ART. XI.—*On some Points in the Geology of the Blue Ridge of Virginia*; by WM. M. FONTAINE.

[Concluded from page 22.]

MY next examination was made in the vicinity of Lynchburg, sixty miles southwest of this point. There the James River, and the canal along its banks, cut the strata nearly at right angles to their strike, thus affording unsurpassed facilities for the study of the country. In order that some idea may be had of the nature of the very considerable area lying between Charlottesville and Lynchburg, I give here a section made by Prof. Rogers, across the valley, about twenty miles northeast of Lynchburg. This is the only connected examination, so far as I know, that has ever been made across this part of the valley, which includes a belt sixty miles long and twenty wide. Of course, many variations from this section are to be expected, in such an extended area. Commencing at the western base of the Blue Ridge, at "Tye River Gap," we have—
 I. Sandstones and slates (Silurian), with high northwest dip; width three-quarters of a mile, extending up the mountain. II. A broad range of granitic rocks; soft, and decomposing, without stratification. These continue three miles to the summit and one mile down the east side. They contain frequent beds of epi-

dotic granite, and a beautiful dark-gray syenite. The latter two are hard and permanent. In this space occur two bands of slaty rocks, one on the west side of the summit, and the other on the east side. That on the west side is one mile below the top, is 200 yards wide and contains gray and reddish slates, with associated greenstone-slate, sometimes amygdaloidal. Dip, moderate, southeast. The other band is half a mile below the summit on the east side. It presents repeated alternations of red and gray slates, white sandstones, and conglomerates, with a high dip, to the southeast, and a width of half a mile. Entire distance four miles. Down the east slope we find gray granitic rocks, with some bands of argillaceous slate, and toward the east have two or three dykes of *greenstone* (pinite porphyry?). Extent four miles. III. From the last point, on the junction of the north and south forks of Tye River, the country up to two miles beyond Lovington is mainly gneissic, with frequent beds of true granite near Lovington. Dip, high, southeast. Extent fourteen miles. IV. Greenish chloritic granite; gneiss; and bluish mica slate. Dip, vertical. Interval occupied, three miles. This last is the position of Buffalo Ridge. V. Findlay's Mountain, one mile wide, composed of coarse quartzite. Dip vertical. After this the dip changes to northwest, and then to southeast, which it retains for a long distance as we pass east.

It will be noticed that in this section the quartzites composing the Ragged Mountains in the central portions of the valley are not found. In No. III the granite mentioned forms the most western ledges of the eruptive rocks to be described near Lynchburg. The chloritic granite is the representative, most probably, of the epidiosites of the northeast. If so, this rock, which is *protogine*, is a metamorphic product from argillaceous slates. In the Catoclin Mountains, to the northeast of Lynchburg, various useful minerals occur; among which, copper ores, galena and magnetic iron may be mentioned. These may, however, be of Triassic age, as great masses of Triassic trap occur in them near these deposits.

Coming now to the vicinity of Lynchburg, and commencing with the examination of Buffalo Ridge, three miles southeast of the town, we find massive mica slates and schists composing the ridge and having the form of a closed anticlinal. No metamorphic core is present. Similar rocks occupy the whole distance up to the town. They are disposed in several rather open anticlinals. Near Mt. Athos, four miles down the river from the ridge, we find magnesian limestone associated with some quartzites, mica and talcose slates, containing deposits of magnetic and specular iron. Here occurs the curious rock called "catawbarite," by Lieber. This is an intimate mixture

of talcose matter with specular and magnetic iron, containing sometimes enough of the latter to be worked as an ore.

Just opposite the town of Lynchburg occurs the most eastern of the ledges of the syenitic rock, which forms an important feature of the east and central portions of the valley. Since the section given above was made by Rogers, the railroad from Washington to Lynchburg has been made. This runs for sixty miles among these ledges, and exposes by numerous cuts their nature. One of the most striking features presented is the great amount of decay exhibited. Often cuts twenty feet deep fail to give perfectly sound material. It weathers to a rusty brown mass, presenting rounded outlines. Some ledges, however, are almost perfectly fresh. The bedding, and relation to the enclosing mica slates, are well shown both here and at Lynchburg, in the natural section presented along James River.

Returning to the latter place, we find, as we proceed up stream, numerous ledges of this rock succeeding each other at short intervals, being overlaid unconformably by mica slate, which passes occasionally into mica schist. These ledges occupy a belt extending to the west some five or six miles, but diminish in frequency westward until mica slates again occupy the entire surface. These latter continue to the distance of some ten miles from the town, when the coarse granites and syenites of "Tobacco Row," and "No Business" Mountains make their appearance.

The ledges in question often present the appearance of low dykes with rounded summits, over which the slates arch unbrokenly. Then they commonly lie in heavy layers, resembling stratified beds to a certain extent. This, however, I consider to be produced by that concentric structure so often seen in cooling masses, and which, when formed on a large scale and viewed in small segments, is easily mistaken for stratification. The rock sometimes breaks through the slates, and one ledge reverses the dip developed by its neighbor, crumpling back the slates, contorting and crushing them. The width varies greatly. I saw one ledge 600 feet wide near the town, but many are no more than 100 feet wide.

The principal component is hornblende, in pretty large crystalline particles, imbedded in a rather scanty cement of fine granular, white feldspar. This is too fine to show crystalline faces, and hence the species could not be determined. Taking the features all together, it most resembles a syenite, formed by imperfect fusion through metamorphic action on some underlying rock rich in basic compounds. Its texture is rather loose, none of the components are perfectly crystallized, or fused together, and hence perhaps the ease with which it decomposes.

The following accessory minerals occur occasionally: garnet, rutile, rubellan, pyrite.

For much of the distance above Lynchburg mica slate predominates. It shows mostly a dip south-southeast, but several reversals occur, and continue for a considerable distance. The fact is to be noted, that in this region there is no constancy of dip indicating a great succession of closed folds. The mountains some ten miles above Lynchburg, containing the granites and syenites of the central parts of the valley, I had no opportunity to examine. From hand specimens obtained, the granite is an exceedingly coarse-grained, rough-looking rock, composed principally of quartz, with a smaller amount of black mica and white orthoclase. The mica has a tendency to aggregate into lumps, so as to give the rock a rather singular aspect, the white ground of the quartz and feldspar being marked with black spots, sometimes of large size. These rocks are to be regarded as forming one system with the syenites at Lynchburg, as is shown in the cuttings along the railroad, which runs through them in the valley.

My detailed examination was resumed on James River, about three miles from where it issues from the east base of the Blue Ridge. The ridge here is a composite one, being formed of several parallel chains; those on the east being composed of crystalline rocks, and those on the west of Silurian strata. The foot hills on the east often rival in height the main chain.

The first rock seen here is a mica schist, with a dip 30° northwest. This on the west is succeeded by a mass of gneiss 900 feet wide, apparently intruded among the slates. Its dip is so confused by vertical joints that I could not make it out. The composition is principally of uncrystallized feldspar, dark mica in fine lines, and quartz distributed in numberless seams of almost microscopic fineness, showing that the rock is highly altered. This is succeeded by a narrow band of mica slate, dipping southeast, toward the gneiss. The slate is succeeded by a wide belt of coarse syenitic rock, which forms some of the highest foot hills of the ridge here. This rock extends for a half mile, and is overlaid unconformably by mica slates and schists, through which it has evidently been protruded. It is a massive coarse-grained rock, composed principally of red feldspar (orthoclase), quartz, and a smaller amount of hornblende. None of the constituents are well crystallized, or distinctly segregated. The feldspar forms large particles and the hornblende shows a tendency to arrange itself in irregular patches and lines. Some greenish feldspar occurs. The junction with the slates on the west side well shows the relation of the two systems. The slates lean upon the syenite with a dip of 45° to the northwest, showing a sharply distinct line of con-

tact. This mass is plainly an outlier of a larger body of similar rock, which is to be found in the main mountain just west of it. The slates and schists continue 200 yards, when they are thrown into a gentle arch by the protrusion of a ledge of pinite porphyry, 300 feet wide. This in all respects resembles the rock at Harper's Ferry. It occupies here the same position relative to the Silurian strata, being about three miles distant from them. After an interval of 150 yards of slate, we have a second outcrop of pinite porphyry, in a ledge about eighty feet wide. This is followed by several hundred yards of mica slates, showing a moderate southeast dip. For some distance the rock is concealed, and then we have about 400 yards of argillites, the first appearance of this rock on this section. These slates do not have the heavy bedding and chloritic composition of those described farther north, but are thinly laminated and cleave well. Their western edge is thrown into a crushed anticlinal, changing from a previous dip to the southeast. This is caused by the appearance of an extensive ledge of pinite porphyry about 600 feet wide. Succeeding this we have a belt of mica slate, about half a mile wide, extending to the crystalline massive rock of the main ridge. These latter slates dip high to the southeast, being almost vertical and regulated in dip and strike by the course of the massive rock of the Blue Ridge. These dips given as southeast are more properly south-southeast and even south in some places, according to the curves of the crystalline mass which determines the position of the main chain.

A few hundred feet from the main mountain we see a ledge of highly-altered quartzite, about forty feet wide, reaching over toward the ridge. This rock is significant, for it resembles a highly indurated form of the Silurian quartzites, which are to be seen on the opposite side, arching over with a reversed dip to meet it. This ledge, however, is much thinner than the Silurian strata, and is impregnated with chlorite and epidote in places, having its texture perfectly compact. The slates between it and the syenite are much altered, being cut by joints, and having lost their slaty cleavage. They are also impregnated with siliceous and ferruginous matters, causing them to assume a red color on weathering. Their edges, viewed across the chasm cut by the stream, show this change very strikingly. They are seen to arch over the east slope of the crystalline rock in the form of a shell.

Passing through the gorge cut by the river in the most eastern of the principal elevations, we find that the river skirts its west base for a short distance. Turning here so as to front this mountain from the west, we see that its entire face, for more than 1,000 feet, is composed of a rugged, precipitous mass of

unstratified crystalline rocks, while a band of reddish rocks, eighty or one hundred feet thick, show their edges skirting the summit. This band is the west edge of the slates which were seen resting on the mountain along the east side.

The Blue Ridge in this part of the State is, as stated before, composed of several parallel ranges of nearly equal height. The one just mentioned is composed of a species of coarse syenite, while the other ranges more to the west are made up of the durable quartzites which here form the Lower Silurian strata.

The entire zone of crystalline, massive rocks here seen is about one mile wide. The most eastern portion, composing the main ridge just described, is a rock in all respects like the coarse syenite mentioned as composing the foot hills farther east. It is truly a protean rock. No two hand specimens will show exactly similar physical features, although the essential constituents are pretty constant. Red orthoclase, in coarse, badly crystallized particles, forms the chief component, but white and green feldspar of the same species also occur. Quartz is next in abundance. The hornblende, which is scanty in amount, never forms distinct crystals. Rutile not well segregated, and films of hematitic matter, are also seen. For some distance next to the slates, on the east, the rock has the fine, well-crystallized texture of a diorite. We have here without doubt an eruption of true igneous rock along the line of junction of the two systems, an occurrence not uncommon.

On the west side we see at the base of the main mass a ledge about 100 feet wide, of a rock of similar composition with the coarse syenite, but of much finer texture; it being in some parts almost compact, and impregnated in spots with chlorite and epidote, so as to give it a bright green color. This again seems to be a modification produced by its position on the border of the principal mass. West of it, the rock changes again, and for about 1,200 feet we have a variety of syenite of fine and more uniform texture, in which the minerals are more individualized, and better crystallized. This extends up to the Lower Silurian strata, which rest against it with a steep north-west dip, the lower beds being so much altered as entirely to lose their characteristic features. This portion of the syenite betrays its more durable character by presenting extensive ledges in the bed of the river, while the coarse rock to the east has been worn down almost entirely. I consider this to be the equivalent of the peculiar syenite to be described as occurring at the Peaks of Otter.

My next examination was made twenty-five miles to the southwest, along a line ten miles in length, extending westward, from Liberty in Bedford County to the Peaks of Otter.

The Catoctin Mountains, as cut by the extension of this line, do not form a continuous range. In its stead, we have isolated elevations, composed of ribs of quartzite standing nearly vertical. To the west of Liberty, for four or five miles, we have mica schists and hornblende schists, much decayed and eroded. Succeeding these come hornblende schists, presenting the same character, and all with moderate southeast dip. On reaching "Big Otter Creek," about two and a half miles from the Blue Ridge, we see a ledge of protogine, showing a width of 600 feet. This has thrown off the hornblende schist nearly vertically to the southeast. This rock, which from its position is the equivalent of the pinite porphyry, is composed of quartz, dull white feldspar, and talc, arranged with granitoid texture. The quartz often appears in shot-like lumps, and sometimes shows quite large irregular masses. It presents in this condition a peculiar sky-blue color and waxy luster. There can be no doubt, I think, that it is the same mass which appears farther north as pinite porphyry, but here like most of the rocks of this region, from more complete metamorphism, having assumed more of the character of a true igneous rock.

Next to this, on the west, we have a belt a quarter of a mile wide of heavy-bedded mica schist, which passes into a bedded syenite or hornblende rock. The exposures here are bad, and the passage from one rock to another cannot be traced, for the surface of all these rocks is much decayed and concealed by clay. Dip of both southeast. This syenite is composed of well segregated hornblende, in large crystals, combined with large crystals of a yellowish-white feldspar, too much decayed to show its true character, but apparently triclinic. This rock is succeeded by a wide belt of massive syenite, which is more igneous-looking in its durability, want of bedding, and apparent protrusion. The latter contains white orthoclase, much hornblende and a little quartz. This extensive belt reaches to within half a mile of the main mountain. It is here succeeded by a very coarse syenite, which exactly resembles that described at Balcony Falls, in the preceding section, with the exception that the red feldspar, which principally composes it, shows distinct cleavage. This extends to within a few hundred yards of the base of the mountain. The interval is occupied by a valley, in which a stream flows, whose alluvial deposits, combined with the vast quantity of transported boulders, conceal the rock. It is apparently the same with the preceding, for the principal mass of the mountain which rises from the valley is composed of the same coarse syenite, showing, however a considerable proportion of white triclinic feldspar. The topography of the locality presents some noteworthy features.

The Blue Ridge is here again a single chain, composed entirely of crystalline rock. There are no considerable hills lying to the east of the main ridge. This latter rises immediately from the valley mentioned, with a rounded, gently swelling slope, bare of surface-earth, but covered profusely with immense boulders derived from the mass composing the Peaks proper.

After attaining the summit of the slope, we find ourselves on a level with a valley lying to the west. This lies along the foot of a chain of mountains situated farther west, which rivals the Blue Ridge in height, and is composed of Silurian strata. The summit of the slope is about 1500 feet above the valley on the east.

On each side of this point rises abruptly a mountain 1600 feet above the pass. That on the right, composed of the same rock with the one on the left, is not an isolated peak, but it is the end of a great mass of mountains which extend northeast as far as the eye can reach, and even surpass in height this *peak*. The elevation on the left, which, with the one just mentioned, forms the Peaks of Otter, is an isolated eminence. It stands up abruptly from the coarse syenitic mass forming its base, like a huge chimney, showing by its bare, abrupt faces, that it is composed of different material from the softly rounded, well-worn base on which it stands. In ascending it we find the coarse syenite accompanying us to within 600 feet of the top of the crag, which forms the highest point. This would seem to indicate that in the pass at least 1000 feet of the older coarse rock has been scooped out, for the two peaks facing each other present similar features. To the southwest, the great elevation seen at the Peaks is soon lost. There the crystalline mass rapidly sinks down into several low finger-like spurs, and farther on no elevation which can be called a mountain occurs. The Virginia and Tennessee railroad passes the Blue Ridge at Buford's Gap without tunnelling, and by moderate grades. In this region, as Rogers has stated, the Silurian range to the west is called the Blue Ridge.

The following then is the structure of the mountain at the Peaks. The main mountain rises in the form of a broad, softly-rounded ridge, composed of coarse syenites, like those described at the east base, and like the rocks on James River west of Lynchburg. From this, as a base, rises abruptly on the west side near the east limit of the Silurian strata, a broad ledge of a totally different rock, which will be presently described. To this latter mass, which is about 900 feet wide, the mountains owe their additional height of 1600 feet.

Many peculiar features of erosion and the transport of matter occur, to adequately describe which too much space would

be required. These can best be explained by assuming the action of ice through this gap. In passing over the coarse decomposing syenites, which form the lower part of the mountain, we see several ledges of a much more crystalline rock penetrating them. This, which has all the characters of a true igneous substance, has made its exit principally on the west side, in the broad ledge which forms the two Peaks. It is a dark, greenish rock, very tough, and exceedingly durable. This furnishes the boulders which cover the east slopes. As the more easily decomposing, supporting framework of coarse syenite crumbled away, this more durable substance fell, and made its way down the gradual slope, perhaps aided by ice.

It is composed principally of a peculiar orthoclase of a sea-green color. This by its predominance gives a green color to the entire rock. The other constituent is a granular mixture of hornblende with a notable amount of magnetic iron. All the constituents are well crystallized, and show brilliant cleavage faces. Sometimes the feldspar occurs in quite large masses. Its crystals are always much larger than those of the hornblende and magnetic iron. Some pyrite is present. From some trials, I am inclined to think that the green color of the feldspar is due to finely disseminated hornblende. It is plainly a true igneous rock, of later date than the coarse syenites. This then would be a true eruptive syenite, whose emission may have aided in producing the great disturbances seen in the Lower Silurian here and elsewhere in the State.

This belt of rocks passes out of Virginia into North Carolina, and is there continued in the broad area marked by Kerr as Upper Laurentian, in his map of that State. I will defer any remarks on the age of the different rocks here presented until after the presentation of some facts gathered from the study of the Silurian strata which join them, for these have an important bearing on this question.

In this article I have devoted most space to the geological structure of the two mountain chains and to the massive crystalline rocks, since my object in making the examination was to discover whether any igneous rocks existed in them, and, if so, to determine the part they played in their structure.

Morgantown, West Virginia, Oct. 16th.