ART. XIX.—*Wm. B. Rogers's Geology of the Virginias. A Review*; by J. L. and H. D. CAMPBELL.

(Continued from vol. xxx, p. 374.)

IN our further treatment of the subject before us, we shall limit our remarks to the most salient points in the higher formations of the geological system of the Virginias, basing them chiefly upon personal observations, and making them supplementary to the comprehensive and able discussions found in the volume under review.

Niagara Group, IV, V, R. (5*a*, *b*, *c* and 6).—In Virginia this comprehensive group consists of alternating beds of conglomerates, hard sandstones and shales—calcareous shales predominating in the upper portion, in which occasional beds of impure limestone occur. In the State Reports the whole series is described under two divisions, IV and V of Professor

Rogers's series; but in his final chapter, p. 717, he puts the whole of IV and the greater part of V together as constituting the Niagara group (5*a*, *b*, *c*), while he regards the higher calcareous shales and limestones as representing the Salina period (6). It is gratifying to find him so ready to subordinate his own system of notation and nomenclature to the more generally applicable and altogether superior system now rendered classic in the science through its adoption by the leading American geologists.

The bold escarpments of Medina and Clinton beds constitute a conspiuous feature in the Little North Mountain and its several outlying ridges, along the western margin of the Great Valley, as may be seen in the Jump and House Mountains of Rockbridge, and in Purgatory and other ridges in Botetourt county. While the dip of these sandstones and the overlying shales is generally toward the northwest, or normal, as far northward as the Jump Mountain in Rockbridge county, an abrupt change occurs at this point, and throughout the remainder of the range, nearly as far northward as the Potomac, the eastern margins of the beds are either inverted or thrown into a vertical position. This inversion is conspicuous where the C. & O. Railway passes through Buffalo Gap, ten miles west of Staunton.

A number of ridges, essentially parallel with the North Mountain range, lie between it and the outcropping margins of the coal rocks farther west, occupying a belt of mountainous country from 20 to 40 miles in width and more than 300 miles in length. The framework of these ridges is generally the massive sandstone beds of 5*a*, *b*, while they are flanked most commonly by remnants of 6, and of several higher groups, as 7 and 8. They are remarkable for their numerous anticlinal arches and folds which usually constitute the crests of the ridges; and for the comparatively wide and shallow synclinal troughs that intervene, and carry the remnants of higher and less durable formations, among which the dark shales of 10 are conspicuous.

The Clinton beds of this group carry, in many places, valuable beds of the fossil and red-shale iron ores, which have been extensively mined in Pennsylvania, Virginia, Tennessee and Alabama, and are noted for the superior quality of iron they yield.

Salina Group.—The existence of the Salina in the Appalachians of Virginia may be regarded as yet an open question. If it has any representative here it is to be found in the calcareous shales with occasional beds of limestone, mentioned by Professor Rogers under V. But while there is reason to suspect that a portion at least of the higher beds of that series

belongs to the Salina (6), additional explorations are required to settle the question definitely.

Lower Helderberg, VI, R. (7), *and Oriskany*, VII, R. (8).—In the recent revision of Professor Dana's "Table of Geological Formations, 1885," we find that he makes the Helderberg the topmost period of the Silurian age, and makes the Oriskany the base of the Devonian. Whatever may be the chronological relations of these two formations, we find them in Virginia to be entirely conformable, to be coextensive with the Appalachian range, to blend considerably into each other in some places—the limestones of the former becoming very siliceous in its upper beds, while the sandstones of the latter are sometimes, though less frequently, calcareous where they come in contact with the underlying limestone beds. While the organic remains of the Helderberg bear close relations to those of the preceding Salina and Niagara periods, they seem to be just as nearly related to those found in the Oriskany, though much more abundant. In Virginia the relations of the Oriskany fossils to any remains found in the Devonian seem to be rather remote. Therefore we are still inclined to hold that "the Oriskany sandstone strata are the passage-beds between the Silurian and Devonian," but truly Silurian. This formation is characterized in Virginia by extensive beds of limonite ores.

We are here treating these groups in conjunction because in our mountain ranges they are most intimately associated. The one rarely, if ever, appears without the other; and where their beds have not been ruptured by contortions and foldings—that is, where the undulations have been such as to give the strata moderate dips—the durable sandstone of the Oriskany is left undecayed in many localities to form the crowning beds of mountain ridges of considerable height, and thus protects against erosion the less durable beds of Helderberg limestone beneath.* As a rule, however, where the sandstones of the Niagara period have been thrust up to a considerable height, the Helderberg and Oriskany strata have been so much ruptured that their fragments have been removed from the higher parts of the ridges by denuding agencies, and their outcropping edges alone are now to be found low down on the slopes and spurs. The Helderberg limestones being more easily disintegrated than the Oriskany sandstones, are often hidden from view, but their position is still indicated by a depression between the sandstone and the main ridge, forming a well-defined "bench" on each spur, while in the adjacent ravines,

* We have a striking and very interesting illustration of this arched structure at the celebrated Blowing Cave in Bath county, three miles west of Millboro Station on the C. & O. Railroad. By a singular oversight Professor Rogers locates the cave in the Oriskany instead of the Helderberg. See this Journal, vol. xviii, pp. 121 and 125 (1879).

eroded by mountain streams, the beds of limestone are commonly denuded, and the two formations may be seen in close contact. The very intimate relations thus shown between these two formations, and the abrupt transition to the next higher group incline us, as already stated, to regard them both as belonging to the same general geological age.

The Corniferous Group of Devonian age (9*a*, *b*, *c*), as far as our observations have extended, and as far as we can draw any inference on that point from Rogers's Reports, has no well-defined representative in the Virginia portion of the Appalachians, we therefore pass to the next higher series, on which we wish to make a few remarks.

No. VIII, R. (equivalent to 10*a*, *b*, *c*, and 11*a*, *b*, Dana), consists of a remarkable series of slates that are found crowded into folds and crumpled masses in the synclines between the sandstone ridges of 5*a*, *b*. The "Black," the "Olive" and the lower portion of the "Ochreous" divisions of Rogers appear to coincide with the *Marcellus*, *Hamilton* and *Genesee* (10*a*, *b*, *c*) of the New York series; while the higher portions of the ochreous beds doubtless represent the equivalents of the Portage and Chemung groups (11*a*, *b*). In many of the valleys where 10*a*, *b* slates form very conspicuous features of the topography in the form of slaty ridges and knobs of various size and shape, beds of 11*a*, *b*, if they ever constituted a prominent feature, have been almost entirely removed by denuding agencies. The remaining slates of 10*a*, *b*, *c* have been so much crushed and warped by the compressing forces exerted by elevation of the bordering sandstone ridges, that it is difficult to determine their thickness with certainty. But in the middle portion of the range, at points where they have been least disturbed and least worn down by erosion, as for example, in parts of Bath and Alleghany counties, we have found them to have an average thickness of about 750 feet. In the higher parts we find some beds of limestone containing remains of corals, crinoids and mollusks of Devonian type.

Catskill group, IX, R. (12).—This series of strata evidently constitutes a transition period from Devonian to Carboniferous age. Its lithological features as represented in its numerous and heavy beds of brown micaceous sandstones, its conglomerates and ochreous shales, and what remnants it contains of vegetable and animal life, although distinctly Devonian, all suggest at least an approaching resemblance to what we find in the overlying, and essentially conformable, beds of the Sub-carboniferous period.

Sub-carboniferous, X, XI, R. (13 *a*, *b*.)—The two divisions of the Sub-carboniferous group are quite well characterized in Virginia, especially in the middle and southwestern parts of the

eastern border of the great coal-field; but the lower division, 13 *a*, is especially worthy of notice, as it is here a real coal-bearing formation. At the date of Professor Rogers's Reports, (1835–41), it promised to be of great economical importance to the State, on account, first, of the intrinsic value of much of the coal found in it; secondly, of its proximity to extensive beds of iron ores, and to points in the general market; and thirdly, of the fact that the eastern portion of the State was, at that period, cut off in a great measure from the coal-field west of the Alleghany range, by want of lines of transportation. But since several railway lines have brought the products of the richer and more available mines into competition with those that are less productive, and more expensive to work, very little mining has been done except to meet demands for local consumption.

Although this limited field has ceased to have any great commercial value, it still possesses a scientific interest from its relations to the salt-wells on the Holston and the Kanawha rivers.

The history of geological investigations and speculations regarding the origin of the beds of gypsum and salt, found in the valley of the north fork of the Holston, in Washington county, is both interesting and instructive. The problem of the true geological relation of these minerals has for a long time been under discussion. Traversing the little river valley in which they are found is a remarkable line of faulting, by which the beds of Sub-carboniferous, 13 *a*, *b*, have dropped down on the northwest side, or the Canadian limestones of 3 *b*, *c*, have been thrust upward on the southeast side, to such an extent that the two formations are now on the same level, although at other points, where they still retain their normal relations to each other, they are several thousand feet apart.

Near this line of dislocation, beds of gypsum, in rather irregular concretionary masses, have been opened and mined at a number of points over an area of several square miles. Within this general area a number of salt-wells have been sunk, penetrating beds of rock-salt of considerable thickness. From the strong brine of these wells salt has been manufactured for many years.

As to the gypsum, all agree that it was once corbonate of lime, changed now to sulphate by the action of sulphuric acid from the adjacent pyritous shales, but there has been a difference of opinion as to the age of the limestones from which the gypsum was produced. In relation to the source and mode of accumulation of the salt beds, there has been a like diversity of opinion. Prof. Rogers himself seems to have greatly modified his views of this region at different periods in the history of his

explorations. In his State Report for 1837 he locates these gypsum and salt beds in the upper part of his No. V—probably Salina or No. 6 of Dana's series. In the Report of 1838 he appears to have found the source of the gypsum at least, in the limestones high up in his No. VIII. Then, in his notes prepared in 1878 for Macfarlane's Railway Guide, he says of the salt and gypsum, that "Both deposits are probably referable to the Sub-carboniferous period." If the solution of this problem proved so difficult and perplexing to a profound and accomplished geologist like Prof. Rogers, it becomes us to approach it with modesty. The question, however, seems to be still open for discussion and for differences of opinion.

In Prof. Dana's Manual of Geology, revised edition, 1880, p. 233, these deposits are referred to the Salina period, (6). Prof. Lesley in his Report on the Geology of some of the southwest counties of Virginia, 1871, regards the gypsum as produced by the action of sulphuric acid or sulphuretted hydrogen from the "Lower coal-measures," on the Lower Silurian limestones of the Holston valley. His theory of the accumulation of the salt is thus expressed: "The appearance of brine in such quantity and of such strength must be considered a local phenomenon explainable without reference to the gypsum. Such an explanation may be found in the very curious lake deposits of the little triangular plain at Saltville; a deposit evidently made in a deep little lake or pond basin filled with red mud, and saturated with salt-water, gypsum drainings, etc. . . . . The salt lies in a solid form, mixed and interstratified with compact red marl or clay, 200 feet below the water-level of the Holston; and the borings have gone down, at the salt-works, 176 feet further without reaching the bottom." If this be the true view, the salt lake must have been formed and filled at a period subsequent to the production of the fissure above mentioned; perhaps in Permian or in Mesozoic time. If the question as to the source of the salt of these beds is ever finally settled, that source will most probably be found in the Sub-carboniferous; in that case the question becomes analogous to that in regard to the same formation in Kanawha valley, where Rogers says, "from these strata there is every reason to believe are derived the saline ingredients which enrich the salt wells of that enterprising and prosperous region," (p. 373).

Saltville is easily accessible by rail, and is surrounded by a variety of interesting geological features, besides the beds of gypsum and salt.

Conglomerate Coal Groups, XII, R. (14 *a*).—The great conglomerate bed, called by English geologists, "Millstone Grit," seems to have been regarded by the early geologists of this country as one simple bed underlying the whole of the Appala-

chian coal-field. But in Virginia, Rogers determined forty years ago, that there were two distinct divisions of the Great Conglomerate, with intervening "seams of coal between these divisions." Hence the lower division is now recognized as the floor of only a sub-division of the true coal measures, to which Rogers gave the appropriate designation, "Conglomerate Coal Group." To him belongs the honor of having determined its true status in the Virginia series, and yet it has most probably proved to be far more important, (as developed in the Quinnemont mines, on New River, and the Blue Stone and the Pocahontas (Flat Top) mines farther to the southwest), than was anticipated by him, when, forty years ago he wrote about it, more as having a prospective than a determined value.

Above the Conglomerate group Rogers recognizes four subdivisions, to which, in his table, p. 717, he applies the terms "Lower Coal Group," "Lower Barren Group," "Upper Coal Group," "Upper Barren Group." The first three seem to be covered by Prof. Dana's 14 *b*, *c*; and the last appears to coincide with 15. For we find on his geological map the area of the "Upper Barren Group" represented as of Permian age,* and mapped down as bordering on the Ohio river, from the mouth of the Great Kanawha to the vicinity of Wheeling, and covering nearly the whole of two tiers of counties along that margin of the State.

MIDDLE SECONDARY, (16–17).—Such is Rogers's designation of the groups of *Mesozoic age*. The lower portion he regards as embracing the Triassic and Jurassic blending into each other; and hence applies to it the term, "Jurasso-Triassic," (16–17), while for like reason he calls the higher portion "Jurasso-Cretaceous," (17–18). Rocks of this age in Virginia are found altogether east of the Blue Ridge, and so far as yet determined they rest, not upon rocks of the next preceding age, but upon Archæan beds—usually in trough-like depressions, or perhaps in basins of erosion. The extensive areas covered by these rocks are generally of irregular oval form, and in interrupted belts having a general N.E. and S.W. trend, corresponding with the usual course of the outcrops of the Archæan beds. The Mesozoic coal field near Richmond forms an exceptional case—its longest axis being north and south, and hence parallel to the corresponding part of the Atlantic coast.

It is worthy of remark, that the northwest margin of the belt of Mesozoic rocks, north of James River, skirts the southeastern base of a range of ridges running nearly parallel with the Blue

* Prof. Fontaine, of the Virginia State University, and Prof. White, of the University of West Virginia, seem to have established the identity of a number of species of the flora of this group with those of the recognized Permian in other regions, American and foreign.

Ridge, and known by different names, as Cittocton Mountain in Loudoun county, Bull Run Mountain in Fauquier; and farther to the southwest, its several parts are known as Southwest, Green and Findlay's Mountains. This leads to the inference that the broken range thus designated was the shore line of the Mesozoic sea in which these groups of strata were originally deposited.

Another point worthy of note, in connection with the topography of the tracts, is that they differ from one another but little in their elevation above tide-level, though separated by intervals of many miles. This has been determined by the surveys of the railway lines by which they are severally traversed, and on which we give the elevations of only such points as are actually on Mesozoic strata. For examples, on the Virginia Midland Road, Manassas station is 317 feet above tide; the average elevation from that point to Culpeper is 300 feet; the portion of the Manassas and Strasburg branch of the same road, as far as it runs on this formation, has an average elevation of 351 feet, the minimum being 317, and maximum 395 feet. On the Richmond and Danville road, Coal-field station is elevated 320 feet above tide, and Powhatan station 317 feet. Farmville on the Norfolk & Western road, where it crosses Mesozoic rocks, has an elevation of 316 feet. At these several points only the Jurasso-Triassic beds (16–17) are found, with none of the newer beds of Jurasso-Cretaceous overlying them, hence we may conclude that they were elevated above the level of the sea before the Cretaceous epoch. And, after making allowance for a considerable amount of erosion and denudation, we may very reasonably conclude that the sea bottom, which received the latest deposits of 16–17, has been lifted through a space of at least 400 feet above present tide-level, plus the depth of the water in which those deposits were made; and that the uplift was simultaneous and very uniform in extent, over an area 200 miles long and 50 or 60 miles wide, or fully one thousand square miles.

TERTIARY AGE.—*Eocene*, *Miocene*, *Pliocene*, (19 *a*, *b*, *c*.)—Rocks of this age cover a very large area in the eastern part of the State. A line from Aquia Creek, on the Potomac, running south through Richmond and Petersburg to the North Carolina line, would mark out approximately the western border of this area, while it covers all the territory between that line and the Atlantic coast. Its total length is about 130 miles by a meridional line, and its width from Richmond eastward to the mouth of the Rappahannock River is about 65 miles, and at the latitude of Norfolk 80 miles.

Although Quaternary Drift obscures much of the surface of this Tertiary region, the banks and bluffs of the many

streams traversing it afford numerous exposures of Tertiary strata, with their characteristic lithological features and fossil remains. These are readily accessible on several lines of railway, and along the rivers below Fredericksburg, Richmond and Petersburg.

We shall direct attention to only a few points of special interest in connection with Prof. Rogers's work in this interesting field. As early as 1835 he writes, "The existence of an extensive Eocene formation in eastern Virginia is now for the first time announced as furnishing an interesting step in the geological inquiries which are now on foot," etc.

The Miocene covers the greater part of the Tertiary of Virginia, but we shall note only two points of special geological interest, as illustrating the appreciation the scientific world has placed upon the work of Rogers in this portion of his great field. His description of the cliffs near Yorktown, and the detailed account he gives of the contents of their fossil beds, have made that region classic ground for the modern geologist, and have given the Miocene the title of "Yorktown Group"—a title found in almost every extended discussion of the Tertiary age among American writers.

A second point relates to the history of the first discovery of the famous *infusorial bed*, which crops out conspicuously along the slopes of the hills on which the city of Richmond stands, and at several other places in Virginia, as well as on the Maryland side of the Potomac. Although this interesting feature of our geology has for years commanded the attention and admiration of the scientific world, and the beautiful picture of its diatoms developed by Ehrenberg's microscope, become familiar to the eye of every geologist, we doubt whether many of our younger co-workers know much about the history of its first discovery. We deem it proper, therefore, to say that, after giving a general account of his first discovery and microscopic examination of the contents of this wonderful deposit of what was then regarded as "infusorial animals," Rogers says, "In view of these interesting facts, the discovery of the *infusory Stratum*, as one of the members of our series of Tertiary deposits, cannot fail to be regarded as an important addition to our knowledge of the Tertiary of this country, and has the greater interest at present, as being the first example yet observed in the *United States* of the occurrence of infusorial remains in any but the most recent geological formations." His latest view of the geological position of this formation is, that it is near the base but still within the Miocene group. We are ready, from personal observations, to accept this conclusion.

Virginia and West Virginia together present a vast field, embracing within itself an almost complete system of geological

formations, of which we have given only some of the prominent features. While a great work has been done by Rogers and others, the material of the field is far from being exhausted; and the amateur student can readily find access to any particular formation or group, which he may desire to make a special subject of study.

Washington and Lee University, Lexington, Virginia, 1885.