ART. XLV.—*The Nonconformity at Rondout, N. Y.*; by
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Description of the formations occurring here—Upper Silurian unconformable on the Lower—Altitude of the rocks and local topography—Glacial and surface geology.

THE reference made in the preceding article on Becraft's Mountain to the clear evidence of the unconformable relation of the Upper and Lower Silurian rocks at Rondout on the Hudson suggests the publication of a more detailed illustration of this noted locality than has yet appeared. The accompanying map and sections are prepared with this object from notes taken during an excursion in April of this year, and with a short descriptive text these may serve as a supplement to the earlier papers by Lindsley* and Dale.†

The formations occurring here are in most respects like those at Becraft's Mountain and in the limestone belt west of Catskill, which I have already described;‡ the following notes will point out their local peculiarities. The Hudson River rocks are sometimes heavy-bedded sandstones of rather fine texture and considerable hardness, as in Huzzy's Hill, a ridge of several hundred feet elevation two miles south of Rondout; and sometimes shaly and much contorted, as along the banks of the stream at Eddyville. They occupy all the area east of Rondout Creek, with small exception, but are generally hidden under terrace rift. The Oneida conglomerate is represented

* Poughkeepsie Soc. Nat. Sci. Proc., ii, 1879, 44-48.

† This Journal, xviii, 1879, 293-295. Dale's figures belong near section II on our map.

‡ l. c., and Bull. Mus. Comp. Zool., Geol. Series, i, 1883, 311-329.

by a stratum of almost quartzitic texture, white or bluish in color, and fifteen to twenty feet thick. The most northeastern point where it was certainly recognized was in New Salem at the beginning of the horse-railroad leading to the cement quarries in Whiteport; thence southwestward it may be frequently seen at the foot of the limestone bluff, a hard, compact bluish quartzose rock. At the foot of the map, where the limestone ridge breaks down, it is white, and so appears again about two miles west in the fine anticlinal near Whiteport where the Water-lime has been deeply quarried. It holds no pebbles or fossils here and is not yet thick enough to have a noticeable effect on the topography.

The first of the limestones is seen in the quarry on the hill overlooking Rondout (Section II), where it rests directly on the Hudson River rocks, as will be further mentioned below. As measured by Mr. J. G. Lindsley, superintendent of the Newark Lime and Cement Co., it is six to eight feet thick, and from its abundance of corals it is considered the equivalent of the Coralline limestone of Schollarie, the thin eastern extension of the Niagara of Western New York.*

The Water-lime and Tentaculite, to which Lindsley adds the Stromatopora and Ribbon limestones, have a total thickness of seventy feet. The layers are generally smooth and even, especially in the upper part and are readily recognized, but fossils are not common. The lower beds are deeply quarried at numerous points in this neighborhood for cement-rock, of which a great quantity is burned, ground, barreled and shipped. The annual yield has in the past few years risen to 2,000,000 barrels, valued at about a dollar a barrel. The openings thus made give excellent views of the deep plunging of the strata into the earth, especially at the Whiteport anticlinal above referred to. At Catskill twenty-five miles north of Rondout the rock is not found adapted for hydraulic cement; and though therefore not economically a water-lime, I am confident that it is geologically *the* Water-lime. The Lower and Upper Pentamerus limestones, about thirty and forty feet thick respectively, generally retain the characters seen at Catskill and Becraft's Mountain; the Lower being heavy, uneven, cherty, with comparatively few fossils; the Upper being also heavy and somewhat uneven bedded, but rich in fossils and free from chert. These are separated by the Catskill shaly limestone, about sixty feet thick (Lindsley gives it only sixteen, which seems much too little), and overlaid by a similar formation, certainly over one hundred feet thick and probably as much as one hundred and fifty. These I have mapped as the Lower and Upper Shaly limestones; they are generally very impure, and hardly

* See J. Hall, Pal. N. Y., iii, 26, and Amer. Assoc. Proc., xxii, 1873, 321.

deserve the name of limestones; their outcrop is very ragged and the Upper Shaly sometimes weathers on cleavage instead of on bedding planes, giving a very deceptive appearance (as on the southwestern synclinal ridge); in spite of its shaly texture, it stands higher than the limestone below it. Fossils are not nearly so numerous as in the Shaly limestone at Catskill; but it is interesting to note that several characteristic species (*Spirifer macropleura*, *Strophomena rugosa*, *Hemipronites radiata*) common to both the Lower and Upper Shaly beds are absent or very rare in the intermediate Upper Pentamerus, and thus seem to confirm the supposition that both these shaly deposits were formed comparatively near the old shore line, which retreated eastward carrying its fauna along with it and so allowed the pure Upper Pentamerus limestone to form, and then came back again with its fauna unchanged, driving the deposition of pure limestone away to the west. The Upper Pentamerus is often deeply quarried for lime, as at the several points where Sections I, II and III cross it. The passage from one to the other of the above subdivisions of the Lower Helderberg limestones is comparatively gradual; but an abrupt

change at the top brings in the Oriskany sandstone and grits, about twenty and thirty feet thick, but variable. The lower member is sometimes absent, but when seen it consists of pure white quartz, sometimes dense, sometimes rather loosely built of subangular white pebbles up to one-third of an inch in diameter, without fossils. This is followed by a hard grit with casts of numerous fossils, among which *Spirifer arenosa* was most frequently found. As usual, the stone fences give the best collecting ground; for example on the ridge northeast of the West Shore bridge across the Rondout, and on the southwestern synclinal. Above this, we find the barren Caudagalli shales, lifeless but for the occasional sea-weed imprints; fine textured and generally with the bedding completely replaced by the characteristic steep cleavage plane. Its thickness is very probably three hundred feet or more. A fine exposure of these shales is found in a bold synclinal bluff advancing toward the creek between Rondout and Wilbur; from here to the railroad bridge, a good downward sequence of formations is exposed. The Corniferous limestone, recognized only by its fine texture, plentiful chert, and position, completes the series.

The interruptions in the sequence of formations at Rondout are of two kinds. One, that may be called passive, consisted essentially in withholding the supply of sedimentary material, so that certain epochs were left unrepresented: thus the Medina, Clinton and Schoharie deposits are completely wanting, and the Oneida and Niagara are almost absent. The other interruption came between the deposition of the Hudson River

and the Coralline or Oneidastrata and was of a much more active character; the Hudson River rocks were upheaved, exposed to erosive forces, presumably of the ordinary subaerial kind, and then submerged to receive the later formations on their worn edges. This is most excellently shown in the old quarry in the hill overlooking Rond-

Fig. 1.

out (at Section II) where the contact line has been perfectly exposed for ten feet or more; a fair inference of nonconformity

can be made at several other points along the slope. The rocks on the western side of the limestone outlier, opposite Wilbur, also give good evidence of non-conformity, but we found no contact there. This locality is described and figured by Mather. The irregularity of the contact in the Rondout quarry completely excludes the possibility of the disagreement of dips in the over- and underlying formations being due to a fault, at least at this point, for as shown in figure 1, the limestone fits closely into channels worn along the strike of the softer sandstone beds, and the two rocks are so firmly consolidated that hand specimens can be easily obtained showing the line of junction. It is noteworthy that the limestone begins immediately with its fully determined calcareous character: there is no band of transitional composition; no fragments of the sandstone are contained in the overlying rock. The old worn surface was swept clean before the corals and crinoids began growing upon it, and their fragments and grindings make the first deposit. Some little pieces of crinoid stems lie directly on the bare sandstones. From the absence of the Oneida sandstone here, it may be inferred that the Hudson River rocks remained out of the Paleozoic ocean longer at this point than they did two miles to the southwest of it, where the earlier Upper Silurian strata lie directly upon the Lower Silurian beds. At the end of the quarry-railroad in Eddyville, already mentioned, a contact is opened for nearly one hundred feet, but unlike the one at Rondout, it is even, and the rocks agree in strike if not in dip. It is therefore probable that this contact is not the original one, but has been produced by faulting or slipping when the rocks were folded. The possibility of such slipping is well shown in the deep quarry (Newark Lime and Cement Company) a little south of Section I, where the Water-lime is folded and slipped so as to be apparently unconformable to itself. The probability of such an occurrence at Eddyville may be inferred from the sharp folding that occurs all along the front of the limestone bluffs. On the other hand, it is also probable that, if an original contact could be seen, it would be truly unconformable, for this relation occurs on both sides of it; at Rondout on the northeast, and at Otisville on the Erie railway,* some forty miles southwest. At some later date, presumably contemporaneous with the great Appalachian disturbance, the entire series of rocks described above were folded and dislocated. The most pronounced effects of this deformation are now seen along the bluffs of Lower Helderberg limestones. Beginning at the northeast near the Hudson, the rocks either stand on end or dip strongly to the west; they fall to a less angle on approaching Rondout and then are for a time more or less hid-

* Geol. New Jersey, 1868, 135. Second Geol. Surv. Penn., G 6, 150.

den in passing through the town. Crossing the creek, they build the limestone outlier, a flat synclinal with steep or vertical dips on the eastern side, and then cross the stream again by the railroad bridge and plunge underground at a high angle. The anticlinal half of this S-shaped curve is not a simple turn, but is complicated by a small additional fold where the stream crosses Section III, as is shown on a larger scale in figure 2.

Fig. 2.

From here, up the valley, the strike is very uniform, and the bluff-front very even. Sections carried across it at several points showed a well-marked synclinal structure bounded on the northwest by a down-fault of moderate throw. In conformity with what seems to be "normal" for the Appalachians, this fault is drawn with the upthrow *overlying* the hade. By following along the axis of this synclinal from Wilbur, one passes over seven different subdivisions of the Upper Silurian that successively come to an end in the rising trough.

This detailed statement of the altitude of the rocks seems necessary in order to contradict the supposition not unfrequently made some years ago that a "great fracture" passed along the Hudson valley between the older and newer rocks. Apart from the folds and local faults of small throw there is no evidence whatever of any great disturbance, and the great fracture is purely hypothetical. The Oneida and Medina lose the mountain-making strength they possess in Pennsylvania because they thin out, not because they are cut off. The Cauda-galli shales cover a broad hilly surface back of the limestones, and in the northern part of the district examined they are overlaid by the Corniferous limestone. The blank area on the map where the three railroads meet is a Corniferous synclinal possibly holding some Marcellus shale, but filled with the drift sand and clay on which Kingston is built: Esopus Creek enters this plain from the west and follows it for some miles northward; and farther on, the arch (or fault) which forms the western side of the synclinal, disappears, and the Corniferous and Marcellus trough is continued as a Marcellus monoclinai valley, occupied by the Kaaterskill on its northward course and crossed by the Catskill at Leeds.*

Glacial striæ were observed at several places with a direction

* See papers by the author in *Appalachia*, iii, 1882, 20; and *Bull. Museum Comp. Zool., Geol. Series*, i, 1883, 328.

S. 15° to 25° W. Unstratified drift, striated loose stones and erratics are uncommon ; the most notable of the latter was found on the line of the West Shore railroad about one mile below the creek ; it was a broken bowlder of a dense conglomerate in which the subangular pebbles were of jasper and quartzite.

Terrace flats cover most of the exposures at low levels, except where the creeks have washed them clean. In cutting out its path since the time of high water level when its old valley was much obstructed by sands, the Rondout has very clearly formed a new channel in the contorted Hudson River shales at Eddyville, the old channel being nearer the limestones. There is some appearance of another old channel south of the limestone outlier opposite Wilbur, but the present valley there is rather large for post-glacial cutting at so low a level.

The points of special interest that may be seen in one or two days' visit to Rondout are : first, the limestone bluffs and their deep quarries along the river, especially the quarry near the town showing the unconformity ; second, the complication of synclinal and anticlinal on the line of the West Shore railroad ; third, the new channel at Eddyville and the limestone synclinal opposite to it. A large quarry is opened on the river bluff a mile north of the map, and several others in a very interesting region between Whiteport and Rosendale southwest of our limits. Two railroads and the river boats afford easy access to the town ; local tugs are constantly running up and down the creek between Rondout and Eddyville ; and the Wallkill Valley railroad serves for longer excursions.

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