ART. III.—*On a Subsidence of land at Coxsackie, N. Y.*; by Rev.
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LANDSLIDES upon a small scale are quite frequent in the soft or semi-consolidated Post-tertiary clays of the Hudson river and its tributaries. In the great majority of cases, however, they do not, either in extent, or in any of the attendant phenomena, depart from the simple, typical, slide-movement.

An occurrence of this kind having come under my observation in 1863, (and in a subsequent visit to the locality in 1864,) which is of remarkable extent, and which combines, besides many other interesting features, the double effect of depression and of elevation, I think it desirable to put an account of it upon record.

The locality is upon the farm of Mr. Casper Flansburgh, four miles north of the village of Coxsackie, N. Y., and two miles west of the Hudson river.¹ The Post-tertiary terrace has here a width of about three miles, having its extreme western limit at the base of a bold ridge of Helderberg limestones, from which line its surface continues quite level and unbroken toward the east, till, at the distance of one mile from the hills, it reaches the ravine which is the scene of this movement. Here a creek has excavated a ravine or valley of a considerable size, cutting through the terrace, which stands at the same level on both sides of the valley. The banks thus formed are by no means steep, but gradual declivities; the terrace level was about 75 feet above the bed of the creek previous to the disturbance. The general course of the creek and valley at this point is N. 45° E; but a little below, and just at the termination of the slide, the course is north; the stream was eight feet wide, and six feet deep.

The terrace consists superficially of light-colored clay soil, mixed with sand and stones. Underneath this there is a thick stratum of light gray clay, quite firmly consolidated into well-defined horizontal laminæ of rock, very soft and porous, very fine, and free from grit, but containing a considerable amount of lime. These consolidated laminæ do not appear except where there has been a recent excavation, as exposure soon destroys their structure; about fifty feet of these layers could be made out at the fracture of the slide; how much greater their depth, I was not able to ascertain. Below these light-colored layers is a deposit of blue clay, everywhere quite distinct from the other, as stated by the New York State Reports: "these clays are almost uniformly associated; the blue lying below the other; the line

¹ I acknowledge, with pleasure, my indebtedness to Mr. Casper Flansburgh, the owner of the property upon which the subsidence took place, for his cordial assistance, and to Mr. H. A. Whitbeck of Coxsackie, for much useful information founded upon his own intelligent observations, and also for valuable sketches of the locality.

of junction is very distinctly marked." (N. Y. State Geol. Rep. 1st Dist., p. 128.) This blue clay is also of very fine quality, and valuable for pottery: it contains more lime than the other, effervescing freely with acids. There is no appearance in this blue clay of consolidation into compact laminae, but there is evidence that it is brought into a semi-liquid condition by the presence of water much more easily and thoroughly than the gray clay above. In the normal condition of the valley, the blue clay was not visible, being covered, even at the lowest points, by its lighter-colored associate.

The terrace-level is cleared and tilled; the whole of the slope of the valley or ravine is, however, timbered with forest trees.

On the morning of March 16th, 1861, Mr. Flansburgh, on visiting this part of his farm, to his utter amazement found his geography of the locality entirely at fault; a precipice, and a yawning gulf took the place of his wooded hill-slope; his sloping ground was nearly level, and his level sloping; a grove of fine trees stood waist-deep in a new pond of water, while the bed of his creek stood aloft high and dry; his trees were pointing in every imaginable direction, looking as if they had passed a hard night.

The movement took place between 5 P. M., of the 15th, and 9 A. M., of the 16th. There is no evidence that it attracted the attention of any one at the time, which is not very strange, as the nearest house is a half a mile distant. From the appearances at the time of visiting the locality, I was not able to form any judgment concerning the amount of local erosion on the edge of the bank at the creek, but am informed that there was a perceptible, though not extensive, undermining. There was no frost in the ground, but it was covered with one foot of very dense snow, which was coated with a heavy crust.

The mass of earth consisting of the slope of the west bank and a part of the summit level, broke off sharply and perpendicularly across the top of the bank about 30 or 40 feet back from the brow; the line of fracture then curved to the east on both sides until it touched the creek, after enclosing a semi-circular tract of about $6\frac{1}{2}$ acres. The flexure seems to have been determined by small ravines running toward the creek at right angles to its course.

The fragment, which was in fact an enormous wedge of earth, 75 feet thick at the back, being now free, was at once subjected to two different forces; for it was immediately separated into two parts by a chasm opening lengthwise and stretching from end to end, (N. and S.), at the distance from the upper edge, of about one-third of the whole width of the detached mass. The portion west of this line, consisting of the brow of the hill, and

the higher part of the slope, at once sunk, partially throughout its whole extent, but most deeply at its western edge, which rested at a depth of 40 feet below its former position at the terrace level; it probably moved also a few feet to the eastward.

The other fragment also sunk considerably at its thicker end, thus bringing its surface nearer to a level; but it had also a decided sliding movement toward the creek, for the distance of from a foot or two at the southern, to 42 feet at the northern end. This measurement was obtained by ascertaining the variation of a line of stakes, trees and other landmarks, from the original line which was known.

The effect of this double movement upon the ground at the creek was extraordinary; the whole bed of the stream, together with a portion of its borders, was lifted bodily, and left at the top of a long and nearly continuous mound. This mound is from 75 to 150 feet wide at the base, and in most places 80 feet high, thus becoming the highest ground on the eastern section of the slide.

At the same time heavy masses of the underlying blue clay were forced up at the outer (eastern) edge of the mound, and, pouring over the adjacent clay of lighter color, now lies in beds in reverse of its geological position, forming a striking feature of the scene. The water-course being thus blocked up, a large pond was formed to the south, submerging a grove of trees in fifteen or twenty feet of water. Another pond was formed along the western side of the mound, and smaller ones in various positions. The creek has since formed a new channel east of the mound at a much higher level than before.

The surface of the mound is much fissured; its trees are tilted, and in many places uprooted from beneath; on the main slope, west of the mound is a tract of about $2\frac{1}{2}$ acres of quite unbroken ground, the only sign of change being the uniform slant of the trees; but at the northern and southern extremities, especially at the northern—there are numerous intersecting fissures, varying from one to ten feet in width, and the same in depth; making the surface to resemble the irregular fragments of a floe of ice left by the tide upon a sloping shore. The positions of the trees are correspondingly irregular. In one instance a fissure one foot in width, opened directly under the roots of a tall maple, splitting its trunk to the height of fifteen feet; one margin of the fissure then slipped past the other nine or ten feet, carrying with it its half of the trunk, twisting the tree and holding it in a sufficiently awkward position.

In forming a correct conclusion as to the nature and direction of the forces which produced this movement, it must be noticed, that the *blue clay* underneath was capable of assuming a condition approaching fluidity, and its appearance as found both in

the front and rear of the area of subsidence, proves it to have been in this condition; on the other hand, the lighter-colored clay above, though softened by water so as to be quite flexible, and capable of parting in any one line of great pressure, yet possessed, in its consolidation into distinct laminae, and in its being interpenetrated by the roots of trees and underbrush, elements of tenacity,—which enabled it to act as an organized mass, which quality was entirely wanting in the under-clay.

There was then a tongue of land of considerable tenacity, a few feet thick at the lower end, and seventy-five at the upper, resting upon a very mobile and smooth clay: the erosion of a shallow channel at the creek, afforded a passage for the *exit* of this clay; and the great and principal force which caused the fracture, was in my judgment, one acting in a *perpendicular* direction, as shown from the fact, 1st, that the fracture is a sharp, perpendicular well defined line, and not the ragged, irregular sloping line usually seen where the soil has been simply drawn down a declivity; 2nd, that immediately after the fracture, the thickest and heaviest portion *did sink* and forced the blue clay before it, outward, and upward, at the lower levels; its own lateral motion being very small.

The following section will further illustrate the action:

Cross section from N. W. to S. E. A, western fragment. B, eastern do. C, chasm. D, new mound, with the bed of the creek at its summit, (80 feet.) E, perpendicular line of fracture. F, former outline of the bank. G, former position of the creek. H, present appearance of the line of fracture. K, masses of blue clay forced up from below, and containing the present bed of the creek.

The eastern fragment, in addition to sinking considerably, slid forty-two feet toward the creek; impelled however in this lateral direction it would seem, not by the principal force, but by a secondary and incidental one, for it did not overwhelm the hollow of the creek, nor did it effect a single *fold* over toward the east, but allowed its lower edge, with the bed of the stream, to be raised by the clay, extended by the subsiding portions, into a mound of equal slope on both sides.

The whole movement appears therefore to be best explained upon the supposition of a body *floating* upon a semi-liquid, and seeking to right itself from a position of very unstable equilibrium; it resembles in many respects the interesting subsidence which occurred at Tivoli on the Hudson in April, 1862.

Although many changes have since taken place in its superficial appearance, much yet remains that is characteristic and wonderful—enough to repay amply the trouble of a visit.

Englewood, N. J., Nov. 11th, 1865.