Analogy and geology—the 'science' of Charles Lyell

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For many, Charles Lyell was the first to apply a truly scientific method to geology. He himself argued that his approach was Newtonian, based upon the uniformity of nature. Just as the laws governing planetary motions do not change from century to century, so also the laws governing geological processes. Hence, by analogy, geo-history should always be reconstructed by assuming that past processes have always acted as they do today, being of the same kind, having the same energy and producing the same effects. Lyell's use of analogy, however, was Huttonian rather than Newtonian. Lyell's understanding of geological processes was dominated by a deistic view of the 'order of nature' rather than observational science:

"The mind is prepared by the contemplation of such future revolutions to look for the signs of others, of an analogous nature, in the monuments of the past."[1]

Some years before writing the first volume of *Principles of Geology*,[2] Charles Lyell had read Bishop Joseph Butler's *Analogy of Religion*.[3] Butler had argued that the only way to gain knowledge of the spiritual world was by drawing analogies with the natural world.[4] He had also stressed the constancy and uniformity of nature which, he believed, necessarily arose from there being a single deity.[5] Of particular interest to Lyell was a statement made in Butler's conclusion:

> "... it is evident, that the course of things, which comes within our view, is connected with somewhat, past, present, and future, beyond it. So that we are placed, as one may speak, in the middle of a scheme ... in a manner equally, with respect to what has been, what now is, and what shall be."[6]

Quoting from this passage in an article he wrote for the *Quarterly Review*, Lyell opined, "no department of science has ever illustrated or confirmed the line of argument adopted by that truly philosophical writer in a more satisfactory manner than geology".[7] To him, Butler's thesis was confirmation that the way to understand Earth's past was by analogy with the present.[8] Only by observing processes currently operating, and extrapolating them backwards in time, could geo-history be correctly reconstructed.

James Hutton,[9,10] upon whose work Lyell had also built much of his thinking,[11] had argued that the earth was subject to apparently endless geological cycles. Continents would be eroded and washed as sediments into ocean basins. These, in turn, would be uplifted, generating new continents at the sites of former oceans. Similarly, the eroded areas of former continents would become new oceans. The new continents would then be eroded into the new oceans ... ostensibly *ad infinitum*. In his *Theory of the Earth*, Hutton wrote:

> "For having, in the natural history of this earth, seen a succession of worlds, we may from this conclude that there is a system in nature; in like manner as, from seeing revolutions of the planets, it is concluded, that there is a system by which they are intended to continue those revolutions. But if the succession of worlds is established in the system of nature, it is in vain to look for anything higher in the origin of the earth. The result, therefore, of our present enquiry is, that we find no vestige of a beginning, no prospect of an end."[12]

Consistent with his deistic worldview, Hutton argued from analogy that the cyclical nature of planetary motion should lead us to conclude that Earth's geological processes were also cyclical. Inherent in the universe, he believed, were 'systems' that were 'connected', mirroring one another in their characteristics and behaviour.[13] Moreover, just as the orbits of planets show no signs of a beginning, so too the processes governing the surface of our earth. Referring similarly to astronomical cycles, Lyell maintained that the geologist should not deny "that the *order of nature* has, from the earliest periods, been uniform in the same sense in which we believe it to be uniform at present [emphasis added]".[14,15]

Analogy and proof

Lyell's writing was full of analogies, with the word "analogy" (or "analogous") occurring 192 times in the three volumes of *Principles*. Sometimes, he used these as illustrative devices to help people understand his arguments. However, there can be little doubt that he also regarded analogies as reasons in themselves to transpose concepts from one area of knowledge to another. In his thinking, understanding a principle in one discipline—for example

astronomy—made it possible to learn something about another discipline—for example geology or biology. Indeed, for him geology and biology were themselves connected, with the inorganic processes of erosion and sedimentation paralleling those of organic decay and reproduction.[16]

In a letter to his friend George Poulett Scrope, Lyell accepted that it might be argued from analogy that, since species "have begun and ended", the earth too may have had a beginning. Actually, Lyell showed little interest in the question of origins, preferring to ask whether there were "proofs of a progressive state of existence in the globe, the probability of which is *proved* by the analogy of changes in organic life"[17] (emphasis original). In fact, drawing on yet more analogies, he claimed that, even if there had been a beginning, it would not be possible to see any signs of it. In the opening chapter of *Principles* he argued that "geology differs as widely from cosmogony, as speculations concerning the creation of man differ from history".[18] Just as mankind's past becomes less and less visible as we travel further back in time, so too with Earth's past. Returning to the parallel between astronomy and geology, he opined:

> "It may be perfectly true that there may be a boundary to the material Universe, and yet the most powerful telescope that man may ever be able to invent may only serve to disclose to us the myriads of new worlds. ... There is no termination to the [human] view of that space which is filled with manifestations of Creative power; why then, after tracing back the earth's history to the remotest epochs, should we anticipate with confidence that we shall ever discover signs of the beginning of the time that has been filled with acts of the same creative power?"[19]

Remarkably, Lyell appeared to draw on parallels with subjects as remote from geology as linguistics and economics.[20] He knew that languages were continuously and gradually changing, and this confirmed him in his view of the earth as being in a state of continuous, gradual change. Economies were understood to be complex, balanced systems with buying in one area and selling in another. In the Lyellian model, geological processes operated in a similar balanced way, for example, with erosion in one area and sedimentation in another. Just as economies operated through numerous small exchanges of money, so geological processes such as erosion and sedimentation acted a few grains at a time, rather than through catastrophic events. Hence, the 'laws of economics' mirrored and confirmed his 'laws of geology'.[21] Further analogies between geology and economics are found in the work of Scrope, who was arguably as influential on Lyell as Hutton,[22] and Lyell's own allusions to Ricardo's theories of production and distribution.[23]

According to Lyell, the fossil record told the story of the continual birth and extinction of species. In his thinking, plants and animals would have been created (or would have arisen by natural processes) with a form specially adapted for their environment. Then, over the millennia, as the environment changed, these would have become extinct, only to be replaced by new species. They did not gradually change; instead, as old forms died out, somehow new ones were born. Consistent with his Huttonian, deistic mindset, Lyell even referred to the "laws which regulate the comparative longevity of species". These laws, he believed, were supported by an analogy with demography:[20] humans have limited life spans so it was reasonable, in his thinking, to view species as existing only for limited durations. And just as censuses recorded changes in human populations, so the fossil record provided data on the 'birth and extinction of species'. As observed by Rudwick, Lyell "regarded an assemblage of fossil molluscan species as directly and validly analogous to a human population". To appeal to such an analogy, however, was surely the height of inconsistency. Lyell's primary axiom held that only currently observed processes could be invoked to explain Earth's history; yet nobody had ever reported an incident of a new species having been born.

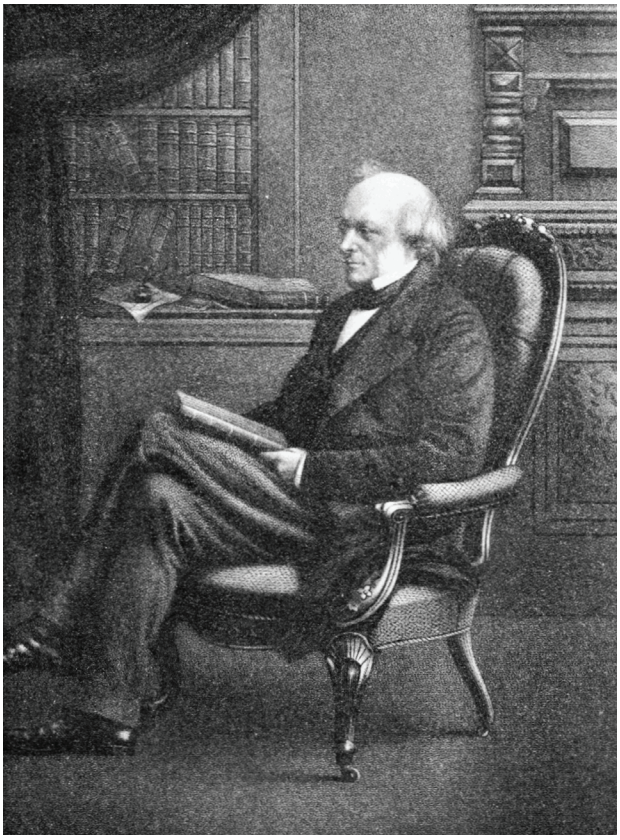

Figure 1. Charles Lyell (1797–1875) whose geological theories were very influential in leading Darwin to his theory of evolution.

Analogy trumping data

For Lyell, the force of analogy justified the setting aside of any amount of data and however compelling that data might be:

> "When we are unable to explain the monuments of past changes [by uniformitarian processes], it is always more probable that the difficulty arises from our ignorance of all the existing agents, or all their possible effects in an indefinite lapse of time, than that some cause was formerly in operation which has ceased to act ... . *But should we ever establish by unequivocal proofs*, that certain agents have, at particular periods of past time, been more potent instruments of change *over the entire surface of the earth* than they now are, it will be more consistent with philosophical caution to presume, that after an interval of quiescence they will recover their pristine vigour, than to regard them as worn out [emphasis added]."[24]

Even *unequivocal proofs* seen *over the entire surface of the earth* would be insufficient to cause the uniformitarian paradigm to wobble. Moreover, Lyell readily admitted that much of the geological record pointed to catastrophic rather than uniformitarian processes:

> "The marks of former convulsions on every part of the surface of our planet are obvious and striking ... . If these appearances are once recognized, it seems natural that the mind should come to the conclusion, not only of mighty changes in past ages, but of alternate periods of repose and disorder—of repose when the fossil animals lived, grew, and multiplied—of disorder, when the strata wherein they were buried became transferred from the sea to the interior of continents, and entered into high mountain chains."[25]

However, these "marks of former convulsions", he believed, were illusory, arising from an imperfect record. Just as human censuses would only show the gradual changes in populations if they were taken on a regular basis, so geological 'censuses' would only show the gradual changes in Earth's history if the 'book of geology' was more compete. Moreover, 'pages' might be destroyed by later erosion.[26]

The return of the dinosaurs

At the heart of Lyell's model was the view that Earth's history was non-directional. Moreover, not only were geological processes cyclical, he believed, but also the earth's floras and faunas. Drawing on the analogy of yearly cycles of warmer and cooler weather (summer and winter) he argued for there also being a "great year"[27] whereby continents would experience millions of years of warmer weather, followed by millions of years of cooler weather:

> "We might expect, therefore, in the summer of the 'great year', which we are now considering, that there would be a great predominance of tree-ferns and plants allied to palms and arborescent grasses in the isles of the wide ocean, while the dicotyledonous plants and other forms now most common in temperate regions would almost disappear from the earth. Then might those genera of animals return, of which the memorials are preserved in the ancient rocks of our continents. The huge iguanodon might reappear in the woods, and the ichthyosaur in the sea, while the pterodactyle [sic] might flit again through umbrageous groves of tree-ferns."[28]

Regarding the return of dinosaurs, Lyell wrote more confidently in a letter to Mantell: "All these changes are to happen in future again & iguanodons & their congeners must as *assuredly* live again in the latitude of Cuckfield as they have done so [emphasis added]."[29] Cuckfield was the village in West Sussex where Mantell had discovered the fossilized remains of Iguanadon.[30] According to Lyell, they would *assuredly* live there again—a view ridiculed by Henry de la Beche (fig. 2).

Lyell and Newton

In titling his treatise *Principles of Geology*, there can be little doubt that Lyell was alluding to Newton's *Principia*. Britain's greatest scientist had produced *the* foundational work in mathematics and physics. Similarly, Lyell was claiming to have brought true science to bear on the history of the earth. "Hutton laboured to give fixed principles to geology," he wrote, "as Newton had succeeded in doing to astronomy."[32] Newtonian science was based firmly upon the uniformity of natural law. Hence, Lyell argued, truly scientific geology should be based firmly upon uniformity of process (meaning also that the rates of such processes have been essentially the same through time). To suggest otherwise would be to imply that the laws of nature might change. Such a blanket assumption, however, had no precedent in *Principia*. Newton wrote:

> "Those qualities of bodies that cannot be intended or remitted [i.e. increased or diminished] and that belong to all bodies on which experiments can be made should be taken as qualities of all bodies universally. For the qualities of bodies can be known only through experiments ... nor should we depart from the analogy of nature, since nature is always simple and ever consonant [i.e. consistent] with itself."[33]

For Newton, the "analogy of nature" does indeed imply that "nature is ever consonant [i.e. consistent]". However such a rule is applied only in respect of "[t]hose qualities of bodies that cannot be intended and remitted [i.e. increased or diminished] and on which experiments can be made".

Figure 2. Awful Changes. A cartoon by Henry de la Beche, poking fun at Lyell's belief that dinosaurs would return to repopulate the earth in some future epoch. Lyell is caricatured here as 'Professor Ichthyosaurus' discussing a human fossil skull.[31]

Lyell never conducted any experiments which demonstrated that geological processes could never have been increased or diminished. His 'science' was therefore emphatically not Newtonian. It is only by the crudest form of analogical reasoning that he could have concluded that the fixed nature of laws governing processes by which material objects interact necessitates that the rates of those processes are also fixed. And common sense itself rebels against such a notion; stationary, slow-moving or fast-moving objects equally obey the physical laws.

Lyell's *bête noire*

That Lyell could have been so resolute in refusing to accept the abundant data falsifying his theories has puzzled many a historian. Perhaps the answer lies in his utter rejection of the God of the Bible whose righteous indignation led him to judge the world through a "penal deluge".[34] Rudwick argued that Lyell's attitude "was underlain by theological concerns as important as (though different from) those of the diluvialists", observing that the "primary target of Lyell's history was . . . the scriptural or 'Mosaic' geology of writers such as Ure and their fundamentalist allies ...".[36] Indeed, Lyell was at pains to stress: "Geological inquiry ought to be conducted as if the Scriptures were not in existence."[37] Referring to a letter written by Lyell to Whewell,[38] where Lyell insisted that he could not "budge an inch", Rudwick commented:

> "Here he [Lyell] revealed the deepest dynamic underlying his insistence on 'uniformity': the most recent of all putative deluges, as championed by his former mentor Buckland, was still his bête noire, because it could be, and had been, used to retain a link, however tenuous, with 'Moses' or biblical literalism."[39]

Indeed, Lyell pursued his crusade to "free the science [of geology] from Moses"[40] with what can only be described as religious zeal. Alluding to Paul's letter to the Ephesians, he wrote to his fiancée: "I am grappling not with the ordinary arm of flesh but with principalities and powers ... and I must put on all my armour."[38]

Conclusion

For many, Charles Lyell was the father of geology and one of the giants of Victorian science. Few realize, however, that his theories rested on little more than a blind appeal to analogy. The late evolutionist and Harvard paleontologist Stephen J. Gould once referred to the extreme rarity of fossil transitional forms as "the trade secret of paleontology".[41] Perhaps the real basis of Lyellian geology is the trade secret of historians of science.

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