# SOME GEOLOGICAL EVIDENCE REGARDING THE AGE OF THE EARTH; PP. 259-308

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# SOME GEOLOGICAL EVIDENCE

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# AGE OF THE EARTH

BY

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# PROCEEDINGS

OF THE

# ROYAL PHYSICAL SOCIETY.

## SESSION CXXVI.

*Wednesday, 18th November* 1896.—Professor J. STRUTHERS, M.D., LL.D., President, in the Chair.

Mr J. G. GOODCHILD, H.M. Geological Survey, F.G.S., F.Z.S., M.B.O.U., retiring Vice-President, delivered the following opening address, entitled "Some Geological Evidence regarding the Age of the Earth":—

(Published 13th April 1897.)

*Introduction.*—Geologists from time to time have attempted many estimates regarding the Age of the Earth, and especially that portion of the Earth's history represented by the interval between to-day and the period when the oldest strata containing fossils were laid down. All who have made the attempt have realised that it is impossible, with our present knowledge, to state the antiquity of the rocks in question in terms of centuries, thousands of years, or even in millions. All we can feel sure of is that the records of the rocks fully justify us in claiming for the earth an antiquity so vast as to be far beyond the power of the human intellect to grasp. When a geologist wishes to form even some faint conception of what this antiquity implies, he turns to astronomy, and, after having formed in his mind some conception of what is meant by astronomical distance, he is able, in some measure, to transfer his conception of those vast intervals of space to

the conception of the equally vast intervals of time with which it is his own special province to deal.[1]

"Vague, indefinite, but unquestionably vast beyond conception," is a phrase that must recur to the minds of most geologists when referring to the subject of Geological Time. Yet, indefinite though it must long remain, it seems to me that almost every attempt that has been made at reasoning out an answer to the question, "What is meant by Geological Time?" has contributed something that has helped to make our ideas upon the subject more and more definite. Speculation is not without its uses in science; and even when it may be based more or less upon error, the correction of that error may at least help to guide others into the track which, sooner or later, will lead them up to the truth.

In dealing with this subject of the Age of the Earth, the fundamental idea which a geologist steadily keeps in mind is that all the changes, physical and biological, which the records of the rocks inform us have taken place upon the Earth in the Past, can only be understood and properly interpreted by reference to changes of the same nature which are known to be in progress during the Present. This, of course, does not imply absolute uniformitarianism (as this is commonly understood), but it allows for catastrophism in certain exceptional cases, along with normal uniformity of action in the rest. The geologist obtains abundant confirmation of the justice of this view in the fact that, throughout the whole series of rocks, and even throughout those strata which are older than the most ancient yet known to contain records of life, the manifestations of Nature's forces show no sign of any action different, in either degree or kind, from those which are known to be at work at the present day. Rain fell in those early days much as it falls now. Wind blew then with apparently no greater force than it does to-day. The tides and currents of those early periods appear to have obeyed exactly the same laws that they do now, and in no

[1] The astronomical models in the Museum of Practical Geology, and the more extended set placed in the Gallery of Scottish Geology and Mineralogy in the Edinburgh Museum of Science and Art, were set out with the express object here referred to.

case do they show any sign of having acted with greater energy than they do at the present day. In short, even as far back as the commencement of the Cambrian Period, the two great geological factors, solar energy and gravitation, appear to have operated then very much as they do now. To a geologist this merely indicates that the close of what has been termed the Astronomical History of the Earth terminated many millions of years prior to the Cambrian Period, and that the Earth must have been in a condition suitable for life through a long period of the time when the Archæan rocks were in process of formation.

Turning to the records supplied by fossils, we find that the life-conditions during Lower Cambrian times were in no respect yet discovered different from what such conditions are to-day. Organisms then, as now, changed under the influence of varying environment and other biological factors at, apparently, at least as slow a rate as now. Hence biologists concur with geologists in claiming, as requisite for the development of the existing forms of life, an interval of time fully as vast as that required to account for the physical changes which are known to have taken place upon the earth.

It is true that some there were, and perhaps there may be some still, who, taking note of these facts relating to the Earth's history, declared that they could perceive no vestige of a beginning, and no prospect of an end. It was only natural that a reaction should set in against views so directly opposed to all that we know through the researches of the astronomer. Mathematicians and physicists of eminence took up the question, and discussed it from their own standpoints, basing their conclusions upon what, at the time, appeared to be well-established facts. The conclusions referred to were by no means identical with those to which geologists had been led. Lord Kelvin, for example, boldly stated his opinion that all geological history showing continuity of life must be limited within some such period as 100,000,000 of years; and Professor Tait was disposed to allow even very much less than that. Lord Kelvin has lately considerably modified the view here referred to,[1] but

[1] "Nature," vol. li., 1895, p. 257.

even yet geologists in general do not feel satisfied with the concession.

It certainly requires that a geologist should feel that he can place considerable reliance upon the value of his own set of facts and inferences before he can venture to call in question the validity of the conclusions arrived at by men of undoubted eminence in their own subjects, such as Lord Kelvin and Professor Tait are. Nevertheless, geologists still shake their heads, and repeat with approval Professor Huxley's well-known saying that "Mathematics may be compared to a mill of exquisite workmanship, which grinds you stuff of any degree of fineness; but, nevertheless, what you get out depends upon what you put in; and as the finest mill in the world will not extract wheat-flour from peascods, so pages of formulæ will not get a definite result out of loose data." In the following pages I shall confine my attention to the purely geological side of the question, leaving the physicists to take up the discussion and deal with it in the light of new facts and views. The results at which they will eventually arrive will not, I feel confident, prove so discordant with geological evidence as those to which reference has just been made.

I propose in the following pages to pass in review certain changes which are known to have taken place in the past, beginning with the latest periods and working backward. I shall therefore commence with the Glacial Period.

*Time required for the Physical Changes that have taken place during the Tertiary Period.*—One of the best regions in the British Islands for the study of the changes which have taken place since the commencement of the Tertiary Period is to be found in the Inner Hebrides. It is true that, in regard to the sequence of glacial events, these islands do not afford us evidence quite as satisfactory as do other regions to the east. This, I think, is probably owing to the fact that the influence of the complex conditions known as the "Gulf Stream" (whether in the bodily transfer of warm water, or in the northward transfer of aqueous vapour, which, by its condensation into rain, warms the air—matters not in the present connection), was maintained close to the edge of the present 100-fathom line west of Europe all through the

Glacial Period. Consequently, from the West of Ireland to the Lofoten Isles, or farther north still, the evidence of glaciation is mainly confined to the low ground. Be that as it may, there must have been an excessively heavy rainfall there, if there was not much snow; and although the low ground, in, for example, Loch Coruisk in Skye, underwent considerable erosion through the action of simple glaciers of large size, the high ground there, as in the Lofoten Islands, was probably never overridden by an ice-sheet for any lengthy period, if it was so overridden at all. I only refer to the matter here in order that some reference may be made to the time which has probably elapsed since the Climax of the Glacial Period. Taking into account the small extent of the physical changes which are known to have occurred since that period, I made a rough estimate in 1887[1] that this time was distant from our own not more than 20,000 years. Observations by others, at home and abroad, have helped to confirm that estimate. Twenty thousand years is, at any rate, well within the estimates commonly made.

How long the Glacial Period lasted is a question still not satisfactorily answered—it certainly must have been one of great length, if one may judge by the amount of erosion that was accomplished on the *eastern* side of the Scottish watershed, where the precipitation from first to last mainly took the form of snow. But we do know that, although the valleys in the west were both deepened and widened by the ice, yet, as valleys, they existed long prior to the Glacial Period.

The time required for the excavation of these valleys by the joint agency of subaerial erosion and ice has next to be taken into account. We have no need to attempt an estimate of the thickness of rock removed during the Glacial Period itself—and almost none has been removed since. It will suffice if we take the average rate of lowering of the surface in general at 1 foot in 3000 years instead of 1 foot in 6000 years as is usually done, and then, in this case,

[1] "Ice-Work in Edenside," Trans. Cumberland and Westmorland Association, No. xi., p. 167.

assume that under the conditions most likely to have obtained in Pliocene and Pleistocene times, that denudation went on more rapidly than is usually the case. Bearing this in mind, we will assume that an estimated 1 foot in 2000 years for the erosion accomplished would be one certainly on the safe side. From the summit level of the Cuchullin Hills to the sea-level is now over 3100 feet. These hills consist of a kind of gabbro, a plutonic rock that, whatever its nature and origin, could not possibly have been formed within a short distance of the surface. One would be almost justified in regarding it as a rock of deep-seated origin, for even if it be, as I have suggested in the *Geological Magazine*, that this gabbro represents basaltic lavas re-crystallised by later intrusions, the metamorphism would still require that a considerable thickness of over-lying rock should have once covered it, and have since been removed. There are no exact means of arriving at an estimate of what that thickness was. But assuming that the Skye Volcano was of the same nature as, and had slopes as low as occur in, the volcanic mass of Hawaii, that alone would give us an elevation of its central portions of, at least, 8000 feet. In the period since the old volcano died out it has been trenched by rain, rivers, and ice to its very core. If this denudation has gone on at the moderate rate of only 1 foot in 2000 years, this rate gives us 16,000,000 as the time required for the formation of the valleys. The quantity of rock that has been removed since the close of the volcanic period can be shown by other examples to be enormous. Sir Archibald Geikie, in his well-known "Scenery of Scotland," refers especially to the excavation since that period of the great valley in which lies Loch Scridain in Mull; also to the extensive removal of volcanic material implied by the shaping of the Sound of Mull; and, further, to the evidence afforded by the dykes. For instance, referring to the dyke that crosses Loch Lomond and rises to near the summit of Ben Voirlich—and assuming that the particular dyke in question is of the same age as the volcanic rocks of Skye, Rum, Mull, etc.—he points out that, if the great valley in which Loch Lomond is situated was actually in existence at