Lichens of Licking County, Ohio

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I.

THE PALAEOZOIC FORMATION.

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No subject open to our investigation is more interesting or economical than that department of inorganic geology embraced under its stratigraphical relations. The conditions attending the origin and deposition of the earth's crust are at the basis of our existence in a certain sense; that is leaving out the ethical element which it is hoped one may consider as the pre-existing state necessary for such physical operations as should best fit man for his abode throughout his entire cycle of life.

Whatever may be the relations sustained by our planet with the rest of the solar system, through the so-called nebular hypothesis; it is suggestive to follow out the comparisons of W. Prinz published in the *Annuaire de l' Observatoire Royal de Bruxelles* for 1891, in which the great continental torsions of the western coasts of America, Europe and Africa, western Siberia through the corresponding coast line of Australia, together with a fourth supposed by him to be indicated by the great chain of islands to which the Marshall group belongs; has been thought to be analagous with similar oblique lines observed on Mars, and less distinctly on Venus and Jupiter.

The similarities afforded by each of the three great continental systems is suggestive as bearing upon the similar primary condition attending their origin and fundamental development. We have counterparts in the respective irregular triangular outlines of North America, Europe, and Asia, in connection with the formation of South America, Africa, and Australia, all with a more or less triangular development, and with the apex of the triangle pointing southward. Similarly as the outlines become less triangular and larger from west to east, we have regularly separating bodies of water also increasing in size, and represented by the Gulf of Mexico, Mediterranean, and the Indian Ocean. The existence of greater depths in the western Atlantic and Pacific, in connection with corresponding altitudes on both of their immediate shore lines, may indicate a great law of stratigraphic equivalence or equilibrium, through which as we already know, great accumulations result in areas of elevation, while vice-versa, lesser deposits might be held as forming the lowest depths. James D. Dana has attributed the zigzag arrangement of continents to torsion with the maximum torsion represented by a belt of volcanoes, and the earth's feature-lines as consequences in part of the pressure or tension attending torsion.

In our own country it can be readily shown that the North American continent had attained the outlines of its present form at the close of the Archaean age, subsequently developing southward into the Appalachian axis; that westward from there the surface deposits prove that it was coexistent with Carboniferous time, while west of a line drawn from the eastern longitude of Dakota the great Mesozoic and Tertiary deposits took place, the great climax of physical activity resulting in the evolution of the Mesozoic age, together with lesser resultant actions at the close of the Tertiary, or during a period very nearly contemporaneous with the Glacial epoch. Coexistent with this, it should also be observed that deposition took place from the north to the south, leaving the southern states adjacent to the Atlantic, Gulf of Mexico, and the Rio Grande of Tertiary and other later formations. We have attempted to show in a very general way the course of development among the sedimentary rocks, and it is thought, that as the general development has been westward, so we may be able to indicate the origin more exactly of portions of the Palaeozoic strata from sources eastward of their main deposition.

Any consideration of the origin of the later fragmentary rocks, involves not only an account of the adjacent land areas, but also the agencies by which they might be removed. The argument of Mr. Bull that the denuding action of tides must have been much greater among the rocks under discussion, cannot apparently find any very strong substantiation in nature, either from an organic or physical basis. Mr. Bull supposes that on account of the greater proximity of the moon at this time, that the action of tides would be greatly increased, causing material to be eroded and deposited in a manner almost inconceivable at the present. There are three objections to this theory: Primarily, that the nebular hypothesis of Laplace involves the fundamental idea that heat is evolved as a result of contraction, not taking into account that the intense heat of the sun would be more apt to cause an expansion instead of contraction along its diameter, according to all the known laws of Physics, while this involves indirectly the relation of our satellite to the earth, and it to the sun. There is moreover, no physical action apparent, with the exception of some cases which will be observed, which would denote any violent physical force. Most of the strata of the Palaoezoic and Mesozoic were deposited during periods when life was very abundant, and its manner of preservation and more particularly of deposition show that the conditions were very quiet, and probably of long duration. In this connection it might also be well to remark that the very nearly equible temperature of the globe which allowed the same animals and plants to flourish on the equator and the Arctic zone at the same time, even as late as the Tertiary period, would also prevent the formation of oceanic currents on a magnitude equal to the present streams, but then as at present, winds acted in promoting such agencies. Another agent which has suggested itself is earthquake waves originating beneath the ocean. We know that the transporting power of water varies as the sixth power of the velocity, consequently if the velocity be increased ten times, the transporting power is increased 1,000,000 times. It has also been ascertained that water moving at the rate of three feet per second will carry angular stones the size of a hen's egg. What would be the result then of a wave 300 miles in diameter, and sixty feet high, moving at the rate of 370 miles per hour in its erosive action upon the adjacent coasts? One can readily conceive that it would be possible to carry boulders two feet in diameter a considerable distance, while the beds of conglomerates which exist in Scotland could be produced by this agency instead of the direct intervention of glacial action as Croll has supposed. We have good reason to believe that earthquake action was as frequent and extensive in the times under consideration as at present, and the great sea-wave just described, which took place during the South American earthquake in 1868, would probable be surpassed by those of previous epochs. Rivers also operated to a large extent, especially during the lower Carboniferous.

Among the elements necessary to the formation of sandstones, and as we shall also consider more particularly of conglomerates, are primarily the elevation of land areas above water as the Archaean rocks of Canada at the beginning of the Palaeozoic age, with other narrow ranges running southwestward parallel with the Atlantic, and still additional areas now represented by the Cordilleras. We have also to take into account that the amount of carbon dioxide in the atmosphere during early geological ages, exerted in connection with water a much more powerful and quickening effect in atmospheric and atmospheric-aqueous action, which must have greatly hastened the denuding action during Silurian, Devonian, and early Carboniferous ages, at the same time changing the chemical arrangement and physical form of the rocks. The lowest orders of plant and animal life also furnished contributions, which taken in connection with the large amount of organic material represented in some limestone formations, as for instance the Hudson group at Cincinnati Ohio, and the carbonaceous elements of many of the black shales constituting the Devonian and the relatively thin, but very important coal seams, clearly indicate the manifold operations of organic existence, as well as the inorganic. In addition to this, we have a counterpart to the formation of coral reefs at the present, duplicated to an unusual extent during the Niagara and lower Devonian, giving rise for example at Louisville, Ky., to a barrier which causes the falls of the Ohio.

An element involving both physical and organic connection is also paramount, as furnishing an index as to the position occupied by the Atlantic ocean. It seems quite apparent that since areas on both sides of its present basin have similarly equivalent, recurring faunas, often quite restricted as in the Cuboids zone, that it was influenced by physical environments which may have also operated in producing sediments for the adjacent coasts, but of this nothing can be said with certainty. Recent surveys have determined the position of three submerged mountain ranges running north and south in its central basin. It is certain that at least portions of the Mediterranean have been eroded to an enormous extent, producing material for the adjacent coasts. Before attempting to trace the origin of some of the sedimentary rocks subsequent to the Cambrian it will be necessary to determine the land areas existing in Ohio. That the Cincinnati geanticine existed at the close of the lower Silurian, forming an island in southwestern Ohio and the adjacent parts of Indiana and Kentucky, is indicated by the absence of upper Silurian and lower Devonian over that area, these formations being deposited on its margins northward. In Tennessee a hiatus is revealed on account of the Devonian black slate resting directly on Lower Silurian beds, clearly indicating the land ares during the upper Silurian and part of the Devonian. This land area had a great influence in building up the subsequent Palaeozoic rocks, as we shall see further on.

The fluctuations and arrangement accompaning the formation of the lower Helderberg strata in eastern New York, show that the upward movement begun there at the close of the Cambrian period, still further progressed after the deposition of the Hudson group, throwing the rocks of that formation above the level of the ocean into anticlinal and synclinal folds east of the Hudson, while decreasing in intensity westward. The Hudson formation may have furnished sediment from which the Oneida comglomerate was in part derived, but it is apparent that the later beds of the Niagara period had a connection with the vastly thicker formation in Canada through a channel possibly leading northeastward from western New York. With only a thickness of 300 to 400 feet in Ontario, increasing to 1,300 feet in Nova Scotia, it seems possible that the sediment was derived from regions north or northeast of New England, while the intimate relation of its fauna to that of England point to a very close biological relationship between the two areas, which oftentimes results from an uniformity of physical environments. The thinning out westward of the lower Helderberg group in New York, together with its comparative thinness in Tennessee, demonstrates it to be an essentially eastern formation. Unlike the Niagara, however, it thins out very rapidly to the westward until in Cayuga county it has almost entirely disappeared. It is obvious, however, to the most casual observer, that the Helderberg escarpment in Albany county must have had a much greater extension northward than at present, and after H. Fletcher's determination of the thickness in Nova Scotia (1,000 feet), we can probably admit the truth of Logan's determination that it was connected with the Canadian basin through the Champlain valley; bounded on the east and west by the folds of the Cambrian and the Adirondack range.

Continuing upward in the geological formations we find the Hamilton group with a thickness of 1,200 feet in the Catskill region, but rapidly thinning to the westward, until in western New York it is scarcely 200 feet thick, while at the falls of the Ohio the beds include 20 feet of impure limestone. In eastern Pennsylvania the greatest maximum thickness is 5000 feet, in the Gaspe region 6000 feet. The associations of the specimens I have seen from Perry (?) Maine would indicate an estuary connection with the Gaspe fauna, outside of the main line of deposition. The manner of preservation is very similar to specimens from western New York. It is impossible not to believe that the Hamilton strata did not extend farther eastward, northward, and northwestward than at present, but all the strata have suffered denudation to an enormous extent, and we would not know of any northwestern connection, but for the Mackenzie river deposits. It is possible that portions of the Hamilton formation were derived from uplifted beds of the Hudson group and other formations east of the Hudson valley, and the Adirondacks may have contributed its share. It is obvious that the sediments could not have been derived from either the west or the southwest, and since according to Dana's determination the Champlain outlet was closed it is apparent from the relative thickness in the Catskill region, Pennsylvania and Nova Scotia, that the parent rocks may have been what is at present the bed of the western north Atlantic ocean, but it is entirely hypothetical. The lithological aspect of the formation is very suggestive as to its origin, especially when taken in connection with the organic remains. In eastern New York the strata are silicious with interspersed beds of shale, and containing land plants very similar to those described by Dawson from St. John. Lepidodendra as drift material, together with Psaronius actually growing and covered by the deposits. Farther westward the strata become thinner and more argillaceous, indicating quiet marine conditions, and greater distance from the source of the sediment. Certainly, however, there was an open connection with the eastern Canadian basin, by means of which an active inorganic and to a lesser extent faunal relation was sustained. It is also apparent that the strata in the Gaspe region were much nearer the original source of the sediment. I have rarely noticed very thin conglomerate beds in the Schoharie valley suggesting shore-line deposits—the precursors of greater strata which were deposited in the Chemung and Carboniferous strata.

Scarcely any subject in Palaeozoic stratigraphy with the exception of the Taconic question has caused more discussion than the relation of the Chemung, Catskill, and Waverly formations. Alexander Winchell would have had us believe that the Waverly and Catskill were in the same basin of deposition and coexistent. Another author contends, and very probably, that the Chemung and Catskill are equivalent formations with only a lithological difference due to different physical environments, while the Chenung and Portage are related but distinct formations. Prof. J. M. Clarke from palaeontological evidence links the Portage with the underlying beds. Prof. J. J. Stevensen on the other hand uses Chemung for a generic term with the divisions Portage, Chemung and Catskill, and finds that the Catskill period presents a closely circumscribed area during the deposition of the last beds of the Chemung but was greatly enlarged to the southward during the formation of its upper beds. We incline to this opinion, at the same time correllating the Chemung of Brown county N. Y., with part of Mather's Catskill group of the Catskill mountains as Mr. N. H. Darton has done, leaving the Catskill group of Stevenson as a formation which had its greatest and typical development south of the Pennsylvania line, and outside of the typical locality which includes strata not understood when Mather made the survey of his district. It may be that the red Bedford shale lying at the base of the Waverly formation in Ohio represents a connection with the Catskill of the east about the latitude of Pittsburg, but it contains recurrent Hamilton species which lingered in the west long after the Hamilton formation was succeeded by later deposits in New York. The Bedford sea could probably be represented as an estuary in Ohio, which was bounded on the west by the fold of Cincinnati rocks and those of later age. The gradual uplifting of northern Ohio which had then begun, continued in operation until the following lower Carboniferous horizons were deposited on a shoreline which steadily progressed southward.

The Chemung group is 350 feet thick in southwesthern Virginia on the Tennessee line, but rapidly thickens northward, being 3800 feet thick on the boundary line between Virginia and Pennsylvania, 4700 feet in Huntington county Pennsylvania, and four thousand feet near the New York line on the Delaware river, while in the Catskill mountains it is 3000 feet thick. In southwestern New York the Chemung is 1200 feet thick. The Chemung strata thin out to the westward and south-westward in Pennsylvania, but northward along the western boundary line it reaches a thickness of 1400 feet in Crawford county near Lake Erie. The Erie shales which represent the western extension of the Chemung in Ohio rapidly thin out as we approach Columbus, almost, if not quite disappearing as we approach that city. Prof. E. Orton states its thickness at 300 feet, but it is very variable. When the stratigraphy is subject to so much variation in thickness, lithological appearance, and distribution, we must be prepared to be somewhat at variance concerning the origin of its individual beds of conglomerates, as well as the remaining strata. Prof. I. C. White has correllated the Panama with the Alegrippus conglomerate,