Time's Arrow and Time's Cycle

Myth and Metaphor in the Discovery of Geological Time

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Newton's celestial mechanics was a triumph, would something similar be done on the terrestrial level? Newton himself was the great icon of the Enlightenment, but when it came to matters beyond that of physics he seemed to have been a literal believer in Scriptural records. He may very well have been an adherent of a recent creation of the world, accepting in principle the date of Bishop Ussher. Still his scientific influence was felt and his impact remained not to go away. The first of three geologists, if such a label would be retroactively appropriate, who are discussed in the book, is Thomas Burnet (1635-15) a British clergyman with the ambition of harmonizing the story told by the Bible with the facts of physics, because after all, feeble would a creator be, whose work was so imperfect that it would require intermittent *ad hoc* interventions, usually referred to as miracles. Burnet corresponded with Newton and often showed himself to be the more rational and levelheaded. However the sacred story he concocted was not based on empirical data, but one sprung out of speculation and wishful thinking, hence in spite of his ambitions he has gone down in posterity as belonging to the dark age of religious dogma. Gould does want to upgrade him, and finds much feed to fascination in his stories and his attempts to combine both cyclical times and historical, the central theme of the book.

Cyclical time is about eternity, nothing begins, nothing ends, deep down everything is the same. As every event occurs again and again, it does not have any unique individual significance, the only thing that is significant are the laws, which somehow are outside of time. Newtons law of gravitation is such a timeless phenomena, and its typical manifestation is the planet revolving around the sun, each revolution being essentially the same as the next. Time with an arrow is something quite different, it is a sequence of non-repeatable events, each unique and thus valuable, however imperfect and contingent. In fact imperfection is the mark of history, only through imperfection does the past leave a trace, perfection is timeless and sweeps away its path to perfection, in fact it is independent of what path has been taken to achieve it[1]. Thus, Gould reminds us, was Darwin able to trace the path of evolution through the clumsiness of the solutions it provides to the challenge of adaptation. A pre-evolutionary attitude was that organisms were perfect adaptations, and thus not deformable, and hence having no history of gradual creation.

The Scottish philosopher James Hutton (1726-97) is considered by latter-day geologist to be the founder of the science, the first who went out into the field and observed. On this one may be skeptical, like most scientists his age he was foremost one to speculate, and his ambition was theoretical, to pose and answer general and far-reaching questions,

[1] One may be reminded of mathematical theorems, they are true and show no vestige of how they have been proved, i.e. the path taken for their discovery, and can in fact be proved in many different ways

and to seek general laws like those of Newton's. The problem that fascinated him was the problem of the soil, how come it does not all wash out in the sea? He also observed the stratification of rocks, and the turmoil they had been subjected to, as well as the lack of continuities, so call unconformities, that characterizes the record left by the depositions of the strate. That it was a record of time was an old idea proposed already by Steno in the early 17th century and propagated by Hooke and later taken up by Leibniz. In those days the great minds did not constrain themselves to narrow furrows of inquiry, but ranged wildly across large vistas open to human curiosity. Hutton envisioned a cycle of erosion and mountain building, thus locally showing history and direction, as mountains were either slowly worn down by the forces of erosion (which is nothing but directed diffusion driven by gravitation) or being elevated to new grandeurs. The first thing was readily observable in the present, while the latter was a source of speculation. Hutton himself suggested that the weight of accumulated sedimentation would depress and raise the temperature of the innards of the earth which would boil over. Hutton's visions was grand and poetically expressed through those famous lines, which attach themselves so readily to memory - *no vestige of a beginning, no prospect of an end.* But did he really think that time was not only deep, but in the abhorred Aristotelean sense extended indefinitely both into the past and into the future? He may very well on metaphysical ground have thought that there may have been a beginning and that there would in the end be an end to it all, his proclamation above does not exclude this, only saying that if so, there are no ways for us to find out, and hence, at least in the eyes of posterity to have made a well needed distinction between metaphysics and science, emphasizing that in the latter we can only rely on what can be observed.

Hutton was no writer of note, his tome 'The Theory of the Earth' (1795), which runs into a thousand pages and more, padded out with long excerpts in French, was more or less unreadable, and had it not been for the sympathetic efforts of his Scottish compatriot John Playfair[2] he may have been forgotten today. Playfair interpreted Hutton and presented him to a wider public, playing down his commitment to a cyclic time (Hutton was after all after an emulation of Newton) and bringing instead forth the directed time, and that the records of the earth really showed a historical passage, what Hutton tended to downplay as being accidental and pointless as it was all doomed to endless repetition. In addition to this he brought out Hutton's emphasis on method, that the key to the past was that the processes that shaped the earth were the same then as they were today, and that there was no need to invent special ones. The principle became later known as 'uniformitarianism'.

The greatest geologists of them all was the Scottish lawyer Charles Lyell (1797-75) whose three volume work - 'Principles of Geology' (1830-34[3]) established geology as a science. It was hugely popular, being written, according to Gould, in a very lively and readable manner, and in fact providing a steady source of income. It was not primarily a text-book it was a lawyers brief to propose the scientific principles of geology based on uniformitarianism, which he by the typical shrewdness of a lawyer with an axe to grind, meant in four different ways. First, it referred to the uniformity and timelessness of natural laws. This is a basic postulate we make in order to be able to do science at all. It is not

[2] Also a mathematician and noted for his modern reformulation of the fifth Postulate of Euclid

[3] To be reissued in about a dozen different edition, none surpassing the freshness of the first

provable by science it is assumed. Just as we make the periods of basic periodic phenomena to be of equal temporal extent in order to be able to speak about time at all, and compare temporal extensions over time[4]. Thus our arts of measuring define what we are measuring. The metric aspect of time is thus not something intrinsic, but something which we endows it with. Secondly he proposed that all the processes we see are the only ones that ever came into play, This is the principle of parsimony, also know as Occam's razor. To invent new processes to solve problems in an *ad hoc* way is not science, it is invoking miracles. This too is something that we cannot prove, it is part of the nature and tacit assumption of science. But in addition to this, he also claimed that the changes are not only slow and gradual, but literally uniform in their pace, something he would exploit later in Tertiary dating, And finally he was just as Hutton, a firm believer in the periodicity of time, even more consistent than Hutton, who may have conceded different periods globally defined, by denying that such changes were global, but instead happening all the time locally. In particular he denied that there was any direction, that the fossil record indicated a steady improvement in sophistication, he rejected as a case of the artifact of its preservation. The lack of fossils in primary rocks was simply due to the fact that those were so old and had been subjected to such metamorphic abuse that all such records had been erased. The last two claims were of a different nature, not tacit assumptions to make sense of science, which means in practice methodologies to conduct it; but claims that could be tested, i.e. falsified in Popperian jargong.

The uniformitarianism of Lyell was contrasted against the catastrophism of his contemporaries. In modern geological thinking, he was the knight of bright light, battling against the dark men of scriptural dogma. A fight for the depth of geological time as opposed to the short blink of Biblical revelation. Nothing could be more false, Gould reminds his readers. The Swiss geologist Agassiz doubted the last two tenets of uniformitarianism, but accepted of course the basic methodology and the appreciation of the slowness of geological change. While Cuvier read the geological record as being of immense length but punctuated by discontinuities caused by catastrophes which wiped out most species. Cuvier too was an ardent gradualist who sought to discredit Lamarck's theories of evolution by noting that no changes in cats and other mummified animals could be detected over several thousand years, and without an empirical base from which to extrapolate, extrapolation would be pure speculation. Lyell went so far as to assume that where there was a marked discontinuity, it was simply a sign of a missing record, just as the apparent directional development of life, was caused by an imperfect record, a negative argument Darwin would later use to explain the absence of 'missing links'. But nevertheless Lyell employed the fossil record to give a measure of length of the Tertiary record[5], thus not only to order events sequentially but also uniformly, be it without a calibration to compare it with more familiar time. By simply measuring the change of the dwindling presence of still extant

[4] Unless with lengths we cannot move around our time-sticks as will, but even with lengths we have the problem whether they change by moving, whatever that means.

[5] Which although younger than the Secondary rocks, paradoxically more confusingly preserved, at least in Europe, by being confined to isolated throughs, and thus making the business of correlation so much more difficult, hence making the study of its intrinsic properties of the strata so much more imperative.

organisms[6] he would get a measure by assuming the uniformity of change. Gould is very impressed by this pioneering application of biostatistics, a discipline hardly in existence, and it is tempting to compare it with the modern method of dating divergence of species, which is based on the very same idea, including that of uniformity of change. However, the ideas of Lyell were just a quantificative refinement of earlier measures of similiarity. In his studies he came up against the abrupt change after the end of the chalk period. He denied on principle that there had actually been such a change, and instead made the hypothesis that a huge swap of the records was missing thus pushing the time back to some 300 million years instead of the contemporary consensual estimate of 65 million years[7].

Finally, Lyell was skeptical of evolution, although he appreciated intellectually the arguments for it, and famously urged Darwin no longer to tarry when there was a real danger of his being scooped and having his priority usurped. According to Gould, by accepting evolution he was cutting his losses, when forced to backtrack from his most dogmatic adherence to his uniformitarian principles. Now we do no longer rule out catastrophic events in the past, although the influence of Lyell has persisted into modern times causing sound resistance to the recent idea of the Cretaceous-Tertiary boundary and the extinction of the dinosaurs being the sudden effect of an impact by a meteor. As to the problems of orogeny which had occupied Hutton, the standard 18th century explanation, championed by Buffon and persisting into the 1960's was that the earth was losing heat, as it should, and that this heat loss accounted for a shrinking of the earth and hence a shriveling and crinkling of its crust. An idea that was anathema to Lyell and his idea of uniformity[8]. This was replaced by continental drift powered by heat convection. The earth may be losing heat and eventually cool down and lose all vestiges of tectonic activity, but this is not an imminent scenario due to radioactive decay and the excessively low rate of heat diffusion. Thus in the end Lyell was vindicated on this issue.

The book must have been bought while I was at Durham. The bookstore label on it says September 9 1988. I have some definite memory of having read it on the train commuting between Gothenburg and Stockholm in 89/90 and that it made quite an impression on me. More so, than the second time around. Or could I have read it later? No vestige of such a reading seems to have survived in my correspondence. But by the time I wrote my essay for the Year Book 2000 of the National Research Council I must have been quite versant with the material. Somehow the stay at Durham and the subsequent stay at Ann Arbor ten years later merge in my mind. Both start to feel rather distant now. As to the book it suffers from the verbosity of Gould. He is didactic, makes the same point over and over again, and shows an unseemly fascination for his own writing and insights. He is no historian of science but loves to dabble into it, being seduced by the enthusiasm of the amateur. Still it has it s awards and he is rather clear on basic issues of science, of which

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[6] Lyell confined himself to mollusks, those being very abundant and well cataloged

[7] Modern dating of rocks is based on radioactivity, the decay of atomic nuclei being far more reliable than evolutionary change, both as to precision (due to a much larger sample) and uniformity of action (due to the timelessness of physical laws)

[8] The changes of climate during the history of the earth was instead due to the changing of landmasses, although the proportion of land to ocean stayed the same. A conception of the past strangely reminiscent of continental drift, or at least the impermanence of the continents.

I may have been far more influenced than I am prepared to admit.

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