

we find further evidence that the ancient ganoids formed the parent stock from which the succeeding fishes, amphibians, and reptiles have diverged. In some sauroid Devonian fishes the position and structure of the teeth foreshadow those of the Labyrinthodont reptiles, in others the throat is protected by gular plates, a fashion retained in the Carboniferous amphibia. Again, in some species the scales are surface pitted, like the scutes of Crocodiles. While, in the notochordal weak-limbed amphibians of the Coal-measures, with minute body scales, and partly osseous skulls, we cannot fail to recognize structural peculiarities now found in the swamp-dwelling mud-fishes. Thus in the anomalous "scaled sirens," we have the "persistent type" of an ancient group of fishes, in which now, as in the old time, the piscine and amphibian characters are so united as to completely efface the line of demarcation between the orders, and effectually link the fishes to the reptiles.

NOTICES OF MEMOIRS.

PROCEEDINGS OF THE MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY, vol. xvi. No. 10, p. 171. Session 1876-77.—ORDINARY MEETING, March 6, 1877.

A PAPER was read by Mr. Arthur Wm. Waters, F.G.S., entitled "Inquiries concerning a Change of Position of the Earth's Axis." The author stated that the cause of the greater warmth in high latitudes during the Tertiary period had not, in the opinion of many, yet received any satisfactory solution.

The Arctic Miocene Flora was considered. 356 Miocene species of plants have already been determined from latitude 70-77 N. in Spitzbergen and Greenland, and include *Taxodium* (swamp cypress of Texas), *Sequoia*, birch, lime, oak, beech, plane, and even magnolia; so that Prof. Heer, by comparison of the localities of these, says that the temperature must have been 30° F. warmer than at present. Fossil floras of the Cretaceous, Jurassic, and Carboniferous periods have been discovered within the arctic circle. Most of these plants are unable to resist severe cold, besides requiring a warm summer, and it seems difficult to accept the fact of their flowering and ripening their seeds, where the winters are so long and the summers so short, and, apart from the lower temperature, where the amount of light is so much diminished.

Several theories have been brought forward to explain the cold of the Glacial Period, the generally received one being that of Mr. Croll, that it was brought about *indirectly* from an increase in the eccentricity of the earth's orbit, modified by the obliquity of the ecliptic. In the longer and colder winters more snow fell, which the summer could not melt away, so that the earth now covered gets little of the warmth of the sun. As this explanation has not always been thought quite satisfactory with regard to the greater warmth, the change of the position of the earth's axis has from time to time been suggested on various grounds.

It was suggested that there are three causes which might change the position of the axis, viz. distortion of the earth by continental and local upheaval altering the centre of gravity, and thus changing the position of the axis; the removal of water by elevation of land displacing the ocean; and the removal of matter in solution; and these two last, though not considered to be the most important in amount, were considered more in detail.

According to Mr. T. Mellard Reade,¹ about one ton of solid matter is removed in solution by the drainage of each square mile, so that about 5000 million tons are removed from the land surface each year; thus in ten years a weight equal to that of Vesuvius is removed from the land to the oceanic area by this means; and as there is more land in the northern hemisphere, this gives a gain for the southern hemisphere of 3230 million tons over the northern. If the earth is divided into a land and water hemisphere, with England as a centre, the gain of the weight of the water hemisphere is about 4300 million tons, or one Vesuvius in twelve years, the place of greatest gain being about 45° S. and the greatest loss 45° N. in antipodal positions.

A statement by Sir G. B. Airy in the *Athenæum*, 1860, was considered in order to see what effect special alteration would have. Removing a weight equal to that of Asia 1000 feet high from the centre of the land hemisphere, and adding a similar weight at the antipodes in a sinking Pacific Ocean, leaving the remaining portion in each hemisphere balanced by the natural configuration, would give an alteration of from 18–27 miles. This alone would require 13 million years at the present rate of denudation, but there are many causes, some of which were mentioned, which would very much reduce the time required for this amount of “soluble denudation,” so that it might be reduced to one or two million years, and the vast thickness of calcareous rocks, which are only the record of others from which they were partly formed, shows how many times such areas must have been transported from land to sea.

The sinking of an area equal to the continent of Asia to the mean depth of the ocean would bring a weight of water sufficient, if the antipodes were a suboceanic rising area, to displace the position of the axis 40–60 miles by the same method of calculation. It is thus seen that these may be disturbing or starting forces, but do not give a large amount of change directly, and that the one to three degrees which Mr. George H. Darwin, M.A.,¹ allows is all that we should expect in recent geological times, unless there is some cumulative effect.

Mr. Waters maintained that if the change was caused by addition of weight, then the earth in re-adjustment would cause phenomena equivalent to an elevation in those semi-hemispheres from which the maximum bulge has been removed, displacing, if it should be an oceanic area, an amount of water to be placed in another region; the

¹ In a paper on Geological Time, read as a presidential address to the Liverpool Geol. Soc. 1876–77.

² Proc. Roy. Soc., No. 175, 1876.

maximum effect of each degree of change is $\frac{1}{25}$ of the weight of the bulge, and the possibility of a redistribution of land and sea preventing a change in an opposite direction of the motion of the poles was pointed out.

The astronomical objections are that any such movement of the axis would be discoverable from the earth's and moon's motions, that is, by precession and nutation of the equinoxes, which are caused by the attraction of the sun and moon on the equatorial bulge. It is from no sufficient change in these motions that we have been told the figure of rotation has not altered in 3000 years (the limit of known observation), but this has been based upon a preternatural rigidity of the earth which is not now maintained by all physicists.¹

It has been seen how the forces under consideration may have acted in opposite directions, and a consideration of recent geological phenomena shows that while large areas have been elevated it has not taken place steadily and uninterruptedly, but that there have been elevations and subsidences (or kindred phenomena) many times repeated, so that, if we turn to the north of Europe, to Belgium, or to Italy, we find, for a general elevation of a few hundred feet to have taken place since the middle of the Tertiaries, there have been subsidences and elevations of many thousand feet in each direction. Now, with the number of forces at work, and the irregular distribution of land and sea, it may be said that a reversal of conditions in one part could not take the axis back to exactly the same place; in other words, the axis might tack.

The great changes in the Tertiary period were briefly considered, showing how much change of level has taken place.

Mr. Waters said the points he wished to bring forward are, that a change of the position of the axis would elucidate many facts which have not yielded to any other explanation, and that a change of the position must take place, but that only a small amount could be directly proved; but if there is a cumulative effect, then it may be explained. The idea thrown out for examination by physicists was whether the frequent changes in direction which are caused by forces working in various parts of the world would not thus give a sufficient increase to the amount calculated.

Referring to recent papers bearing on this subject, the author adds:—

Since this paper was written, "Le Déplacement Polaire" of Dr. Jules Carret has come into my hands. This little work is written to demonstrate from various grounds that the position of the axis has changed, but without inquiring into the cause. The greater part of the book is devoted to proving that the present distribution of land and sea can only be accounted for by such a change, and this he thinks explains the polar land area and the antipodal position of nearly all the land to water areas. He shows that the effect of a change of position of the axis with the unequal diameters of the

¹ Sir William Thomson says in his Glasgow address: "A slow distortion of the earth as a *whole* would never produce any great angular separation between the instantaneous axis and axis of maximum moment of inertia for the time being."

earth, which are unequally divided by the centre of gravity, will be to cause the land to be antipodal to the water, and the slight exceptions are near to the circumference, dividing the globe into land and water hemispheres, which is where the exceptions would be expected.

By these exceptions he concludes that the poles have moved in a curved direction. If we divide the earth by a plane (grand circle polaire) perpendicular to the equator and to the direction in which the position of the poles have been changing, the points of intersection at the equator form two pivots for this motion, and here the effect of re-adjustment will be a minimum, while before and behind will be an area of elevation and submergence respectively. If the motion is curved, the plane (*g.c.p.*) we have just supposed must cut the tangent of this curve at right angles. The changing position of this tangent changes the position of the plane, and the points of intersection are removed from the elevation to the submergence area on one side, and the opposite points from the submergence to the elevation area, so that land antipodal to land is the consequence.

REVIEWS.

I.—THE ANCIENT LIFE-HISTORY OF THE EARTH. A Comprehensive Outline of the Principles and Leading Facts of Palæontological Science. By H. ALLEYNE NICHOLSON, M.D., D.Sc., M.A., etc., Professor of Nat. Hist. in the University of St. Andrews. 8vo., pp. xvi. and 407, and 276 woodcuts. (Edinburgh and London, W. Blackwood and Son.)

IT affords us much pleasure to bring under the notice of our readers a recent publication, which, we trust, will be the means, at any rate to a great extent, of assisting the student of Palæontology in his battle with the many conflicting and unsolved problems of the science. In his "Palæontology" Professor Alleyne Nicholson treated the subject from a purely zoological point of view, as a branch of the comprehensive Science of Biology. In the present work, on the contrary, the same subject is discussed as a subdivision of Geology, from its historical aspect, with the introduction of purely structural details, only so far as may be necessary to a due understanding of the ancient forms of our globe. Such a work as the present is best appreciated by those who have gone beyond the mere threshold of palæontological science, and learnt how difficult it is in working up any given subject to obtain an epitome of the various views which have been passed upon it. The comparative absence of works such as Professor Nicholson's "Ancient Life-History" from our language is a fact we must all deplore, but one we hope ere long to see remedied to a great extent; and it is particularly on this account that the present work is the more welcome. True, we have Prof. Owen's "*Palæontology*," a host in itself, the value of which was evinced by the fact that a second edition was called for before the book was a year old; but on