Geology and Astronomy.

THE AGE OF THE EARTH.

We copy from our contemporary, the *English Mechanic and World of Science*, a communication from its correspondent on a subject which will be found interesting to geologists and astronomers.

In recent numbers of the *English Mechanic* this subject has had frequent attention. To account for the extremes of climate which this earth has suffered during past geological ages, "a change in the position of the poles" has been supposed by several writers. If by this is meant that in bygone ages the position of the axis of rotation has altered geographically, maintaining all the while its original angle of inclination to the ecliptic, the proposition seems absurd. The axis and diurnal rotation have determined the oblate spheroidal form of the earth, and that axis could not alter its position geographically without disturbing this form, and bringing about convulsions and cataclysms of the severest kind. But if this "change in the position of the poles" mean a change in the obliquity of the axis to the ecliptic, no objection can be taken to it on that score. I am aware that many writers have adopted this explanation, and some have even ascribed these changes to a disturbance of the equipoise of the earth, produced by the elevation of continents in the northern, and the depression of land to form oceans specifically lighter in the southern hemisphere. Unless these elevations and depressions occurred uniformly and regularly both as to time and distribution—in other words, unless we could believe that the internal forces acted directly under some law which controlled and directed their intensity and distribution, we can scarcely ascribe to their influence the regular recurrence of such periods of tropical heat and polar cold as our earth has been subjected to.

We must remember that Agassiz discovered in Brazil that glaciers once deposited their boulders and moraines in latitudes within the present tropical zone at the sea level, and further that in the recent Arctic Expedition, coal-beds, the remains of a tropical flora, were found within the Arctic circle. That these extremes of heat and cold, so widely apart, were not exceptional, but rather recurrent, we gather from the records of geology. It is generally allowed that the primary condition of the earth was one of great heat. If we adopt Prof. Haughton's theory, we have the period during which the temperature of the earth exceeded that of boiling water, represented by the unstratified rocks. Then we have the period between the boiling points of water and the temperature at which albumen coagulates, represented by the stratified azoïc rocks. After these, however, we have the Laurentian, Cambrian, and Silurian rocks, equivalent to an immense age of geological time, and represented by forms, some of them as high as vertebrata. Succeeding this, we find towards the close of the old red sandstone, remains of a glacial epoch. This again is succeeded by the Devonian—which was, perhaps, partially contemporary with the old red—and by the carboniferous, which was undoubtedly a tropical formation. Then again we have the Permian system, separated from the Carboniferous by an uncomformity, which may represent un enormous age, and towards the close of it we find a second glacial epoch. In the secondary rocks which succeed this, separated from it by another uncomformity, we again find traces of a tropical climate, particularly in the Lias, where we have another coal formation. Between these rocks and the Pliocene we have evidence of a gradual cooling of temperature until in post-Pliocene times we find a third glacial epoch.

Now, it seems to me that any theory of past conditions which does not take these extensive changes into consideration is incomplete, and I submit the following as perhaps a possible explanation.

In the time of Eratosthenes, in the second century before the Christian era, the sun's declination was found to be 23° 51′ 19·5″, and this measurement was confirmed by contemporary observers. At present it is 23° 27′ 24″—that is a difference of 23′ 55·5″ in in 2,000 years, or 71·7″ yer century. Admitting the possibility of error in these early observations, we take, then, those of Bradley in 1755, and since his time the diminution of the obliquity of the earth's axis to the plane of the ecliptic has been at the rate of 45·7″ per century. It is plain, then, that the obliquity of the earth's axis is slowly changing, and has also probably changed during past geological ages. It is possible that there may be a limit to this motion—that the present diminution of obliquity may only be the return from a former increase. But it is equally possible that the revolution may be completed, and that in time the present position of the North Pole, with respect to the ecliptic, may be occupied by the South Pole—that the change may be continuous from zenith to nadir, and onwards from nadir to zenith again.

At present the magnetic poles do not coincide with the axis of revolution, and there is no reason for believing that they follow that axis in any change of position it may make. Supposing the obliquity increased to 30° or 35°, we should then have in our temperate latitudes great extremes of climate—a long and very severe winter, followed by a short but hot summer—a climate more rigorous than that of Canada, and somewhat like that experienced on some parts of the shores of the Yellow Sea in China, and sufficient to account for a glacial epoch. Again, when the axis of revolution coincided with the ecliptic, the present order of things would for the most part be reversed—the Poles would largely enjoy a tropical climate, and the Equator almost a Polar one.

Now, it is probable that this motion of the axis of revolution is not one in which our earth alone takes part, but one in which all the planets of the system join. We find these at all various angles of obliquity, from about 3° of inclination, or almost perpendicular in the case of Jupiter, to almost exact coincidence of the two planes in the case of Uranus.

Should this be a motion in which all the planets participate, we can easily understand their various obliquities, on the theory that they had at various periods been thrown off from the sun as it receded to its place in the centre of the system.

But now for the age which this would assign to the earth, at least since the time of the old red Sandstone. We have seen that the change is, according to the most recent measurements, 45·7″ per century—that is, 7,877 years per degree, or 2,835,720 years for a complete revolution. But since the conditions would be the same when the Poles were exactly reversed, the same latitude would experience similar conditions twice in the course of a complete revolution. And it is further evident that the conditions would again remain much the same at any point near the Poles during the period in which the Poles approached, crossed, and receded from the zenith. Starting, then, with the glacial epoch of the old red Sandstone:—As the diurnal axis, after crossing the ecliptic, approached to an angle of, say 30°, we might look for the beginning of such an epoch, and it would last till the zenith had been crossed, and a similar position reached on the other side—that is, while the axis passed through an angle of 60°, which is equal to a period of 472,620 years. After a similar period we—that is, our northern temperate latitudes—would be in the middle of a tropical period, represented by the Carboniferous, when the diurnal axis coincided with the ecliptic. This state of matters would last with varying intensities over a period of 945,240 years—that is, from the close of the old red glacial to the beginning of the Permian glacial. This latter period would, like that of the old red, last for 472,620 years, while the Pole passed through the nadir from 30° W. to 30° E. of it. Again, we would enjoy a tropical period of 945,240 years, corresponding to that of the Lias, and this would only be interrupted by the preliminary glaciation which appeared, comparatively recently, in post-Pliocene times, when the angle of obliquity would be about 30° or 35°.

The present angle is 23° 27′ 24″, so that rather more than 50,000 years may have passed since then. We are still moving towards the zenith, and as the diurnal axis approaches this point we may expect a renewal of glacial action.

No doubt countless ages must have elapsed while the primary heat of the earth was being gradually radiated into space, and further long epochs must have passed during the deposition of the Laurentian, Cambrian, Silurian, and earlier old red sandstone rocks; but dating from the close of this latter period, when glaciation first appears, we have seen that a more or less continuous period of glaciation lasted during .. .. 472,620 years.
The carboniferous tropical epoch more or less continuous, embraced a period of .. .. 945,240 "
The Peruvian glacial epoch occupied .. .. 472,620 "
The Lias tropical to the close of the Pliocene .. 945,240 "
And since the last glacial to the present time .. 50,000 "

2,885,720 years.

According to Lyell, the earlier geologists were ever "prone to represent nature as having been prodigal of violence and parsimonious of time," but the undoubted tendency nowadays is to represent nature as having been parsimonious of violence and prodigal of time. The period given above, while greatly in excess of the calculations of the earlier geologists, is almost as greatly under those of some of the more recent ones; but let it be remembered that I do not assert that this is the age of the