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GEOLOGY AS A DISCIPLINE

1.1. Introduction

Our home, blue with water, white with clouds, green with life - is a planet unique in our solar system and probably rare in the universe. When we had the first view of our planet from space we were startled to see how beautiful and how fantastic our home appeared, very different from the other planets of our solar system.

Practically everything we do each day is connected in some way to the Earth: to its land, oceans, atmosphere, plants, and animals. The food we eat, the water we drink, most of the materials of our homes and offices, the clothes we wear, the energy we use, and the air we breathe are all grown in, taken from, surround, or move through, the planet Earth.

It is forecasted that by 2025, eight billion people will live on Earth. If we are to continue extracting resources to maintain a high quality of life, then we, as individuals and citizens, need to know more about our planet - its processes, its resources, and its environment. Only through a study of the Earth we can understand and appreciate our complex planet.

1.2. Earth Science

Earth Science is an all-embracing term for the sciences related to the planet Earth. The term Earth Science or Geoscience is currently used for the four basic areas of science: Geology, Meteorology, Oceanography and Astronomy. Only a portion of Astronomy viz., the scientific studies of Earth's neighbours in space, forms part of this branch of science.

Geology deals with the composition of earth materials, earth structures, and earth processes and it is also concerned with the history of the organisms on the planet and how the planet has changed over time. Geologists search for fuels and minerals, study natural hazards, and work to protect the earth's environment.

Meteorology is the study of the atmosphere and how processes in the atmosphere affect Earth's weather and climate. How climate changes over time in response to the actions of people, is a topic of urgent worldwide concern.

Oceanography is the study of oceans and the subject matter includes their composition, movement, organisms and processes. The oceans cover most of our planet and provide important food resources and other commodities. Oceans are increasingly being used as energy sources. The oceans also have a major influence on the weather and climate.

Astronomy is the study of the universe. The moon drives the ocean's tidal system. Impacts of asteroids throughout the Earth's history have frequently and locally modified the Earth's surface. The energy from the sun drives our weather and climates. Study of other objects in the solar system helps us learn Earth's history. Many aspects of the Earth's early history are revealed by objects in the solar system that have not changed as much as the earth has. Therefore, knowledge of basic astronomy is essential for an understanding of the Earth. Astronomers can also use their knowledge of Earth materials, processes and Earth history to learn about other planets.

There are numerous sub-disciplines in Earth Science, reflecting diverse areas of specialization in Geography, Soil Science, etc. New developments, however, have expanded the branches of Earth Science to include a collection of studies called Environmental Sciences. These are aimed to investigate the environmental conditions that positively and adversely affect all living things on Earth.

Earth scientists use tools from Physics, Chemistry, Biology, and Mathematics in their studies of the rock record to unravel how the Earth system works, and how it evolved to its current state.

Earth Science empowers us to think globally and act locally, to make sound decisions about issues important in our lives as individuals and citizens. People who understand how Earth systems work can make informed decisions about where to buy or build a home in safe areas of the Earth's surface. They can debate and resolve issues related to clean water, urban planning and development, national security, global climate change, and the use and management of natural resources.

An informed society, conscious of its complex relationships with our planet, recognizes the importance of and insists on Earth Science education at all grade levels - elementary, secondary and higher education. When we give emphasis to Earth Science education, everyone benefits from it. If we intend to live - on and with - this planet, we truly need to understand how it works, and understand the interactions of the many components that make up the Earth. The Earth Science provides an integrated and interdisciplinary approach to a true understanding of our planet. Earth

Science education also improves critical thinking skills. It offers a historical perspective and improves our ability to predict the future. To understand Earth processes that affect us now and tomorrow, geoscientists look for evidences for what happened in the past. This connects students to the past, as well as challenges them to think about the future.

Earth Science poses questions that are exciting as well as practical to children and adults alike: Why are earthquakes frequent in the Himalayan region? Why are the marble-stones of Taj Mahal deteriorating and getting mottled? Why do landslides constitute a frequent natural disaster in the hilly regions of Western Ghats during monsoon season? Why is beach erosion more severe in some parts of the Kerala's coast and what can we do about it? Why is a river floodplain not a good location to build a house? Where do we get fresh water for our daily use? How can one help protect the environment?

Problems and issues in Earth Science are ideally suited for an inquiry based education approach - an educational process that most closely resembles the reality of scientific endeavour. Earth Science has been part of the curriculum in schools of many developed countries well over the last century. The world-over, while educationalists define science literacy they reaffirm the centrality of Earth Science in education. Earth Science should be taught in parity with physical, chemical and biological sciences as part of the country's national strategy for science literacy.

1.3. Geology

Geology is one of the branches of Earth Sciences. It is the scientific study of the whole earth - its origin, structure, the material with which it is made, the nature of processes that act on these materials, the products formed, and the history of the planet. It also includes the study of organisms that have once inhabited our planet such as dinosaurs (excluding the present day organisms) and how those have changed over time.

Geology deals mainly with the composition, structure, physical properties, and history of Earth's components, and the processes by which they are shaped. Our lives and civilization depend upon how we understand and manage our planet - Earth processes affect us all. Weather patterns influence the availability of water resources. The potential for forest fires, earthquakes, volcanic eruptions, hurricanes, and floods can kill large number of people and cause enormous damage to life and property.

Geologists typically study rocks, sediments, soils, rivers, and natural resources. Expanding technologies and growing populations increase the demand on natural resources. As we extract and use these resources, we cause an impact on Earth today, which will in turn cause an impact to those who come after us. To enhance our careful control on (stewardship of) the environment, we must proceed into the future with a sound understanding of the mechanisms of Earth systems.

1.4. Branches of Geology

The subject of geology has several clearly defined divisions. The important branches include the following:

- Physical Geology** : It is concerned with the study of the agents and processes which modify the Earth's surface as well as the uppermost layers of the Earth, such as weathering, erosion, sedimentation, volcanism, earthquakes and crustal deformation.
- Geomorphology** : It is the science of landforms such as mountains, valleys, plateaus, deltas, sand dunes, etc. It includes the study of origin and evolution of various types of landforms.
- Mineralogy** : The study of minerals, including their physical, chemical and optical properties.
- Crystallography** : The study of crystals. This forms a subdivision of Mineralogy.
- Economic Geology** : This branch of geology is concerned with the study of mineral resources - earth materials of economic value. These materials include metallic and nonmetallic minerals, building stones and fossil fuels.
- Petrology** : It is the study of rocks and consists of their description, classification and genesis.
- Historical Geology** : It is the study of the events in the Earth's history and includes the branches of science known as Stratigraphy and Palaeontology.
- Palaeontology** : This branch deals with the study of fossils. It attempts to reconstruct the history and evolution of life.

- Stratigraphy** : It is the branch of geology which is the study of time and space relationships of layered rocks.
- Structural Geology** : It deals with the study of rock structures such as fold, fault, joints, etc., and their classifications.
- Engineering Geology** : It deals with the application of geology in civil engineering, especially in the construction of building foundations, selection of dam sites, tunnel alignment, landslide prevention and coastal protection, etc.
- Hydrogeology** : It is the branch of geology dealing with the study of all aspects of groundwater.
- Environmental Geology** : This branch of geology is concerned with the problems of environmental pollution, waste disposal and urban development and natural hazards, such as flooding and erosion and their mitigation or prevention.
- Marine Geology** : The study of geological aspects of oceans and ocean basins, geological action of waves and currents.
- Mining Geology** : This is also an applied branch of geology and concerned with extraction of economic minerals from the Earth and their beneficiation (processing of the mined materials).
- Petroleum Geology** : This branch of geology is concerned with exploration and extraction of petroleum and natural gas.

Check your progress

1. What are the four basic areas of Earth Science?
2. Petrology deals with the study of rocks, whereas Stratigraphy is the study of _____.



Let us do

Geology is very much related to other basic branches of sciences. Earth science includes and applies knowledge from Biology, Chemistry, Physics, Ecology, and Mathematics to tackle complex interdisciplinary issues. Study the figure (Fig.1.1) given below carefully and elaborate the interrelationships of Geology with other disciplines.

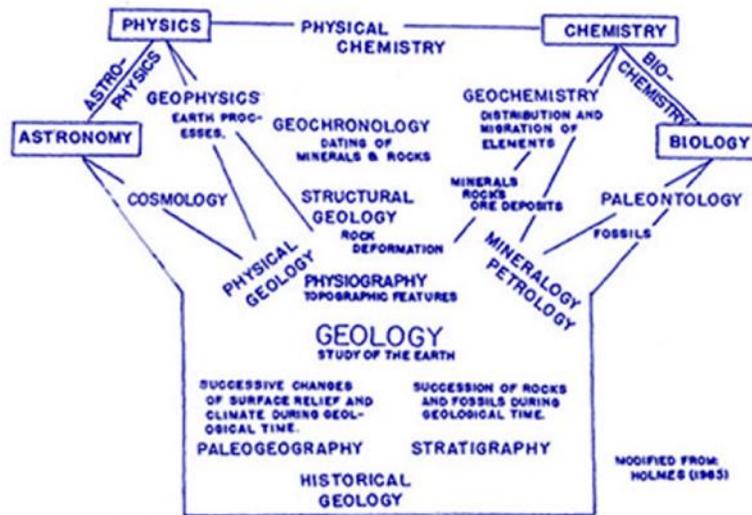


Fig. 1.1: Interrelationship of Geology with other disciplines

1.5. Geology and Human society

From the perspective of sustainable development, Geology and Geologists have a great role to play in the service of human kind. Earth Science will be beneficial to the human society only if inputs of the theoretical as well as practical knowledge will be made for the beneficial purpose of mankind, in the form of exploration for coal, petroleum, natural gas, new ore deposits, predictions of climatic changes, environmental changes, measures to safeguard from natural disasters, etc.

A sound geological knowledge helps society to move toward greater sustainability. Geologists develop new technologies to extract resources more efficiently, to reduce the pollution, for effective waste disposal methods.

Fossil fuels and uranium currently provide most of our energy resources. Coal, oil and natural gas, require tens to hundreds of millions of years to form. These will remain the dominant source of energy for some more decades of the future until energy from other sources are made available in substantial amounts.

Soil, rocks and minerals provide essential metals and other materials for agriculture, manufacturing and building. Soil develops extremely slowly from weathered rock, and the erosion of soil threatens agriculture in many parts of the country. Minerals provide the raw materials for much of our industries. Many electronic and mechanical devices have specific requirements for particular rare metals and minerals that are not adequately available.

Natural resources are limited. Earth's natural resources provide the foundation for all the physical needs of the human society. Most of them are non renewable on human time scale and many will run critically low in the near future. Moreover Earth resources are distributed unevenly around the planet. Water resources are essential for agriculture, manufacturing, energy production and life. Geologists and engineers help to locate and effectively manage our fresh water resources.

Today we live in a time when the earth and its inhabitants face many challenges. Our climate is changing and this to a great extent is ascribed to anthropogenic causes. We also have several other challenges such as to develop new sources of energy that will have minimal impact on climate; locate new sources of metals and other mineral resources as known sources are depleted; and, determine how earth's increasing population can live and avoid serious threats such as volcanic activity, earthquakes, landslides, floods and more. These are just a few of the problem areas where solutions require a deep understanding of geology. The geological knowledge is essential for the search of new mineral resources, both on land and in ocean floors, prevention of hazardous environmental pollution, ways to tackle the consequences of climatic changes and so on.

Economic Geology is important for locating and extracting minerals and fossil fuels such as coal, oil, gold, iron, and aluminum. Locating these deposits requires efforts of able geologists to study the geologic setting and several other factors before deciding what location will produce the most mineral resources and later extract them economically. Geologists are also consulted with regard to construction projects. In some cases, such as areas with active faults, the geologists are able to predict the type of movement and the magnitude of movement likely to occur in the event of an earthquake. This helps in the design and construction of buildings and highways to make them safer in areas that experience frequent earthquakes. In areas that depend on groundwater as the only source of water geologists are able to determine how deep the wells should be

drilled to recover the maximum amount of water without putting stress to the surrounding aquatic systems and creating environmental problems.

Natural hazards that result from natural processes pose risks to humans. These hazards include earthquakes, tsunamis, hurricanes, floods, droughts, landslides, volcanic eruptions, extreme weather, lightning-induced fires, coastal erosion and comet and asteroid impacts. Earth scientists are presently in a position to predict and forecast when and where natural hazards may occur.

The expertise of geologists, geophysicists and other earth scientists is required by government and private agencies concerned with agriculture and forestry, water supply and hydro-electric power generation, civil engineering, waste disposal and contaminated site remediation and conservation of natural resources.

Check your progress

1. List out any three areas where the geological knowledge is useful in your daily life.
2. Mention the role of geologists in managing environmental problems.



1.6. Major geological organizations in India

There are a number of organizations and institutions in India related directly or indirectly with the subject of Geology or Earth Sciences. The major national organizations and institutions and their salient features are listed below:

Geological Survey of India (GSI): The Geological Survey of India (GSI), established in 1851, is a government organization for conducting geological surveys and studies. GSI is the prime provider of basic Earth science information to the government. The headquarters of GSI is in Kolkata.

Oil and Natural Gas Corporation (ONGC): The Oil and Natural Gas Corporation (ONGC), conducts exploration and production activities in India of crude oil and natural gas. The headquarters is in Dehra Dun, Uttarakhand.

Central Ground Water Board (CGWB): Central Ground Water Board (CGWB), which is under the Ministry of Water Resources, Government of India, is the national apex agency entrusted with the responsibilities of providing scientific inputs for management, exploration, monitoring, assessment, augmentation and regulation of groundwater resources of the country. Its headquarters is in Faridabad, Haryana.

Mineral Exploration Corporation Limited (MECL): Mineral Exploration Corporation Limited (MECL) is functioning under Ministry of Mines, Govt. of India, for systematic exploration of minerals. The company has its corporate office in Nagpur, Maharashtra. MECL has made noteworthy contributions in development of the nation by the new recent discoveries of coal, lignite, base metals, gold, bauxite and limestone deposits.

Indian Bureau of Mines (IBM): The Indian Bureau of Mines (IBM) established in 1948, under the Ministry of Mines, is engaged in scientific development of mineral resources and protection of environment in mines other than coal, petroleum and natural gas, atomic minerals and minor minerals. The headquarters is in Nagpur, Maharashtra.

Atomic Minerals Directorate (AMD) for Exploration and Research: It is the oldest unit of the Department of Atomic Energy (DAE). Its headquarters is in Hyderabad. The principal mandate of the organization is to carry out geological exploration and discover mineral deposits required for nuclear power programme of India. Two sectional offices are located in Thiruvananthapuram and Vishakhapatnam for the investigation of beach sand and offshore deposits.

National Remote Sensing Centre (NRSC): It is an autonomous body under the Department of Space (DOS). This organization undertakes and facilitates remote sensing activities in the country. NRSC in Hyderabad has been converted into a full-fledged centre of ISRO since 2008.

Wadia Institute of Himalayan Geology (WIHG): It was established in June, 1968 as a small nucleus in the Botany Department, Delhi University. The institute was shifted to Dehra Dun during April, 1976. It is an autonomous research institute of the Department of Science and Technology, Government of India. Initially named as the Institute of Himalayan Geology, it was renamed as the Wadia Institute of Himalayan Geology in memory of its founder, the late Prof. D. N. Wadia, in appreciation of his contributions to the geology of the Himalayas.

Coal India Limited (CIL) : It is a public sector coal mining company with its headquarters in Kolkata and it is the world's largest coal mining undertaking.

Neyveli Lignite Corporation Limited (NLC) : It is a lignite mining and power generating company in India. NLC operates the largest open-pit lignite mines.

Indian Space Research Organization (ISRO): It is the primary space agency under Government of India. Its primary objective is to

advance space technology. It was established in 1969 and its headquarters is in Bengaluru. The Vikram Sarabhai Space Centre (VSSC) is a major space research centre of the Indian Space Research Organization (ISRO), focusing on rocket and space vehicles for India's satellite programme. It is located in Thiruvananthapuram, Kerala.

Centre for Earth Sciences Studies (CESS): This premier research institute in Kerala was established in 1978, at Akkulam in Thiruvananthapuram. The primary objective of CESS is to promote modern scientific and technological research and focus on developmental programmes relevant to the country in general and Kerala State in particular. In January 2014 the CESS was taken over by the Government of India and is presently under the Ministry of Earth Sciences.

Centre for Water Resources Development and Management (CWRDM): Recognizing the need for catering to the research and development needs in the field of water management, the Centre for Water Resources Development and Management (CWRDM) was established by the Government of Kerala. It is situated in Kozhikode and is an autonomous research organization.

Kerala State Mining and Geology Department: It is an undertaking of the Government of Kerala that deals with geological exploration and mining within Kerala. Its headquarters is in Thiruvananthapuram and has regional offices located in all districts.

Kerala State Groundwater Department: It is a department of the Government of Kerala concerned with the exploration and exploitation of groundwater resources of the state. It has its headquarters at Thiruvananthapuram and regional offices in all the districts.

Kerala State Landuse Board: Kerala State Land Use Board was established in 1975 under the Department of Planning and Economic Affairs, Government of Kerala. It assists the state government in matters of framing policies for optimum land use and natural resource management in the state, with the basic objective of providing necessary advisory support on matters related to the optimum use of land and land resources viz., soil, water and vegetation. Its headquarters is in Thiruvananthapuram and has a regional office in Thrissur.



Let us sum up

Geology is the scientific study of the Earth. It forms one of the four basic areas that constitute Earth Sciences or Geoscience. It investigates what happened in the past and what is happening now, with reference to the planet Earth. Geology is concerned with all aspects of the Earth related to its origin, its landforms, minerals, rocks, environment, structural features found in the rocks, etc. All earth materials including water, soil, minerals, fossil fuels, etc., are discovered, exploited and managed with the help of earth scientists or geologists. The subject of Geology has several clearly defined divisions which form the various branches of Geology. It is very much related to other basic branches of sciences. As far as sustainable development is concerned, the progress of science will only be beneficial to mankind and in this aspect geology and geologists have a great role to play in the service of human kind. Geologists will help society move toward greater sustainability. In India there are a number of organizations and institutions which deal directly or indirectly with the subject of geology or Earth Sciences.



Significant Learning Outcomes

The learner can:

- describe Earth Science and geology
- understand the various branches of geology.
- recognize the role of geology in human society.
- identify the major organizations of the country related to geology.



Let us assess

1. Describe the importance of earth resources in the development of a country.
2. Explain the functions of any three major geological organizations of our country.
3. Mention five disciplines related to geology.