

Principles of Geology
Being an attempt to explain the former changes of the Earth's
surface, by reference to causes now in operation

Excerpt from the 1830 book by Sir Charles Lyell (edited and annotated by David Fenimore)

[Epigraph]

"Amid all the revolutions of the globe the economy of Nature has been uniform, and her laws are the only things that have resisted the general movement. The rivers and the rocks, the seas and the continents have been changed in all their parts; but the laws which direct those changes, and the rules to which they are subject, have remained invariably the same"

— *Illustrations of the Huttonian Theory*, 374.

... astonishing and unexpected are the connections brought to light, when we carry back our researches into the history of nature. The form of a coast, the configuration of the interior of a country, the existence and extent of lakes, valleys, and mountains, can often be traced to the former prevalence of earthquakes and volcanoes, in regions which have long been undisturbed.

It's not just spectacular cataclysms which have shaped the earth, writes Lyell, but gradual processes like sedimentation and erosion over unimaginably long periods of time (what Lyell called the "uniformitarian" principle).

On the other hand, many distinguishing features of the surface may often be ascribed to the operation at a remote era of slow and tranquil causes—to the gradual deposition of sediment in a lake or in the ocean, or to the prolific growth in the same of corals and testacea¹. To select another example, we find in certain localities subterranean deposits of coal, consisting of vegetable matter, formerly drifted into seas and lakes. These seas and lakes have since been filled up, the lands whereon the forests grew have disappeared or changed their form, the rivers and currents which floated the vegetable masses can no longer be traced, and the plants belonged to species which for ages have passed away from the surface of our planet.

... the geologist ... has the power of passing rapidly from the events of one period to those of another—of beholding, at one glance, the effects of causes which may have happened at intervals of time incalculably remote, and during which, nevertheless, no local circumstances may have occurred to mark that there is a great chasm in the chronological series of nature's archives.

In the vast interval of time which may really have elapsed between the results of operations thus compared, the physical condition of the earth may, by slow and insensible modifications, have become entirely altered, one or more races of organic beings may have passed away, and yet have left behind, in the particular region under contemplation, no trace of their existence. To a mind unconscious of these intermediate links in the chain of events, the passage from one state of things to another must appear so violent, that the idea of revolutions in the system inevitably suggests itself.

¹ seashells

It's hard for a human being to accept the fact that what is now icy Arctic may millions of years ago have been a tropical rainforest, and vice versa. It seems like magic to us, because we cannot think in terms of such a gigantic time scale.

The imagination is as much perplexed by such errors as to time, as it would be if we could annihilate space, and by some power, such as we read of in tales of enchantment, could transfer a person who had laid himself down to sleep in a snowy arctic wilderness, to a valley in a tropical region, where on awaking he would find himself surrounded by birds of brilliant plumage, and all the luxuriance of animal and vegetable forms of which nature is there so prodigal. The most reasonable supposition, perhaps, which a philosopher could make, if by the necromancer's art he was placed in such a situation, would be, that he was dreaming; and if a geologist forms theories under a similar delusion, we should not expect him to preserve more consistency in his speculations, than in the train of ideas in an ordinary dream.

By careful scientific research we can determine that the most radical transformations of the earth's surface obeyed the same natural laws of matter and motion that we see in operation today.

But if, instead of inverting the natural order of inquiry, we cautiously proceed in our investigations, from the known to the unknown, and begin by studying the most modern periods of the earth's history, attempting afterwards to decipher the monuments of more ancient changes, we can never so far lose sight of analogy, as to suspect that we have arrived at a new system, governed by different physical laws.

The presence of fossils in various strata of the earth's crust are evidence that life and other matter obeyed the same principles as now; i.e., no "miracle of creation" is necessary.

In more recent formations, consisting often of strata of great thickness, the shells of the present seas and lakes, and the remains of animals and plants now living on the land, are imbedded in great numbers. In those of more ancient date; many of the same species are found associated with others now extinct. These unknown kinds again are observed in strata of still higher antiquity, connected with a great number of others which have also no living representatives, till at length we arrive at periods of which the monuments contain exclusively the remains of species with many genera foreign to the present creation. But even in the oldest rocks which contain organic remains, some genera of marine animals are recognized, of which species still exist in our seas, and these are repeated at different intervals in all the intermediate groups of strata, attesting that, amidst the great variety of revolutions of which the earth's surface has been the theatre, there has never been a departure from the conditions necessary for the existence of certain unaltered types of organization.

The continued existence of life requires the same ("uniform") conditions to have been operating millions of years ago as now.

The uniformity of animal instinct, observes Mr. Stewart², pre-supposes a corresponding regularity in the physical laws of the universe, "insomuch that if the established order of the material world were to be essentially disturbed, (the instincts of the brutes remaining the same,) all their various tribes would inevitably perish." Now, any naturalist will be convinced, on slight reflection, of

² Dugald Stewart, *Philosophy of the Human Mind* (1792)

the justice of this remark. He will also admit that the same species have always retained the same instincts, and therefore that all the strata wherein any of *their* remains occur, must have been formed when the phenomena of inanimate matter were the same as they are in the actual condition of the earth.

The same conclusion must also be extended to the extinct animals with which the remains of these living species are associated; and by these means we are enabled to establish the permanence of the existing physical laws, throughout the whole period when the tertiary deposits were formed. We have already stated that, during that vast period, a large proportion of all the lands in the northern hemisphere were raised above the level of the sea. (159-161)

Those who argue that the earth's surface was shaped more dramatically at some earlier period, e.g. by "Noah's flood," are in effect arguing that different physical laws than those we observe today were in operation then.

... We can only estimate the relative amount of change produced at two distinct periods, by a particular cause in a given lapse of time, when we have obtained some common standard for the measurement of equal portions of time at both periods. We have shown that, within the last one hundred and forty years, some hundred thousand square miles of territory have been upheaved to the height of several feet, and that an area of equal, if not greater extent, has been depressed.

Now, they who contend, that formerly more movement was accomplished by earthquakes in the space of one hundred and forty years, must first explain the measure of time referred to, for it is obvious that they cannot in geology avail themselves of the annual revolution of our planet round the sun. Suppose they assume that the power of volcanos to emit lava, and of running water to transport sediment from one part of the globe to the other, has remained uniform from the earliest periods, they might then attempt to compare the effects of subterranean movements in ancient and modern times by reference to one common standard, and to show that, while a certain number of lava-currents were produced, or so many cubic yards of sediment accumulated, the elevation and depression of the earth's crust were once much greater than they are now.

We don't currently have enough data in geology or biology [very new sciences in 1830] to make any generalizations at all.

Or, if they should declare that the progressive rate of change of species in the animal and vegetable kingdoms had always been uniform, they might then endeavor to disparage the degree of energy now exerted by earthquakes, by showing that, in relation to the mutations of assemblages of organic species, earthquakes had become comparatively feeble. But our present scanty acquaintance, both with the animate and inanimate world, can by no means warrant such generalizations; nor have they who contend for the gradual decline of the activity of natural agents, attempted to support such a line of argument. That it would be most premature, in the present state of natural history, to reason on the comparative rate of fluctuation in the species of organic beings in ancient and modern times, will be more fully demonstrated when we proceed, in the next division of our subject, to consider the intimate connection between geology, and the study of the present condition of the animal and vegetable kingdoms.

While earthquakes terrorize humans, they are a natural process by which the planet evolves.

To conclude: it appears, from the views above explained, respecting the agency of subterranean movements, that the constant repair of the dry land, and the subserviency of our planet

to the support of terrestrial as well as aquatic species, are secured by the elevating and depressing power of earthquakes. This cause, so often the source of death and terror to the inhabitants of the globe, which visits, in succession, every zone, and fills the earth with monuments of ruin and disorder, is, nevertheless, a conservative principle in the highest degree, and, above all others, essential to the stability of the system. (478-79)
