TUFA DEPOSITS AT CLIFTY FALLS STATE PARK.

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The river bluffs in the vicinity of Clifty Falls State Park are underlaid with limestone of both the Upper and Lower Silurian deposits. The erosion of Clifty Creek and its tributaries displays many sheer cliffs of these limestone formations along the sides of the canyons. The Upper Silurian is very near the surface of the soil and consists of a 35-foot group of deposits. In places eighty to ninety feet of Lower Silurian shows below the latter, but the present article is concerned only with the Upper Silurian and especially the top layer. This layer consists of 24 feet of limestone. Recently the writer's attention was attracted to three deposits of tufa along this layer where it is bared along the sides of Hoffman's Hollow.

Perhaps an explanation of the general nature of tufa would make the meaning of the present article more clear. Tufa is an incrustation of carbonate of lime around a nucleus of organic matter, such as debris of leaves and twigs or growing mosses and liverworts. G. W. Wilson[1] reported a bed of travertine along the west bank of the Wabash River in Tippecanoe County. The term travertine is applied generally to all calcareous deposits on plant matter, and especially to the more extensive beds. Tufa is a more definite name for deposits of a porous and less compact structure formed from springs. Sinter is used occasionally as a synonym for tufa.

Hoffman's Hollow is a side canyon running approximately northeast from the main hollow of Clifty Creek. The upper eastern half of Hoffman's Hollow consists of a shallow ravine with a creek which, at Hoffman's Falls, drops some ninety feet into the "box canyon" half of the hollow.

In the upper and shallower portion of the ravine there appears frequently a small cliff of limestone extending along the banks of the stream. Along one of these small cliffs on the north side there are two deposits of tufa. The third deposit is found along the talus of the box canyon several hundred yards west from the falls.

One of the deposits in the ravine is quite small and consists of an irregular mass of tufa built over loose stone and soil (fig. 1, A). In this instance the seepage is from a limestone shelf very near the level of the flats, from which the water falls about 12 feet. The tufa found in all three deposits is formed by the moss, *Mniobryum albicans* (Wahlenb.) Limpr., which seems to be the most active nucleus for the incrustation.

The other deposit in this shallower half of the Hollow has been molested by the conversion of its seepage into a drinking fountain. The

[1] Proc. Ind. Acad. Sci., 1905: pp. 183-184. 1906.

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water now runs from a pipe driven back into the stone, whereas it once seeped from the limestone a few feet above the floor and under a shelf of rock (fig. 1, B). Here it has built around the Mniobryum an irregular oval mass on the slanting surface of the rock. At the bottom of this mass there is a pool from which the seepage overflows down an irregular surface of loose rock and soil forming smaller and scattered mats of tufa for a few feet.

The third deposit is larger than these last two and in all probability is least molested since it is in a rather remote situation. This formation is along the same limestone layer but has a northern exposure. Here water seeps from a fault in the limestone which resulted in a vertical fissure in the cliff several inches wide (fig. 1, C). The tufa has completely clogged the lower four feet of the crevice. This deposit is some three feet in diameter at the bottom and is in the form of a truncated cone. It is fairly well covered by the Mniobryum which is especially luxuriant in growth in and around the pool on the summit

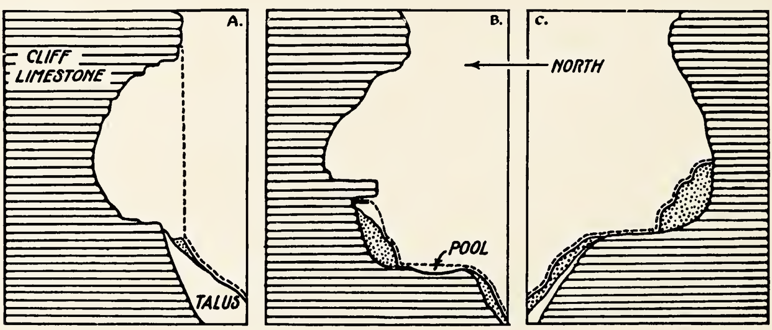

Fig. 1—Diagramatic sections through limestone cliffs at points where tufa is formed.

in which the rivulet pours. The seepage trickles down rather evenly all over the surface and after crossing the narrow path at the base forms an irregular and spread-out secondary mass of tufa followed by several successive smaller masses growing directly below it on the slope. A secondary succession of mosses is growing on the cliff along the edges of the damp tufa. *Amblystegium irriguum* (Wils.) B. & S. grows in a narrow strip around both sides and around the top. On the eastern margin, which is more protected and more moist, *Gymnostomum curvirostre* (Ehrh.) Hedw. interrupts the Amblystegium near the summit of the deposit. On November 4, 1928, large beads of Nostoc were growing on this moist surface in and around the Gymnostomum.

A comparison of all three deposits as to shelter, exposure, flora and source of seepage shows marked resemblances. The immediate surroundings of the two deposits in the upper end of the hollow are not quite so heavily forested as those of the lower deposit, but the former have a southern exposure which probably makes up for this deficiency. All three deposits are in rich mesophytic situations. They are all fairly well protected by the projection of the cliff as can readily be seen from the diagrams. Mniobryum is in these three instances the active nucleus for the incrustations. The seepage comes from between loose layers of limestone in the first two instances and from a fault in the stone in the last. All are along the same geological layer of limestone.

There are possibly two general reasons for the presence of these beds. First, the presence of calcareous mineral which for some reason was deposited around the moss; and secondly, the protection offered by the projecting cliffs and trees which probably checked erosion. What factor is actually responsible for the precipitation of the mineral from the drain water would be a problem in itself. It is probably due to the photosynthetic action of the Mniobryum in which it absorbs the carbon dioxide from the solution and to evaporation when the water, spread out over greater surface of moss, comes in contact with air currents. That evaporation may be one of the factors causing the precipitation seems clear when it is recalled that stalactites and stalagmites in caves are formed by evaporation and reduced carbon dioxide pressure. Tufa has a comparatively rapid growth requiring high precipitation in a short time. This condition could occur since the seepage spread out over a relatively larger area of moss comes in contact with dryer currents of air.

Subterranean streams and seepage are known to contain an excess amount of carbon dioxide, which is held by the pressure naturally incurred. When limestone is exposed to carbon dioxide it breaks down yielding excess amounts of carbonate of lime to the water before it appears at the surface. On leaving the crevice the consequent reduction of pressure alone could make possible the precipitation. Furthermore, the moss, which is partly submerged, would use up carbon dioxide in its photosynthetic processes and this would still more reduce the amount of carbon dioxide in solution. Seemingly, therefore, the seepage precipitates carbonate of lime because of evaporation and because of a loss of carbon dioxide.