

CHAPTER

1

# GEOLOGY AS A DISCIPLINE

## *Introduction*

**E**arth is a unique planet in which life exist. *Geology* is the branch of science which studies the planet earth, its origin, structure, history, interior and exterior, the different processes and their effects etc. This unit introduces *Geology* as a major branch of Earth science.

Earth science empowers people to think globally and act locally. People who understand how Earth systems work can make informed decisions about issues important in their lives as individuals and citizens. They can resolve issues related to clean water, urban planning and development, floods, tsunamis, earth quakes, landslides, volcanisms, national security, global climate change, disposal of waste, production of adequate food materials, protection of environment and biodiversity and the efficient and scientific use and management of natural resources.

An informed society, conscious of our complex relationships with our planet, recognizes the importance of and insists on Earth science education at all grade levels - elementary, secondary, adult and higher education. Earth science problems and issues are ideally suited for an inquiry based education approach. Earth science education also improves critical thinking skills of the learners by offering them a historical perspective and improving their ability to predict future events. By understanding earth processes that happen now, one can look for evidence of what happened in the past. This connects learners to the past, as well as challenging them to think about the future- an educational process that most closely fulfills the reality of scientific outlook. ┘

**Values/Attitude:** •Through this unit, the teacher shall inculcate in the learner, scientific tempo and values • Cultivation of scientific values • Creation of social commitment • positive attitudes towards protection of environment and nature

**Time: 12 Periods**

Concept/Content/Ideas	Process/Activities	Learning Outcome
<p>Meaning of Earth Science, Geology as a discipline</p> <ul style="list-style-type: none"> <li>✓ Communication skill</li> </ul> <p>Divisions of Geology</p> <ul style="list-style-type: none"> <li>✓ Presentation skill</li> </ul> <p>Geology and human society</p> <ul style="list-style-type: none"> <li>✓ Skill of inference</li> </ul> <p>Institutions and Organizations related to Geology</p> <ul style="list-style-type: none"> <li>✓ Recognition skill</li> </ul>	<p>Brief introduction by the teacher about the nature of science, planet earth and Geology.</p> <p>A general discussion is conducted on different branches of earth science and preparation of a discussion note (to portfolio).</p> <p>A brain storming session on various objects or areas of the study of earth such as minerals, rocks, water etc. (to process and portfolio assessment)</p> <p>A group discussion on application of rocks, minerals, water, fuels, technologies etc. in the daily life and how it helps to the development of the country and in the service of humanity. Learner prepares a note on the role of geology in serving humanity (to portfolio)</p> <p>Quiz, slide show on various geological organizations of the country and the state.</p>	<ul style="list-style-type: none"> <li>• Explains the meaning of Earth Science and identifies geology as a discipline of science.</li> <li>• States the various branches of geology</li> <li>• Describes the role of geology in human society</li> <li>• List out the major organizations of the country related to geology</li> </ul>

## Towards the Unit

### Unit Analysis

#### 1.1 Branches of Geology

The teacher introduces the topic by providing an opportunity to arouse interest in the subject and review the concepts related with geology as discipline of Earth science.

#### Suggested activity

##### **Brain storming and discussion**

Learners are directed into a brain storming session on the various aspects of the subject so that respective areas of study related with Geology can be familiarized.

The brain storming begins after writing up a key word/ phrase such as rock, water and fossils. The teacher welcomes as many as responses as possible in order to ignite active discussion in the session. No response shall be told as wrong. Every response should be accepted. Allow them to tell their ideas irrespective of its relevance with the field of Geology. Areas coming within the study of Geology are highlighted. These areas are then linked to their corresponding branches as given below

Water-Hydrogeology

Rocks- Mineralogy

Teacher then exhibits a chart showing the study areas (branches) and their corresponding dimensions/aspects /materials / processes of the earth. Teacher unfolds the vastness and breadth of the subject and focuses on the scientific nature of the discipline.

#### 1.2 Geology and human society

Geology and geologists have a great role to play in the service of human society. It can resolve issues surrounding the use and management of mineral, water, soil and energy resources, mitigation and management of natural hazards, planning and execution of civil engineering projects, environmental protection, understanding the functioning of Earth system and so on.

## Suggested activity



### Group discussion

In this learners share their experiences, ideas and opinions with each other. They get more chances to talk in groups. Shy learners are more likely to feel comfortable expressing their ideas in these more intimate setting. The teacher introduces the topic, highlighting the significance of the topic and its key areas. The various aspects related with discussion points may be pinpointed. To initiate the discussion on the topic, teacher asks a few questions such as

What are the environmental issues that we face today?

How can we manage natural disasters?

How can we get metals that form the backbone of modern industries?

In order to work together and produce a group product, the teacher divides the whole class into some groups. Discussion points are given as mentioned below, for an example

- Understanding earth processes
- Prospecting and exploration of minerals
- Role of geology in civil engineering
- Locating ground water resources
- Disaster management
- Conservation of Earth resources
- Environmental protection
- Industrial development and its harmful impacts

The groups collect information regarding the topic using the text material. When discussion begins, the teacher can use some lead points so that the members can contribute their ideas in the group. Reference materials other than text book can be suggested. The seating arrangements may be organized in a way that all members are able to see each other in a circular or square formation.

The teacher may provide additional support materials needed, in order to ensure the desired outcome. Teacher checks the interaction of members within each group and provide tutorial assistance when and where necessary. The learners are prompted to write down things that the earth scientists can serve for humanity. Teacher circulates and monitors the progress of the

learners in each group. Stimulate the discussion if it begins to stagnate. Participation of all learners should be assured. Keep the background of the learners in mind and sufficient time should be allowed to explore learners' own ideas regarding the topic. Each learner should be accountable for accomplishing the tasks assigned.

Each group leader or representative presents the consolidated ideas of the group. The group discussion is followed by a general discussion in which, learners are allowed to raise their doubts regarding the topic. The whole class is then allowed to present their ideas regarding the significance of earth science to human society. Ensure contribution of all the learners. Draw out also those learners who lack confidence.

The teacher provides feedback of the activity and consolidates the discussion highlighting the role of geology and earth scientists in serving humanity. The summaries of the discussions should be noted down in the activity log by the learners.

### Repository of activities

1. Presentation of the functions, services and activities carried out by various geological organizations of the country searching and collecting data from their websites
2. General discussion on the role of geologists and earth scientists in serving humanity

### Sample questions

1. Which one of the following is not a branch of Earth Science?  
(Geology, Oceanography, Archaeology, Meteorology)
2. Pick the odd one out  
(Historical geology, Palaeontology, Astronomy, Stratigraphy)
3. Fill in the blanks using the hints given
  - (a) Study of rocks : Petrology
  - Study of layered rocks : .....
  - (b) Landforms : Geomorphology
  - Rock structures : .....
4. Make appropriate pairs from the following  
(Minerals, Fossils, Petrology, Mineralogy, Hydrogeology, Palaeontology, Rocks, Water)

5. Name the following
  - a. An institution in Kerala that assists the state government in matters of framing policies for optimum land use
  - b. An organisation in India that carries out exploration of mineral deposits required for nuclear power programme of the country
6. Match column A with B and C

<b>A (Organization)</b>	<b>B (Function)</b>
G S I	Petroleum Exploration
N R S C	Survey and Exploration
O N G C	Scientific Research
C E S S	Remote Sensing

7. Name any three geological resources that satisfy the physical needs of human society
8. Distinguish between Economic geology and Environmental geology
9. List out two geological organizations that are functioning in Kerala
10. How does geological knowledge help the industrial growth of a nation?

## references

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CHAPTER

2

## ORIGIN AND STRUCTURE OF THE EARTH

### *Introduction*

**G**eology, the science of the earth, is mainly concerned itself with the study of the earth's structure, history, constituents, origin and evolution etc. The earth is a member of the Solar System. The study of every object of the solar system provides clues regarding the origin of our planetary system and its evolution. Therefore a study of the solar system enables us to understand the history of the planet earth, in a better manner.

One of the unique features of Earth is that each of the planet's three major realms are in constant motion and in perpetual change. The atmosphere and the hydrosphere move in dramatic and complex ways. Movement, growth, and change in the biosphere are readily appreciated. Earth's seemingly immobile lithosphere is also in motion, and it has been so throughout most of its history. The existence of life depends on the interaction of these four spheres.



The scientists peered into Earth's depths using indirect methods. They traced the paths of earthquake-generated seismic waves, measured the amount of heat that escapes from inside earth and they discovered how the earth's mobile interior is churning slowly and how such movements affect processes that takes place on the surface of the planet. The internal layers of the Earth identified on the basis of composition are crust, mantle and core. The major internal layers classified on the basis of physical properties are lithosphere, asthenosphere, mesosphere, outer core, and inner core. Materials within each of these units are in constant motion, making earth a ever changing, dynamic planet. Through this unit, the learners are expected to develop an all-encompassing view of how the Earth operates as a constantly changing dynamic system. ┘

**Values/Attitude:** • Creating awareness about the interrelationship of land, water, air and living beings and sustainable development

**Time: 28 Periods**

Concept/Content/Ideas	Process/Activities	Learning Outcome
<p>Solar System Astronomical Unit Milky way galaxy. ✓Observation skill ✓Skill to analyse things Origin of the Universe - Big bang theory, Origin of the Earth- Nebular and Planetesimal hypotheses ✓Skill of comprehension ✓Skill to form hypothesis ✓Skill of logical and rational thinking and reasoning Shape and Size of the Earth ✓Recognition skill Geologic Time ✓Skill to sequence things Interior of the Earth ✓Comprehension skill ✓Illustration skill</p> <p>Earth System components ✓Skill of presentation ✓Skill to establish cause and effects ✓Skill of prediction and inference</p>	<p>Video Observation of solar system and all features related to it. Use of multimedia and internet access for getting astronomical concepts (process assessment) Video, diagrams, demonstration using a dotted balloon, discussion, debate and preparation of notes in activity log (to portfolio)</p> <p>Demonstration with globe</p> <p>Demonstration with Chart.</p> <p>Group activity with a boiled egg and construction of a model of internal structure of earth (to process and portfolio assessment). A seminar regarding various components of the earth system and preparation of a seminar report (to portfolio) (Presentation in seminar is considered for process assessment)</p>	<ul style="list-style-type: none"> <li>• Discusses the general characteristics of the members of the solar system</li> <li>• Describes the origin of the universe in the light of the big bang theory.</li> <li>• Explains the origin of the earth based on the nebular and planetesimal hypotheses</li> <li>• Realizes the true shape and size of the Earth.</li> <li>• Compares the relative time units of the Geologic Time Scales</li> <li>• Illustrates the internal structure of the earth</li> <li>• Appraises the characteristic features of the basic components of the earth system- atmosphere, hydrosphere, lithosphere and biosphere</li> </ul>

## Towards the Unit

 Unit Analysis

## 2.1. Origin and Evolution of the Universe

## Suggested activity

**Demonstration and discussion****Introductory activity**

The Big Bang is the name of a widely held scientific theory of the evolution of the universe. The theory states that the present day universe came into being as a result of very rapid expansion subsequent to a tremendous explosion, from its highly compressed primordial state, which resulted in a significant decrease in density and temperature. To understand this theory, start by picturing the universe expanding steadily.

Through this activity, the learners are expected realise that galaxies are moving and that the universe is expanding.

Materials needed:- round balloon, mirror, and black marker.

**Procedure:**

- (1) Inflate the balloon a small amount until it is about the size of a softball.
- (2) While holding the partially inflated balloon, place about fifteen random dots on the balloon.
- (3) Stand in front of the mirror and observe the expanding balloon to a larger size.

As the balloon is inflated in front of the mirror, the dots all move away from each other. Learners will observe that some dots move more or farther apart than others, but they will see that no dots get closer together. Most astronomers believe that the galaxies in the universe are moving away from each other in a similar fashion to the dots on the balloon. Also similarly to the dots of balloon, astronomers also came to know that not all galaxies are moving apart at the same rate. It was determined by Dr. Edwin Hubble in 1929 that the farther away a galaxy is, the faster it appears to move away from Earth. Because no two galaxies appear to be getting closer as they move (just like the dots on the expanding balloon), scientists hypothesize that the universe is expanding.

## 2.2 The internal structure of the earth

### Suggested activity

#### Demonstration

#### Introductory activity

According to the chemical composition of the rocks, earth's interior can be differentiated into broadly into three layers - crust, mantle, and core. Some portions of these layers are relatively harder or softer than adjacent layers, even though they have the same composition. This is because they exist at environments of different pressures and temperatures.

#### Materials needed:-

- Hard-boiled egg, plastic knife

#### Procedure

First, ask students what is represented by a globe. Explain to them that a globe is a model of the Earth. Present a model of the Earth's interior. Ask learners how they think scientists know what the Earth is made of. Explain that the Earth is made of three main layers: crust, mantle, and core. Draw them on the black board using colored chalk. Explain that the core is divided into two layers: solid inner core and liquid outer core. Ask learners how scientists came to know about the liquid and solid nature of the two layers. Tell them that the layer forming the crust is composed of several pieces. Scientists refer to these pieces as crustal plates or lithospheric plates. The plates are not geographically stationary but move relative to one another. This phenomenon is called plate tectonics. Now use an egg as a model of the Earth's interior.

1. Ask the students what part of the Earth the eggshell corresponds to
2. Ask the students to gently tap the egg on the table to produce cracks all around the egg shell . Ask them, with respect to the Earth what is roughly equivalent to the pieces of the egg shell
3. Show the students to cut the egg to get a cross section of the egg.
4. Ask students to name the different layers of the Earth's interior using the egg as a model that represents the Earth.

It is worthy to explain that the egg has one inner section (yolk) whereas the Earth's core comprises a solid inner core and a liquid outer core.

### 2.3. Basic components of the Earth system

The Earth-system concept treats earth as an integrated whole. It provides a physical basis for recognizing the working of the Earth. The Earth system science is a new approach to seek a deeper understanding of the physical, chemical biological and human interactions of the planet Earth. The major components of the earth system are the lithosphere, the hydrosphere, the atmosphere, and the biosphere.

#### Suggested activity

##### Conducting a seminar

A seminar can be arranged for an in-depth analysis of the topic. The teacher shall introduce the topic and its significance in the study of the earth by conducting a general discussion.

##### Planning

Planning of the seminar shall be done collectively by the teachers and learners. Groups of learners are formed to collect details on special aspects of the topic of study. The sub topics of the seminar are identified as lithosphere, atmosphere, hydrosphere, cryosphere and biosphere. The sub topics are assigned to concerned groups.

##### Data collection

The teacher suggests various sources for the collection of relevant information regarding the topic. Data collection from reference books and authentic sites shall be encouraged. Provide ample time for the students for collection of data from library books, journals, and media.

##### Preparation of seminar papers

Based on the information collected, the group members prepare a draft seminar paper. It shall be prepared only after a careful study. All the relevant aspects related with the nature and characteristics, physical and chemical behaviors, movement of energy and matter related with each components of the Earth system, their mutual interactions, systemic function etc. are to be dealt in detail. Active participation of the members of the group should be ensured by the teacher and the leaders of each group. The draft paper is submitted to the teacher for comments. The comments made by the teacher can be subjected to group

discussion and later a finalized seminar paper can be prepared. The seminar papers prepared by the groups are to be corrected by the teacher before their presentation in the whole class. Teacher shall encourage the students to prepare seminar papers with the help of modern audi-visual technologies by making slides and using movies, animations and pictures related with topics concerned.

### **Presentation of the seminar paper**

One of the members from each group or the group leader shall present the seminar paper in the class. Each presentation is followed by a general discussion which may be led by a moderator elected from the class. Learners may be permitted to raise doubts or provide supplementary information or ideas . Each learner should get an opportunity to participate in the discussion and their doubts should be cleared. The moderator sums up all the deliberations made in the session. The teacher consolidates the discussion, incorporating all the relevant points in mind. All the learners are asked to note the relevant points that appear as an outcome of the discussion conducted during the seminar.

### **Preparation of seminar report**

The teacher, peer groups and learners should evaluate the progress of the seminar. Each learner should thus prepare a seminar report covering the ideas emerge during the discussion. The planning, data collection, preparation of seminar paper, participation in groups, presentation and interaction during the conducting of seminar are all considered for process assessment. The seminar report prepared and kept by each learner is also considered for portfolio assessment.

### **Repository of activities**

1. Making a model or chart of the solar system
2. Preparation of diagrams in groups showing evolution of various stages of the solar system according to nebular and planetesimal hypotheses. A debate and a discussion can be conducted to highlight the merits and drawbacks of these two hypotheses.
3. Arranging a visit to a planetarium ,viewing movies and videos showing members of solar system, galaxies and other features of the universe
4. Exploring the universe using movies or internet facilities and showing the Sun's place , direction of rotation and location of spiral arms of the Milky Way galaxy etc.

5. Preparation of diagram showing various layers of atmosphere and demonstration using chart with diagram
6. Hydrologic cycle- video, chart with diagram. Conducting a debate on how human activities affect the hydrologic cycle.
7. Discussion - how the sub systems of the earth / geo spheres are interconnected?

**Self assessment tool for the learner**

Sl. No	Evaluation Item	Very well	Some what	No idea
1	I know the identification features of planets and their classification.			
2	I can describe the Big Bang Theory, related to the origin of the universe.			
3	I can also describe the Nebular Hypothesis and Planetesimal Hypothesis regarding the formation of solar system.			
4	I know the difference between meteors and meteorites			
5	I can draw and label the structure of earth.			
6	I am aware of the fundamental difference between a geoid and an oblate ellipsoid.			
7	I can name the divisions of geological time such as eon, era, period and epoch .			

**Peer group Evaluation**

(To be performed by the peer groups of the learner)

Sl. No	Evaluation Item	Response of learner	Remarks of peer learner
1	What is the basis of classification of planets of the solar sytem ?		
2	What term is applied for the present day fragments of planets that once existed in our solar system?		

3	What is the term used to describe the true shape of the earth?		
4	Can you name the icy zone in the solar system beyond the planet Neptune?		
5	Name the layer of earth that occur just below the lithosphere?		
6	Which are the three types of meteorites?		
7	Name the layer of atmosphere that exceeds 85 km above the earth surface?		
8	What divisions of the atmosphere are known as Homosphere and Heterosphere?		

### Teacher Evaluation

Sl No	Evaluation Item	Yes	No
1	The learner is able to describe the different views regarding the origin of universe.		
2	Learner is able to list out the characteristics of each planet of the solar system.		
3	The learner can describe the structure of earth's interior based on the chemical composition as well as on physical behaviour.		
4	Learner is aware of the importance of green house effect.		
5	Learner can draw a diagram of the hydrological cycle and can point out its components.		



## CONTINUOUS EVALUATION ITEMS

### Assignment:

1. Conducting seminar on origin of the universe or origin of the solar system and structure of Earth's atmosphere (portfolio assessment)
2. Preparing a model of
  - A. Solar system using suitable scheme (ie., AU = 5 cm.),
  - B. Internal structure of the earth using low cost materials (process assessment).
3. Conducting quiz about the topics such as the sun, planets, satellites, etc. (unit assessment).
4. Preparing a chart of geological time scale (portfolio assessment).
5. Written test incorporating multiple choice questions prepared by the teacher and the learners. (unit assessment)

### Sample questions

1. Which of the following combinations are all considered to be gas giants / Jovian planets?
  - a. Mercury - Mars - Saturn - Jupiter
  - b. Mars - Venus - Earth - Jupiter
  - c. Moon - Venus - Mars - Earth
  - d. Jupiter - Saturn - Uranus - Neptune
2. The layer of the Earth having the greatest density is the
  - (1) \_\_\_\_\_. It is very dense because it contains a lot of
  - (2) \_\_\_\_\_.
  - a. (1) Crust; (2) Silicon
  - b. (1) Mantle; (2) Magnesium
  - c. (1) Outer core; (2) Silicon
  - d. (1) Inner core; (2) Iron
3. Which of the Earth's internal layers is completely liquid?
  - a. Lithosphere
  - b. Asthenosphere
  - c. Outer core
  - d. Inner core

4. A layer of ozone in the----- layer absorbs ultraviolet light from the sun
  - a. Troposphere
  - b. Stratosphere
  - c. Mesosphere
  - d. Thermosphere
5. Choose the correct arrangement of the divisions of geologic time scale.
  - a. Periods, Eras, Eons, Epochs
  - b. Periods, Eons, Epochs, Eras
  - c. Eons, Eras, Periods, Epochs
  - d. Eons, Epochs, Eras, Periods
6. Which of the following shows Earth's internal layers in their correct order from the surface towards the centre?
  - a. Lithosphere, Asthenosphere, Mesosphere, Outer core, Inner core
  - b. Inner core, Mesosphere, Lithosphere, Asthenosphere, Outer core
  - c. Inner core, Outer core, Mesosphere, Lithosphere, Asthenosphere
  - d. Asthenosphere, Mesosphere, Lithosphere, Inner core, Outer core
7. Differentiate between the terms meteor and meteorite
8. The lithosphere is made up of:
  - a. weak and ductile layer of the mantle that behaves plastically
  - b. the crust and the uppermost part of the mantle
  - c. the crust and the entire mantle
  - d. continental crust and oceanic crust only
9. Name the following
  - a. Heavenly bodies which have their orbits in between Mars and Jupiter
  - b. The part of the Geosphere where frozen water and ice exists
  - c. The part of the Atmosphere where weather phenomena take place
  - d. The greatest division of the Geologic Time Scale

10. Briefly describe the events according to Planetesimal hypothesis that are thought to have lead to the formation of solar system
11. What is ionosphere? Where is it located?
12. The thickness of the crust is variable from region to region. Which crust is thicker, continental or oceanic? What type of rock that the oceanic crust is made up of?
13. What is meant by the term 'green house effect'?
14. What is the current estimated age of the universe? What does the term singularity in 'Big bang theory' signify?
15. The geologic time or the time span right from the birth of the earth up to the present day is divided into a number of larger time units and subdivided into many smaller units. Give a brief description of these time units.

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