

ART. XIX.—*Geology of Virginia: Continuation of Section across the Appalachian Chain*; by J. L. CAMPBELL, Washington and Lee University.

IN the number of this Journal for July last, a general outline of the geology of the Great Valley of Virginia was given, and illustrated by a section embracing the several epochs represented in the valley proper, and in the two mountain ranges forming its boundaries on the southeast and northwest. That section may be regarded as a typical representation of the several varieties of rock that come to the surface for many miles on both sides of it.

In the present paper I propose to give what may be regarded, in part at least, as an extension of the same section—the results of observations made in the same general direction, but not exactly on the same line. Moving the line of section about eight miles toward the northeast of my former route, I shall fall back and begin again within the limits of the Great Valley; the reasons for which are, first, to renew the connection with the lower Silurian limestones, that will again make their appearance in an interesting anticlinal valley at the other end of the section; and secondly, that we may pass through or near a considerable number of points of no little interest, and easily accessible to the scientific traveler or the student of geology.

What is here presented is, in its main features, the result of a survey made several years ago, in conjunction with the Hon. Wm. H. Ruffner, LL.D., the present Superintendent of Public Instruction in Virginia, and who is a gentleman of no mean attainments in geological science. Some important details that are introduced, as well as some of the generalizations, are the fruits of subsequent observations made by myself in review of our original work. The main conclusions, however, stand as originally agreed upon.

It would hardly be proper to call this an “ideal” section, since some of the most interesting portions of it represent *real*

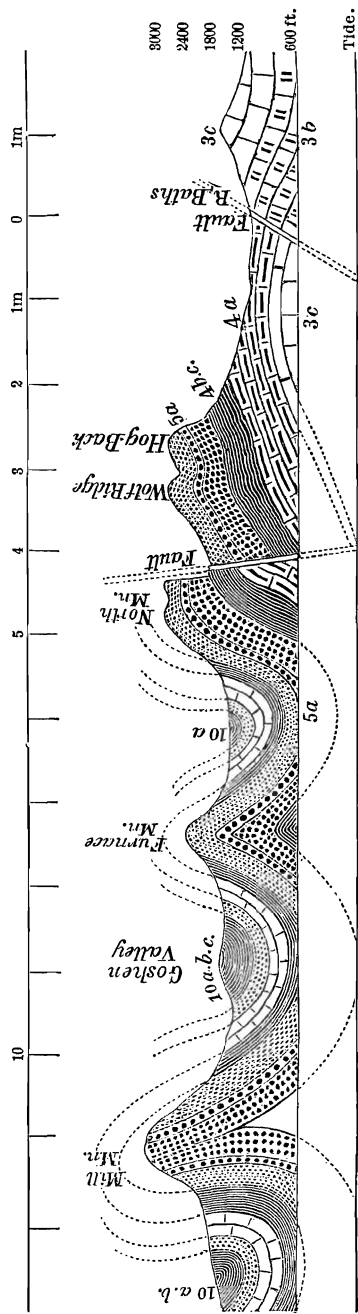
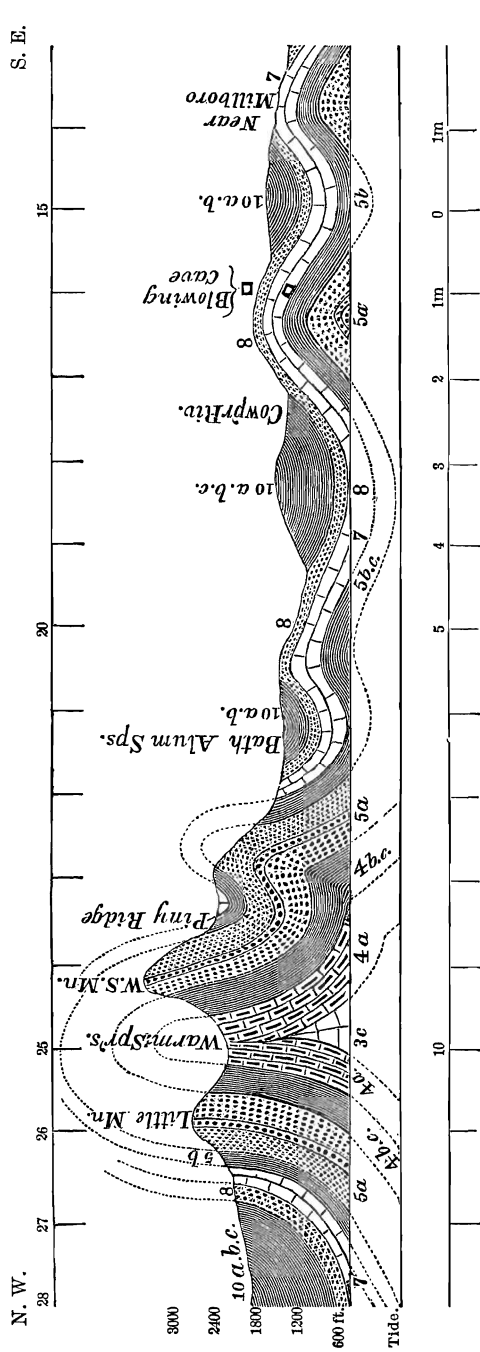
sections that nature has opened up to our view on a grand scale—where the geologist may revel, or the student of science find interesting and profitable employment for many days together. It passes through or near several mountain gorges of considerable depth and extent, as well as many points of minor interest, where mountain streams have cut their channels through the lower hills and thus exposed the various formations along its lines.

On my former section the series of Professor Rogers was given with sub-divisions; and a table appended to present a comparison of these with the corresponding periods and epochs given in Professor Dana's Manual, so far as the equivalents have been definitely determined in this part of the Appalachian chain. On the section accompanying the present paper, the numbers and letters refer to Professor Dana's system.

Beginning, then, with the southeastern extremity, near the Rockbridge Baths, we find a natural section cut by the North River through a part of 3 *a* and the whole of 3 *b* and *c*, etc. (Calceiferous, Quebec and Chazy=No. II Rogers). In the immediate vicinity of the Baths these formations are very much obscured by the Quaternary deposits of drift from the mountains above, but they may be studied conveniently at points a mile lower down on the river cliffs, or on the neighboring hills a little remote from the river, on the southwest side, where the section passes. For a description of the rocks of this period, the reader is referred to the number for July.

The line of fault presented on the former section continues, with a single interruption, some distance beyond the present section, crossing the river a short distance above the Baths (N.W.)—the older (3) being still thrust upward over the edge of the newer (4 *a*). This junction of the displaced strata can be seen indistinctly along the river banks at low water, but may be more distinctly traced in the hills southwest of the river, and on Hays' creek northeastward.

This fault has doubtless much to do with determining the temperature of these thermal Baths, the waters of which have a temperature of 72° F., and are kept in gentle but constant agitation by escaping bubbles of gas, consisting largely of nitrogen and carbonic acid. The remedial virtues of the Baths have been long recognized. As we pass up the river in a northwesterly direction we soon find the Trenton limestones forming the bottom of the river-bed where the strike of the strata can be distinctly seen crossing the stream nearly at right angles. The same rocks also crop out on the neighboring hills, which generally have a rounded shape and are strewn with quantities of local drift from the adjacent mountain gorges. There are no cliffs here; for these argillaceous lime-



stones and overlying shales were too fragile to withstand the denuding force of the vast floods of water and masses of sandstone boulders that have, at some past period of time, come down with violence from the neighboring mountains and the valleys beyond. Both the lithological and fossil characters of these rocks show that they are the same as those on which Lexington stands; but here, as well as along the base of House Mountain, they are softer, and not so extensively permeated with white veins, as they are around Lexington, where the crushing forces to which they have been subjected have not only tended to harden many of the beds, but have produced innumerable fissures that have been filled up by infiltration, and now present beautiful veins of calc spar. But the underlying coralline bed that forms the base of this epoch, and crops out so conspicuously near Lexington, is not brought to the surface at this point, yet is found at the distance of a few miles on both sides of our present line of section. I have, therefore, included it.

At the distance of two miles above the Baths, we come to the base of Hog-back Mountain,\* at its northeast terminus, and about a mile northeast of where our section crosses. Here the North River cuts it off from what was once its northeast continuation, called Jump Mountain. The Medina sandstones (Rogers, No. IV) that crop out along the faces of the two ridges sink gradually as they approach the river—showing a marked depression at the point where the river has found its way through. Such, however, is not the case with the contiguous and nearly parallel ridge of North Mountain farther west.

The spurs of Hog-back and the face of the main ridge, to the height of several hundred feet, display an extensive outcrop of 4 *b*, *c* (Utica and Cincinnati shales.) These appear occasionally beneath the hard sandstones of 5 *a*, as we pass up through the wild, winding cañon that here gives passage to the waters that come down from the mountain valleys above, and meet at the upper entrance of the gorge to form the North River. Just where the river issues from the mountain pass, the stream separates into two parts, forming a small island, in the middle of which rises a spring of sulphur water, now known as Wilson's Spring. It evidently rises from the shales of 4 *b*, that here form the bottom of the river.

This is the point at which the turnpike leads us into "Goshen Pass," through which we follow the winding course of the river for several miles.

In pursuing his course through this crooked gorge the geo-

\* This and Wolf Ridge, immediately in rear of it, have evidently been once connected with the two ridges of House Mountain, represented on the former section; though now separated by a beautiful valley three miles wide.

logical student will find a problem to solve of no little complexity, arising in part from the windings of the river, and in still greater part from the rupturing and faulting of the mountains themselves. After passing the ends of both Hog-back and Wolf ridges (see section) at the distance of about a mile and a half above Wilson's Spring, he will find the course of the river nearly coincident with the strike of the Medina sandstones that here dip so steeply on the N.W. face of Wolf Ridge as to pass the lower beds beneath the stream, while those higher up are cut through in the direction of their strike. Within view of this point, and on the opposite side of the river, a great downfall from the next ridge (N. Mt.) has occurred, around which the stream makes a loop of half-a-mile in extent; this slip, however, is quite limited; for above, and on the right and left of the fallen mass the Medina sandstones again crop out along the face of the North mountain ridges with a moderate northwesterly dip, displaying their full thickness of about 500 feet along the southeast face, and, with one slight undulation, and subsequently increased dip passing beneath the Little Goshen valley beyond.

After careful and repeated examinations of this portion of the "Pass," Dr. Ruffner and myself agreed that the phenomena presented could be accounted for only upon the hypothesis of a *fault* running parallel with the axis of the mountain chain. Repeated observations since our original survey have tended to confirm the conclusions originally formed.

In following the course of the loop in the river, mentioned above, we travel a short distance with the strike of the rocks toward the southeast, then turn and cross the fault (filled up with the débris from the face of the broken mountain), and finally change our course to the northeast again following the line of strike in nearly an opposite direction, and passing beneath the outcropping sandstones that rise far above our heads. But we soon deviate from this course to one at right angles to the mountain, and by which we are conducted through another natural section of 5 *a*, *b* and *c*, and apparently pass out, right upon the beds of Devonian shales. At the base of the mountain, however, from the gap of which we have just issued, 7 and 8 are concealed from view, as evinced by the fact that they crop out at many points along the base of the mountain at some distance from the road on both right and left. In this Little Goshen valley there are indications of extensive beds of limonite ores, some of which were worked many years ago. They are found in both 5 *b*, *c*, and in 8.

This valley offers no special facilities for studying the Devonian shales, which are found much more fully and favorably exposed farther west, but along its western border for a distance

of four or five miles from the turnpike, in a northeasterly direction, some interesting developments of 7 and 8 are found along the foot of what is here called Furnace (or Knob) Mountain, through a gorge of which the Big Calf-pasture, the chief fork of North River, comes down from the Great Goshen valley on the west. In this gap tolerably well-defined arches of 5 *a*, are displayed on the right as we pass up the river, while on the left (Bratton's Mountain) the same rocks are overlaid by a bed of 5 *b*. The arch on the right hand is the one represented on the section.

Between this and Mill Mountain lies Goshen Valley, a beautiful agricultural region, and one that presents some points of scientific interest that are readily reached by the student of geology. The section passes near the Cold Sulphur Springs about  $1\frac{1}{2}$  miles southwest of Goshen depot on the Chesapeake & Ohio railroad. The waters of these springs flow from exposed strata of 10*a*, dipping slightly toward the Mill Mountain on the northwest. In this valley, as well as throughout this whole region, the Salina Period (6) is but indistinctly represented, if at all, while the Corniferous Group (9*a*, *b*, *c*), appears to be entirely wanting. But the very fossiliferous limestones of the Helderberg (7), and of the sandstones of the Oriskany Period (8) are well exposed at Craigsville, nine miles northeast of Goshen on the railroad, where a beautiful encrinal marble is quarried from 7, and also at points nearer to Goshen. Just west of Panther Gap in Mill Mountain (through which both railroad and turnpike pass), at several points a short distance from the base of the mountain, good exposures may be found. The mountain itself, at this point, is cut by Mill Creek, and its Medina sandstone axis is exposed in the form of a closed anticline pushed over toward the northwest so as to give all the strata a southeasterly dip.

Before leaving Goshen Valley we must observe the fact that, about the depot and the Cold Sulphur, the upper member of 10 has been swept off, and in many places a large portion of the middle member (*b*) has also disappeared. There is a ridge however, beginning a mile or less north of the depot, on which all the members (10*a*, *b*, *c*) appear. I have not found what remains of this group to exceed 450 or 500 feet any where in this valley.

Resuming our line of section west of Panther Gap we find the thickness of 10*a*, *b*, *c* to have increased and the lithological characters to have undergone some modifications. Beds varying from siliceous slates to argillaceous sandstones are found cropping out, especially in *b*, as may be seen both on the railroad and the turnpike. Large quantities of these rocks have been brought from the tunnel near Millboro depot. Calcareous concretions of a disc-like form, full of veins of infiltrated carbonate

of lime (*septaria*), increase in size and number; while thin beds of fossil limestone, especially in *a*, are occasionally exposed to view.

At Millboro depot a line of stages leaves the railroad for the Warm Springs, fifteen miles to the west. At the distance of two miles we reach the old Millboro Springs where we again find sulphur water rising from the Devonian strata (10). Another mile brings us to the famous "Blowing Cave," where it is well worth while for the explorer to allow himself at least one full day. He is now upon the banks of the Cow-pasture River, one of the upper forks of the James. Here the river cuts through a ridge (Cave Hill), exposing to view an arch of Helderberg limestone (7) into which a cavern of unknown depth extends from which a breeze of considerable force issues continually in warm weather. Above the limestones is a second arch of Oriskany sandstone (8), in which are numerous *Spirifer* shells well preserved. These two formations may be studied here with great convenience; and, if an additional exposure is desired, it may be found two miles farther toward the northeast, where Stuart's Creek exposes a similar arch in the same hill, and where fine specimens of *Favosites* are easily obtained.

Exposures of the members of 10 may be studied along the banks of the Cow-pasture both above and below the passage through Cave Hill. A short distance below, in what is called "Alum Bank," we found a thin bed of limestone remarkably full of fossil shells. At other points higher up and lower down the river similar exposures occur.

Near this place is one of the numerous so-called "Alum Springs"—the *Wallawhatoola*, an old Indian name. The waters here, as at the Rockbridge and the Bath Alum Springs, collect slowly from the crevices of the dark pyritous shales of No. 10. Springs of this class are very numerous among the Devonian shales in Virginia; and waters of similar character sometimes issue from shales of earlier and later dates. Their chief mineral constituents are sulphates of alumina, lime, magnesia, potassa, soda, iron (*ferrous* sulphate), with more or less *free* sulphuric acid. In the *Wallawhatoola* I found, with the spectroscope, a decided trace of lithia.

The shales of this region, and especially in this valley of the Cow-pasture River, present three tolerably well characterized beds; the equivalents, no doubt, of the three recognized epochs of the Hamilton Period\*—Marcellus, Hamilton and Genesee. The lower member consists of dark—sometimes black, sometimes bluish-black—shales that split readily into thin layers, and even fine scales or slender columnar fragments. The middle member has a decidedly greenish tint—olive in

\*This is No. VIII of Professor Rogers's series.

many places, especially where it appears along the public roads, and in cuts on the railroads. The highest division is much variegated in color and texture; the beds of shale are yellow, brown and red, while considerable strata of sandstone of argillaceous character are found alternating with the shales.

Among all these are found beds of very calcareous shales passing often into impure limestones that abound in Encrinites, Atrypas, Spirifers, etc. The upper member has generally more calcareous beds in it than either of the others. This whole region has been greatly denuded, but the sharply rounded, and often cone-like hills that are left standing, with deep ravines cut out between them, present a striking feature of the landscape, and, at the same time, afford the means of an approximate estimate of the thickness of the whole series of shales, which cannot be less than seven hundred feet.

Along the faces of many of the hills that have been recently denuded by floods in the river and its tributaries, the planes of stratification, and of slaty (metamorphic) cleavage, are both well displayed—the latter so distinct that an unpracticed eye might readily mistake them for the planes of original stratification.

About four miles west of the Blowing Cave the turnpike crosses a ridge called Mair's Mountain, capped by a low arch of Oriskany sandstone (8), beneath which are exposures of the Helderberg limestones (7) where a small stream has cut its way through the ridge. Beyond this ridge we find another synclinal trough filled with the shales of No. 10, out of which rise the waters of the Bath Alum. Near this watering place is a cave formed by the washing out of the softer bed of Medina rocks so as to leave a regular arch which becomes narrower and lower toward the rear of the cavern, giving the whole cavity the shape of a semi-cone with the dividing plane for the floor. This is an object of interest to visitors. Its location is beneath the ridge, marked "Piny Ridge," on the section.

A mile beyond the Bath Alum, our line begins to ascend the lofty ridge of the Warm Springs Mountain. To the structural geologist this presents an object of the highest interest. As we follow the windings of the turnpike we find ourselves surrounded first by the debris of the Clinton sandstones and shales (6 and 7 are concealed), and as we approach the crest of Piny Ridges the Medina sandstones (5 *a*) make their appearance *in situ*. We are thence conducted by a spur across to the face of the main ridges, where the road is cut out of the sandstones, exposing their lithological and fossil features in a very interesting way. Ripple marks and casts of shells in the brown and purple sandstones, and fucoids in the shales, are of frequent occurrence.

On reaching the depression of the summit where the road



crosses, we turn to the left and follow the crest of the ridge for half a mile toward the southwest to the top of what is known as "flag rock"—the highest outcrop of Medina sandstone on this mountain, having a steep southeasterly dip. From this point, 33±0 feet above tide level, the mountain scenery on all sides is very grand. Along the base of this ridge, on the northwest side, lies the Warm Springs Valley—a narrow strip of the Lower Silurian limestones of the Great Valley again brought to the surface. On the opposite side of this narrow valley another ridge, Little Mountain, rises to a less elevation, but is composed of the same kind of rocks as the main mountain, but dipping toward the northwest.\* The olive-colored sandstones, generally found at the base of the Medina group in this region, appear near the summit of both these opposing ridges, and are succeeded by the fragile sandstones and shales of the Cincinnati and Utica epochs that form the steep slopes of both mountains. These are succeeded by the Trenton (4 a) limestones that dip beneath them, but form more gradual slopes toward the middle of the valley, where the older Chazy (3 c) limestones make their appearance. The latter are not largely developed where the tepid waters of the Warm Springs rise, but widen out considerably toward the southwest. A short distance to the northeast of the springs we found Trenton fossils in abundance, like those we had found just below the entrance of Goshen Pass.

In this anticlinal valley the Lower Silurian rocks come to the surface for a distance of several miles on both sides of the section, the general range being parallel with the Appalachian chain.

The two ridges that here face each other were doubtless parts of a great open anticlinal fold that was formed, when, by powerful lateral pressure from a southeasterly direction, the strata were pushed up from their original horizontal bedding. But it is hardly probable, judging from the present condition of things, that they ever formed complete arches across the valley. It is certainly more reasonable to suppose that such masses of strata of varying hardness and strength, and with an aggregate thickness of more than two thousand (2000) feet, were so ruptured at the time of upheaval as to form a rugged gorge, extending for many miles along the crest of the fold, and that subsequent erosions and denudations by ice and water widened it out, and shaped it into the beautiful valley as we now find it. This is a valley of thermal waters; for, besides the Warm Springs, near which our section crosses, and the baths of which range in temperature from 95° to 98° F.; the Hot Springs, five miles to the southwest, with temperatures varying from 100° to 108° F., and the Healing Springs in the same

\* Along some parts of this broken ridge the sandstones are vertical or even inverted.

neighborhood, with a temperature of 85°, rise in the same anticlinal fold.

About half a mile southwest of the Warm Springs the collected waters of this portion of the valley find their way out in a northwesterly direction through a deep ravine, in which are found exposures of all the formations from 4 to 8.

*General remarks.*—(1.) Throughout the whole region represented on the accompanying section, conformity of strata prevails, and so continues till we reach the Carboniferous in West Virginia. (2.) The Medina sandstones that are from 405 to 500 feet thick along the North Mountain thin out to about 350 on Warm Springs Mountain. Here, too, the structure is less conglomerate, and the marks of shore-line formation are less numerous and distinct than they are farther east. (3.) It may be well to mention some of the prominent points along the line of section convenient for observation. At the lower entrance of Goshen Pass, and in Warm Springs valley, exposures of 4 may be readily found. No. 5 (Medina) may be successfully studied in Goshen Pass and on Warm Springs Valley; while the region around Millboro Springs affords to the explorer some of the finest exposures of 7, 8 and 10. But the accompanying section may serve as a key to a wider range of observation. Perhaps the best point of departure would be Goshen, on the C. & O. Railroad. If he wishes to extend the section farther toward the northwest, the turnpike from Warm Springs to Huntersville, in West Virginia, affords a favorable route for horse-back explorations.

Washington and Lee University, Va., April, 1879.