Rogers (W. R.)

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Geological Notes. By Prof. William B. Rogers.

Art. I. On the Newport Conglomerate.

It will be remembered that in a communication to the American Association in 1860, and in fuller detail in a paper on "The Metamorphism of Conglomerates," published in Silliman's Journal the following year, the late distinguished Geologist, Prof. Edward Hitchcock, endeavored to show that the generally elongated form and closely fitting arrangement of the pebbles in the Newport conglomerate were due to the influence of heat or other agencies softening the rock, combined with a continued pressure and tension, by which the pebbles were squeezed and drawn out in their semi-plastic condition.

To this view I objected, on the ground that such an action applied on a large scale must have had the effect not only of flattening the pebbles in a uniform direction, but of developing a cleavage or lamination of them, all parallel to their flat sections as they lie in the mass. For this and other reasons set forth in the Proceedings of the Society, in a paper communicated the same year, I maintained that the forms and arrangement of the pebbles were those which had resulted from the wearing action of the tides and currents, by which they had been originally moulded in the process of their deposition and accumulation; not doubting, however, that in some metamorphic districts conglomerate rocks are to be found, which have sustained great internal changes through the effects of heat, chemical action and violent pressure.

At a subsequent meeting of the American Association (1869), the plastic theory was again brought forward, and an argument in its favor was drawn from the then recent experiments of Prof. Tresca of the

Conservatoire des Arts et Métieres, on what he calls the "flow of solids," and this argument seems hitherto to have passed unchallenged. When, however, we refer to the results of these experiments, we find the fact that in all cases the solid subjected to the moulding force exhibited a striking alteration of its structure; a bar of metal, for example, thus forced through a contracted opening, being reduced in diameter, and presenting after its changes a series of concentric, loop-like curves, marking surfaces of lamination or partial separation, caused by the relative motions of the different parts. It would seem, therefore, that any flattening and elongation of the pebbles in the conglomerate could not fail to be followed by some analogous alteration of structure, and as the pressures or tensions must be conceived to have pervaded the rocks generally, it was to be expected that such induced lamination, or other structure, would be found common to all the pebbles making up the mass. But on careful examination of the principal exposures of the Newport conglomerate, I have met with no evidence of such superinduced structure, although from the fact that the pebbles are for the most part rolled fragments of quartz, quartzite, sandstones and silicious slates, having a more or less jointed or laminated character, an opportunity is frequently presented on the smooth face of the rock for studying their internal structure.

As an illustration of how independent the lamination and joints of the several fragments are of such hypothetical moulding forces, I have made a tracing of the conglomerate surface, at a particular locality of the Purgatory Rocks, on transparent cloth, which enables me to lay down the actual outlines of the several pebbles with the direction of the laminæ in each. In this diagram it may be seen that the lamination has very various directions, and that it extends entirely across the pebbles, leaving no room for supposing even a superficial moulding effect from pressure. The predominant direction of the laminæ, as might be expected, conforms to the general direction of the oblong pebbles, but even in cases where the conformity is most striking, and the appearance of flattening by pressure most marked, pebbles are interspersed in which the lamination has various transverse directions, sometimes even at right angles to the strike.

It would seem, therefore, in view of these facts, that there is nothing in the structure of the Newport conglomerate to sustain the hypothesis referred to, or to call for further mechanical agency than the transporting and wearing actions under which it is believed such

materials have been generally moulded and accumulated, together with the tangential or other pressures, which have been concerned in determining their stratigraphical position. Of the operation of these latter forces there can of course be no question, as the rocky masses of the conglomerate have been forced into steep and alternating dips. Moreover, the cracked and fissured condition, so frequent in the larger masses of quartz and quartzite, suggests the action of a crushing force. Nor can it be doubted that chemical changes have been wrought in the material in which the pebbles are embedded, and even occasionally in the surfaces of the pebbles themselves, giving rise to the crystalline grains of magnetite scattered through the former, to the mica-like scales which are found adhering to the pebbles, as well as the cavities left by their removal, and to the slight pitting or striation with which the pebbles are sometimes marked.

In regard to the generally elongated form of the pebbles in these rocks, my observation of the breakers at various points on our coast has led me to the conclusion that there is a marked difference in the action of the impinging waves, due to differences in the slope and smoothness, and the greater or less irregularity and contraction laterally of the shores, so that while in some cases the movement is chiefly a vertical whirling in the direction of the advancing wave, in others it includes also various gyrations transverse to this. In the former of these conditions the movement imparted to the pebbles at the shore would, it might be expected, grind them by mutual attrition, and the wearing action of the sand, into oblong forms, while in the latter conditions it would tend to bring them into lenticular, or into more or less spherical shapes. The former of these modes of action seems to prevail at many localities along the Newport shores, and the latter is well exemplified by the lenticular forms so abundant in the pebbles brought from the coast of Newfoundland.

The flattened shape of many of the large masses may, to some extent, be ascribed to the attrition operating upon them while partly embedded and at rest, but chiefly to the laminated structure of many of the fragments, causing them to break by concussion into flat masses and to yield to erosive forces more rapidly in the planes of the laminæ than in transverse directions.

There is often a difficulty in determining the dip of these conglomerate beds, from the fact that in some of them the pebbles, in-

stead of lying with their longer sections parallel to the planes of bedding, are placed partly edgewise to these planes, but by tracing the separating beds or layers of sandstone it is usually possible to discern the inclination of the strata. This oblique arrangement of the pebbles resembles what is to be seen in similar accumulations of large pebbles along the upper part of steep sea beaches of the present day, or it may possibly have been caused, as has been asserted in some cases, by an actual turning of the pebbles from their originally flat position by the oblique action of the upheaving force.

A striking feature in the general structure of these rocks, is the system of vertical joints by which they are traversed, and which have often been alluded to by former observers. These joints, ranging nearly east and west, or at right angles to the strike of the beds, are usually at distances of twelve to fifteen feet apart, but in some cases they divide this interval by parallel clefts only a few inches asunder. Where this is the case the wearing action of the waves finds comparatively little opposition, and the cliff in process of time is cut back, so as to form a chasm of greater or less length, whose vertical parallel sides extend from the top of the cliff to its base. Of these effects of erosion, one of the most striking is the well-known chasm at Purgatory, near Newport, which has been erroneously regarded as due to the decay of a dyke of trap, supposed to have occupied the cavity.

As already stated, the above objections to the plastic theory are meant to apply simply to the mass known as the Newport conglomerate, having its typical locality in the Purgatory rocks, and are not intended to throw doubt on the evidences of metamorphic action, mechanical and chemical, with which, in other cases, geologists are familiar. Of the reality of former movements within the substance of rocky strata we have abundant illustration in the actions by which slaty cleavage has been induced, and by which, in connection with this structure, the lengthening, shortening, and other distortions of the enclosed fossils have been brought about. These distortions, however, in most cases, are to be explained not so much by a direct compressing or extending force, as by the effect of the sliding of the laminæ upon each other in definite directions, carrying with them the corresponding linear elements of the fossil, or its impression; so that without any necessary condensation or stretching of the mass, the distorted forms may be regarded as so many geometrical projections of the fossil on differently inclined planes.

In recent explorations of the conglomerate, I have obtained impressions which, although indistinct, are suggestive of the "Lingula," found many years ago in the conglomerate rock in the neighborhood of Fall River, a deposit probably on the same, or nearly the same, geological horizon with the Newport conglomerate. Besides these specimens, which were broken from the rock in place, I have found numerous large pebbles on the adjoining beach crowded with well-preserved impressions of the same fossil. These pebbles, both in place and scattered, consist of a gray silicious rock or quartzite, seemingly referable to some member of the primordial group, of which a remnant is exposed in southeastern Massachusetts, and perhaps a larger extent is concealed by drift, and which probably at one period spread northeastward over extensive areas now covered by the sea.

Art. II. On the Gravel and Cobble-stone Deposits of Virginia and the Middle States.

The surface deposits here referred to are extensively exposed in many parts of the belt which marks the junction of the older rocks with the tertiary and upper secondary formations in the Middle States. These deposits, especially in the great river valleys and adjoining slopes, as at Richmond and Washington, consist chiefly of layers of quartz gravel, like the surface gravel of the adjoining primary region, and of larger smoothly rolled masses derived from the silicious slates, quartzites and sandstones of remoter tracts lying to the west and northwest, mingled and interstratified with ferruginous sands and clays, which impart to the mass a more or less reddish color.

In most localities, the larger pebbles are found in the upper part of the deposit, often strewing the surface thickly where the finer matter has been removed either by natural erosion or in the progress of improvement, as may be seen at numerous exposures in and around Washington. In other cases, as at Alexandria and at Richmond, the cobble stone deposit is usually overlaid by stratified sand and gravel of considerable thickness. It is from these sources that the cities of Richmond, Washington, Baltimore and Philadelphia, have been supplied with the paving materials at one time so generally in use.

In a pile of such paving stones in Richmond, Virginia, many years ago, I found a large pebble of compact vitreous sandstone, containing distinct impressions of *Scolithus linearis*, the well-known characteristic fossil of the Primal or Potsdam formation, having its nearest outcrop on the western side of the Blue Ridge. In subse-

quent observations, especially those recently made in and around Richmond, Washington and Georgetown, I have found that a considerable proportion of this pebbly or cobblestone deposit consists of fragments of the harder silicious Paleozoic rocks, and has therefore been derived from the Appalachian belt. Indeed, so common are the fossiliferous fragments, that an observer can hardly fail to discover them at any of the excavations where the coarser materials are exposed, as well as in the piles of cobblestones in the neighborhood.

In the specimens exhibited to illustrate this paper, collected chiefly at Washington and Richmond, it will be seen that the casts of Scolithus are very distinct and abundant. These masses are from two to six inches in diameter, but in some of the localities much larger specimens may be seen crowded with the fossil. Along with them are occasionally found rounded masses or cobbles of fossiliferous sandstone and of conglomerate, referable to higher positions in the Appalachian series, ranging probably to the carboniferous rocks. The absence from these deposits of fragments derived from the limestones, shales and argillaceous slates of the Appalachian belt, is readily accounted for by the comparative ease with which such materials would be disintegrated by the mechanical and chemical actions concerned in their transportation and deposition, and the same explanation accounts for the fact that so few fragments of the granites, schists and gneissoid and hornblendic rocks of the wide intervening belt have been preserved in this formation, and that it retains little distinctly representing these rocks, except an abundance of quartz gravel and cobbles, derived from them.

The deposit in question extends at Washington over the entire plain on which the city is built, having an average of seventy-five feet, and rising on the north to about one hundred feet above mean tide. Thence it spreads over the adjoining slopes, covering the high ground on which Columbian College is situated, and the still higher hill of the Soldier's Home, which is more than two hundred feet above tide. At the latter locality the rolled fragments have a less average size than at the lower level, though still often several inches in diameter. In the neighborhood of the Capitol, and in the railroad cutting near the Navy Yard, they are often as much as a foot in diameter, and a recent excavation near Georgetown, some forty feet above the creek, has brought to light masses of these transported rounded rocks of still greater dimensions, some of them large enough to be called boulders.

Although the surface formation in question shows itself in, and adjoining, the valleys of all the principal streams in the Middle States, the fragments of paleozoic rocks have thus far been observed only in the deposit as exposed in those river valleys which penetrate westward and northwestward as far as, or into, the Appalachian belt It is reserved for further observation to ascertain whether they are wholly absent from the shorter valleys, and also to determine to what extent the general deposit is continued from valley to valley over the intermediate higher grounds.

Although from the facts thus far observed, it would seem that the transporting agency by which these deposits were accumulated was chiefly or wholly operative in the lines of the river valleys, the great height to which, as before stated, the deposit reaches, shows that the relative level of the water, or probably ice, concerned in the transportation, must have been much above the water level as it now exists, and that the then actual river valleys were of correspondingly greater width. The distances over which the fragments of Appalachian rocks found in these surface deposits have been carried, may be judged from the following facts.

The distance from Richmond, in a straight line to the nearest outcrop of the Primal or Potsdam sandstone west of the Blue Ridge, is about eighty miles; that following the course of the James River is one hundred and sixty miles; the distance from Washington to the western side of the Blue Ridge in a straight line is about forty miles; that along the Potomac River between fifty and sixty miles.

What relation this deposit bears to the drift of the more northern regions as to the manner and time of its production, is a question of great interest. The materials of the deposit are distinctly stratified, and the fragments, instead of being angular, as so common in the drift proper, are well rounded and smooth. Nor has there been thus far observed, any case of that striation of surface which is so frequently met with in the larger fragments of the northern drift Tracing the formation, however, as it shows itself successively at Richmond, Washington, and other localities still further northward, the stratification becomes less perfect, and the coarser materials are more scattered through the mass, and after crossing the Delaware the whole deposit cannot be distinguished from the material considered in that region as a modified drift.

Speculating on the causes by which these deposits have been formed, it may, on the one hand, be imagined that during the glacial

period the icy covering of the north and west prolonged itself in the valleys of the great rivers, as far south as the James, and even the Roanoke River, bringing down to the belt of land now marking the limit of tide water, debris from the Appalachian rocks, mingled with materials derived from the intervening region, and that the grinding and sorting action of the waters subsequently obliterated glacial marking, and gave to the whole deposit the distribution and stratification which it now presents; or, on the other hand, it may be conceived that the transporting force of the rivers themselves, swollen and rapid as they must have been in the closing ages of the glacial period, brought about the same results. But even, in this case, it is highly probable that glacial action had much to do with the original accumulation of the rocky debris on the flanks of the Blue Ridge, and in the Appalachian valleys beyond.

In the belt partially occupied by the surface deposit here referred to, there is exposed another group of strata, with which, at first view, the sandy and argillaceous layers of this formation might readily be confounded. These are the silicious, argillaceous and pebbly beds, which, underlying the tertiary in Virginia, and the well marked cretaceous formation further north, have, in the latter region, been regarded as belonging to the base of the cretaceous series of the Atlantic States. In Virginia the formation consists typically of a rather coarse, and sometimes pebbly sandstone, in which the grains of quartz and felspar are feebly cemented by kaolin, derived from the decomposition of the latter, and of argillaceous and silicious clays variously colored, and more or less charged with vegetable remains, either silicified, or in the condition of lignite. These constitute the group of beds designated in the Virginia geological reports as the Upper Secondary Sandstone, and referred by me long since (1842) to the upper part of the Jurassic series, corresponding probably to the Purbeck beds of British geologists. From the Potomac northward, this group of deposits, as exposed in the deep railroad cuts between Washington and Baltimore, and on to Wilmington, is made up of variegated, soft, argillaceous and silicious beds, which, from the preponderance of ferruginous coloring towards the Delaware, has been called by Prof. Booth the red clay formation. At a few points only towards the bottom of the deposit, it brings to view a bed of the felspathic sand, or crumbling sandstone, above referred to. Traced transversely, it is seen to dip beneath the cretaceous greensand at various points in New Jersey, Delaware and Maryland,

but in Virginia disappears in its eastward dip beneath the Eocene tertiary.

How far we may consider this group of sediments in Maryland, Delaware and New Jersey, as merely a continuation of the Virginia formation above described, can be determined only by further investigation. But the discovery in them at Baltimore, by Prof. Tyson, of stumps of cycads, would seem to bring them into near relation with the formation at Fredericksburg containing similar remains, and to favor their being referred, at least in part, to the horizon of the upper Jurassic rocks. Possibly we may find here a passage-group analogous to the Wealden of British geology. Whatever may be the result of farther discovery, it would seem to be premature at this time to assume the whole of these deposits from the Potomac northward, as belonging to the cretaceous series.

Where the tertiary or the cretaceous rocks are present in this belt, there is, of course, no danger of confounding the superficial gravel and cobblestone deposit with the formation just described, but in their absence, which is usual in the river valleys, this deposit rests immediately on the broken and denuded surface of the secondary, and by the intermixture of materials makes it more difficult to discriminate between them.

Excellent opportunities for observing the contact of the superficial deposit with the denuded and much older formation below, are presented in the neighborhood of Washington, among which may be specially mentioned the vertical cut at the extremity of 16th Street, at the base of the hill occupied by Columbian College, and also the continuation of 14th Street, ascending the same hill. At the former ocality the crumbling felspathic sandstone, or slightly adhering sand, is exposed to a height of about thirty-five feet, with a very gentle eastern dip, and having the color, composition and diagonal bedding characteristic of the Fredericksburg and Aquia Creek sandstone. The gravel and cobblestone deposit lying upon it descends with the slope of the hill to the general plain below, resting at a somewhat steep angle against the denuded edges of the underlying beds.[1] From this and other localities, it becomes obvious that the latter formation has been deeply and extensively denuded before and during the deposition of the surface strata, which form the chief subject of this communication.

[1] Since this was written (April, 1875), the excavation and grading have greatly changed the exposure by covering up much of the lower deposit.

At Richmond this gravel and cobblestone deposit presents itself at various heights from the river bank to the tops of the hills, mantling the irregularly denuded surface of the underlying formations; resting at one place on the Upper Miocene, at others, on the infusorial stratum, which lies at the base of the Miocene, or on the Eocene, or on the yet older deposit, referable probably to an upper secondary period. The well smoothed pebbles are chiefly of quarzite and silicious slates, including not a few which are marked with Scolithus. In the Rappahannock valley, and between it and the Potomac, the formation may be seen resting directly either on the massive secondary sandstone, or on the looser deposit situated next above, or on the Eocene tertiary, which at some points occupies hollows in the denuded surface of the sandstone.