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ORIGINAL ARTICLES.

I.—ON THE PERMANENCE OF CONTINENTS AND OCEAN-BASINS, WITH
SPECIAL REFERENCE TO THE FORMATION AND DEVELOPMENT OF
THE NORTH AMERICAN CONTINENT.

By Prof. JOSEPH LE CONTE.

UNDER the influence, perhaps, of the prevailing idea of evolution in all things, the conviction has been growing in the minds of geologists in recent times that the larger features of the earth's surface have grown from the earliest times, and therefore that the places of the continents and ocean-basins have been substantially permanent. Prof. Dana is largely the originator and expounder of this view, and he has applied it with great skill to the American continent. But while I believe the view is substantially true, I cannot but think that it may be, and has been, pushed too far. It is true indeed that the opponents of the view have attributed to its advocates a strictness in the use of the term 'permanent' which they have never urged. It is true that by permanence is meant only permanence of *place*, not of outline, and that substantial permanence is not inconsistent with very large changes by oscillation, especially at the end of the great Eras. But, making every allowance for such latitude of meaning, there has been, undoubtedly, some confusion of thought and looseness of statement on this subject. We give a few examples.

Prof. Dana in his admirable manual, p. 149, gives a figure (fig. 206), which he calls "Archæan map of N. America." This is really a map of *Areas of exposed Archæan rocks*, and for such it is doubtless intended. It cannot, of course, be a map of the land of *Archæan* times (since Archæan rocks were formed on sea-bottom), but is approximately a map of land of early *Silurian* times. But being called an Archæan map of the continent, and being found in the chapter on Archæan times, the inattentive reader is led to infer that it represents land of that time; more especially as the rest of the present continent is spoken of and represented as submerged, and therefore by implication this part as, then, land. And as Prof. Dana afterwards treats these areas as the nucleus from which the continent was developed, he seems to begin this development from the *land of Archæan times*. I am quite sure that many have been misled by this figure and the accompanying statements.

Again, Prof. Chamberlin in his excellent "Geology of Wisconsin," vol. i. p. 62, gives a map somewhat similar to Dana's, which he

calls a "Map of Laurentian land." It is, of course, again a map of Laurentian rocks, and therefore not of land of Laurentian times. But being evidently intended as a map of land of some time, and being given in the chapter on Pre-Laurentian history, the inference is unavoidable that it is intended to represent the land at the *beginning of the Laurentian (Archæan) time*. It is hardly necessary to say it is, again, approximately a map of earliest Palæozoic (Primordial) times. Thus it has come to pass that many, without reflection, have held that the development of the American continent may be traced from a nucleus existing in Archæan times. But of this there is in fact not the slightest evidence.

On the other hand, Prof. Hull has recently published a very interesting and suggestive paper "On the Geological Age of the North Atlantic Ocean,"¹ in which he tries to show that the places of the present continents were not declared *until the Mesozoic*. If this be so, then indeed the doctrine of the permanence of continents must be given up entirely; for the Mesozoic and Cainozoic together form but a small part of the entire history of the earth.

I believe that the truth lies between these extreme views. I believe that the place of the American continent was established and its nucleus formed *at the beginning of the Primordial time*; and that thus, in regard to the development of earth features, no less than of earth faunas, the name Primordial is peculiarly appropriate. This, I think, is the real view of Dana. I wish now to give as clearly and as briefly as possible what seem to me the main steps in the history of the American continent from the earliest times.

1. Of all rocks the Archæan are by far the most widely diffused on the American continent, although of course largely covered by later deposits. Not only do they form the surface rocks over large areas, but they seem everywhere to underlie other rocks; for wherever these latter have been pierced by wells or cut through by cañons, we find the Archæan beneath. It is hardly too much to say that they form the foundation rocks of the whole continent. If so, then, of course, in *Archæan times the American Continent was all sea-bottom*. Where was the land at that time? We know not for certain; but the subsequent development of the continent southward and westward suggests that its place was to the north-eastward. This view is farther strengthened by the fact that the development of the European continent south-westward would point to the north-westward as the place of the earliest land. Prof. Hull therefore, with much show of reason, assigns the North Atlantic as the place of the Archæan continent. The land from which such enormous masses of sediments were derived must have been indeed of continental proportions, and must have existed during immense periods of time, perhaps equal to all subsequent times put together. Its débris carried into south-eastward and south-westward seas formed the Archæan rocks of Europe and America.

2. At the end of the Archæan, America (and probably Europe also) *became largely land*. This is a point of very great importance,

¹ Trans. Roy. Dub. Soc., 1885, vol. iii. p. 305.

but not generally recognized. The evidence of this fact is found in the eroded condition, universal so far as known, of the Archæan rocks underlying all other rocks, even the lowest primordial. No one has ever seen conformable relation between the Archæan and any other later rocks. Not only is this unconformity found all about the border of the Canadian Archæan area and the Appalachian area and about all the smaller areas in the most widely separated parts of the continent, but the grand Cañon of Colorado cuts through the whole stratified series and into the Archæan exposing the line of contact, and we find the same unconformity; the St. Louis Artesian pierces the whole Palæozoic, and again from the sudden change in the character and condition of the rocks from unmodified into metamorphic, we must conclude unconformity. But unconformity means *eroded land surface*. Therefore we must conclude that well-nigh the whole continent was land at the end of the Archæan. It is almost certain therefore that at the end of the Archæan, there was a veritable exchange of sea and land, and that the North Atlantic Archæan continent became sea at that time. If so, the strata which were then formed, and of which the eroded surface of Archæan rocks is the sign and measure, are now beneath the sea, and therefore irrecoverably lost. This period between the Archæan and the Primordial I have elsewhere¹ called the "Lost Interval," because we have no record of it in the stratified rocks.² Judging by the amount of erosion of Archæan rocks, and also by the prodigious advance in the progress of life when the record commences again in the Primordial, this lost interval must have been a period of immense duration. There are in the history of the earth many other intervals, partially or locally lost, represented by local unconformities, the most important of which occurred at the end of the Palæozoic; but none of these are to be compared with that which occurred at the end of the Archæan.

3. The Palæozoic commenced with another large crust-movement, but not a complete interchange of sea and land as before. The American continent was again largely, but not completely submerged. It went down until only the now-known Archæan areas, together with an eastern area of unknown size now covered by the sea, were left. The continent then consisted of a large V-shaped land-mass corresponding to the well-known Canadian Archæan area, a large eastern land-mass, including the Appalachian Archæan area, but extending eastward at least as far as the submerged continental border, and a large mass in the Rocky Mountains, and especially in the Basin region, while a great interior continental sea occupied the position of the drainage basin of the Mississippi river. The so-called map of Archæan land of Dana and Chamberlin would represent approximately the condition of things at this time, if the eastern border-land were extended as far as the submerged continental

¹ Am. Journ. Science, 1877, vol. xiv. p. 101. Le Conte's Elem. of Geol. p. 291.

² Some intermediate rocks have been found, *e.g.* the Kewenawan series, but the gap is still immense.

border.¹ *This*, the Primordial continent, *was the nucleus*, from which, by gradual growth, as so well shown by Dana, the American continent was formed. This growth was somewhat regular during the Palæozoic, but with another large oscillation at its end. The American continent existed, indeed, before, not however during the Archæan, as many seem to think, but during the "lost interval"; but it was almost destroyed at the beginning of the Palæozoic, to recommence its development with the nucleus already described. Thenceforward the plan thus outlined was apparently never lost.

4. During the Palæozoic the growth of the continent was comparatively regular, but at its end coincidently and correlatively with the formation of the Appalachian Range, the eastern land-mass was greatly diminished by submergence, and the eastern coast-line advanced westward far beyond its present position, especially in the southern part, probably as far as the well-known position of the Tertiary coast-line. After this oscillation, the development was again more regular, and in its broader outlines is well known. The great interior Palæozoic sea was diminished and became the interior Cretaceous sea, and this later retreated southward, to become finally the present Gulf of Mexico. There were probably many other times of lesser oscillation. The last of these was in later Tertiary and early Quaternary, during which the continent in its northern part again extended to the submerged continental border, with probable connection with Europe in the North Atlantic region.

Prof. Hull, in his paper already referred to, makes the changes in the latter part of the Palæozoic and at its end much greater than I have supposed, in fact equivalent to another almost complete exchange of sea and land. According to him (see his map, fig. 3), during the Carboniferous the whole of the North Atlantic and the northern parts of North America and of Europe formed together an enormous continental mass, the oceanic part of which was again submerged at the end of this period, to nearly the present limits of the two continents. It is not impossible nor even improbable that during the later Palæozoic the American continent may have grown on its eastern margin; or even that at some time during the long Palæozoic era there may have been a connection far to the north between the two continents; but of the complete abolition of the Atlantic Ocean, as shown on his map, I confess I see no sufficient evidence. The great thickness of the Carboniferous strata would, it is true, require a large land-mass to the east; but there is no reason why the eastern land-mass, which sufficed to contribute the 30,000 feet of Silurian and Devonian sediments, should not have been sufficient to contribute the much smaller amount of sediments of the Carboniferous period.

To recapitulate briefly: 1. During the Archæan the American continent probably did not exist at all. 2. The first evidence we find

¹ The Silurian continent has been thus extended by Prof. Hull in his map, fig. 2; but why he has carried the northern part of the continental border westward so as to cut through Labrador, I cannot imagine. The whole of Labrador was surely land in Primordial times.

of its existence is during the "Lost Interval." It was then a large land-mass of unknown size and shape, but evidently of continental proportions. 3. At the beginning of the Palæozoic this continental mass was nearly lost by submergence; all that remained being the well-known Archæan areas, with a large extension on the eastern margin of the present continent. The masses formed the nucleus from which grew the present continent, with more regularity than before, but with some very large oscillations, the greatest of which was at the end of the Palæozoic, and the last of which was at the end of the Tertiary and beginning of the Quaternary.

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II.—NOTE ON THE GEOLOGICAL RELATIONS OF ROCKS FROM ASSOUAN AND ITS NEIGHBOURHOOD.

By Sir J. WILLIAM DAWSON, C.M.G., LL.D., F.R.S.

DR. BONNEY having been so kind as to examine microscopically and describe a collection of crystalline rocks which I made in the vicinity of Assouan on the Nile, I have prepared the following notice of the geological conditions, to accompany his descriptions, referring, however, to the notes on the locality given in my paper in the *GEOLOGICAL MAGAZINE* for Oct. 1884. Reference may also be made to the paper of Lieut. Newbold in the *Journal of the Geological Society*, vol. iv., and to that of Mr. Hawkshaw in the same journal, vol. xxiii. Lartet has given in his *Geology of Palestine* a summary of the observations of Russegger, Rivière and Figari Bey on the crystalline rocks of the Nile, and the allied rocks of the Sinaitic Peninsula have been described by him, by Bauerman¹ and by Holland,² and more recently by Hull.³ All these authors have given, more or less distinctly, a series of gneisses and micaceous and hornblendic schists associated with intrusive granites and diorites as the oldest rocks of these districts, and succeeding these in geological age, certain slates and associated rocks, with porphyry and basanite in beds and veins.

The best section which I had an opportunity to examine of the older series was near the town of Assouan, in a railway cutting crossing the ridge between the river and the valley lying to the east of the town, and which exposed the beds in a perfectly fresh and unweathered state for about a quarter of a mile, beyond which they were more or less imperfectly seen for about 800 yards, until they were covered by the lower beds of the Nubian Sandstone unconformably superimposed on them.

I have given a section of the beds exposed in this cutting in the paper above cited. They are nearly vertical with a strike N. 10° E. As seen in the cutting, about four-fifths (Series *A* in Note) of the thickness exposed consisted of schists with black mica and black hornblende, the remainder being orthoclase gneiss regularly stratified and numerous dykes of reddish hornblendic granite (Series *B*. in Note). Further to the south the same rocks are seen to be

¹ Quart. Journ. Geol. Soc. vol. xxv. ² Ord. Survey Sinai. ³ Mount Seir.