

Introduction and Scope

1.1 INTRODUCTION TO GEOLOGY

Geology (in Greek, Geo means Earth, Logos means Science) is a branch of science dealing with the study of the Earth. It is also known as earth science. The study of the earth comprises of the whole earth, its origin, structure, composition and history (including the development of life) and the nature of the processes. The word was first used in 1778 in the work of Jean Andrea de Luc (a Swiss-born scientist who lived at Windsor for much of his life as adviser to Queen Charlotte) and at much the same time in the work of Swiss Chemist, S.B. Saucer.

Geology is a fascinating subject.

Geology feels the pulse of the earth.

Geologists contribute their part to the nation through the discovery of new deposits of rocks and minerals of economic value.

A student should know what lies beneath the crust and how long back the earth came into existence.

1.2 DIFFERENT BRANCHES OF GEOLOGY

For studying the earth in detail, the subject of Geology has been divided into various branches as follows:

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|---------------------------|--------------------------------|
| (i) Physical Geology | (ix) Economic Geology |
| (ii) Crystallography | (x) Mining Geology |
| (iii) Mineralogy | (xi) Civil Engineering Geology |
| (iv) Petrology | (xii) Hydrology |
| (v) Structural Geology | (xiii) Indian Geology |
| (vi) Stratigraphy | (xiv) Resources Engineering |
| (vii) Paleontology | (xv) Photo Geology |
| (viii) Historical Geology | |

(i) Physical Geology

As a branch of geology, it deals with the “various processes of physical agents such as wind, water, glaciers and sea waves”, run on these agents go on modifying the surface of the earth continuously. Physical geology includes the study of Erosion, Transportation and Deposition (ETD).

The study of physical geology plays a vital role in civil engineering thus:

- (a) It reveals constructive and destructive processes of physical agents at a particular site.
- (b) It helps in selecting a suitable site for different types of project to be under taken after studying the effects of physical agents which go on modifying the surface of the earth physically, chemically and mechanically.

(ii) Crystallography

As a branch of geology, it deals with ‘the study of crystals’. A crystal is a regular polyhedral form bounded by smooth surfaces.

The study of crystallography is not much important to civil engineering, but to recognize the minerals the study of crystallography is necessary.

(iii) Mineralogy

As a branch of geology, it deals with ‘the study of minerals’. A mineral may be defined as a naturally occurring, homogeneous solid, inorganically formed, having a definite chemical composition and ordered atomic arrangement. The study of mineralogy is most important.

- (a) For a civil engineering student to identify the rocks.
- (b) In industries such as cement, iron and steel, fertilizers, glass industry and so on.
- (c) In the production of atomic energy.

(iv) Petrology

As a branch of geology it deals with ‘the study of rocks’. A rock is defined as “the aggregation of minerals found in the earth’s crust”.

The study of petrology is most important for a civil engineer, in the selection of suitable rocks for building stones, road metals, etc.

(v) Structural Geology

As a branch of geology, it deals with ‘the study of structures found in rocks’. It is also known as tectonic geology or simply tectonics.

Structural geology is an arrangement of rocks and plays an important role in civil engineering in the selection of suitable sites for all types of projects such as dams, tunnels, multistoried buildings, etc.

(vi) Stratigraphy

As a branch of geology it deals with ‘the study of stratified rocks and their correlation’.

(vii) Paleontology

As a branch of geology, it deals with ‘the study of fossils’ and the ancient remains of plants and animals are referred to as fossils. Fossils are useful in the study of evolution and migration of animals and plants through ages, ancient geography and climate of an area.

(viii) Historical Geology

As a branch of geology, it includes “the study of both stratigraphy and paleontology”. Its use in civil engineering is to know about the land and seas, the climate and the life of early times upon the earth.

(ix) Economic Geology

As a branch of Geology, it deals with “the study of minerals, rocks and materials of economic importance like coal and petroleum”.

(x) Mining Geology

As a branch of geology, it deals with “the study of application of geology to mining engineering in such a way that the selection of suitable sites for quarrying and mines can be determined”.

(xi) Civil Engineering Geology

As a branch of geology, it deals with “all the geological problems that arise in the field of civil engineering along with suitable treatments”. Thus, it includes the construction of dams, tunnels, mountain roads, building stones and road metals.

(xii) Hydrology

As a branch of geology, it deals with “the studies of both quality and quantity of water that are present in the rocks in different states”(Conditions). Moreover, it includes:

- (a) Atmospheric water,
- (b) Surface water, and
- (c) Underground water.

(xiii) Indian Geology

As a branch of geology, it deals with “the study of our motherland in connection with the coal/petroleum, physioigraphy, stratigraphy and economic mineral of India”.

(xiv) Resources Engineering

As a branch of geology deals with “the study of water, land, solar energy, minerals, forests, etc. fulfill the human wants”.

(xv) Photo Geology

As a branch of geology deals with “the study of aerial photographs”.

1.3 RELATIONSHIP OF GEOLOGY WITH OTHER BRANCHES OF SCIENCE AND ENGINEERING

In order to carry out civil engineering projects safely and successfully, geology should be related to the other branches of bordering sciences as described as follows:

1. Geochemistry

As a branch of science, it deals with geology in such a way that it concerns with the abundance and distribution of various elements and compounds in the earth.

2. Geophysics

As a branch of science, it is related with geology in such a way that it concerns with the constitution of the earth and the nature of the physical forces operating on with in the earth.

3. Geohydrology

As a branch of science, it is related with geology in setting of ground water. In other words, Geohydrology is an “interaction between Geology and Hydrology”.

4. Rock Mechanics

As a branch of science, it is related with geology in dealing with the behaviour of rocks that is subjected to static and dynamic loads (force fields).

5. Mining Engineering

Geology is related to mining engineering in dealing with the formation and distribution of economic minerals and response to fracturing processes. With out the knowledge of structural features of rock masses and mode of occurrence and mineral deposits, a mining engineer cannot determine the method of mining.

6. Civil Engineering

Before constructing roads, bridges, tunnels, tanks, reservoirs and buildings, selection of site is important from the viewpoint of stability of foundation and availability of construction materials. Geology of area is important and rock-forming region, their physical nature, permeability, faults, joints, etc. Thus, geology is related to civil engineering in construction jobs with economy and success.

1.4 IMPORTANCE OF GEOLOGY FOR CIVIL ENGINEERING

The role of geology in civil engineering may be briefly outlined as follows:

1. Geology provides a systematic knowledge of construction materials, their structure and properties.
2. The knowledge of Erosion, Transportation and Deposition (ETD) by surface water helps in soil conservation, river control, coastal and harbour works.
3. The knowledge about the nature of the rocks is very necessary in tunneling, constructing roads and in determining the stability of cuts and slopes. Thus, geology helps in civil engineering.
4. The foundation problems of dams, bridges and buildings are directly related with geology of the area where they are to be built.
5. The knowledge of ground water is necessary in connection with excavation works, water supply, irrigation and many other purposes.
6. Geological maps and sections help considerably in planning many engineering projects.

7. If the geological features like faults, joints, beds, folds, solution channels are found, they have to be suitably treated. Hence, the stability of the structure is greatly increased.
8. Pre-geological survey of the area concerned reduces the cost of engineering work.

1.5 SCOPE OF GEOLOGY

Engineering Geology: A well established interdisciplinary branch of Science and Engineering has a scope in different fields as outlined below:

- (a) *In Civil Engineering:* Geology provides necessary information about the site of construction materials used in the construction of buildings, dams, tunnels, tanks, reservoirs, highways and bridges. Geological information is most important in planning phase (stage), design phase and construction phase of an engineering project.
- (b) *In Mining Engineering:* Geology is useful to know the method of mining of rock and mineral deposits on earth's surface and subsurface.
- (c) *In Ground Water:* Resources development geology is applied in various aspects of resources and supply, storage, filling up of reservoirs, pollution disposal and contaminated water disposal.
- (d) Land pollution.
- (e) Nuclear explosion.
- (f) Oceanography.
- (g) Space exploration.

In each of the above-mentioned fields Geology has to deal with an integral part of the earth.

1.6 EARTH AS A PLANET

The earth is a planet belonging to the solar system of the Milky Way Galaxy, with a natural satellite, the moon. It is the third planet from the Sun. The planet on which we live is called the earth. There is a lot of disagreement between the scientists regarding the shape of the earth. In recent times a new phrase being used is that the earth is like a GEOID (Greek, GEO = earth, OID = like) i.e., our planet is like the earth. They believe that the interior of the earth is shrinking day by day. This shrinkage may be either due to loss of heat or reorganization of molecules under enormous pressure and high temperature. It is thus obvious that the outer portion must shorten its circumference to adjust the shrunken interior.

Table 1.1 Chart of the diameter and the area of the earth, according to the present state of knowledge about it

Equatorial Diameter	12,757 kms	7,926.7 miles
Polar Diameter	12,714 kms	7,900.0 miles
Floor area of the Sea 70.78%	381 million sq. kms	139.4 million sq. miles
Area of the Land	149 million sq. kms	57.5 million sq. miles
Total	510 million sq. kms	196.9 million sq. miles

1.7 STRUCTURES AND COMPOSITION OF EARTH

The outer envelopes of the gaseous material surrounding the earth are called atmosphere. Under the atmosphere is our earth on which we live. That part of the earth, which is in the form of a land, is known as the earth's crust. It also includes the highest peaks of mountains and floors of the oceans. Part of the land, which is visible on the Globe, is called the Lithosphere (Greek, Litho = Stone).

We know that nearly 75 per cent of the whole surface of the earth is covered with natural waters like oceans, seas, lakes, rivers etc. Which is in the form of more or less, a continuous envelope around the earth. This envelope of water is called Hydrosphere (Greek, Hudous = Water). Thus, Lithosphere and Hydrosphere in a combined form is known as the Earth's crust. Under the Earth's crust is the interior of the Earth. It is further sub-divided into three shells. Depending upon the nature, the material is made up as shown in the Fig. 1.1.

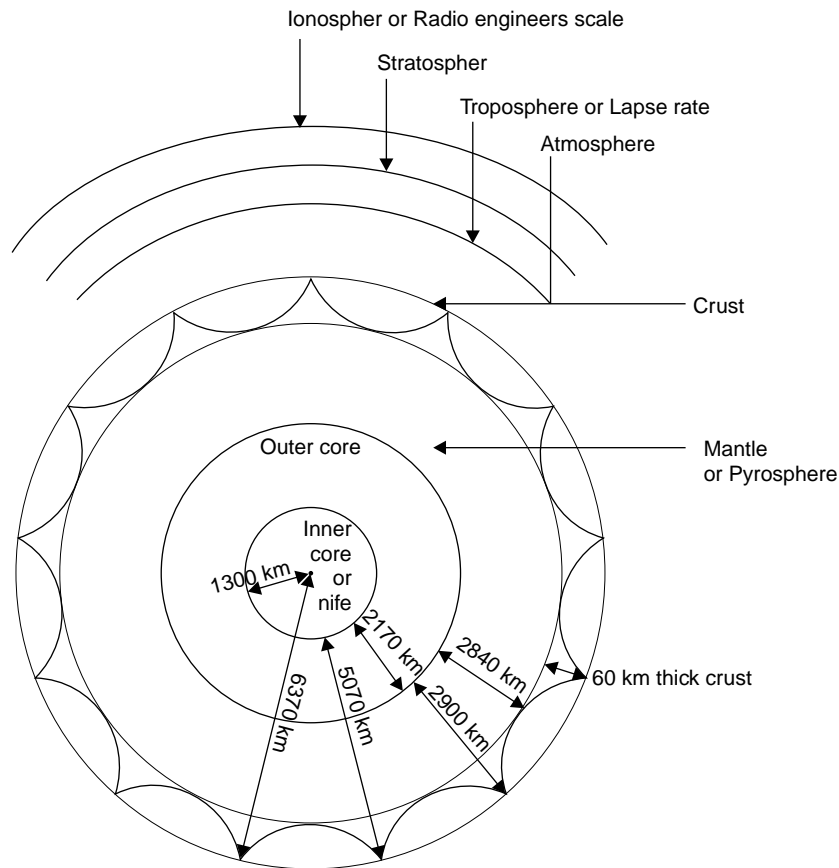


Fig. 1.1 (a) Exhibiting the earths interior as well as exterior

The earth is composed of different rocks. In an ordinary sense the term rock means something hard and resistant but the meaning of the word has been extended so as to include all natural substances of the Earth's crust, which may be hard like granite or soft like clay and sand. It has been estimated that 95 per cent of the Earth's crust is made up of primary i.e., first formed (Igneous) rocks which is mostly composed of Granite having Quartz, Feldspar, Biotite mica and Hornblende in varying proportions the

remaining 5 per cent of the crust is made up of Secondary (Sedimentary or Metamorphic) rocks (as shown in Fig. 1.2). The Earth's crust is in the form of a very thin layer of solidified rocks and is heterogeneous in nature. These rocks may be classified on the basis of their density into the following two groups:

1. Sial (Si = Silicon and Al = Aluminium) having density 2.75 to 2.90.
2. Sima (Si = Silicon and Ma= Magnesium) having density 2.90 to 4.75.

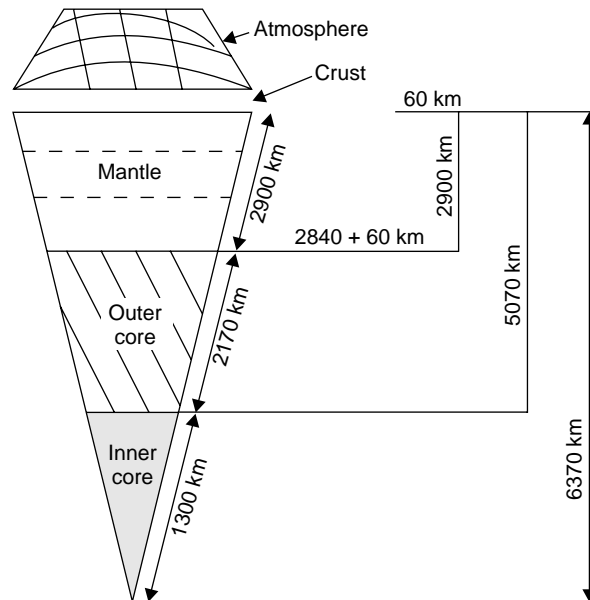


Fig. 1.1 (b) Diagram of a wedge of earth showing the major zones and boundaries

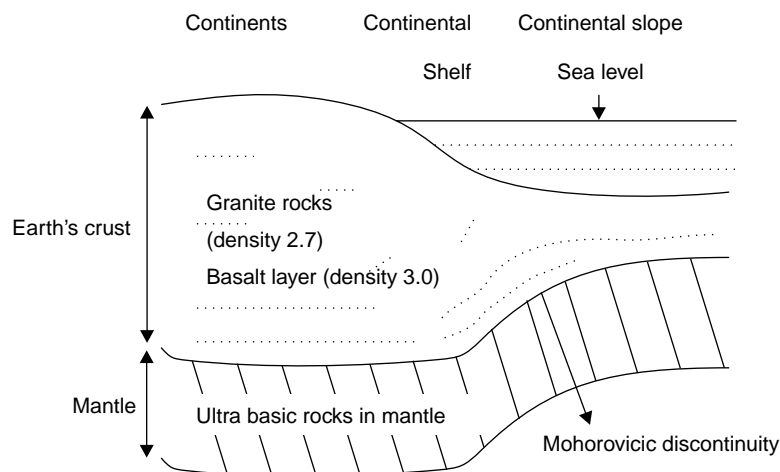


Fig. 1.2 Diagram showing the X-Section of continent and ocean basins

It has been estimated that the Sial rocks are about 70 per cent of the Earth's crust, which include chiefly Granite and Silica. These rocks are generally on the upper regions of the crust.

Sima rocks include heavy and dark coloured rocks like Basalts. In these rocks, the percentage of Silica is reduced and Magnesium attains the next importance in place of Aluminium of Sial rocks. These rocks are generally found on the floors of the Oceans and beneath sial rocks.

Mantle: It is the part of the earth below the crust and surrounding the core. The imaginary line that separates the lithosphere from the mantle is known as 'Moho' (Mohorovicic discontinuity). Because of high temperature and great pressure, the mineral matter in this part is the molten condition.

Core: It is the innermost layer of the earth; it extends from below the mantle (Gutenberg discontinuity) to the central part of the earth. On the basis of earthquake waves, the core has been further divided into two cores.

(a) Outer core

(b) Inner core

The outer core is 2,250 km thick and surrounds the core. It is believed that it is still in molten condition.

The inner core is also called 'Nife' because it consists of Nickel and iron. Its thickness is about 1,228 km. It is very hard in nature.

Table 1.2 Thickness and composition of different layers of the earth

<i>Layers of the earth</i>	<i>Thickness</i>	<i>Composition</i>
1. Crust: Sial Sima Moho (Mohorovicic Discontinuity)	0 – 60 km	Silicon, Aluminum Silicon, Magnesium
2. Mantle or Pyrosphere Lower Mantle Upper Mantle	60 – 2900 km Gutenberg Discontinuity	Silicon, Magnesium, Iron and Nickel
Core or Barysphere Outer core or Mesosphere Inner core or Nife	2900 km to 5150 km 5150 km to 6378 km	Nickel and Iron

1.8 HIGHLIGHTS

- Geology as a branch of Natural Science is concerned with the Earth's surface as well as sub-surface.
- Geology as a wide tree has the several branches such as Physical Geology, Crystallography, Mineralogy, Petrology, Structural Geology, Stratigraphy, Paleontology, Indian Geology, Civil Engineering Geology and Mining Geology.

- Geology plays a vital role in the field of civil engineering and choosing suitable sites for reservoirs and in the construction of dams, tunnels and mountain roads, etc.

QUESTION BANK

1. How is Geology related to engineering? Discuss the scope and application of the geological knowledge in planning and execution of civil engineering works.
2. Give different branches of Geology and their application to engineering. Discuss the importance of geology in the field of civil engineering.