KHWARZIMIC SCIENCE SOCIETY

THE HISTORY OF ANCIENT GEOLOGICAL THOUGHT

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Meaning of geology

'Geology' is derived from the two Greek words, "geo" and "logos" respectively manning the "earth" and "discourse". Geology is the study of the physical history of the earth, its composition, it structure and the processes that form and change it.

The history of geology

The study of the earth as a modern science is only four or five generations old. Ancient scholars attempted to explain specific isolated phenomena, e.g., volcanic activity, tides and earthquakes and they tried to account for the origin of deltas, springs, rocks and gems and marine fossils found. Their explanations were ingenious and amazingly perceptive but they were not based on accumulation of data or the testing of theory against performance; hence they were not scientific. Yet they questions raised were no doubt, geological.

The ancient

Ancient people considered many geological features and processes as the artifact of gods and goddesses. They regarded the natural environment with fear and wonder mixed with mystery and superstition. Thus the ancient Sumerians, Babylonians and other peoples, although made remarkable discoveries in astronomy and mathematics, went astray in geological inquiries simply by personifying geological processes. Irish legends, for example suggest that giants were responsible for certain natural formations such as a weathered formation of basaltic columns, they coined as "Giant's Causeway". Such a mythology was also popular among the civilisations of the new world: for example, furrows on the flanks of what came to be known as the "Devil's Tower" in Wyoming, were thought by Native Americans, to be the claw marks of a giant beer. Towards the left is the Devil's tower and the right picture is of the Giant's Causeway. If you want to know more about them, click on the respective image.

MORE ABOUT THE DEVIL'S TOWER:

The legend says that Devil's Tower was created when a bear tried to kill a warrior and he ran up this gigantic rock or tree. The bear clawed and clawed away
trying to get up this stump, which is the reason for the vertical lines. The warrior ended up killing the bear with his last arrowed and of course therefore saved the universe.

MORE ABOUT THE GIANT'S CAUSEWAY:

The lunar landscape of the Giant's Causeway, lurking below the gaunt sea wall where the land ends, must have struck wonder into the hearts of the ancient Irish.
'When the world was moulded and fashioned out of formless chaos, this must have been the bit over - a remnant of chaos.' - Thackeray
Like the early people of North Antrim, Thackeray was very impressed by the strangeness of this place. Like other sophisticated visitors he had read that the Causeway is a geological freak, caused by volcanic eruptions, and cooling lava.

The Causeway proper is a mass of basalt columns packed tightly together. The tops of the columns form stepping stones that lead from the cliff foot and disappear under the sea. Altogether there are 40,000 of these stone columns, mostly hexagonal but some with four, five, seven and eight sides. The tallest are about 40 feet high, and the solidified lava in the cliffs is 90 feet thick in places.

Similarly in ancient Greece and Rome, many gods were identified with geologic processes. For example, they thought that the terrifying powers of volcanoes belonged to gods. they explained the awesome mountains through religious beliefs and folklore. The Romans thought that *Vulcan*, their god of fire and metalworking, kept his forge beneath a fire-breathing mountain on an island near Sicily.

The Greek philosopher *Thales of Miletus*, in the 6th century BC, has been credited with making the first clean break with this traditional mythologizing. He regarded geological processes as natural and orderly events that could be studied in the light of reason, rather than as supernatural interventions. The Greek philosopher *Democritus* advanced this naturalistic philosophy with the theory that all matter is composed of atoms. Building on his atomic theory, he offered rational explanations of all geologic processes: earthquakes, volcanic eruptions, the hydrologic cycle, erosion and sedimentation. His teachings as expounded by the Roman poet *Lucretius* in his poem "On the Nature of Things" can be readily found in English translation.

*Aristotle, t*he most influential natural philosopher of ancient times, recognized in the 4th century BC that fossil seashells embedded in sedimentary rock strata were similar to shells found along the beach. From this observation he surmised that the relative positions of land and sea must have fluctuated in the past, and he also realized that such changes would require great lengths of time.

Theophrastus, a pupil of Aristotle, contributed to geological thought by writing the first book on mineralogy, "Concerning Stones", in which the famous lapidaries were organized alphabetically.

Renaissance

The renaissance was truly a new beginning for the earth sciences - people began to observe geological processes much as the ancient Greeks had done. *Leonardo da Vinci*, who is better known as a painter and engineer was also the pioneer of natural science. He realized for example that landscapes are sculptured by erosive processes and that fossil shells in Apennine limestones were the remains of marine organisms that had lived on the floor of a former sea that must have extended over Italy.

Following Leonardo, the French Natural philosopher, *Bernard Palissy*, worked on the nature and scientific study of soils, groundwater and fossils. The classic works on minerals written in this period, however, were by *Georgius Agricola,* a German mining expert, who published *De Natura Fossilium (1546)* and *De Natura Metallica (1556).* Agricola recorded the most recent developments in the fields of geology, mining, metallurgy and mineralogy. He also classified fossils according to their known physical characteristics.

17th century

Nicolaus Steno stands prominent among the 17th century scientists. In 1669, he showed that the interfacial angles of quartz crystals were constant, regardless of shape and size of crystals and by extension, the interfacial structure of other crystal species should also be constant. Thus by drawing attention to the significance of crystal form, Steno laid the foundation of the science of crystallography. Steno's observations on the nature of rock strata led him to formulate the law of superposition and the law of horizontality - which together state that sediments must be deposited horizontally and the older layers must be at the bottom.

18th century

The maturity of geological science awaited the fulfillment of two conditions: a scientific approach and the development of other sciences to the level at which they could provide example and tools to the geologist. The first condition was met in the 18th century when *Abraham Gatlob Werner*, a professor at mining academy proposed to classify fossils (anything dug from the earth) according to their composition. His "Letztes Mineral System" (1817)classified minerals into four classes: earthy, saline, combustible and metallic. Only five years later, *Rene-Just Haiiy* wrote the "Treatise de Crystallographie" in which he regarded crystal structures as the basis of classification of minerals. With this approach, mineralogy took its place among the sciences.

Geologic thought during the 18th century was characterized by debates between contrasting schools. It was the fundamental nature of rock that engaged the attention of pioneer geologists during the period 1775-1825. One group led by Werner, held the opinion that the earth's crust is a series f layers derived from mechanical and chemical sedimentary deposits laid down by a vast ocean, in succession, in a regular sequence, just like the peels of an onion. This school earned the title of "Neptunists", after the god of sea. The other group was made up of sea workers who could not reconcile the Neptunists' views with their own observations. *Jean-Etiense Guettard* in 1752 and *Nicolas Desmarest* in 1765 affirmed the fiery origin of basalt and many other kinds of racks. They and their followers were dubbed the "Plutonists" after the god of the under-world. They believed that all rocks were solidified from a molten material and they were later on altered by other processes.

Werner's influence was great and the Neptunist theory squared with the generally conservative views of cosmogony, withheld the success of the Plutonist theory. Finally a disciple of the Neptunist theory, *Christian Leopold von Buch* migrated to the Plutonist camp and showed to the world the volcanic origin of many rocks, thus adding respect to the Plutonist views.

19th century

However both Plutonists and Neptunists believed that the processes by which the earth's crust had reached its present stage where often violent and abrupt. This view has since been called the "catastrophic" view. It was led by the French naturalist *Georgus Cuvier*. It favoured religion as it accorded, for example with the Biblical Deluge and with such experiencable phenomena such as earthquakes and eruptions.

Uniformitarianism

The head-on collision with catastrophism came with the publication of the book "Theory of the Earth" in 1795, written by *James Hutton*. He advanced the concept of "Uniformitarianism". The style of the book obscured the power of the concept till finally in 1802, *John Playfair* published "Illustrations of the Huttonian Theory of the Earth". Thereafter this viewpoint gained in acceptance and was fully established in *Sir Charle Lyell's* "Principles of Geology" that appeared in nearly 1820.

The theory of uniformitarianism can be considered as the watershed between old and modern geological science. It proposes that the processes that are still operating in the earth and which have been operative for millions of years account for how the earth exists today. These processes can be observed and tested even today. This necessitated drastic revisions in the age of the earth and other geologic processes - such as the destruction of mountains by erosion had been there for millions of years and had sculpted the modern landscape. This theory brought Lyell at loggerheads with theologists who believed that the earth was barely

4000 years old.

Minds had to be prepared for this and other revolutionary attacks by modern thought on time-honoured teachings and on what appeared to be common sense. Lyell became a major influence on modern geologic theory, courageously attacking theological prejudices concerning the age of earth and rejecting attempts to interpret geology in the blind imitation of the then adored Christian Scripture. Defence of uniformitarianism required field work, the assemblage of data, the aid of auxiliary sciences and brilliant theorizing and it required audacity. Using the sound approach of Hutton and Lyell, the geologists of the 19th century were able to advance their filed of knowledge at a rapid pace, having emerged from the morass of false assumptions.

A landmark was the contribution of the British civil engineer, *William Smith* (1769-1839), founder of the science of stratigraphy. He grasped the fact that fossils are the indicators of the relative ages of rock strata, and he may be credited with laying the foundations of historical geology. He also published the first geological map of England in 1815; 6 years earlier *William Maclure* (1763-1840) had published a geologic map of the USA. Cuvier during the same period published his work on fossils from a biologist's point of view. He thus laid the beginning of the science of paleontology.

A major puzzle facing the geologists was the origin of mountains and continents. One of the first Huttonians, as the followers of Hutton are called, to investigate this problem was *James Hall* (1811-1898). His field work resulted in the theory of geocynclines propounded in 1856 and this in turn raised the question as to how a geocyncline could eventually create a mountain range. As an answer, *Clarence J. Dutton* (1841-1912) proposed the theory of isostasy in 1889.

Many 19th century geologists came to appreciate the earth as a thermally and dynamically active planet, both internally and externally. Those known as "neocatastrophists" or "structuralists" believed that structural upheavals accounted for the formation of topographic features. Thus the English geologist, *William Buckland* and his followers postulated frequent changes of sea level and upheaval of landmasses to explain geological suspicions and breaks in stratigraphic sequence. Hutton, by contrast regarded earth's history in terms of overlapping successive cycles of geological activity. He regarded long belts of folded rocks as orogenic belts, taken to be the result of a variety of such cycles and referred to the process of mountain formation as a process of orogenesis.

Another important 19th century concept was the idea of glacial ages, presented in 1837 by *Louis Agassiz* of Switzerland. Evidences consisted of features obviously produced by glaciation.

20th century and plate tectonics

Technological advances in the 20th century provided new, sophisticated tools for geologists, enabling them to measure and monitor earth processes with a precision previously unattainable. In terms of basic theory, the field of geology underwent a major revolution with the introduction and development of the plate tectonics theory: that the earth’s crust is divided into a number of plates that have moved about, collided and separated over geologic time. This hypothesis is related to the concept of continental drift, first proposed in modern form by the German geophysicist *Alfred Wegener* in 1912. The hypothesis gained support later in the century as deep-sea exploration provided evidence for sea-floor spreading. Since then, the concept of plate tectonics has been related to the origin and growth of continents, the generation of continental as well as oceanic crust and the nature of the earth's underlying layers and their evolution throughout time. Thus 20th century geologists have developed a theory that unifies many of the major processes that have shaped the earth and its landforms.

The unknowns

In the 20th century, geology has matured as a science, yet finds itself still struggling with basic problems. Not only are the origins of continents and mountains in deep question, but also is the concept of isostasy not properly understood and accepted. The mantle is still undiscovered, though there have been attempts to probe into it in the form of presumptuous projects like the Mohole Project (an attempt to drill a hole that will reach the Mohovicic Discontinuity). The significance of the great ocean trenches, the tectonically active island arcs and the mid-oceanic ridge are still ill-understood. Then there is the mystery of the earth’s heat, which seems inadequately accounted for by such factors as crustal radioactivity, solar heating and an original molten state of the planet. It is still not positively known what has caused the glacial ages and whether we are now in an interglacial period that is to be followed by another ice age. The origin of certain granites remains a major problem in petrology. The lack of well-preserved fossils in rocks older than about a billion years - one-fifth of the earth's age - leaves the origin of life in almost complete obscurity. Although radioactive dating has offered a probably reliable estimate of the age of the earth, the processes that led to its formation - including the question whether the primordial planetary mass was hot or cold - are still matters of speculation.

On many fronts geology still faces tremendous unknowns

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