seen by obtaining the electrical discharge in different gases, such as carbonic-acid gas or nitrogen, and comparing these photographs with those taken in free air. Although we can study certain phenomena of atmospheric electricity successfully in our laboratories, yet we cannot charge a cloud with positive electricity, and fill the sky with different strata of hot and cold air. It is generally believed to-day among scientific men, that the electricity of thunder-storms cannot be attributed to sudden evaporation or condensation of moisture; for direct experiment has failed to reveal any electricity which is due to these causes. Mr. Freeman made many delicate experiments in the physical laboratory of Johns Hopkins university to decide the question whether evaporation produces electricity, and he could find no evidence of any that was due to this cause. Herr Kayser has also lately experimented at the physical laboratory of Berlin upon the electrical effects of condensation, with negative results. Personally I feel that all the experiments hitherto conducted on the electricity due to evaporation and to condensation have been conducted on too small a scale to test the question; and I do not see how they can be conducted on a larger scale. When we think of the immense plan upon which these operations are conducted in nature, of the evaporation from every square foot of the ocean, and of the rapid condensation through miles of space, we can realize that an infinitesimal amount of electrical charge, too small to be detected in a laboratory, might be integrated into a large amount, and, becoming localized, might produce the tremendous electrical disturbances which we witness in thunder-storms.

How, then, can we conduct future investigations upon thunder-storms? The most promising direction for scientific work seems to be in the establishment of systematic observations on thunder-storms, and on atmospheric electricity in general, over a large tract of country. In certain regions, thunder-storms follow certain definite paths, and other tracts are never visited by them. There is a general impression that electrical storms are, in common language, attracted by rivers, and are more severe about large bodies of water in general. However this may be, nothing but systematic daily simultaneous observation, long continued, can increase our knowledge. If the government, in connection with the signal-service, should establish a number of electrical stations throughout the west and south, where thunder-storms and tornadoes are so frequent, daily thunder-storm maps might be issued, showing the probable path of the electrical disturbances. Perhaps we should then see, in districts peculiarly infested by thunder-storms, certain 'insurance-against-danger-by-lightning retreats,' in which Benjamin Franklin's lightning-rod should rise from a small hut, completely covered with a network of metallic rods which are connected with running water or a large extent of moist earth. These safe retreats would certainly be a great desideratum for many who now suffer greatly from nervous terrors during thunder-storms.

JOHN TROWBRIDGE.

THE FORMATION OF CAÑONS AND PRECIPICES.

ONE of the most remarkable natural objects in the state of New York is to be seen at the crossing of the Genesee River, at Portage station, on the New-York, Lake Erie, and western railroad, 362 miles from New-York City, and 83 from Buffalo. The railway here spans a deep gulf on an iron bridge 820 feet long and 235 feet high, near the upper end of a wonderful cañon. There are three falls of the river immediately below the bridge, measuring 60, 90, and 110 feet respectively. The gorge runs out in the Genesee shales at Mount Morris, being 20 miles long by the meanderings of the river, which falls 500 feet in that distance. In some places the banks are 350 feet high, nearly perpendicular, and the ravine is wholly impassable. It is a fine example of the work of water; and there are hundreds of others in that state, on a smaller scale, in the upper part of the Portage group. One of these is the celebrated Watkins Glen, a beautiful cañon two miles long, with a succession of cascades. The neighboring glen at Havana is very similar; and there are a number of others farther north, several of which may be seen at Big Stream, Rock Stream, Dresden, and other places. Taghanic and Lodi Falls, and the glens and ravines about Ithaca on Cayuga Lake, and many other similar places, are all on the Portage formation, which forms a narrow east and west band across western New York. It might be added, that both Seneca and Cayuga Lakes are, in part at least, simply old Portage glens, now filled with water. To many reflecting persons who, as summer tourists, visit these very curious and beautiful resorts, the thought occurs, why these cañons are in these particular places above all others, and how they have been caused, the work of glaciers, or some convulsion of nature, being the common explanation; and amateur geologists puzzle themselves about their origin. It looks as though there was something special about the Portage group of rocks, everywhere abounding, as it does, in glens, gorges, and cañons, to which the formation of these remarkable places is due. Why is the Portage, of all the ten or twelve formations in this state, the favorite one for these phenomena, being composed, as it is, of sandstones and shales very similar to those in other localities where nothing of the kind is found?

The explanation is simple enough; namely, that it is owing to the peculiar alternation of thin beds of soft shale and harder sandstone rocks, and the presence of a stream of water running into lower ground, which performs the work of erosion, and the size of which must be adapted to the work; and upon that, too, the size of the gulf depends. Beginning at the lower end or mouth of the present cañon, the action of the waterfall first removes a little of the softer layers of shale, leaving the thin beds of harder sandstone projecting for a time, which, in their turn, are also broken off from want of support, in masses small enough to be entirely carried away by the stream, especially during the winter floods; thus preventing the formation of a slope, and exposing the bottom of the falls to another erosion. Thus, by the recession of the falls, the cañon is formed, provided another requisite is afforded; namely, that the side-walls must maintain their erect position: otherwise a valley, instead of a cañon, is formed.

This raises another question; namely, why do not these precipitous side-walls, composed of apparently soft rocks, slope themselves down, and form well-rounded hills, as they do elsewhere? The answer is, because the harder layers of sandstone form what a mason would call 'the binders,' which hold the natural wall in its upright position. The erosion of the cañon is done by the stream of water undercutting, like the work of the coal-miner, and then breaking down, the unsupported 'top-bench;' while, in the mean time, the action of the air and frost on the side-walls is so much slower than that of the stream of water, that, while the latter is rapidly cutting back, and making the ravine longer and deeper, the sides remain in their original upright position. As the falls recede, and a thicker sandstone or shale rock occurs, without the proper alternation of strata, it will form the permanent upper end of the gulf, which will be a precipice if it is a sandstone, and a slope if it is a thick bed of shale. It thus happens that the Portage portion of nature's masonry, and the necessary streams of water passing over it, are nicely adapted to the formation of glens and cañons. In localities where there are no streams of sufficient size passing over the Portage group to a lower level, as on the summit levels, there are high hills, it is true, but no glens or gorges. The eroding action of the elements being more uniform over the whole surface, and the transporting power of a rapid stream to carry away the falling fragments being wanting, therefore slopes, instead of precipices, are there produced.

There are also, in the state of New York, limestone glens, as they might be called, which are due to the same cause. At Trenton Falls, on the Utica and Black-River railroad, eighteen miles north of Utica, East-Canada Creek has cut a narrow passage, three miles in length, through the Trenton limestone, the formation being named from this locality. It is a cañon with vertical walls a hundred feet high, in which are the celebrated and very beautiful falls. The cause of the erosion is, that the limestone rock is in thin layers, of from six to ten inches thick, separated quite regularly by thin layers of shale of about the same thickness. It is owing to this regular mixture of hard and soft rock, in alternate courses, that the stream has been able to wear away the rock by undermining the shale into a succession of cascades; and, what is equally important in forming a cañon, the stream, a wild torrent from the Adirondack forests, is large enough to carry away the fragments of the overlying limestone as fast as it gives way. After cutting its channel back to a village called Prospect, a thicker and harder layer of gray limestone is encountered, which has stopped the recession of the falls, the stream being unequal to its destruction; and that is the end of the ravine.

The gulf of the Genesee River from Rochester to Lake Ontario was caused in the same way: for although the rocks are much thicker and stronger than any of those above referred to, yet the river is a correspondingly larger stream, and was able to cut through the alternating beds of Medina, Clinton, and Niagara limestone, shale, and sandstone; and the flood of water is powerful enough, with the aid of the fall below, to carry away the material, and prevent the formation of a talus.

At Niagara Falls and the gorge below, in the same formations as at Rochester, is a repetition of the same operation on a vast scale; and as the river there is larger than the Genesee, so the cañon is also longer, deeper, and more thoroughly cut down, the river's wearing and transporting power being in proportion to the great beds of shale, sandstone, and limestone.

In many localities in the state of New York and elsewhere, there are glens and ravines cut wholly out of the Genesee and Hudson River shales, where there are no alternations of hard and soft strata, as in the Portage. Precipitous hillsides are also of frequent occurrence, although the face of the rock soon turns to soil. The reason why the edge of apparently so soft a rock of such fine material withstands the weather, and presents these naked sections for such a length of time in mural banks in ravines, river-courses, and upon the shores of lakes, is on account of its uniformly foliated structure. A very slight examination will serve to show the thin laminae of which the entire rock is composed, like sheets of paper, reminding one of the resisting power of the edge of a book. The hardness of some kinds of coal is also owing to its laminated formation. A precipitous wall, whether built by nature or by art, must either be laid with a good cement, or it must be composed of material having a good bed, 'breaking joints' both inward and laterally.

A peculiarity of the loess or bluff formation on the Mississippi and Missouri Rivers is, that although it is very fine, soft, and easily excavated with the spade alone, yet it presents very steep slopes and precipices resembling those of solid rocks. Unlike all other formations of an earthy nature, it remains unchanged by the atmosphere and the action of frost. Road-cuts and embankments, however steep, stand for years like a wall; and wells dug in it require to be walled only to a point above the water-line, while the remainder stands so securely without support, that the spade-marks remain upon it for years, although it is not at all cemented together. In the city of St. Joseph, and all other places where the bluff formation is found, these peculiarities can be easily seen; and they appear very remarkable to an eastern man, accustomed to the sloping down of banks of sand and clay. The explanation of it is, that, as is well known, the bluff is a lacustrine deposit. The material forming it floated in flakes in a quiet, shallow lake. The minute particles, assuming a flattened form, however it may have been caused, were very quietly and gently deposited in layers, like little sheets of paper. There was no current, no movement of the particles to form rounded grains of sand, irregularly deposited in accidental disorder. On the contrary, the bluff is a well-built piece of miniature natural earth masonry, well bound together: hence there is no rolling tendency in the material, and, when cut down at right angles to the layers, it does not form a slope, like other kinds of earth. Thus, from precipices of rock of the heavier strata to those composed of the smallest, their mechanical structure is of great importance, and the same homely comparison of the 'stretchers and binders' of an artificial wall applies.

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THE EQUATORIAL COUDÉ.

IN spite of the loss of light in the two reflections from its mirrors, — which loss will vary with the condition of the reflecting silver films, but, under the best conditions, should not much exceed twenty per cent, — the equatorial coudé of the Paris observatory would seem to be the coming form for nine-tenths of the equatorial work of an observatory. This form of 'elbow equatorial' has been described of late in so many scientific periodicals, that it is sufficient here to say that the polar axis forms a part of the tube, at the upper end of which the observer sits like a microscopist at his desk, and at whose lower end a 45° mirror turns the course of the rays into a tube at right angles to the axis; and at the outer end of this tube is the objective, with still another 45° mirror outside of it, which turns round the axis of this tube. This gives the motion in declination, and the rotation of the whole round the polar axis gives the motion in right ascension. All the movements, the reading of all the circles, the illumination, and every thing connected with the management and use of the telescope, are directly under the observer's control as he sits at his desk, where there is every facility for attaching spectroscopic, photometric, and micrometric apparatus to the eye-piece end, which keeps its fixed position. Moreover, the observer and all this accessory apparatus can be entirely roofed in, and the room warmed in cold weather, if desired, and the observer made as comfortable, and the work as convenient, as that in any laboratory, while the whole heavens are at his command.

There can be no question as to the desirability of this, when compared with the discomfort and exposure in the common observatory dome, and with the difficulty of attaching accessory apparatus to, counterpoising, and using it upon, the moving end of an ordinary equatorial. Still further, the observing-room can be made entirely dark when desired; and the increased sensitiveness of the retina, under these circumstances, will be a great gain in delicate spectroscopic and photometric work. Also, in work upon the sun, the possibility of protecting the accessory apparatus entirely from the sun's direct rays, and even of working in the dark if desired, will be a great improvement upon the inconveniences unavoidable in the common observatory dome.