to the valley wall.

The shale-tufa contact is not clearly defined. It is normally a gradational change over a width of 1 to 2 feet. The shale has a crumbled, flaggy character. Calcium carbonate has filled all open spaces around the shale fragments, giving a breccia-like appearance to the rock. The percentage of $CaCO_3$ increases toward the contact as it grades into tufa.

Cavern deposits in Pop's Cave are breakdown, numerous stalactites of the soda-straw type, rimstone, flowstone, popcorn, and an abundance of cave pearls. Rimstone and flowstone development is quite prominent even in the smaller caves, and covers most of the floor of Pop's Cave, including the tufa-shale contact.

Cave pearls are one of the most unusual features of Pop's cave, as they are generally considered to be a rare type of formation. They are light gray, spherical in shape, and consist of concentric bands of calcite around a core of shale, a glacial pebble, or organic matter. Their diameters range from 1/32 to 3/4 of an inch. There are several thousand pearls on the floor of the cave. They appear to form by calcium-rich water falling from the ceiling onto the central core material and coating it with calcite. The agitation of the falling water also seems of sufficient force to move the pearls around enough to prevent them from becoming cemented to the floor. These pearls are very lustrous in their cavern environment, but lose their luster once removed and allowed to dry.

The soda-straw stalactites are, by comparative observation, somewhat larger in diameter than the normal cave soda-straw, but are still within a diameter range of being soda-straws as opposed to a normal stalactite. They vary in length from a fraction of an inch to 11 inches. A few normal sized stalactites and stalagmites were also observed.

Cave "popcorn" (a cave explorer's term for botryoidal masses of calcite formed in a still-water, submerged environment) occurs in the rimstone pools where the rimstone dam has attained sufficient height to develop a standing pool of water 6 to 12 inches deep. In areas where rimstone dams have developed leaks, the popcorn is now above water and is no longer being formed. The popcorn is formed on the walls, floor, and any object within the rimstone pool.

Breakdown is the dominant feature of the small caves of the upper level. In one cave, glacial till was exposed in the ceiling and is beginning to slump into the cave. In a few years, a true surface sinkhole may develop here.

Surface karst features that have developed include several slump features on the valley wall, and were apparently formed by the collapse of cave passages at those points. It may be improper to call these features sinkholes or karst windows, as the slumping has carried downward past the level of the caves. These features may only be the result of slippage along the shale-tufa contact owing to the weight of the tufa, and thus are not true collapse sinkholes. One slump structure is, however, only evident from the top of the valley-top bluff and may in reality be a true sinkhole. These slumps are small features (no greater than 40 feet long), but subdivide the bluff into a series of tufa-shale faces. In the tufa faces, two levels of caves can be traced for several hundred feet along the bluff, which suggests that on each level of cavern development there was once only one cave, which is now divided into several segments by slumping. The slumping is, nevertheless, directly related to the tufa either by cave collapse or slippage, and as such may be considered a karst feature.

Most investigations in karst geomorphology stress the importance of landscape denudation and reduction by the solution and removal of carbonates. The tufaceous carbonates in this locale, on the contrary, appear to provide a protective "cap" for the shale, and actually retard the rate of shale erosion (Fig. 4). This protective relationship is observed at various points for a distance of one-half mile upstream from Pop's Cave. Much of the tufa has been removed by valley wall slumping and occurs as large blocks of breakdown on the flood plain or in the stream bed, but locally, small patches of the tufa remain in place over the shale. Here, the protective relationship is shown by an outward protruberance of the shale and tufa cap beyond the general alignment of the valley wall.

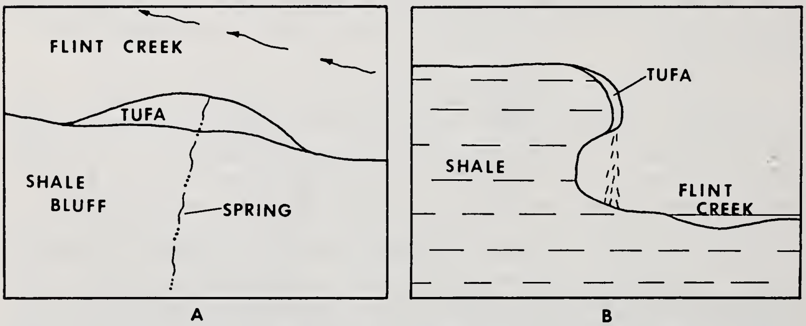

FIGURE 4. *Schematic plan view (A) and cross-section (B) of protective relationships between tufa and shale along Flint Creek.*

Although some tufa is currently being deposited, the overall net effect is gradual removal of older tufa by undercutting of the steep slopes, and by solution and slump on the gentler slopes. The springs and seeps that once provided the $CaCO_3$ for tufa deposition may now be generally undersaturated, and have begun to redissolve the tufa. This reversal of process is probably owing to the gradual decrease with time in the amount of carbonate in the till, but may also be partly owing to changes in soil structure, vegetation, or climate. Long-term lowering of the local water table, in direct response to reduction of local base level as provided by downcutting of Flint Creek, was probably a factor in originating the tufa deposits and multilevel caves, but is now a factor contributing to their destruction.

Acknowledgments

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