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Enlightenment Geology

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The Rise of Earth Science

Geology lay at the root of this and patrons began to sponsor studies of the structure of the Earth in an attempt to make finding the locations of minerals and wealth easier. The coalfields across Europe began to dictate the locations of settlements, as cities sprang up in industrialized regions and scholars began to study the formation of strata.

After the work of Agricola, Gessner, and Steno, geology became a distinct scientific discipline, an essential part of the drive towards understanding the universe and an important foundation underpinning the Industrial Revolution. Coal, metal ores, precious metals, and jewels became the catalyst for change, overseeing revolutions in agriculture, industry, manufacture and mining.



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Enlightenment Geology – Neptunists and Vulcanists

In the 18th Century, geology was an amateur pursuit, but this soon changed when society began to tap into mineral wealth. The knowledge of scholars and observations of miners was blended with the findings of the gentleman fossil hunters. As is the case still, paleontology and geology overlapped closely, allowing dating and the unfolding of the story of the history of the Earth.

Before this period, Biblical doctrine held sway and most scholars and earth scientists tried to fit their findings into the Biblical creation view that the Earth was 600 years old, with most of the surface features a result of the Biblical Flood. As the Enlightenment unfolded and the vileness of the Inquisition faded, scholars felt free to challenge this view and espouse different views and theories about what processes shaped the Earth.

John Woodward (1665-1728) felt that the flood was a global event, whereas John Ray (1627-1705) felt that it was localized and that the shaping of the Earth was due to volcanoes. This argument, between 'Neptunists' and 'Vulcanists' developed, although both groups shared some common ground, believing that the shaping of the Earth was due to catastrophic events.

Moving even further away from the Biblical deluge, Lazzaro Moro, of Venice (1687-1764) proposed that the flood had no effect at all and George Louis Le Clerc de Buffon (1707-1788) claimed that the Biblical timeline was woefully short although, with the benefit of hindsight, his proposal of 80 000 years was little better.

These views still carried some inherent danger, due to resistance from the Church, although that particular threat was receding as the Enlightenment progressed and people felt free to challenge doctrine.

Geology in the Enlightenment and Classification



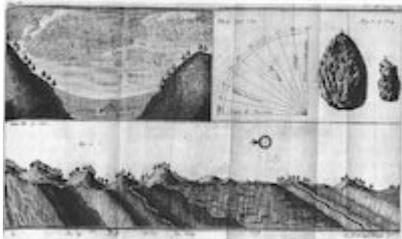
Portrait of Johan Gottlob Lehmann (Public Domain)

Away from the theoretical aspects, empirical geology was progressing as scholars studied rock formations in mines and canal embankments. In France, Jean Ettienn-Guettard (1715-1786) and Niclas Desmarest (1725-1815) completed a geological survey of the country, producing a detailed geological map of rock formations in 1780. In Germany, where great

wealth lay in mining, geologists explored the mining regions and began to develop theories about rock formation and stratification.

Moro had proposed the idea of primary and secondary rocks, with primary rocks stemming from the initial formation of the planet and containing metal ores and precious stones. Secondary rocks derived from the primary rocks, via some process, and contained fossils. The German geologist, Johann Lehmann, in 1756, added tertiary rocks to the classification, distinguishing three types of mountain.

- Mountains arising from the formation of the Earth
- Mountain ranges resulting from deposition underwater
- Mountains formed by vulcanism



Johann Gottlob Lehmann's geological sections of strata, 1759 (Public Domain)

In Italy, Giovanni Arduino (1714-1795) used four classes of rock, primitive, secondary, tertiary, and volcanic, basing these classifications on appearance, properties and the occurrence of fossils. The Russian geologist, Peter Pallas (1741-1811) used three classes and pointed out that the sea must have covered some areas, proposing that mountains could be elevated by uplifting processes, using the term, 'Commotions of the Globe.' Georg Christian Fuchsel (1722-1773) published a geological map, in 1762, called, '*A History of the Earth and the Sea, Based on a History of the Mountains of Thuringia*'.

Scientists began to study the formation of minerals in the laboratory and, in the same way that governments and rulers supported alchemists in their quest for wealth, European rulers poured money into geology. The difference was that geologists began to produce tangible results and returns on investments.

The end of the 18th Century saw the science develop further, with the German geologist, Abraham Werner (1714-1817) establishing an academy in Freiburg. He drew up a system of rock and mineral classification based upon the properties of rocks, a system which was widely adopted across Europe. Werner was a Neptunist, believing that all rocks formed when the Earth was covered by an ocean, including igneous rocks, so he dismissed the idea of vulcanism. He also proposed that geological time was divided into 'formations,' where a body of rock was laid down at the same time, a way of punctuating geological timescales.

Enlightenment Geology and the Plutonists



Portrait of James Hutton, the founder of modern geology (Public Domain)

Charles Lyell and James Hutton (1726-1797) further contributed, with Lyell producing a textbook, *'Principles of Geology'*, laying out the basic theories and principles governing the science. The Scotsman, Hutton, was notable in that he opposed the ideas of Werner. He studied rock formations in Scotland and the North of England, proposing that igneous rocks were younger and developed from molten extrusions from the center of the Earth.

His paper, *'Theory of the Earth'*, published in 1785, developed a following and he and his followers became known as Plutonists, after the God of the Underworld. Hutton was not really accepted on the continent, the domain of Werner, and Britain still saw resistance from Biblical creationists. Hutton goes down in history as one of those scientists whose importance was not realized until after their death. The mathematician, Playfair, in his paper *'Illustrations of the Huttonian Theory of the Earth'*, saw Hutton's ideas accepted into the mainstream.

The debate continued into the 19th Century, but the evidence supported the Plutonists, and even pupils of Werner accepted the theories of Hutton, in an example of evidence falsifying a theory. Leopold van Buch (1744-1852) studied extinct volcanoes in Auvergne that confirmed Hutton's ideas.

Hutton also destroyed the idea that all geology was created by catastrophic events, pointing out that processes that happened in the past still occurred, making the Earth dynamic and changing, a process called uniformitarianism.

William Smith (1769-1839) used fossils to study stratigraphy and the formation of rocks, showing that there were laws behind the processes of rock formation, creating detailed geological maps in the process. The Welsh paleontologist, Edward Lhwyd (1660-1709), produced an illustrated guide to British fossils, allowing geologists to make on the spot identifications.

Geological Time Scales

By the 19th Century, most geologists agreed on the processes governing geology, but disagreed on the timescale, which became the next area of speculation and theorizing, finally banishing Biblical Creationism to the fringes of science. Geologists began to name the eras of the Earth, with names that we still use today, such as Carboniferous for the formation of coal;

Cretaceous for chalk; and Jurassic, after the limestone Jura Mountains.

This was partly at the instigation of paleontologists seeking to classify rocks containing fossils. Baron Cuvier (1769-1832), a Frenchman, proposed that deposition occurred in a series of catastrophic steps, with all species destroyed and then arising again. This dominated geology for decades, but was eventually superseded by gradualism.

The geologists and paleontologists continued to subdivide the major ages, adding Devonian, Cambrian, Precambrian, Silurian, Ordovician, and a whole host of other names to the epoch timeline. Thus, geologists established a timescale for the order of rock formation, although the exact amount of time taken was the subject of much debate.

Many religious authorities still held to the idea that the Earth was created in 4004 BCE, built upon Biblical timescales, but this started to fall out of fashion. Physicists such as Lord Kelvin, reasonably, assumed that the planet was less than 100 million years old, based upon models and calculations of rates of cooling. This was a reasonable assumption given that they had no way of knowing that radioactive substances buried in the mantle of the Earth generated huge amounts of heat. This was not rectified until the discovery of radioactive minerals in 1896.

Enlightenment Geology and Wealth

Geology in the Enlightenment was one of the most important of the sciences, not just for the way in that it finally banished Creationism, but also in the way that it generated wealth and quick returns. This enabled wealth to flow into Europe, providing the spark for the Industrial Revolution and allowing the promotion of pure science, letting great scientists and thinkers in other disciplines to flourish.

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