

### The Geological Calculus

MR. WALLACE'S essay, completed in NATURE, No. 18, brings to the front the question whether or no we can measure the Geological Past by the historical unit of years. Have we any basis for fixing with any certainty the date of any geological epoch? Mr. Wallace's answer in the affirmative to this is worthy of a careful analysis, because it represents fairly the ideas current in the minds of many geologists.

There are three ways by which the attempt to solve the problem has been made:—(1.) The slow geological changes which have been noted during the period of history, such as the modification of coast line, the silting up of estuaries, and the like. This method Mr. Wallace very justly discards as being "too minute, too limited, and too uncertain to afford the basis of even any approximate measurement" of the geological past. (2.) The change in organic life. This also is a unit of measurement "which we have not yet been able to get; for the whole length of the Historical Period has not produced the slightest perceptible change in any living thing in a state of nature." Professor Huxley, in 1869, gave expression to very much the same view, in his Presidential Address to the Geological Society. This method, therefore, of approaching the problem may also be given up as hopeless. (3.) The excentricity of the earth's orbit which Mr. Croll has used, in making his ingenious computation of the lapse of time since the glacial period, on the hypothesis that the severity of climate at that time was due solely to astronomical causes, and not, as had been previously supposed, to changes in the physical geography of the earth. But, as Sir Charles Lyell argues, since the distribution of land and water and the course of marine currents now modify climate, they cannot be fairly supposed to have had no share in causing the severity of the glacial period. And therefore, the fact that they are ignored in Mr. Croll's computation, destroys its value as fixing the glacial date, although there may be astronomical reasons for a depression of temperature at certain times in the northern hemisphere without the aid of any terrestrial agent. This, indeed, is practically admitted by Mr. Croll, when he reduces the date of the last glacial period from 750,000 to about 80,000 years ago, because of the amount of sub-aerial denudation that has taken place since that time. There are, moreover, two fatal objections to any estimate that can be formed of the amount of denudation since the glacial period. First of all, the denudation now going on, over any wide area, has not yet been ascertained with anything like accuracy, and it acts unequally, even in any one limited region. Secondly, as we do not know the original thickness of the glacial deposits, or the extent to which the existing valleys were excavated in pre-glacial times, it is impossible to estimate the amount of denudation since that period, even if we had trustworthy data from our own experience. This third method, therefore, of measuring geological time, is not more satisfactory than the former ones.

Mr. Wallace, however, assumes in the second part of his essay that the *vera causa* of the glacial epoch was the high excentricity of the earth; and then he proceeds to reduce Mr. Croll's lowest estimate by 20,000 years, by using precisely that argument of observed change in physical geography which in the first part was discarded as "too uncertain." From this untenable standpoint hangs the following chain of reasoning.

"Now it is most important to observe that, for the last 60,000 years, the excentricity has been very small—for three-fourths of the time less than it is now. During this time the opposite phases of precession, each lasting 10,500 years, will have produced scarcely any effect on climate, which in every part of the earth will have been *nearly uniform for that long period*. But this is quite an exceptional state of things; for the curve of excentricity shows us that, during almost the whole of the last three million years, the excentricity has been high—almost always twice, and sometimes three and four times as much as it is now. If, therefore, Mr. Croll's theory be correct, there will have been a change each 10,500 years during this vast period (in all the extra-tropical regions at least) from a very cold to a very mild climate. This will necessarily have caused much migration, both of plants and animals, which would inevitably result in much extinction and

comparatively rapid modification. Allied races would be continually brought into competition, altered physical conditions would induce variation, and thus we should have all the elements for natural selection, and the struggle for life, to work upon and develop new races. High excentricity would therefore lead to a rapid change of species; low excentricity to a persistence of the same forms; and, as we are now and have been for 60,000 years, in a period of low excentricity, *the rate of change of species during that time may be no measure of the rate that has generally obtained in past geological epochs*. Thus we should have explained the extraordinary persistence of organic forms during the historical period, as well as during the preceding Neolithic age, although slight changes of climate and of physical geography have undoubtedly taken place; and it would prove to be not so much the *usually* slow rate of organic change, as the fact of our living in the midst of an *exceptionally uniform climatic epoch*, that has hitherto prevented us from obtaining a measure of the average duration of species."

The major premiss latent in this argument is, that all climatal change from the glacial epoch to the present day has depended solely on the excentricity of the earth's orbit, a proposition which Mr. Wallace himself would be the last to endorse. If it be admitted that the alteration of a marine current here, or the elevation of a sea-bed there, be factors in climatal change, the estimate of 60,000 years in which they are not reckoned is without value. The study of the mammalia, of historic, pre-historic, and post-glacial times does not warrant the conclusion that the persistence of organic forms was "extraordinary," nor the recognition of an "exceptionally uniform climatic epoch." The mammals have exhibited on the whole a steady diminution *in size* from the post-glacial to the present day, owing probably to the fact that they have been worried off their feeding and hunting grounds by man. The non-development of new species during that time may be ascribed to its short duration as compared with past geological epochs, rather than to exceptional conditions of life caused by exceptional excentricity. The deposits in Britain since the glacial epoch are a mere surface film compared with those of previous geological periods. The steady northern retreat of the reindeer during historic times, taken in conjunction with its pre-historic range, testifies to a gradual increase of temperature in central and northern Europe, to say nothing of the historical evidence of the former severity of winter in Gaul and Italy from Cæsar's time to the present.

There is another point which ought not to be omitted. Mr. Scott Moore is quoted as maintaining that the group of mammalia commonly called "Quaternary" is pre-glacial because of the "striking fact, that none of the supposed pre-glacial gravels ever rest on the boulder clay, but always on an older rock, which could hardly have been the case in every instance were they all post-glacial." So far from this being true, the famous Bedford section proves, as Mr. Wyatt showed in 1860, that the mammaliferous and flint-implement producing gravels are post-glacial without the possibility of a doubt. On the Norfolk coast mammaliferous gravel overlies the boulder clay in certain places. The mammalia found in making the Ipswich tunnel were derived from a river deposit, clearly of later date than the boulder clay of the district. Very many other cases might be quoted that would show that this sweeping generalisation is without any foundation in fact.

But can we measure geological time by the lapse of years? If so, we shall have solved a problem infinitely harder than that which has foiled the archæologists. Can they fix the date, say of the introduction of iron into Europe, or of the dawn of the age of bronze or of stone? No man would venture to answer yes. Modern historians are becoming more and more alive to the worthlessness of the so-called chronology of the Assyrian kings and of the Manethonian dynasties. If, then, we are ignorant of the date of any one of these events, which are, comparatively speaking, of yesterday, and we can simply tell that one succeeded another in a definite order, how can we reasonably expect to fix the date of any one period of the geological past? The attempt can only be made by forsaking those laws of rigid induction by which geology has become a science—by the assumption of a premiss which we have no right to assume. The strict interpretation of geological phenomena only warrants our saying that, one event, say the deposition of the chalk, took place in Europe after another,—the deposition of the Neocomian strata,—how much after none can tell. In other words, the geological "when" merely implies before and after, while in

history the idea not only of sequence, but of the lapse of how long before and how long after, can be mastered. The attempt to fathom the geological past with our short historical sounding line has up to the present time resulted merely in estimates, varying according to the assumed basis in each by thousands of centuries, that have been about as valuable in geological theory as Archbishop Usher's chronology has been found in Biblical criticism. The problem is hedged in by innumerable difficulties, which cannot be overcome in the present state of science.

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