THE EUROPEAN DISCOVERY OF TIME

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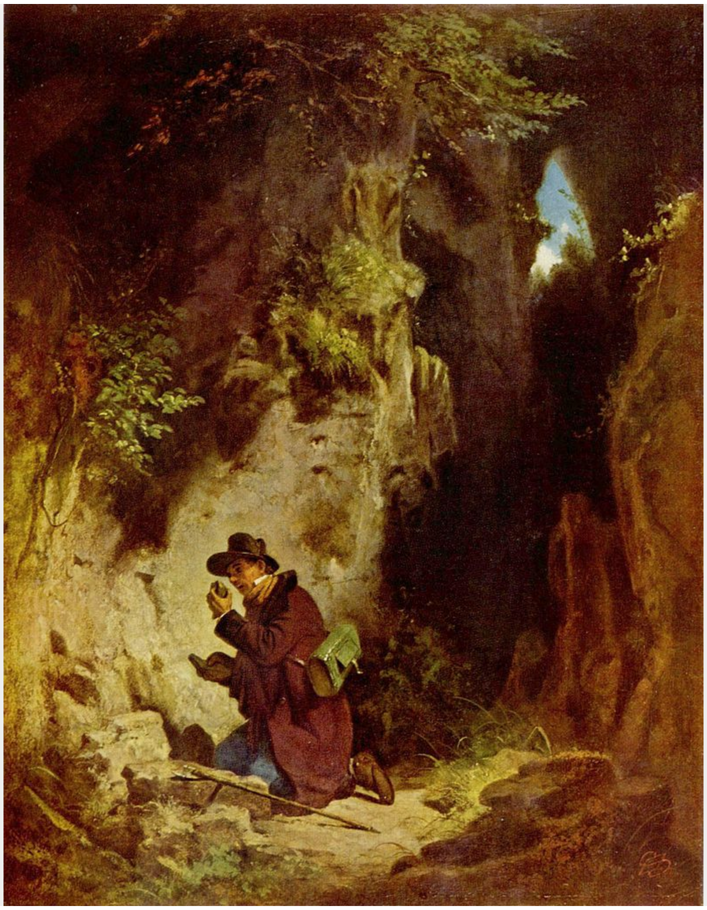

Geology, a seemingly innocuous field concerned with the study of rocks and minerals, is the field responsible for the discovery of time. European geologists were the first to realize that the Earth had a history, that it came to be in the course of time, and that humans could discover this history by studying the rock strata and fossils of the Earth's crust. Don't confuse the measurement of time, which began with the invention of sundials in ancient Egypt, with the discovery of time. Neither calendar nor chronology was worked out with the intention of discovering the Earth's time.

Every mythical account of the origins of the world postulated that the Earth was either formed through an initial "moment of creation" or that it was part of an "eternal order" embedded in a "cyclical cosmos". Newtonian physics had nothing to say about the development of nature, but assumed that once God created the universe it had remained the same. The task of the scientist was to understand the "universal laws of nature at work" that ordered the repetitive movements of the world and its parts. God, in Newton's words, was "like a watchmaker" who may occasionally tinker with the motions of the planets "to ensure that it continued operating in good working order," but scientists essentially dealt with the world as it had been set in motion by God. The reigning consensus prior to 1750 accepted the Biblical narrative that the Earth was 6,000 years old. The notion that natural objects were formed over the course of millions of years was inconceivable—until the science of geology came into its own in the 1800s.

The Consolidation Of Geology As A Science

While evidence was accumulating about strange rocks with fossilized marine shells found inland in stratified layers, these anomalies were explained within the Creation-story and the accepted time-scale. Robert Hooke (1635-1703) reasoned that the Earth had a history characterized by earthquakes, floods, deluges, eruptions, which had altered the earth and its living organisms, but this history, he insisted, was explainable within the Biblical narrative. Thomas Burnet (1635-1715) argued in *Telluris Theoria Sacra* that the Earth was hollow with most of the water inside until Noah's Flood, at which time mountains and oceans appeared, as the sun's rays dried up the Earth and the crust was split open into continental land masses.

John Woodward in his *Essay Towards a Natural History of the Earth* (1695) argued that the 'whole Terrestrial Globe was taken all to Pieces, and dissolved at the Deluge". The existence of fossilized remains confirmed the Mosaic Flood as described in the Bible. New rock strata came to be formed, after the Flood, by a process of sedimentation, with the remains of animals and plants relegated to the deepest strata. This emphasis on the action of water through the Flood in the formation of fossilized rock strata came to be known as the "Neptunist" view of the Earth's history. Other geologists like John Ray advocated the "Vulcanist" view that the mountains and dry land had been raised above the oceans by the internal fires of the Earth at the command of God.

While the Neptunist view tended to sit comfortably with the Flood cataclysmic narrative and the view that it was possible to explain the appearance of rocks, fish, animals, and man, in the order presented in the Book of Genesis, the Vulcanist view became associated with a more gradual process occurring over a longer time scale. John Whitehurst, in a daring book published in 1788, *Inquiry into the Original State and Formation of the Earth* (1778), argued that the geological record suggested a much older history of the Earth than the Noachian Flood. The Italian Giovanne Arduino (1714–1795) even denied the Flood and contended that the rock strata of the earth, which he classified with the names Primitive, Secondary and Tertiary, also pointed to a much older Earth.

The beginnings of the idea of an older Earth, however, is associated with Georges Louis Leclerc (the legendary Comte de Buffon), who was less a geologist than a historian of nature and *encyclopédiste*. Buffon hypothesized that the Earth originated from a collision of a comet and the sun, much earlier than the Biblical 6000 year account. He suggested this argument in his multivolume work, *Histoire naturelle, générale et particulière* (1749–1788), and in his *Introduction to the History of Minerals* (1774), although it was in his *The Epochs of Nature* (1778) that he formulated in explicit terms the idea that "the surface of the Earth has taken different forms in succession; even the heavens have changed, and all the objects in the physical world are, like those of the moral world, caught up in a continual process of successive variations". He inferred the age of the Earth experimentally by heating a small metallic globe and measuring the rate at which it cooled, which yielded an estimate of 75,000 years old.

While scriptural geologists attracted to the Neptunist view, such as Alexander Catcott in his *Treatise on the Deluge* (1768), would try to defend the Genesis account of a recent Creation by arguing that a global Flood could account for the geological record, the growing scientific temperament in Europe pushed the Neptunist view in a more secularized direction. The German geologist Abraham Werner (1749-1817) thus proposed that in the beginning the Earth was covered by a primeval ocean which gradually receded to its present location, depositing by a process of crystallization and chemical precipitation almost all the rocks and minerals in the Earth's crust over the course of about one million years. In his estimation, heat was not an important initial geological force; volcanic heat from the interior of the earth was a late and a secondary rock-forming agency after the main strata had been consolidated through slow sedimentation. In the spirit of science, Werner devised a comprehensive color scheme for the description and classification of rock strata according to their mineral content and age. His Neptunist theory, however, could not account for the disappearance of the original ocean after the strata had been formed.

John Playfair, a Scottish clergyman, popularized Hutton's ideas in his *Illustrations of the Huttonian Theory of the Earth* (1802) and defended Hutton against the charge of atheism by arguing that uniformitarian geological processes were like Newton's laws of regular planetary motion. Hutton's theory, however, was not widely accepted by a British geological world unwilling to break altogether with the Biblical narrative. Meanwhile, the French Georges Cuvier, known as the "founding father of paleontology," countered uniformitarianism with another geological hypothesis called "catastrophism," which argued that the geological features of the earth, along with the history of life, could be explained by catastrophic events, not a single catastrophe, but several, causing the extinction of many species of animals and resulting in the sharp lines of demarcation between the successive strata and the presence of distinctive fossil remains in each layer of rock.

But soon a new perspective known as "uniformitarianism" came on the horizon thanks to the Scottish James Hutton (1726-1797), identified by some as the first student of the earth who may properly be called a geologist. In his *The Theory of the Earth, or an Investigation of the Laws observable in the Composition, Dissolution, and Restoration of Land upon the Globe* (1788), he provided a rigorous explanation, grounded in scientifically acceptable principles and based on the existing geological data, why the age of the Earth was indefinitely long. The same geological forces that are seen to be in operation in our present-day, he argued, should be used to explain the past geological formation of the Earth. "The past history of our globe," in his words, "must be explained by what can be seen to be happening now… No powers are to be employed that are not natural to the globe, no action to be admitted except those of which we know the principle."

The powers of nature act uniformly through time, rather than suddenly through cataclysms. This is the uniformitarian principle. While stressing the internal heat of the Earth, he did not neglect the geological effects of water, observing two sorts of rocks in the Earth's crust, one of aqueous origin and the other of igneous origin. The intense internal heat of the Earth was responsible for uplifting mountains to form land masses, bending and stilting strata, where they would then be subjected to erosion, re-deposition and volcanism; and these processes acted over a very long time scale.

In time, however, the uniformitarian school gained the upper hand, particularly after Charles Lyell published his celebrated three volume work, *Principles of Geology* (1830-33), which synthesized thirty years of geological discoveries in favor of Hutton's uniformitarian theory. Although Lyell did not argue in favor of the transmutation of species, some in the geological community felt ill at ease with the notion that the succession of fossils in the rock strata pointed in the direction of the evolutionary succession of species.

The Anglican priest Adam Sedgwick (1785–1873), notwithstanding his proposal of the Cambrian and Devonian period of the geological timescale, thought that a uniformitarian history of the earth could be harmonized with the Bible, though he never explained how, other than objecting to the evolution of new species. It was not until Charles Darwin's theory of evolution (1859) was widely accepted that Lyell's theory ceased to be widely opposed.

We often hear that Darwin obtained the idea of the mechanism of evolution from Thomas Malthus's famous essay on population. We rarely hear that it was Lyell's theory, in Darwin's own words, that led him to the theory of evolution itself. Once the Biblical time barrier on the history of the Earth was broken by geologists, a historical revolution was precipitated in biology, leading to Darwin's theory of natural selection about how species form and change over time. The current geological consensus today is that the Earth's history is a slow, gradual process punctuated by occasional natural catastrophic events.

Every participant in these debates was a European. The rest of the world was oblivious about this revolution in geology, as it was about Newtonian science, and the amazing revelation that the Earth's history was very old and could be explained with the powers of the human mind.

Chinese "Geology"

Be on guard about the multicultural claim that geology began in ancient China. Joseph Needham, in his exhaustive work, *Science and Civilization in China*, offers a section with the title "The sciences of the earth: Geology and related sciences," arguing that long before the "largely modern, post-Renaissance science" of geology emerged in the West, the Chinese in the eleventh century already "understood those conceptions which, when stated by James Hutton in 1802, were to be the foundation of modern geology" (293). However, no actual Chinese treatises on geology are brought up by Needham, for none existed. What we get instead are isolated passages from various Chinese "masters" which supposedly amounted to explanations of the "origin of mountains, uplifting, erosion, and sedimentary deposition".

Here is one passage from Shen Kua written "about the year 1070" supposedly explaining "how the earth formed as a deposit from the water":

> Now I myself have noticed that Yen-Tang Shan is different from other mountains. All its lofty peaks are precipitous, abrupt, sharp and strange; its huge cliffs, 300 metres high, are different from what one finds in other places…Considering the reasons for this I think that the mountain torrents have rushed down, carrying away all sand and earth, thus leaving the hard rocks standing alone (292).

This is followed by another passage where Shen Kua explains the origins of "uplifted strata":

> …Naturally mud and silt will be carried eastwards by these streams year after year, and in this way the substance of the whole continent must have been laid down.

Needham provides pictorial representations of fossil animals along with descriptive passages to show that the Chinese anticipated modern European geology. He mentions "the most famous text" on the origins of the earth, namely, the "Collected Works of Master Chu Hsi" (1130-1200):

> I have seen mountain conchs and oyster shells, often embedded in rocks. These rocks in ancient times were earth or mud, and the conchs and oysters lived in water. Subsequently everything that was at the bottom came to be at the top, and what was originally soft became solid and hard. One should meditate deeply on such matters, for these facts can be verified" (290).

These are the best passages provided by Needham. They are intelligent descriptions for their time, but nowhere near a science of geology. Isolated descriptions, without principles and without a theory, do not constitute a science. Geology became a science in the West in the wake of the Galilean-Newtonian science of mechanics, the theory of universal gravitation, the theory of the circulation of the blood, along with the consolidation of the science of chemistry, botany, paleontology, and evolutionary biology.

The Chinese believed that the Earth was flat until the Jesuits taught them otherwise in the seventeenth century. None of the geologists Needham mentions wrote a treatise that can be classified as "geological" in dealing with the origins of the Earth. If the Chinese were so advanced in their geological reflections back in ancient times, anticipating Hutton, how come no further insights came out of China in the next thousand years? After Hutton, Europeans would go on to develop techniques to date the rock strata of the Earth as well as a variety of methods to understand the Earth's structure and evolution, including field work, rock description, geophysical techniques, chemical analysis, physical experiments, and numerical modelling.

The Treatises Of Theophrastus, Agricola, And Steno

As it is, the ancient Greeks were already writing treatises that were more theoretical in their geological insights than the descriptive passages of the Chinese. Theophrastus (372-287 BC) in his treatise On Stones, classified rocks and gems based on their behavior when heated, grouping minerals by common properties, and writing about the fossilized remains of organic life. The Wikipedia page on Shen Kuo (1031-1095) portrays him as a scientist in all the fields of human knowledge:

> He was a mathematician, astronomer, antiquarian, meteorologist, geologist, entomologist, anatomist, climatologist, zoologist, botanist, pharmacologist, medical scientist, agronomist, archeologist, ethnographer, cartographer, geographer, geophysicist, metallurgist, mineralogist, encyclopedist, military general, diplomat, hydraulic engineer, inventor, economist, academy chancellor, finance minister, governmental state inspector, philosopher, art critic, poet, and musician.

Clearly, the multicultural establishment has lowered the criteria of what constitutes a science in their eagerness to be inclusive; yet they can barely hang on to China as a viable intellectual competitor. The etymology of all the sciences are European, because Europeans originated all the sciences; and so is the idea of logos, of making an argument through reasoned discourse, not through mere assertions and descriptions, but on the basis of explicitly stated principles.

The etymology of geology tells us that the root of this word is very recent; only in 1795 do we find explicit statements about geology as a "science of the past and present condition of the Earth's crust," from Modern Latin *geologia* "the study of the earth". German *Geologie* is attested in 1785. The word-forming element meaning "the Earth" comes from the Greek term *geo*-, and the word-forming element meaning "discourse, treatise, doctrine, theory, science" comes from the Greek term -*logia*.

The Chinese did not write a single treatise on geology because they lacked a notion of writing treatises, doctrines and theoretical scientific works. Whereas Shen Kuo left us with no scientific treatises, we have two surviving botanical works by Theophrastus, *Enquiry into Plants* and *On the Causes of Plants*, which are recognized as the first systemization of the botanical world with plants classified according to their modes of generation, their localities, their sizes, and their practical uses.

Before Hutton, we have the German Georgius Agricola (1494-1555), who wrote full treatises, including *De Natura Fossileum*, *De Ortu et Causis Subteraneum*, and *De Re Metallica*, where he attempted to explain the existence of mountains, volcanoes, and earthquakes, recognized the power of wind and water as an erosive force, associated the hot interior of the Earth with volcanoes and earthquakes, and put together a classification system of the mineral kingdom. *De Re Metallica* remained the standard textbook on mining and metallurgy for over two hundred years. Herbert Hoover, a mining engineer before he became U.S. President, translated *De Re Metallica* into English in 1912, believing that Agricola was "the first to found any of the natural sciences upon research and observation, as opposed to previous fruitless speculation." If anyone deserves to be celebrated for making an essential contribution to the beginnings of the science of geology, it is Agricola.

Then we have the Danish Nicholas Steno (1638-1686), who went beyond mere description to formulate path breaking geological principles in an actual treatise, *Dissertationis prodromus*, published in 1669. This treatise is acknowledged today for establishing, on the basis of inductive reasoning, four of the foundational principles of the science of stratigraphy: the law of superposition, the principle of original horizontality, the principle of lateral continuity, and the principle of cross-cutting relationships.

The Earth Is 4.54 Billion Years Old

I left other names from this account of the discovery of geological time, such as William Smith, who published three works from 1815 to 1817, gave geology a descriptive methodology for assigning relative ages to the various strata of the Earth, and provided the first geological map of England and Wales. After the 1830s, geology became a professional vocation with many names making important contributions and reaching ever more accurate estimations of the Earth's age with the assistance of European physicists and chemists.

In 1896 radioactive isotopes were discovered by the French physicist Henri Becquerel showing that heat from their decay pointed to an Earth hundreds of millions of years old. Between 1903 and 1906, the renowned New Zealand physicist Ernest Rutherford (1871–1937) determined that isotopes could be used to date rocks. By the 1930s, through the efforts of Arthur Holmes, the age of the earth had expanded to about 2 billion years. In 1946, Willard Libby proposed an innovative method, radiocarbon dating, which allowed for the dating of organic materials by measuring their content of carbon-14. This method provided objective age estimates for carbon-based objects that originated from living organisms. The "radiocarbon revolution" finally allowed Europeans to reach the conclusion that the Earth was 4.54 billion years old.

Ricardo Duchesne has also written on the creation of the university. He the author of The Uniqueness of Western Civilization, Faustian Man in a Multicultural Age, Canada in Decay: Mass Immigration, Diversity, and the Ethnocide of Euro-Canadians.

Featured image: "The Geologist," by Carl Spitzweg; painted ca. 1860.