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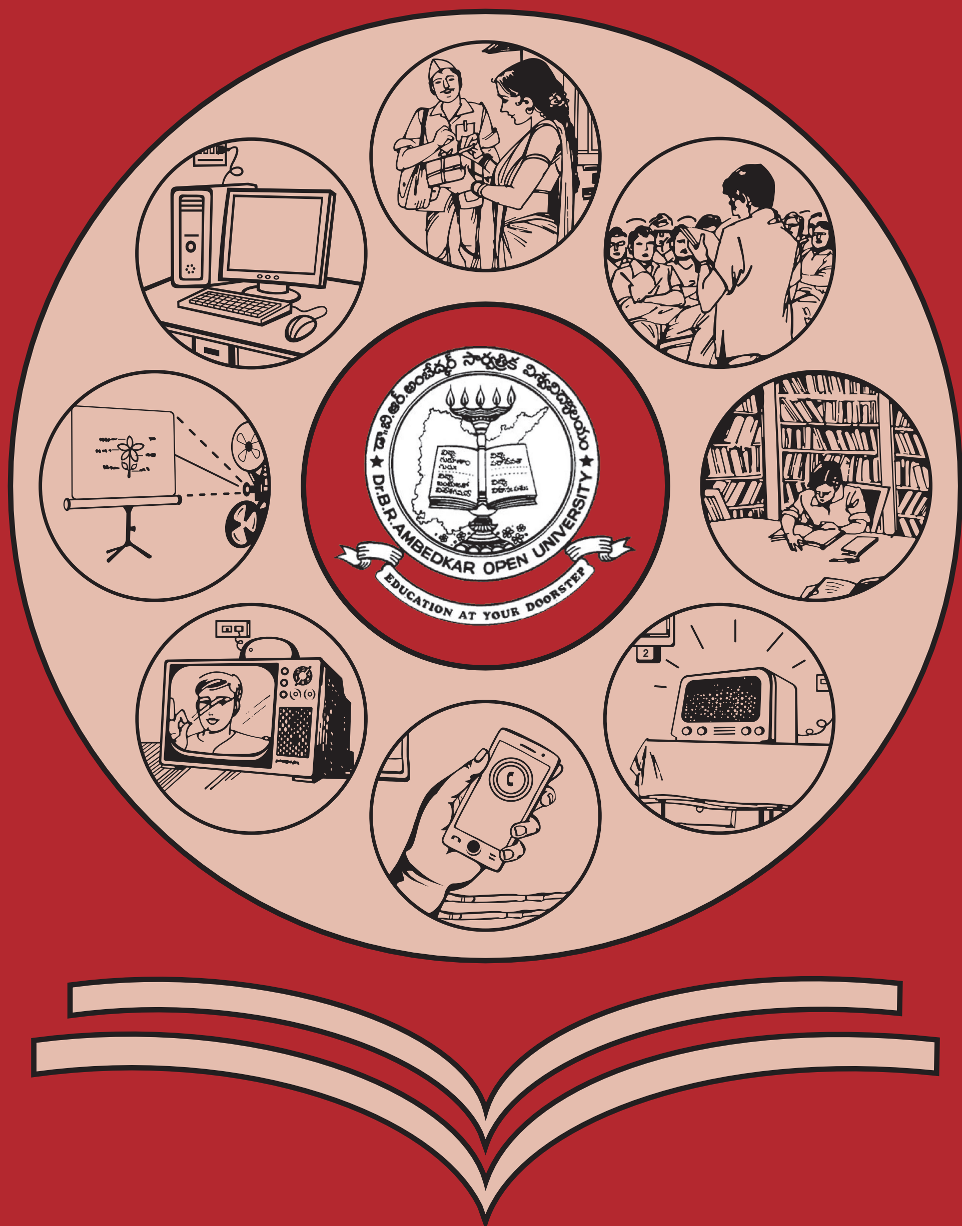

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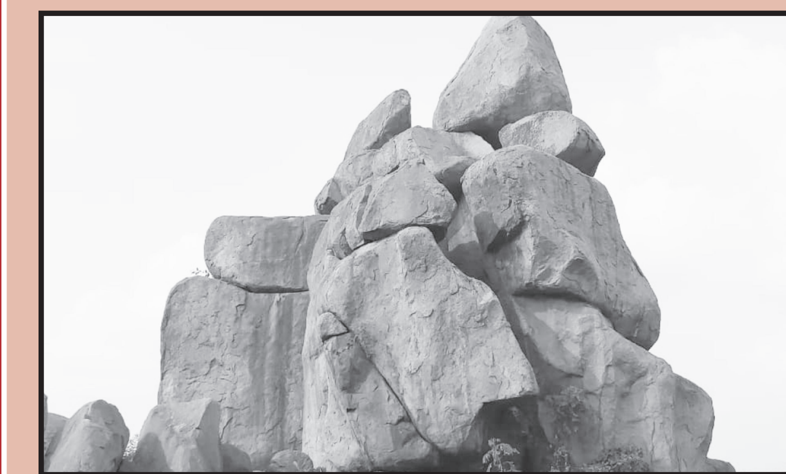
B.A.

FIRST YEAR

GEOGRAPHY

FUNDAMENTALS OF GEOMORPHOLOGY

SEMESTER - I



CLIMATOLOGY & OCEANOGRAPHY

SEMESTER - II

Dr. B.R. AMBEDKAR OPEN UNIVERSITY

HYDERABAD

BA228GEO-E

B.A.

FIRST YEAR SEMESTER - I

GEOGRAPHY

FUNDAMENTALS OF GEOMORPHOLOGY

"We may forgo material benefits of civilization, but we cannot forgo our right and opportunity to reap the benefits of the highest education to the fullest extent....."

Dr. B. R. Ambedkar

Dr. B.R. AMBEDKAR OPEN UNIVERSITY
HYDERABAD
2022

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PREFACE

The contents of this book is prepared as per University Grants Commission CBCS method which introduces geography as a discipline and identifies the physical geography as one of the subject. This textbook was designed for Geography course which is a three-year degree in Social sciences offered by Dr B R Ambedkar Open University. This book dealt with the syllabus contents of Geomorphology for 1st year BA course.

The study of physical geography is emerging as a discipline of evaluating and managing natural resources. In order to achieve this objective, it is essential to understand the intricate relationship between physical environment and human beings. Physical environment provides resources, and human beings utilize these resources and ensure their economic and cultural development. A better understanding of physical environment is absolutely essential for sustainable development. New vistas have opened up in the field of physical geography as a result of researches being carried out by the environmental and space scientists, atmospheric scientists, conservators and managers, oceanographers and the researchers in the allied fields. Themes of global warming, sea-level rise, ozone depletion, eco-development, conservation of Biodiversity, resources and Sustainable development etc. have become issues of concern for the physical geographers.

Geomorphology is a significant branch of Physical Geography. It is concerned with the study of landforms which is essential to geography. In describing existing landforms, geomorphology investigates the past processes that have created them, and anticipates the future developments that will change them. Over millions of years, the Earth has gone through many changes which have shaped its current form and structure. The Earth has transformed a lot. All of these processes are still continuously going on and shaping our Earth currently. The most notable processes are geomorphic processes since they create the shape and form of the Earth as we see it now. Hence, the study of these geomorphic processes is critical to understand the phenomena and process that are occurring in nature. Hence, it is the study of various features that are found on the Earth, such as mountains, hills, plains, rivers, moraines, cirques, sand dunes, beaches, spits, etc., that are created by various agents such as rivers, glaciers, wind, ocean, etc.

Course content is divided into five Blocks. Each block consists of 3 units. Block one is the general introduction. This introductory chapter is intended to acquaint the students with distinctiveness of geography as a field of learning in social science as well as in natural science. The philosophy and methodology of the subject is discussed in such a way that students develop a keen interest in the subject and pursue it for higher studies. Block 2, discusses about theories, land forms, rock formations etc., block 3, 4 deals with geomorphic processes, earth quakes, Volcanoes, atmosphere etc. Block V deals with types of Maps, its usefulness etc.

The book features diagrams, maps and a glossary to aid understanding of key ideas and suggestions for further reading to allow readers to develop their interest in the subject.

The members of the syllabus committee impressed that the course-content of each sub-field should be sufficiently rich in quantitative and cartographic techniques and field methodology, taking advantage of the latest developments in information technology (GIS, remote sensing etc.). For emerging thrust areas, the subject matter of geography made innovative, skill oriented and employment oriented to attract students to geography.

University welcomes comments and suggestions which will enable us to undertake further revision and refinement.

B.A. GEOGRAPHY - FIRST YEAR

SEMESTER - I

Paper 1: FUNDAMENTALS OF GEOMORPHOLOGY

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BLOCK - I: INTRODUCTION TO GEOMORPHOLOGY

This introductory chapter intended to acquaint the students with distinctiveness of geography as a field of learning in social science as well as in natural science. The philosophy and methodology of the subject is discussed in such a way that students develop a keen interest in the subject and pursue it for higher studies.

The land and oceans found on the Earth deals with the classification of landforms - first, second and third order landforms. Our earth is a dynamic planet. Its surface consists of lofty mountains, high plateaus, large plains, rivers and deep valleys etc. The surface of the earth is constantly undergoing changes due to various internal and external forces. In this unit we will study how the earth is formed and what lies in the interior of the earth?

This block contains 3 units. They are:

Unit 1: Scope and content of geography and geomorphology
Unit 2: Land and Sea – formation and distribution
Unit 3: Interior of the earth

Unit - 1: Scope and Content of Geography and Geomorphology

Contents

1.0 Objectives
1.1 Introduction
1.2 What is Geography
1.3 Geography and Social Sciences
1.4 Branches of Geography
1.5 Nature of Geography
1.6 Scope of Geography
1.7 Systematic approach
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1.0 OBJECTIVES

To introduce the latest concepts in physical geography, essentially geomorphology; to the students of geography in a brief but adequate manner.

The nature and scope of Physical Geography, its Inter-relations with other branches of earth sciences; and the place of Geomorphology in Physical Geography.

1. 1. INTRODUCTION

You have studied geography as one of the components of your Social Science course up to the secondary stage. You are already aware of some of the phenomena of geographical nature in the world and its different parts. Now, you will study 'Geography' as an independent subject and learn about the physical environment of the earth, human activities and their interactive relationships. Therefore, a pertinent question you can ask at this stage is — why should we study geography?

The proposed course aims at explaining the nature of the subject. It throws light on the importance of geography and describes the nature of geography as a subject. It attempts to enrich knowledge and illustrate basic concepts as well as technical terms which are building blocks of geographic knowledge. Effort has been made to develop the concepts in a graded and sequential manner and deepen the interest in the subject. Geography is one of the oldest earth science and its roots date back in the works of the early Greek scholars.

Geography, as a field of learning is related to the study of location and spatial relations of things and events on the surface of the earth. Geography is fundamentally a holistic discipline, studying things and events in their total context. This implies study of systems of a really inter – connected and inter-dependent parts of diverse origin. A geographer, therefore, is a person who asks questions about the significance of location, distance, directions, spread and spatial lead to change and development in the discipline.

Today geography is recognized as a spatial science, concerned with the study of the location and arrangement of phenomena (physical, biotic and human) on the surface of the earth and the process that generate these distributions. With the advancement in geography, its nature (meaning, content, purpose and scope) has also changed with increased dependence on other disciplines.

1.2. WHAT IS GEOGRAPHY?

The term *geography* was first coined by Eratosthenes, a Greek scholar who lived in 3rd century B. C (276-194 BC.). The word has been derived from two roots from Greek language *geo* (earth) and *graphos* (description). Now, you should be able to attempt the answer of the question posed as to "What is geography"? In very simple words, it can be said that geography is the "description of the earth". Literal meaning of geography is to describe about the "earth's surface". In other words "Geography is largely the study of the interaction of all physical and human phenomena and landscapes created by such interactions." It is about how, why, and where human and natural activities occur and how these activities are interconnected.

The enquiries of geographical nature had begun with the basic question i.e. "what is where?" The emphasis of study of the classical schools of thought particularly during the Greek, Roman and Arab period was on this question. The nature of query shifted to "why what is where? "After the age of discovery. However, a further refinement was seen in the Modern period, when geographers began to seek answers to the question as "how and why what is where?"

In an attempt to answer each set of questions, geography has gained a new and more meaningful definition every time. This, in its simplest form geography maybe defined as*" the study of spatial location and distribution of various phenomena on the surface of the earth*".

Geography as a discipline is concerned with three questions: What? Where? And Why? Geography as a discipline is related to space and takes note of spatial characteristics and attributes. It studies the patterns of distribution, location and concentration of phenomena over space and interprets those providing explanations for these patterns. It takes note of the associations and inter-relationships between the phenomena over space and interprets those providing explanations for these patterns. It also takes note of the associations and inter-relationships between the phenomena resulting from the dynamic interaction between human beings and their physical environment.

Geography, not only investigates what is where on the Earth, but also why it is there. Geographers study the location of the activities, carefully identify patterns using maps and find out the reasons for these patterns. The areas are then described based on the distribution of land forms, population, house type and agriculture. They discover the linkages and movements between places and are able to infer the spatial processes that are working in an area.

Today geography is known as the science of spatial distribution. The 'spatial' here means pertaining to 'physical or real space', which is solid, observable and measurable. The geographers are concerned with 'physical space' and not astronomical, microscopic or abstract space. It is 'topographical space' i.e. over the surface of the earth. The distribution of any element (physical, biotic, or human) is spatial in nature, it occupies a portion of the earth's surface, or has a location over it, and which a phenomenon is also of specified magnitude, so that it could be physically identified, measured and represented on a map. However, no spatial distribution on this surface of the earth is static; it is dynamic.

You are aware of the fact that reality is always multifaceted and the 'earth' is also multi-dimensional, that is why many disciplines from natural sciences such as geology, pedology, oceanography, botany, zoology and meteorology and a number of sister disciplines in social sciences such as economics, history, sociology, political science, anthropology, etc. study different aspects of the earth's surface. Geography is different from other sciences in its subject matter and methodology but at the same time, it is closely related to other disciplines. Geography derives its data base from all the natural and social sciences and attempts their synthesis.

You know that earth is our home. It is also the home of many other creatures, big and small, which live on the earth and sustain. The earth's surface is not uniform. It has variations in its physical features. There are mountains, hills, valleys, plains, plateaus, oceans, lakes, deserts and wilderness. There are variations in its social and cultural features too. There are villages, cities, roads, railways, ports, markets and many other elements created by human beings across the entire period of their cultural development.

Geography integrally explores the physical dimensions of our planet as well as the demography and the lands and its inhabitants. The prime objective of this area of study is to develop a mutable relationship between the people and the lands they live in, amongst other factors, which gives it an all-round interdisciplinary approach. Some of the multidisciplinary crossovers of this subject include History, Science, Environment, and Population Studies thus making Geography a diversified area of study. It also additionally contains the study of culture, ethnicity, the earthy characteristics of the planet, and economies of different regions. The physical environment has provided the stage, on which human societies enacted the drama of their creative skills with the tools and techniques which they invented and evolved in the process of their cultural development.

Thus, geography was perceived to study all those phenomena which vary over space. Geographers do not study only the variations in the phenomena over the earth's surface (space) but also study the associations with the other factors which cause these variations. For example, cropping patterns differ from region to region but this variation in cropping pattern, as a phenomenon, is related to variations in soils, climates, demands in the market, capacity of the farmer to invest and technological inputs available to her/him. Thus, the concern of geography is to find out the causal relationship between any two phenomena or between more than one phenomenon.

Human beings have claimed their contribution using natural resources. With the help of technology, human beings moved from the stage of necessity to a stage of freedom. They have put their imprints everywhere and created new possibilities in collaboration with nature.

The study of Geography is about observing such patterns. Another aspect of geography is to understand the factors or reason behind areal differentiation, how do social, cultural, economic and demographic factors change our physical landscape and create new or altered landscapes by human interventions. For example, human settlements are transformation of forest or barren lands for living purpose by human being.

Today, all over the world there are problems related to providing food security, health, effective energy use and environmental conservation. Equally important are equality issues and sustainable development. All these can be achieved by using our resources in sustainable ways. Study of geography is, therefore, necessary to learn more about environmental processes and to understand how land use planning can help us to overcome problems.

1.3. GEOGRAPHY AND SOCIAL SCIENCES

Each social science has interface with one branch of geography. Philosophy provides roots to a discipline and in the process of its evolution; it also experiences distinct historical processes. Thus, the history of geographical thought as mother branch of geography is included universally in its curricula. All the social science disciplines, viz. sociology, political science, economics and demography study different aspects of social reality. The branches of geography, viz. social, political, and economic and population and settlements are closely linked with these disciplines as each one of them has spatial attributes. The core concern of political science is territory, people and sovereignty while political geography is also interested in the study of the state as a spatial unit as well as people and their political behavior. Economics deals with basic attributes of the economy such as production, distribution, exchange and consumption. Each of these attributes also has spatial aspects and here comes the role of economic geography to study the spatial aspects of production, distribution, exchange and consumption. Likewise, *population geography* is closely linked with the discipline of *demography*.

The above discussion shows that geography has strong interface with natural and social sciences. Geographers use data obtained from sister disciplines and attempt synthesis over space. Maps are very effective tools of geographers in which the tabular data is converted into visual form to bring out the spatial pattern.

After studying this lesson, you will be able to: appreciate the use of Geography in daily life; trace development of Geography as a discipline; identify the different branches of Geography and its scope.

Geography has three main branches: physical, geomorphology, oceanography, human and regional. Physical geography deals with nature of physical phenomena such as climatology, soil and vegetation. Human geography deals with the relationship between human societies and the earth's surface. Regional geography is **a major branch of geography**. It focuses on the interaction of different cultural and natural geofactors in a specific land or landscape, while its counterpart, systematic geography, concentrates on a specific geofactor at the global level. Geography as an inter disciplinary subject.

1.4. BRAN.CHES OF GEOGRAPHY

1. Physical Geography

(i) *Geomorphology* is devoted to the study of landforms, their evolution and related processes.

(ii) *Climatology* encompasses the study of structure of atmosphere and elements of weather and climates and climatic types and regions.

(iii) *oceonography* studies the realm of water over the surface of the earth including oceans, lakes, rivers and other water bodies and its effect on different life forms including human life and their activities.

(iv) *Pedology / Soil Geography* is devoted to study the processes of soil formation, soil types, their fertility status, distribution and use.

2. Human Geography

(i) *Social / Cultural Geography* encompasses the study of society and its spatial dynamics as well as the cultural elements contributed by the society.

(ii) *Population and Settlement Geography* (Rural and Urban). It studies population growth, distribution, density, sex ratio, migration and occupational structure etc. Settlement geography studies the characteristics of rural and urban settlements.

(iii) *Economic Geography* studies economic activities of the people including agriculture, industry (tourism, trade, and transport, infrastructure), services and other sectors.

(iv) *Historical Geography* studies the historical processes through which the space gets organized. Every region has undergone some historical experiences before attaining the present day status. The geographical features also experience temporal changes and these form the concerns of historical geography.

(v) *Political Geography* looks at the space from the angle of political events and studies boundaries, space relations between neighboring political units, delimitation of constituencies and develops theoretical *framework* to understand the political behaviour of the population.

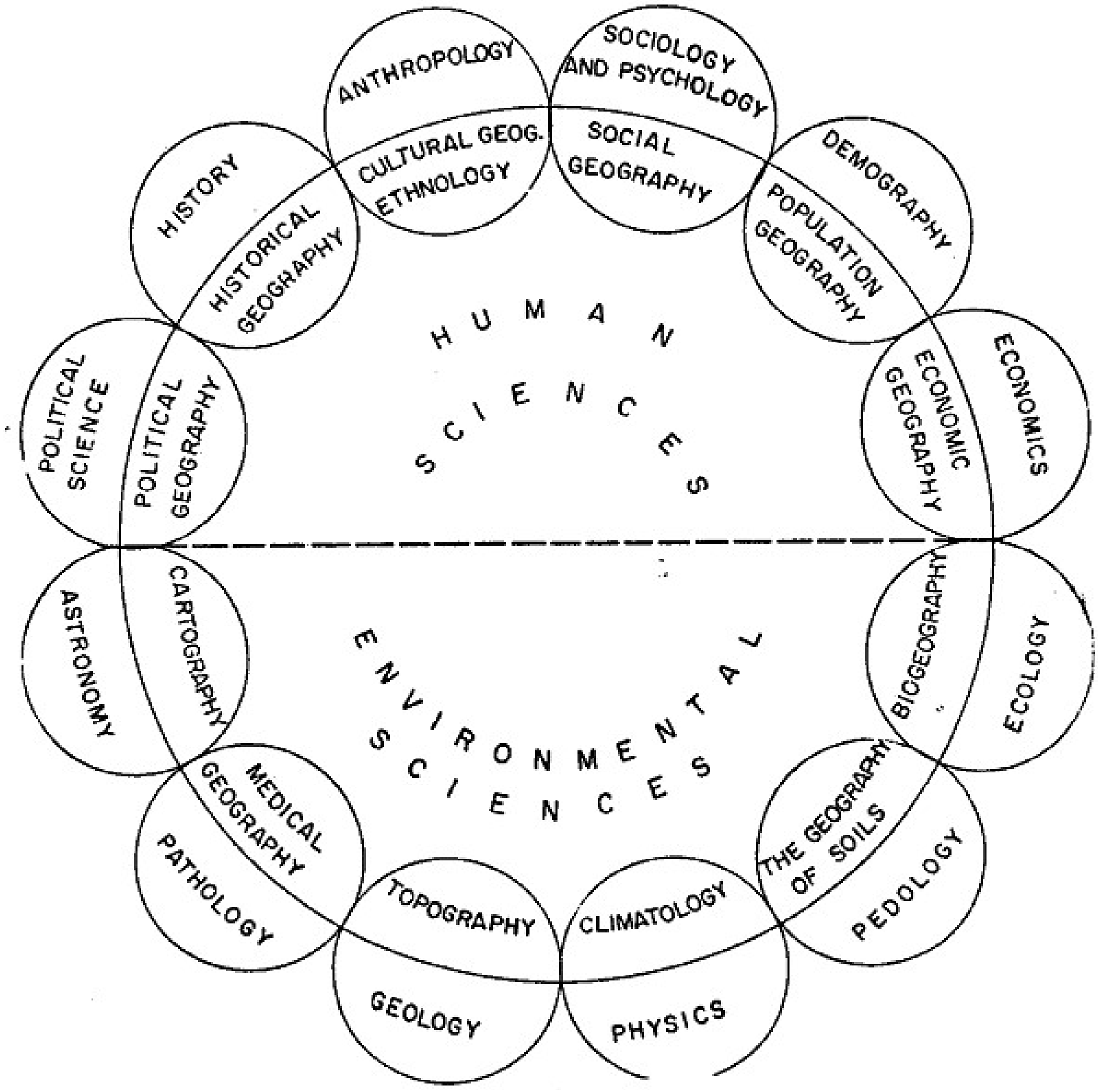


Fig 1.1: Branches of Geography

Check your progress

1. Define geography

1.5. NATURE OF GEOGRAPHY

Geography is the study of locational and spatial variation in natural and human phenomena of the earth. The special skills of geography are those related to the significance of location and spatial relation of things and events. Geography addresses both the questions of where, as well as why phenomena occur in particular places. Geography is both an art and a science. Although it is different from other sciences in its subject matter and methodology, it is closely related to other disciplines.

Geography deals with enormous range of phenomena, ranging from physical, biotic to human. The four spheres, namely lithosphere, atmosphere, hydrosphere and biosphere constitute the geographic environment. This makes geography is highly interdisciplinary drawing upon and contributing to numerous other fields of knowledge.

1.6. SCOPE OF GEOGRAPHY

Geography has now acquired the status of science that explains the arrangements of various natural and cultural features on the earth surface. Geography is a holistic and interdisciplinary field of study engaged in understanding the changing spatial structure from past to the future. Thus, the scope of geography is in various disciplines, like armed services, environment management, water resources, disaster management, meteorology and planning and various social sciences. Apart from that, a geographer can help in day to day life like tourism, commuting, housing and health related activities.

We live on the surface of the earth. Our lives are affected by our surroundings in many ways. We depend on the resources to sustain ourselves in the surrounding areas. Primitive societies subsisted on 'natural means of subsistence', i.e. edible plants and animals. With the passage of time, we developed technologies and started producing our food using natural resources such as land, soil and water. We adjusted our food habits and clothing according to the prevailing weather conditions. There are variations in the natural resource base, technological development, adaptation with and modification of physical environment, social organisations and cultural development. As a student of geography, you should be curious to know about all the phenomena which vary over space. You learn about the diverse lands and people. You should also be interested in understanding the changes which have taken place over time. Geography equips you to appreciate diversity and investigate into the causes responsible for creating such variations over time and space. You will develop skills to understand the globe converted into maps and have a visual sense of the earth's surface. The understanding and the skills obtained in modern scientific techniques such as GIS and *computer cartography* equip you to meaningfully contribute to the national endeavor for development.

The scope of geography covers its whole sphere of influence, the range of study and the practical importance of the discipline. More precisely, it may be understood in three ways, viz: Geography as a discipline of knowledge and research, geography as a sister –discipline to other fields of study, and Geography as a discipline of profession.

Today, geography is the only discipline that brings all natural and human sciences on a common platform to understand the dynamics of the spatial configuration of the earth surface. There are two main approaches in geography: 1. Systematic approach 2. Regional approach.

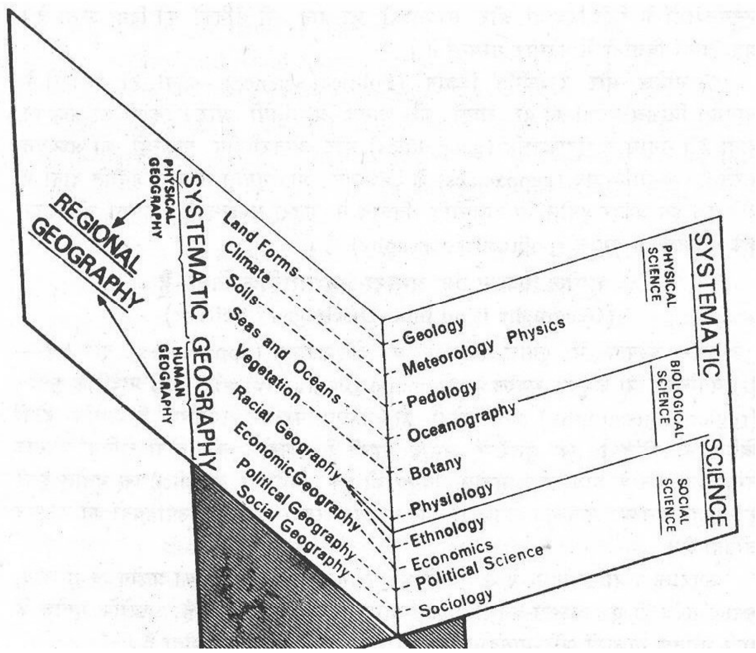
1.7. SYSTEMATIC APPROACH

A study of specific natural or human phenomenon that gives rise to certain spatial patterns and structures on the earth surface is called systematic study. Ordinarily, systematic geography is divided into four main branches.

Physical geography: It deals earth systems like atmosphere (air), the hydrosphere (water), the lithosphere (earth solid rock) and biosphere, which encompassed all of earth's living organisms.

Biogeography, including environmental geography: It focuses on various kinds of forests, grasslands, distribution of flora and fauna, human nature relationships and the quality of the living environment and its implications for human welfare.

Human geography: It describes culture, populations, and dynamics of social, economic, and political aspects of space.



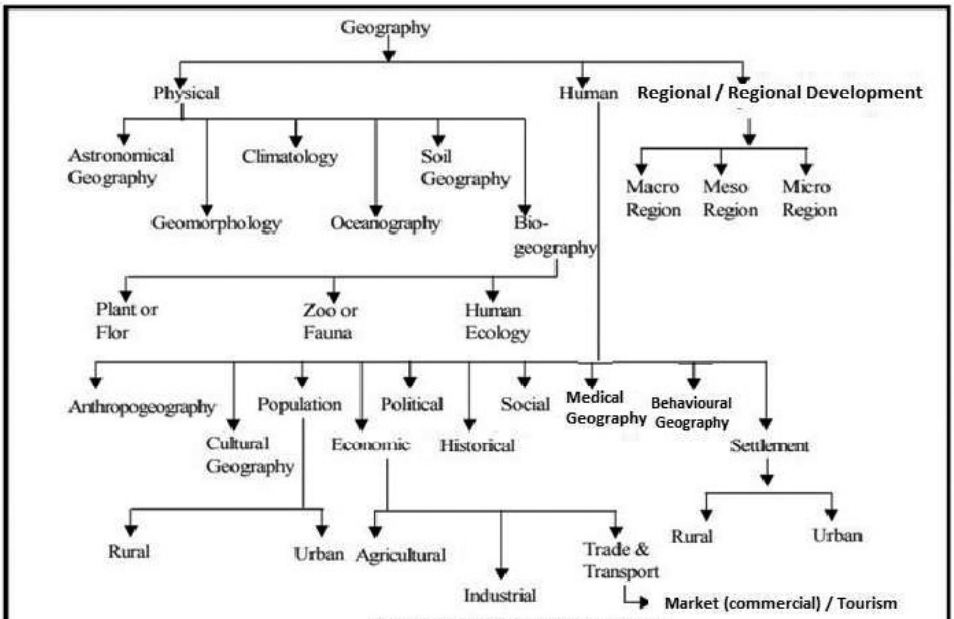


Fig:1.2 Branches of Geography

Geographical methods and techniques: It deals with methods and techniques for field studies, qualitative quantitative and cartographic analysis and Geographic Information System and Global positioning system (GIS and GPS) and remote sensing.

Regional approach:

Unlike systematic geography, regional geography starts with the spatial imprints of one or all the systematic geographic processes discernible as regions of different sizes. Regions could be based on a single factor like relief, rainfall, vegetation, per capita income. They could also be multifactor regions formed by the association of two or more factors. Administrative units like, states, districts, tehsils also can be treated as regions. The main sub branches of regional geography are:

Regional studies; Regional analysis; Regional development; Regional planning including areas and community planning.

1. 8 CAREER SCOPE OF GEOGRAPHY

Geography has a number of sister-disciplines, it also provide assistance in the understanding of various other disciplines, in fact, geography serves all those disciplines that serve it. For instance, geography and history have always gone hand in hand, the common thing between the two being 'description', i.e. in terms of space for the former and in terms of time for the later. More recently we find that geography has become the backbone of the fields like Remote Sensing and Geographic Information system (GIS).

Studying the diverse lands and environments on our planet as well as the relationship between human beings with the land they live in, Geography is truly a vast stream which intersects with varied branches of Social Science. Pursuing a degree in Geography, you can explore wide-ranging opportunities across both the public and private sector. Owing to the immense scope of Geography, here are the major employments areas you can explore are:

Urban and Rural Planning; Cartography; Climate Analysis; Population Analysis; Nature Conservation, Sanctuaries; Environmental Science; Travel and Tourism and Education etc.

Now that you are familiar with the major employment areas under the career scope of Geography, some of the top job opportunities you can explore with a degree in Geography are as follows:

Environmental Consultant; Cartographer; Town planner ; Geographical Information Systems Officer; Landscape Architect ; Hydrologist; Meteorologist; Pollution Analyst; Travel and tourism Advisor and Planner; Wildlife Conservationist etc. The students of geography can opt for teaching at schools and college level, and take up professions as TGTS (Trained Graduate Teachers) or PGTS (Post Graduate Teachers) in the school level and as lecturers, Readers or professors at university level.

Besides its academic growth, the professionalization in geography is also increasing day by day. Pertaining in so many spheres, geography opens job avenues in numerous areas, and the discipline is becoming more and more job-oriented. A graduate or Post graduate in geography, for instance, has a lot of scope being absorbed in the fields of education, administration, research, Cartography. In the administration the jobs may be taken through UPSC (Union Public Service Commission), SSC (Staff Selection Commission), town and country planning, surveying, Group 1,2,3,4 state services. The prospects are also open in the departments of Remote sensing, GIS, Demography, Defence, Meteorology, soil Science, Forestry, industry, agriculture and environmental science.

Remote sensing and GIS is the recently emerging area of job prospects for the geographers. This field also opens a booming career options for the students of geography those who wish to be a breed apart in the corporate world. The geoinformatic institutes to train and empower the students with analytical deci.sion making and management skills, besides enabling them to offer complex

complex geoinformation solutions in infrastructure development, natural resources monitoring and urban development wherein the data are analyzed and used in areas like disaster management, environment, logistics and asset management, to name a few. A number of institutes offer courses of different types and durations in this field.

Computer technology is now overwhelming the world and computers can handle vast amount of information in comparison to the traditional skills. Therefore, computer assisted cartography is emerging as another field of profession. Particularly young generation of geographers has a considerable degree of mastery over this technology. A number of organizations are offering professional courses in this field. The research field areas like environmental impact assessments, Cities and Communities, Climate and Earth Systems, and Geospatial Information Science and Technology etc.

Check your progress

2. Write about the scope of geography

1.9. NATURE OF GEOMORPHOLOGY

Geomorphology is the study of landforms, their processes, form and sediments at the surface of the Earth (and sometimes on other planets). Study includes looking at landscapes to work out how the earth surface processes, such as air, water and ice, can mould the landscape. Landforms are produced by erosion or deposition, as rock and sediment is worn away by these earth-surface processes and transported and deposited to different localities. The different climatic environments produce different suites of landforms. The landforms of deserts, such as sand dunes and ergs, are a world apart from the glacial and periglacial features found in polar and sub-polar regions. Geomorphologists map the distribution of these landforms so as to understand better their occurrence.

The word "geomorphology" was first coined and used between the 1870s and 1880s to describe the morphology of the surface of the Earth. But it was popularized by the American geologists William Morris Davis who proposed the "geographical cycle" also known as "Davis cycle".

Geomorphology is an important branch of Physical Geography (geomorphology, climatology, biogeography, oceanography). It is concerned with the scientific study of the origin and evolution of the relief features of the earth.

The term geomorphology has been derived from Greek words and combination of three words i.e. '*geo*'(earth), '*morphe* '(form) and '*logo*' (a discourse). Thus geomorphology is the description (discourse) of various forms (morphe) of the earth's surface. Geomorphology is the systematic and organized description and analysis of various landforms of the earth.

According to Strahler, geomorphology is an analysis of the origin and evolution of earth features. Geomorphology not only study the physical, chemical and biological processes affecting the evolution of landforms but also the structure of the earth's crust, the geological processes as well as the climatic influences, because it is the combined influence of all these factors that determines the landforms.

According to W.D. Thornbury, geomorphology is the science of landforms including the submarine topography. The word' *landforms'* includes not merely micro features of the land and but also major relief features such as continents, plain and plateaus and a discussion of their origin and evolution is equally relevant.

Earth-surface processes are forming landforms today, changing the landscape, often very slowly. Most geomorphic processes operate at a slow rate, but sometimes a large event, such as a landslide or flood, occurs causing rapid change to the environment, and sometimes threatening humans. So geological hazards, such as volcanic eruptions, earthquakes, tsunamis and landslides, fall within the interests of Geomorphologists. Advancements in remote sensing from satellites and GIS mapping has benefited Geomorphologists greatly over the past few decades, allowing them to understand global distributions.

So geomorphology is a diverse discipline. Although the basic geomorphological principles can be applied to all environments, Geomorphologists tend to specialize in one or two areas, such Aeolian (desert) geomorphology, glacial and periglacial geomorphology, volcanic and tectonic geomorphology, and even planetary geomorphology. Most research is multi-disciplinary, combining the knowledge and perspectives from two contrasting disciplines, combining with subjects as diverse as ecology, geology, civil engineering, and hydrology and soil science.

Check your progress

3. Discuss about nature of geomorphology

1.10 SCOPE OF GEOMORPHOLOGY

Geomorphology is the scientific study of landforms and the processes that shape them. Geomorphologists seek to understand why landscapes look the way they do: to understand landform history and dynamics, and predict future changes through a combination of field observation, physical experiment, and numerical modeling. Geomorphology is practiced within geology, geodesy, geography, archaeology, and geological engineering. Early studies in geomorphology are the foundation for pedology, one of two main branches of soil science.

The Subject matter of Geomorphology incorporates Structure, Process, systematic analysis and evolution of Landforms (time).

Structure is an arrangement of interrelated elements in a material object or system. It is determined by internal a force which includes plate tectonic, diastrophism and volcanic action. It includes study of geo-materials (lithology, deposition of rock beds and composition of rocks etc.)

Processes are mainly related to external or exogenic forces. These forces contribute to shape a landscape. They are also called destructional processes or denudational processes.

'Systematic analysis and **evolution of landforms** (time factor), is also an important in geomorphic evolution like structure and processes, because the interaction structures does not provide adequate explanation of surface processes with geological structures the length of time the process has been operating which will give us an idea of the relative stage of development.

For systematic analysis of landforms, we can classify landforms into three categories. They are; 1.Generic classification of landforms, 2.Genetic classification of landforms, and 3. Classification on the basis of scale and lifespan.

Generic classification of landforms is the description of entire group or class of landforms i.e., Mountain Plateau and Plains (example, Himalayan Mountain ranges, Tibetan Plateau and the Northern plains in India).

Genetic Classification of Landforms: It means classification of landforms by dominant set of geomorphic processes. For example, Tectonic landforms, fluvial landforms, Karst landforms, Aeolian landforms, Coastal landforms and glacial landforms.

Classification of landforms on the basis of scale can be understood by rearranging the earth's landforms into three different orders: for example,

1) First order relief features: it includes Continental Platforms and Ocean Basins. .

2) Second order relief features: The relief features of the second order are superimposed on First order category of landforms for example, plains, plateau and mountains.

3) Lastly, third order relief features are superimposed on II order relief features such as Valleys, Canyons and Dunes.

Two major approaches in geomorphology are:

Historical approaches: it involves historical evolution of landforms

Functional approaches: it involves time –independent series of landforms evolution reflecting association between landform characteristics and existing environmental condition.

Check your progress

4. Discuss about the scope of geomorphology

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5. Discuss the classification of landforms on the basis of scale

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1.11. SUMMARY

Inspite of its interdependence cutting across on so many sister disciplines, one cannot deny that geography in itself is an independent field of study. It is the science of place, i.e. the study of surface of the earth, the locational and distributional of its physical and cultural features, the areal pattern or places that they form, and the interrelation of these features as they affect humans. Geography is a synoptic science that uses the same elements as the other sciences but in a different context. It integrates data spatially, making elaborate use of maps as special tool. Geography may be studied by way of several interrelated approaches, i.e. systematically, regionally, descriptively and analytically. Not only the definition, purpose and methodology of geography is changing, but its scope and subject matter is also widening with time.

1.12. WHAT YOU LEARNT

Geography is a science of space. Geography is both a natural and social science as it studies both environment and the people. It connects the physical and cultural world. Physical geography studies the earth systems that create natural environment. Human geography is concerned with the political, economic, social, cultural and demographic processes. It is concerned with the different ways in which resources are used.

Earlier geography merely described places. Even though, this is still a part of geography, the pattern of description has changed a lot in recent years. Now we understand the cause and impact of natural and human phenomena in creating physical and human landscapes.

Geography has three main branches: Physical human and regional. Physical geography is further subdivided into several other branches namely; Geomorphology, climatology, oceanography, soil and biogeography. Human Geography is also subdivided into other branches like, cultural, population, social, economic and political. All these subjects are interrelated to each other.

1.13 CHECK YOUR PROGRESS- MODEL ANSWERS

1. Geography is to describe about the earth's surfaces. In other words "Geography is largely the study of the interaction of all physical and human phenomena and landscapes created by such interactions."
2. The scope of geography is in various disciplines, like armed services, environment management, water resources, disaster management, meteorology and planning and various social sciences. Apart from that, a geographer can help in day to day life like tourism, commuting, housing and health related activities.
3. Geomorphology is the study of landforms, their processes, form and sediments at the surface of the Earth (and sometimes on other planets). Study includes looking at landscapes to work out how the earth surface processes, such as air, water and ice, can mould the landscape.
4. Geomorphologists seek to understand why landscapes look the way they do: to understand landform history and dynamics, and predict future changes through a combination of field observation, physical experiment, and numerical modeling.
5. Classification of landforms on the basis of scale can be;

1) It includes Continental Platforms and Ocean Basins. .2) the relief features of the second order are superimposed on First order category of landforms for example, plains, plateau and mountains. 3) Lastly, relief features are superimposed on II order relief features such as Valleys, Canyons and Dunes.

1.14 MODEL EXAMINATION QUESTIONS

1. Answer the following questions in about 30 lines

1. Define term geography and explain why geography is called mother of all sciences.
2. Why human geography is important. Explain with suitable examples.

2. Answer the following questions in about 10 lines

1. Define term physical and human geography.
2. What are the sister's disciplines in geography?

3. Define geomorphology

4. Distinguish between population geography and economic geography.

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UNIT- 2: LAND AND OCEANS

Contents

2.0 Objectives

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2.2 Distribution of Oceans, Continents

2.3 First order land Forms

2.4 Second order land Forms

2.5 Third order land Forms

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2.0 OBJECTIVES

To understand the continents and oceans.

To learn about the characteristic features of the different land forms and oceans.

To know about the classification of landforms.

To understand the oceans and its features.

This lesson focuses on land and oceans found on the Earth. It deals with the classification of landforms - first, second and third order landforms.

2.1. INTRODUCTION

The Earth is covered by water which occupies 71 percent and land that occupies 29 percent of the Earth's surface. The surface of the Earth is not even, because it has lofty mountains, deep oceans and other landforms. Land and water are unevenly distributed on the earth. Continents cover 29.2% of earth surface. The ocean is divided in to three basins called Atlantic, Pacific and Indian. Ocean basin covers 70.8% of earth surface. The southern hemisphere is dominated by oceans (80.4%). Northern hemisphere contains most of the land and is still dominated by ocean (60.7%).

Three Major Components of the earth include the hydrosphere, the lithosphere, and the atmosphere. Oceans constitute the hydrosphere; the lithosphere is the layer of rocks; the atmosphere is the layer of air. The biosphere encompasses parts of these three layers. It extends several meters into the soil (lithosphere) several hundred meters (over 6 miles) into the atmosphere, and more than 11,000 meters into the ocean. The average depth of ocean is four km. Oceans are predominant in the Southern Hemisphere, often referred as the marine hemisphere. Landmass, on the other hand, dominates in the northern Hemisphere, which is known as the land hemisphere. The land hemisphere includes the continental masses of Eurasia, North America and Africa above the equator. The marine hemisphere comprises South America, Africa below the equator, Australia, New Zealand, and Antarctica.

2.2. DISTRIBUTION OF OCEANS AND CONTINENT

The positions of the continents and the ocean bodies have not been the same in the past. Moreover, it is now a well-accepted fact that oceans and continents will not continue to enjoy their present positions in times to come. If this is so, the question arises what were their positions in the past? Why and how do they change their positions? Even if it is true that the continents and oceans have changed and are changing their positions, you may wonder as to how scientists know this. How have they determined their earlier positions? You will find the answers to some of these and related questions in this chapter.

The landforms can be classified as; first order land forms; second order land forms and third order land forms.

2.3. Continents and oceans are grouped as **FIRST ORDER LANDFORMS**.

The vast land masses on Earth are called Continents and huge water bodies are called Oceans. There are seven continents. They are Asia, Africa, North America, South America, Antarctica, Europe and Australia. Asia is the largest continent, whereas Australia is the smallest one. Apart from continents, there are five oceans located on the Earth's surface. They are the Pacific, Atlantic, Indian, Southern and Arctic Ocean. Among these oceans, the Pacific Ocean is the largest and the Arctic Ocean is the smallest.

Check your progress

1. What is a continent?

----

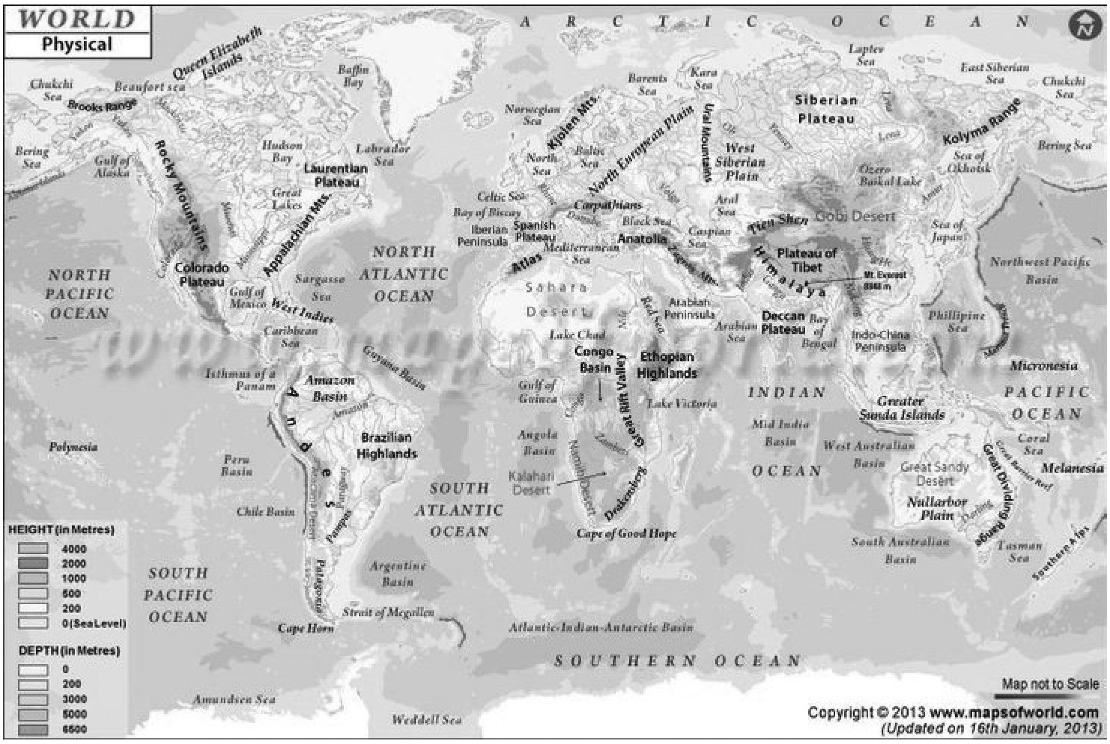
2. List out the name of the continents according to their size.

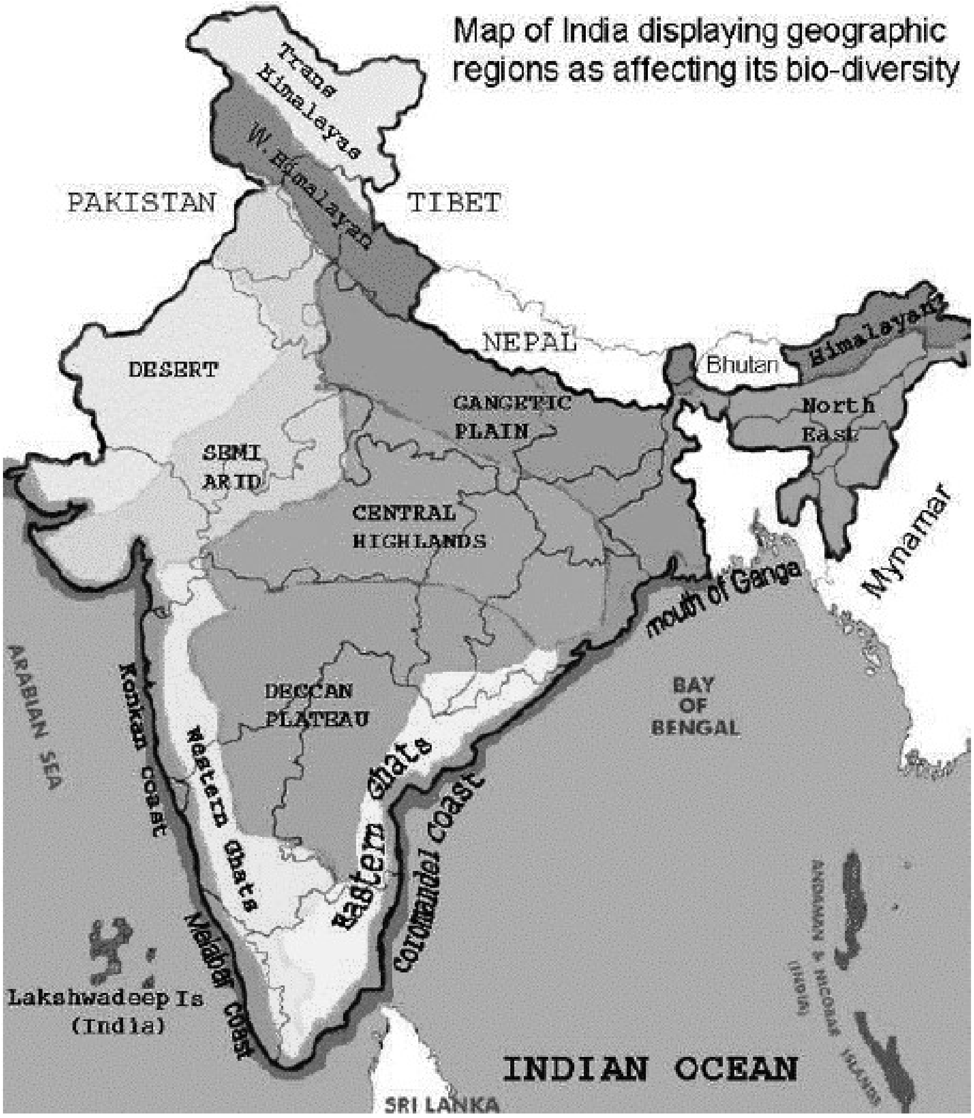
2.4. The **SECOND ORDER LANDFORMS** are categorized as mountains, plateaus and plains.

Mountains:

A landform that rises 600 mts above its surroundings and has steep slopes is called a mountain. Mountains are found in isolation or in groups. If the mountains extend for a larger area continuously, it is called a mountain range. These ranges stretch for hundreds or thousands of kilometers. The Himalayas of Asia, the Rocky Mountains of North America and the Andes of South America are such examples. The Andes Mountain in South America is the longest mountain range (7,000 km) in the world. The highest point of a mountain is known as peak. Mt. Everest is the highest peak (8,848 m) in the world.

Mountains are the sources of rivers. They provide shelter to flora and fauna. Here, tourism is an important activity. During summer, people go to mountain regions to enjoy the pleasing cool weather.





Plateaus

Plateaus are the elevated portions of the Earth that have flat surfaces bounded by steep slopes. The elevation of plateaus may be a few hundred meters or several thousand meters. Tibetan Plateau is the highest plateau in the world. So, it is called as the ‘Roof of the world’. The flat topped part of the plateau is called Tableland. The plateaus are generally rich in minerals. The Chota Nagpur Plateau is one of the mineral rich plateaus in India. Therefore, mining is one of the major activities of the people living here. The Deccan Plateau in peninsular India is of volcanic origin.

Plains

Plains are flat and relatively low-lying lands. Plains are usually less than 200 metre above sea level. Sometimes they may be rolling or undulating. Most plains are formed by rivers and their tributaries and distributaries. These plains are used extensively for agriculture due to the availability of water and fertile soil. They are most suitable for human inhabitation. Hence, they are the highly populated regions of the world. The oldest civilizations like the Mesopotamian and the Indus civilizations developed in river plains. The Indo-Gangetic plain in North India is one of the largest plains in the world. The plains formed by river Cauvery and Vaigai are important plains found in Tamil Nadu. Coastal plains are the low lying lands adjacent to oceans and seas.

Check your progress

3. Write a brief note on plateaus.

2.5 THIRD ORDER LANDFORMS

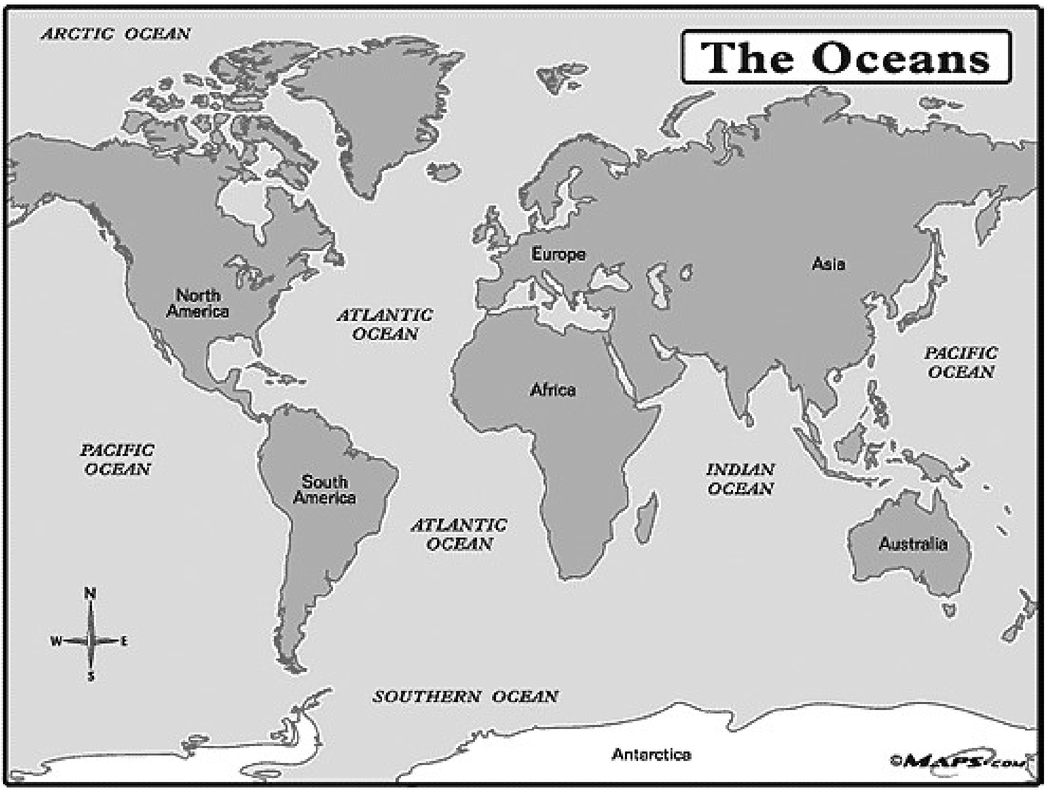
Third order landforms are formed on mountains, plateaus and plains mainly by erosional and depositional activities of rivers, glaciers, winds and waves. Valleys, beaches and sand dunes are some examples of third order landforms.

Oceans

The Earth looks blue when we see it from space. This is because, two-thirds of it is covered by water. The water is found in oceans and seas. Oceans are vast expanse of water. Seas are water bodies partially or fully enclosed by land. There are five main oceans in the world.

The Pacific Ocean: The Pacific Ocean is the largest and deepest ocean on the Earth. It covers about one-third of the Earth's total area and spreads for about 168.72 million sq.km. It is bounded by Asia and Australia in its west and North America and South America in its east. It stretches from the Arctic Ocean in the north to the Southern Ocean in the south.

This ocean's shape is roughly triangular with its apex in the north at the Bering Strait which connects the Pacific Ocean with the Arctic Ocean. The Bering Sea, the China Sea, the Sea of Japan, Tasman Sea and the Philippine Sea are some of the marginal seas of the Pacific Ocean. Indonesia, Philippines, Japan, Hawaii, New Zealand are some of the islands located in this Ocean. The deepest point Mariana Trench is 10,994 mt and is located in the Pacific Ocean. A chain of volcanoes is located around the Pacific Ocean called the Pacific Ring of Fire.



The Atlantic Ocean is the second largest ocean on the Earth. It covers one sixth of the Earth's total area and spreads for about 85.13 million sq.km. It is bounded by North America and South America in the west and Europe and Africa in the east. Like the Pacific it stretches from the Arctic Ocean in the north to the Southern Ocean in the south. The shape of the Atlantic Ocean resembles the letter 'S'. The Strait of Gibraltar connects the Atlantic Ocean with the Mediterranean Sea. The Atlantic Ocean is the busiest shipping route between the Eastern and Western hemispheres. The deepest point is the Milwaukee Deep in the Puerto Rica Trench. It has a depth of about 8600 mt. The Caribbean Sea, the Gulf of Mexico, the North Sea, the Gulf of Guinea and the Mediterranean Sea are important marginal seas of the Atlantic Ocean. St. Helena, Newfoundland, Iceland and Falkland are some of the islands found in this ocean.

The Indian Ocean: The Indian Ocean is the third largest ocean on the Earth's surface. It covers an area of about 70.56 million sq.km. It is named after India. It is triangular in shape and bounded by Africa in the west, Asia in the north and Australia in the east. The Andaman and Nicobar Islands, Lakshadweep, Maldives, Srilanka, Mauritius and the Reunion Islands are some of the islands located in the Indian Ocean. Malacca strait connects the Indian Ocean and the Pacific Ocean.

The Bay of Bengal, the Arabian Sea, the Persian Gulf and the Red Sea are some of the important marginal seas of the Indian Ocean. The Java trench (7,725 mt) is the deepest point in the Indian Ocean.

(Palk Strait connects the Bay of Bengal and Palk Bay).

- 6° Channel separates Indira Point and Indonesia
- 8° Channel separates Maldives and Minicoy islands
- 9° Channel separates Lakshadweep Islands and Minicoy islands
- 10° Channel separates Andaman and Nicobar Islands

The Southern Ocean: The Southern Ocean surrounds the continent of Antarctica and is enclosed by the 60°S latitude. It covers an area of 21.96 million sq.km. It is bordered by the southern parts of the Pacific, the Atlantic and the Indian Oceans. The Ross Sea, the Weddell Sea and the Davis Sea are the marginal seas of this Ocean. Farewell Island, Bowman Island and Hearst Island are some of the islands located in this ocean. The water in this ocean is very cold. Much of it is covered by sea ice. The deepest point in this ocean is South Sandwich Trench with a depth of 7,235 mt.

The Arctic Ocean: The Arctic Ocean is the smallest ocean. It covers an area of 15.56 million sq.km. It lies within the Arctic Circle. It remains frozen for most of the year. The Norwegian Sea, the Greenland Sea, the East Siberian Sea and the Barents Sea are some of the marginal seas of this ocean. Greenland, New Siberian Island and Novaya Zemlya Island are some of the islands located in the Arctic Ocean. The North Pole is situated in the middle of the Arctic Ocean. The Eurasian Basin is the deepest point in the Arctic Ocean, which is about 5,449 mt in depth.

Check your progress

4. Discuss about importance of the oceans.

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5. Write in brief about the importance of the Pacific Ocean

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6. Name the continents which surrounded by the Atlantic Ocean

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2.6 CONTINENTAL DRIFT

Observe the shape of the coastline of the Atlantic Ocean. You will be surprised by the symmetry of the coastlines on either side of the ocean. No wonder, many scientists thought of this similarity and considered the possibility of the two Americas, Europe and Africa, to be once joined together. From the known records of the history of science, it was *Abraham Ortelius*, a Dutch map maker, who first proposed such a possibility as early as 1596. *Antonio Pellegrini* drew a map showing the three continents together. However, it was *Alfred Wegener*—a German meteorologist who put forth a comprehensive argument in the form of "the continental drift theory" in 1912. This was regarding the distribution of the oceans and the continents.

According to Wegener, all the continents formed a single continental mass and Mega Ocean surrounded the same. The super continent was named PANGAEA, which meant all earth. The mega-ocean was called PANTHALASSA, meaning all water. He argued that, around 200 million years ago, the super continent, Pangaea, began to split. Pangaea first broke into two large continental masses as Laurasia and Gondwanaland forming the northern and southern components respectively. Subsequently, Laurasia and Gondwanaland continued to break into various smaller continents that exist today. A variety of evidence was offered in support of the continental drift.

2.7 EVIDENCES TO SUPPORT THE CONTINENTAL DRIFT

1. The matching of continents (jig-saw fit): The shorelines of S. America and Africa have remarkable match. A map was produced by Bullard in 1964 to show the jigsaw fit of these two continents. It was fit around 1000 fathom line of the shoreline.

2. Rocks of same age across the oceans: the belt of ancient rocks of 2000 million years from Brazil coast matches with those of Western Africa. Marine deposits of South America and Africa belong to Jurassic age.

3. Tillite: Sedimentary rock formed out of glacial deposits. Sediments from India have similar counter parts at different continents of south. Tillile indicates prolonged glaciations. The same glaciation is found in Africa, Falklands, Madagascar, Antarctica and Australia. The glacial Tillite indicates that unambiguous evidence of palaeo climates and drifting of continents.

4. Placer deposits: Formation of placer deposits of gold in Ghana coast has no source rock. The gold bearing veins of rocks are found in Brazil

5. Distribution of fossils: Identical species of animals and plants are found along the coastal regions of the different continents. Lemurs occur in India, Madagascar and Africa. The contiguous Land mass was called LEMURIA. The fossils of mesosaurus were found in only South Africa and Brazil.

Forces for drifting the continents

Wegner suggested that the movement responsible for the drifting of the continents was caused by; A. Polar fleeing force; b. Tidal force.

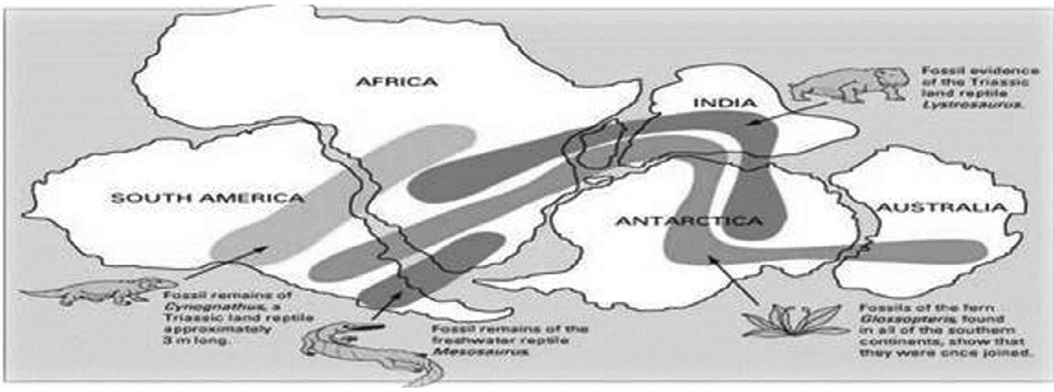

Fig. 2.1: **Distribution of fossils**

The first characteristic is explicitly contained in the general proposition above. A glance at Fig. taken from Stieler's Hand atlas impresses one strongly with the antipodal relation of land and water; but Fig. gives a truer impression. The former shows the eastern hemisphere with the western hemisphere projected through upon it, the latter shows the land hemisphere with the water hemisphere projected upon it.

If all the land were in one hemisphere, then the antipodal relation of the land to the water would be perfect. But this is not so; there is some land in the water hemisphere. Does it project upon water in the land hemisphere?

Tidal force: Wegener suggested that these two forces are responsible for the movement of plates. Most of the scholars consider that these forces are not sufficient to move the plates.

2.8 DISTRIBUTION OF LAND AND WATER ON THE EARTH

The shapes of the various continents and seas, their relative areas, and their dispositions with regard to each other, have always been attractive problems for geographers and a number of characteristics have been formulated. They are:

The earth can be divided into two hemispheres in such a way that nearly all the land is concentrated in one hemisphere, and the other is nearly all covered with water.

The land is everywhere opposite the water. The land is concentrated around the arctic regions, and the water around the Antarctic regions. The land sends three projections towards the south, and the oceans three projections towards the north.

The continents are roughly triangular in shape, pointing southward. The oceans are roughly triangular in shape, pointing northwards.

The continents are divided into a northern and a southern group by 'Mediterranean seas; and the southern group is offset to- wards the east.

Imagine we have all pondered over these curious characteristics; and must confess that the antipodal relation of land and water has, until recently, an absorbing though baffling million years, with no threads leading to its solution. But the matter turns out to be rather simple, after all. It can be shown that nearly all the characteristics enumerated above are comprised in the following:

The land area of the earth is a loosely connected, and deeply dissected area, about five-sixths of which is concentrated in one hemisphere, whose pole lies about half way between the equator and the north geographic pole. And the position of this land area on the earth has no relation whatever to the earth's equator and axis of rotation.

A glance at Fig. will show that this is a true statement; we shall discuss later this concentration of the land.

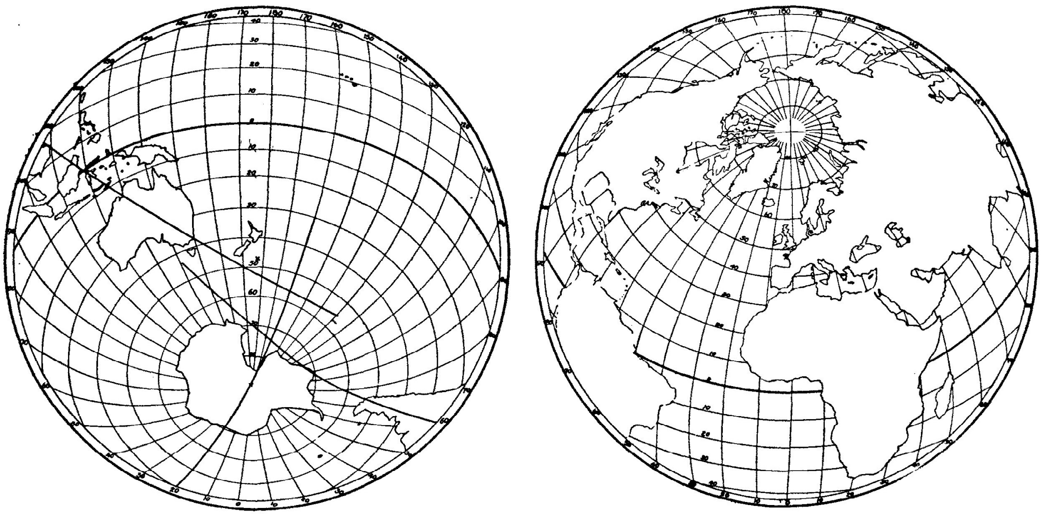

Fig: Land and water hemispheres. Lambert's equivalent area projection

The first characteristic is explicitly contained in the general proposition above. A glance at Fig. taken from Stieler's Hand atlas impresses one strongly with the antipodal relation of land and water; but Fig. gives a truer impression. The former shows the eastern hemisphere with the western hemisphere projected through upon it, the latter shows the land hemisphere with the water hemisphere projected upon it.

If all the land were in one hemisphere, then the antipodal relation of the land to the water would be perfect. But this is not so; there is some land in the water hemisphere. Does it project upon water in the land hemisphere?

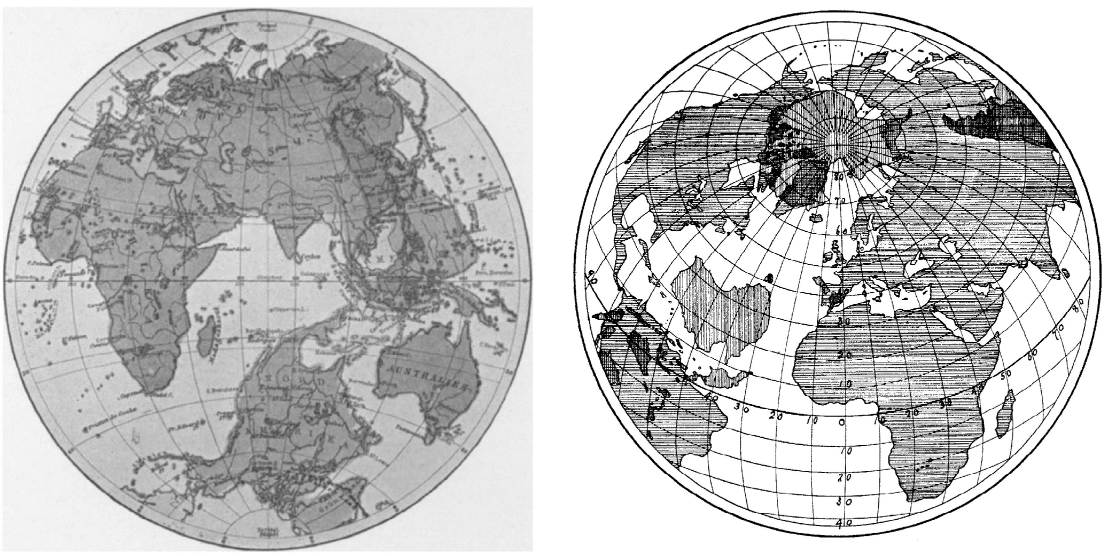

Fig: Antipodal relations: from stealers Hand Atlas. Land and water hemisphere

There are three main land masses in the water hemisphere: Australia, with some of the large islands north of it; the Antarctic continent, and the southern end of South America; to these may be added the much smaller area of New Zealand. Fig. shows that Australia projects against the North Atlantic Ocean; and some of the adjacent islands against the northern part of South 'America; the southern part of South America projects almost entirely against China; the Antarctic continent projects partly against the Arctic Ocean and partly against the lands surrounding it. New Zealand projects partly against Spain and partly against the adjacent sea. The total area of the lands in the water hemisphere is about one eleventh of the area of the hemisphere. A little less than one half this land projects against water and a little more than one half against land, and this is almost exactly the proportion we should expect if the land in the water hemisphere were distributed without any definite relation to the water in the land hemisphere. For in the latter the ratio of the land to the water is practically one half the hemispheres is water and one half is land. So far then as the antipodal relation of land and water is not explained by the existence of a land and a water hemisphere, it is purely accidental; and there is no necessity to look for a special explanation for it.

The fact that the center of the land hemisphere is pretty far north, being a little more than half way from the equator to the north pole, places the arctic regions well within this hemisphere and therefore naturally surrounds them with land. And similarly the Antarctic regions being well within the water hemisphere is naturally surrounded by water.

The projections of South America, Africa, and Australia are said to point towards the south. These projections of the land area point equally well towards the antipodes of the center of the land hemisphere, *i.e.,* in a general way, away from the land mass; a relation which is a natural consequence of the concentration of the land in one general mass. Japan and Mexico, for instance, are quite as far from the center of the land hemisphere as the south end of Africa; but in their neighborhood the outline of the land maintains its distance from the center.

South America is certainly well separated from North America; and Australia from Asia; but Australia is really a very big island and is only a continent by courtesy. The separation of Africa from Europe is quite insignificant. the Mediterranean's are the indications of a zone of weakness lying along what was once the earth's equator, with the pole in Behring's sea; that the southern hemisphere contracted more than the northern and thus tended to increase its rate of rotation, producing stresses which caused fractures along the then equator.

We may say, in closing, that the existence of a water hemisphere and a land hemisphere is due to the non-coincidence of the center of mass and the center of figure of the earth ; that this is due to a difference of density in the two hemispheres, probably confined to a hundred miles or so of the surface; and that this, in turn, is due, not to unequal contraction or anything of that kind, but to a difference in the composition of the rock in the two areas.

2.9. WHAT YOU LEARNT

The surface of the Earth is covered by 71 percent of water and 29 percent of land.

The landforms are classified as first order, second order and third order landforms.

Continents and oceans are the first order landforms.

There are seven continents and five oceans on the Earth's surface.

Mountains, plateaus and plains are the second order landforms.

Valleys, beaches and sand dunes are the third order landforms.

Many islands and marginal seas are found in the oceans.

2.10. CHECK YOUR PROGRESS – MODEL ANSWERS

1. The vast land masses on earth are called continents.
2. From the largest to the smallest, they are Asia, Africa, North America, South America, Antarctica, Europe and Australia.
3. Plateaus are the elevated portions of the Earth bounded by steep slopes. The elevation of plateaus may be a few hundred meters. Tibetan Plateau is the highest plateau in the world. So, it is called as the 'Roof of the world'. The flat topped part of the plateau is called Tableland. The plateaus are generally rich in minerals. The Chota Nagpur Plateau is one of the mineral rich plateaus in India.
4. Oceans are the life blood of planets Earth/Human kind. They flow oven nearly three quarters of our planet. They hold 97% of the planets water. Absorb the most carbon from it.

   They produce more than half of the oxygen in the atmosphere. The oceans along with the atmosphere, keep temperature fairly constant worldwide
5. The Pacific Ocean is the largest and deepest ocean on the Earth. It is bounded by Asia and Australia in its west and North America and South America in its east. It stretches from the Arctic Ocean in the north to the Southern Ocean in the south. The deepest point Mariana Trench is 10,994 m- and is located in the Pacific Ocean. A chain of volcanoes is located around the Pacific Ocean called the Pacific Ring of Fire.
6. The Atlantic Ocean is bounded by North America and South America in the west and (Europe and Africa in the East)

2.11 MODEL EXAMINATION QUESTIONS

Answer the following questions in detail

1. Write down the classification of landforms.
2. Plains are highly populated. Give reasons
3. Discuss about the importance of oceans.
4. Distinguish between a Mountain and a Plateau
5. Name the oceans which surround North America and South America.
6. What are oceans? Name them.

2.12 GLOSSARY

Erosion is the process of removal of surface material from the Earth's crust. The eroded materials are transported and deposited on the low lying areas. This process is called as Deposition.

Island - A land surrounded by water on all sides.

Bay - A broad inlet of the sea where the land curves inwards.

Strait - A narrow stretch of water linking two large water bodies.

Trench - The deepest part of the ocean.

Peninsula - The land surrounded by water on three sides.

2.13 FURTHER READINGS

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UNIT - 3: INTERIOR OF THE EARTH - STRUCTURE AND COMPOSITION

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3.3 Internal Layers of the Earth
3.4 Earth movements
3.5 Structure of the Earth's interior
3.6 Temperature, Pressure and Density of the Earth's interior
3.7 Realm of the Earth
3.8 Original & Evolution of Life on Earth
3.9 Milky way
3.10 Earth's Beginnings
3.11 Conclusion
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3.13 What would you understand about the interior of the earth?
3.14 Check your progress - Model Answers
3.15 Model Examination Questions
3.16 Glossary
3.17 Further Readings

3.0 OBJECTIVES

To explore the key concepts of Earth's structure:
To know about the interior of the earth
The structure of Earth
Movement of Earth's crust
To understand the role of plates

3.1. INTRODUCTION

The interior of the earth can be understood only by indirect evidences as neither any one has nor anyone can reach the interior of the earth. The configuration of the surface of the earth is largely a product of the processes operating in the interior of the earth. Exogenic as well as endogenic processes are constantly shaping the landscape. A proper understanding of the physiographic character of a region remains incomplete if the effects of endogenic processes are ignored. Human life is largely influenced by the physiography of the region. Therefore, it is necessary that one gets acquainted with the forces that influence landscape development. To understand why the earth shakes or how a tsunami wave is generated, it is necessary that we know certain details of the interior of the earth. It is interesting to know how scientists have gathered information about these layers and what the characteristics of each of these layers are. This is exactly what this chapter deals with.

Most of our knowledge about the interior of the earth is largely based on estimates and inferences. Part of the information is obtained through direct observations and analysis of materials. The most easily available solid earth material is surface rock or the rocks from mining areas. Besides mining, scientists have taken up a number of projects to penetrate deeper depths to explore the conditions in the crustal portions. This and many deep drilling projects have provided large volume of information through the analysis of materials collected at different depths. Volcanic eruption forms another source of obtaining direct information. However, it is difficult to ascertain the depth of the source of such magma. Knowing the total thickness of the earth, scientists have estimated the values of temperature, pressure and the density of materials at different depths. The details of these characteristics with reference to each layer of the interior are discussed later in this chapter.

The internal structure of the Earth is layered in spherical shells: an outer silicate solid crust, a highly viscous asthenosphere and mantle, a liquid outer core that is much less viscous than the mantle, and a solid inner core. Scientific understanding of the internal structure of the Earth is based on observations of topography and bathymetry, observations of rock in outcrop, samples brought to the surface from greater depths by volcanoes or volcanic activity, analysis of the seismic waves that pass through the Earth, measurements of the gravitational and magnetic fields of the Earth, and experiments with crystalline solids at pressures and temperatures characteristic of the Earth's deep interior. Earth is called as blue Planet. 71% of the earth is covered by water.

3.2 THE STRUCTURE OF THE EARTH

Earth's inside structure is quite different to its hard, crusty shell. We sometimes get a glimpse of Earth's interior through the action of active volcanoes. Earth's rocky crust is by no means stationary and we regularly see evidence of crust movement in the form of earthquakes. Earthquakes in ocean regions produce destructive ocean waves called 'tsunamis'.

The universal acceptance of plate tectonic theory is recognized as a major milestone in the earth sciences. It is comparable to the revolution caused by Darwin's theory of evolution or Einstein's theories about motion and gravity. Plate tectonics provide a framework for interpreting the composition, structure and internal processes of Earth on a global scale.

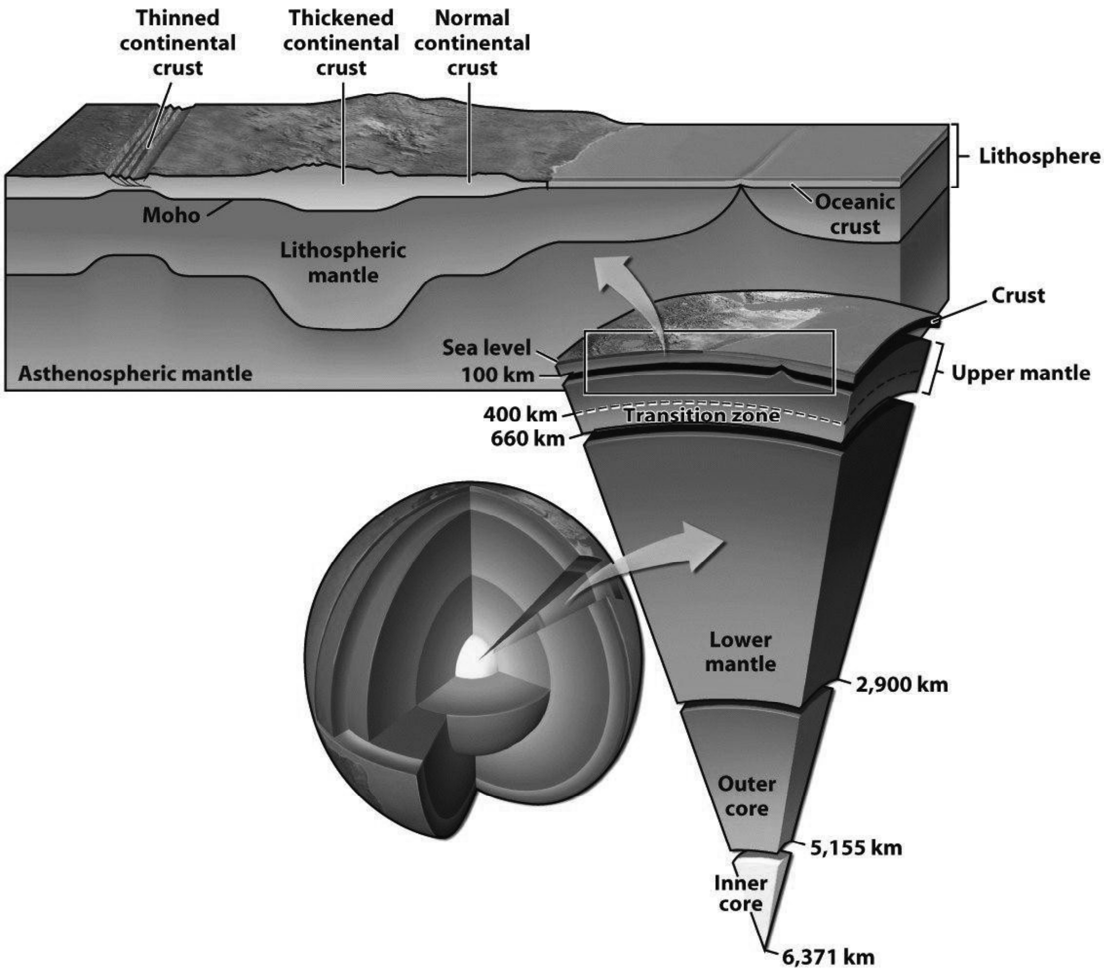
The structure of the earth may be compared to that of an apple. The earth too has shells like that of an apple. If we cut a section through the earth, we will get a view as shown in fig. On the basis of the study of earthquake waves the spherical earth is found to be three concentric layers. They are: The crust, the mantle and the core. Each layer has its own chemical composition and properties.

3.3 INTERNAL LAYERS OF THE EARTH

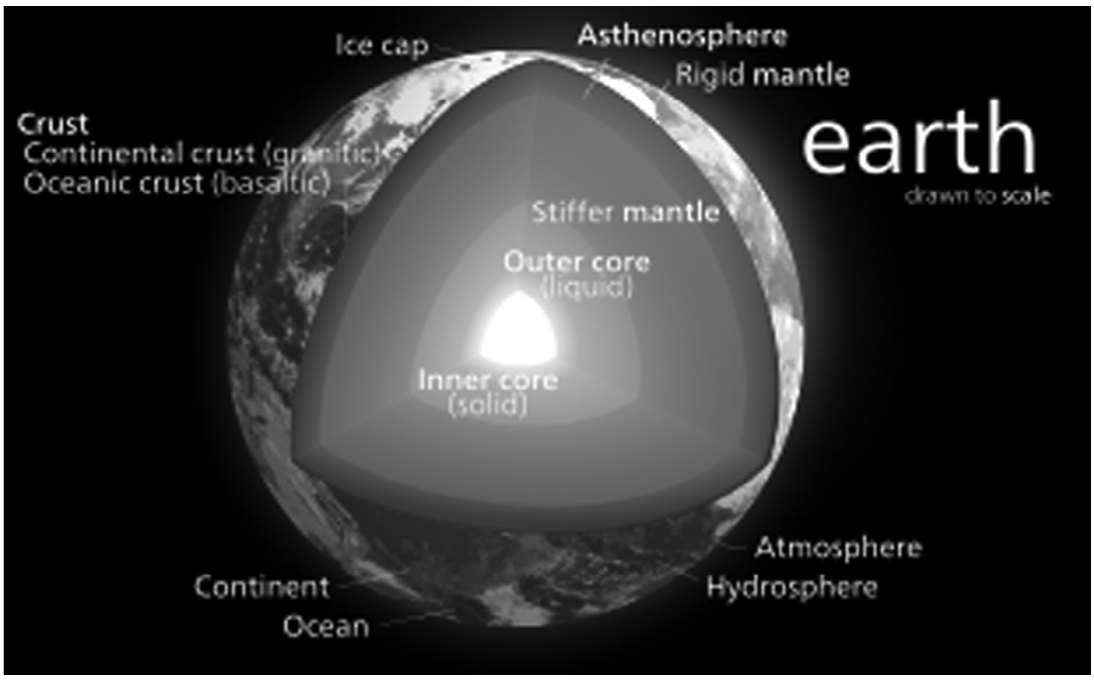
The Earth is made up of three main layers: *crust, mantle,* and *core.*

Beneath the oceans, the crust generally extends to about 5 km. The thickness of the crust beneath the continents is thicker and averages about 30 km.

Below the crust is the mantle, a dense, hot layer of semi-solid rock approximately 2900 km thick. At the center of the Earth lies the core, which is actually made up of two distinct parts, a 2200 km-thick liquid outer core and a 1250 km-thick solid inner core. As the Earth rotates, the liquid outer core spins and generates the Earth's magnetic field.



Thinned continental crust
Thickened continental crust
Normal continental crust
Lithosphere
Moho
Oceanic crust
Lithospheric mantle
Crust
Sea level
100 km
Upper mantle
Asthenospheric mantle
400 km
Transition zone
660 km
Lower mantle
2,900 km
Outer core
5,155 km
Inner core
6,371 km



Ice cap
Asthenosphere
Rigid mantle
Crust
Continental crust
Oceanic crust
earth
drawn to scale
Stiffer mantle
Outer core
(liquid)
Inner core
(solid)
Atmosphere
Hydrosphere
Continent
Ocean

Check your progress

1. Write about internal layers of the earth.

3.4 THE EARTH MOVEMENTS

The lithosphere is broken into a number of plates known as the *Lithospheric plates*. Each plate, oceanic or continental moves independently over the asthenosphere. The movement of the Earth's lithospheric plates is termed as tectonic movements. The energy required to move these plates is produced by the internal heat of the earth. These plates are moves in different directions at different rates.

At places, these plates move away from each other creating wide rifts on the earth's surface. At some places, these plates come closer and collide. When an oceanic plate collides with a continental plate, the denser oceanic plate is forced below the continental plate. As a result of the pressure from above.

The rocks heats up and melt. The molten rocks rise again forming volcanic mountains along the continental edge. Alternatively, a trench may be formed between two plates. In some cases when two continental plates converge, neither plate can be forced under the other. Instead, folds may be created. Great mountain ranges like the Himalayas have been formed in this way.

The movement of these plates causes changes on the surface of the earth. The earth movements are divided on the basis of the forces which cause them. The forces which act in the interior of the earth are called as Endogenic forces and the forces that work on the surface of the earth are called as Exogenic forces. Endogenic forces sometimes produce sudden movements and at the other times produce slow movements. Sudden movements like earthquakes and volcanoes cause mass destruction over the surface of the earth.

Major Lithosphere Plates

The outer rigid layer (about 70-100 km thick) of the Earth, comprising the crust and uppermost mantle, is divided into a number of plates. There are about 12 major plates such as

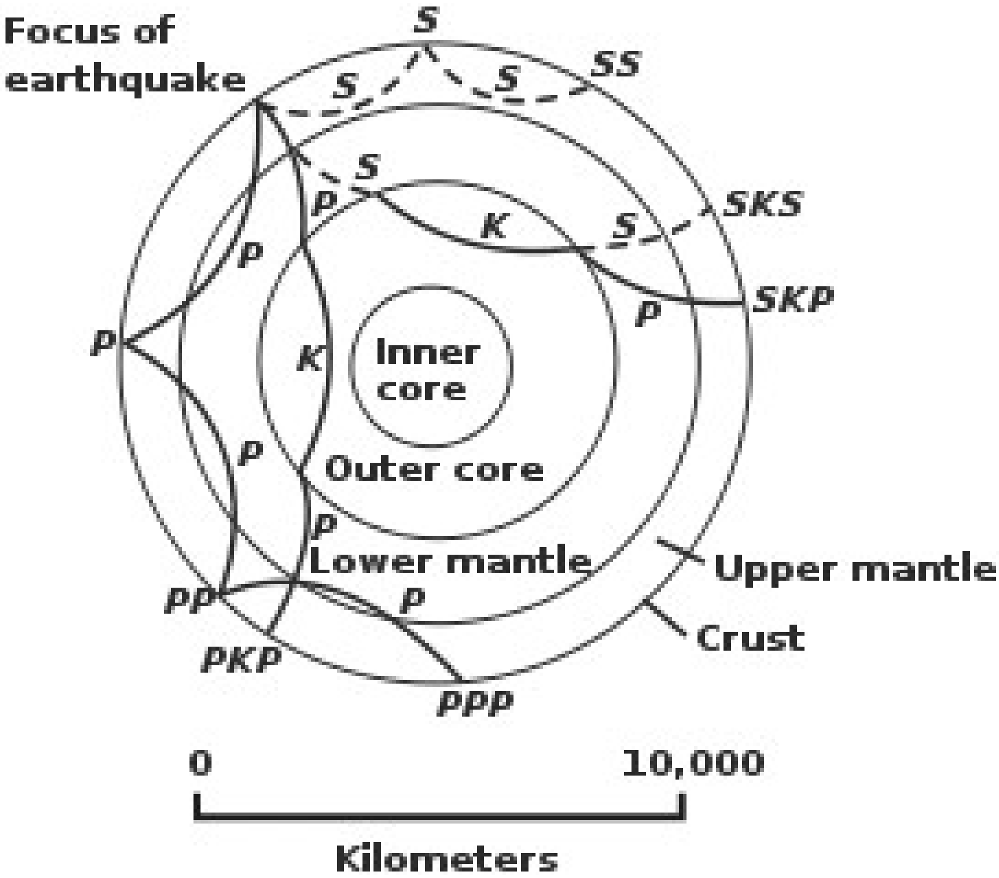
North American, South American, African, Indian, Eurasian, etc., covering the entire surface of the Earth.

Mass

The force exerted by Earth's gravity can be used to calculate its mass. Astronomers can also calculate Earth's mass by observing the motion of orbiting satellites. Earth's average density can be determined through gravimetric experiments, which have historically involved pendulums. The mass of Earth is about 6×10^{24} kg.

Structure

Earth's radial density distribution according to the preliminary reference earth model (PREM). Earth's gravity according to the preliminary reference earth model (PREM). Comparison to approximations using constant and linear density for Earth's interior.



Depth		
Kilometres	**Miles**	**Layer**
0–60	0–37	Lithosphere (locally varies between 5 and 200 km)
0–35	0–22	Crust (locally varies between 5 and 70 km)
35–60	22–37	… Uppermost part of mantle
35–2,890	22–1,790	Mantle
210-270	130-168	… Upper mesosphere (upper mantle)
660–2,890	410–1,790	… Lower mesosphere (lower mantle)
2,890–5,150	1,790–3,160	Outer core
5,150–6,360	3,160–3,954	Inner core

Check your progress

2. define endogenic and exogenic forces.

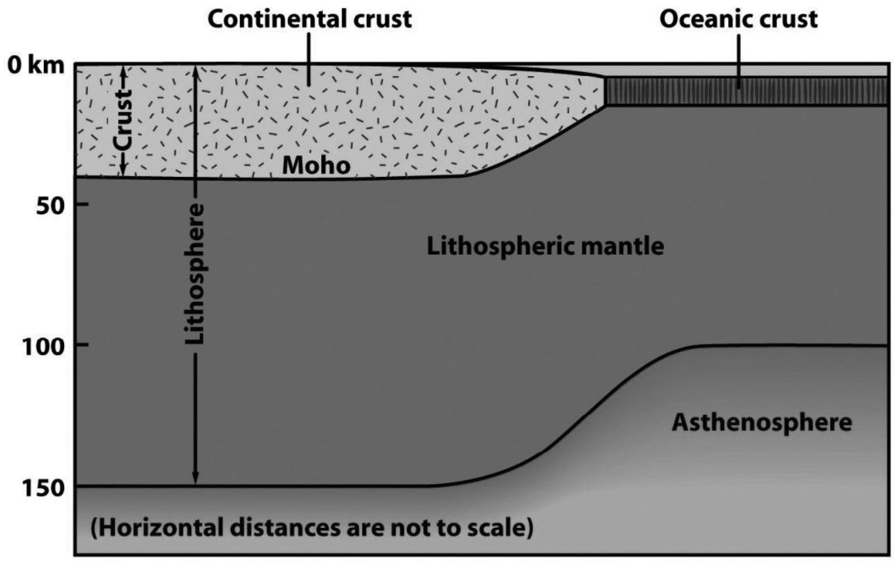
3.5. STRUCTURE OF THE EARTH'S INTERIOR

Structure of earth's interior is fundamentally divided into three layers – **crust, mantle and core**. The structure of Earth can be defined in two ways: by mechanical or chemically. Mechanically, it can be divided into lithosphere, asthenosphere, mesospheric mantle, outer core, and the inner core. Chemically, Earth can be divided into the crust, upper mantle, lower mantle, outer core, and inner core. The geologic component layers of Earth are at the following depths below the surface:

The layering of Earth has been inferred indirectly using the time of travel of refracted and reflected seismic waves created by earthquakes. The core does not allow shear waves to pass through it, while the speed of travel (seismic velocity) is different in other layers. The changes in seismic velocity between different layers causes refraction owing to Snell's law, like light bending as it passes through a prism. Likewise, reflections are caused by a large increase in seismic velocity and are similar to light reflecting from a mirror.

Crust

The Earth's crust ranges from 5–70 kilometres (3.1–43.5 mi) in depth and is the outermost layer. The thin parts are the oceanic crust, which underlie the ocean basins (5–10 km) and are composed of dense (mafic) iron magnesium silicate igneous rocks, like basalt. The thicker crust is continental crust, which is less dense and composed of (felsic) sodium potassium aluminium silicate rocks, like granite. The rocks of the crust fall into two major categories – sial and sima (Suess, 1831–1914). It is estimated that sima starts about 11 km below the Conrad discontinuity (a second order discontinuity). The uppermost mantle together with the crust constitutes the lithosphere.



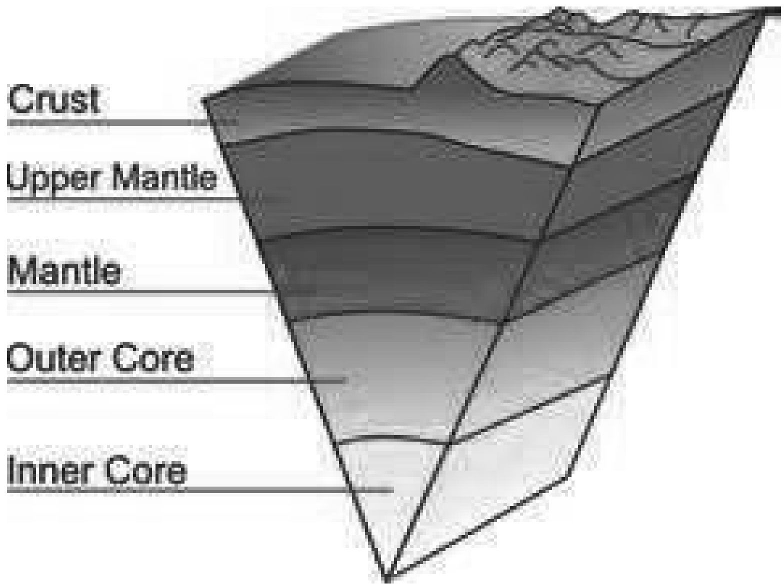
The crust-mantle boundary occurs as two physically different events. First, there is a discontinuity in the seismic velocity, which is most commonly known as the Mohorovičić discontinuity or Moho. The cause of the Moho is thought to be a change in rock composition from rocks containing plagioclase feldspar (above) to rocks that contain no feldspars (below).

Second, in oceanic crust, there is a chemical discontinuity between ultramafic cumulates and tectonized harzburgites, which has been observed from deep parts of the oceanic crust that have been abducted onto the continental crust and preserved as ophiolite sequences. The discontinuity between the **hydrosphere and crust** is termed as the **Conrad Discontinuity.**

The lower part is a continuous zone of denser basaltic rocks forming the ocean floors, comprising mainly of silica and magnesium. It is therefore called Sima. It has an average density of 3.0g/cm^3. The sial and the sima together form the earth's crust. Since the sial is lighter than the sima, the continents can be said to be 'floating' on a sea of denser sima.

Many rocks now making up Earth's crust formed less than 100 million (1×10^8) years ago; however, the oldest known mineral grains are about 4.4 billion (4.4×10^9) years old, indicating that Earth has had a solid crust for at least 4.4 billion years.

The crust forms only 1 per cent of the volume of the earth, 84 % consists of the mantle and 15 % makes the core. The radius of the earth is 6371 km. 98.5% of the crust is comprised of just 8 elements. Oxygen is (by far!) the most abundant element in the crust. This reflects the importance of silicate minerals. As a large atom, oxygen occupies ~93% of crustal volume.



Mantle

The portion of the interior beyond the crust is called the mantle. The mantle is the thickest of Earth's layers and takes up 83% of Earth's volume. It extends down to about 2900 km from the crust to Earth's core and is largely composed of a dark, dense, igneous rock called 'peridotite', containing iron and magnesium. The discontinuity between the crust and the mantle is called as the mohorovich discontinuity or Moho discontinuity. It is separated from the crust by a boundary called Mohorovicic discontinuity. The mantle is about 2,900 km thick. It is divided into two parts. (i) The upper mantle with a density of 3.4 – 4.4g/cm3. Extends down to 700 km. (ii) the lower mantle having a density of 4.4– 5.5g/cm3 extends from 700 to 2,900 km. The discontinuity between the **upper mantle and the lower mantle** is known as **Repetti Discontinuity**. The portion of the mantle which is just below the lithosphere and asthenosphere, but above the core is called as **Mesosphere**.

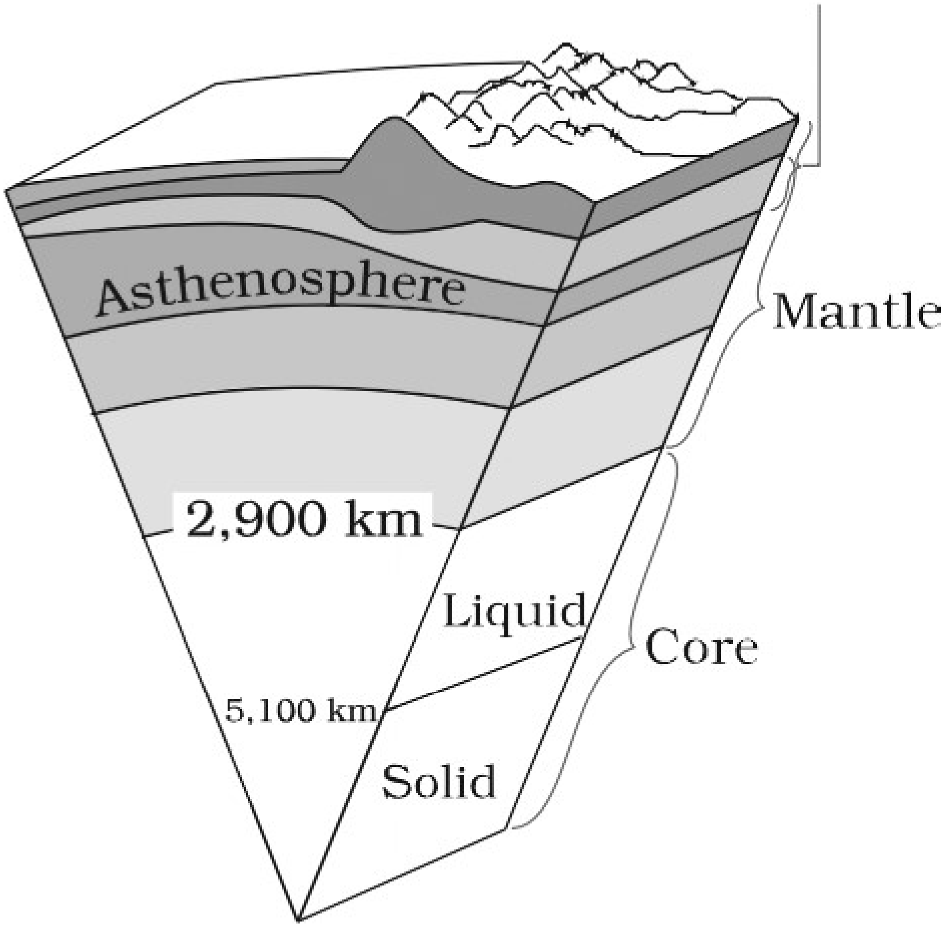


Fig: The interior of the earth

The mantle has three distinct layers: a lower, solid layer; the Asthenosphere (between 80-200km), which behaves plastically and flows slowly; and a solid upper layer. Partial melting within the asthenosphere generates magma (molten material), some of which rises to the surface because it is less dense than the surrounding material. The upper mantle and the crust make up the lithosphere, which is broken up into pieces called 'plates', which move over the asthenosphere. The interaction of these plates is responsible for earthquakes, volcanic eruptions and the formation of mountain ranges and ocean basins.

As mentioned above, the mantle is divided into upper and lower mantle. The upper and lower mantle is separated by the transition zone. The lowest part of the mantle next to the core-mantle boundary. The mantle is composed of silicate rocks that are rich in iron and magnesium relative to the overlying crust. Although solid, the high temperatures within the mantle cause the silicate material to be sufficiently ductile that it can flow on very long timescales. Convection of the mantle is expressed at the surface through the motions of tectonic plates.

Asthenosphere - The Asthenosphere is the part of the mantle that flows and moves the plates of the earth. As there is intense and increasing pressure as one travels deeper into the mantle, the lower part of the mantle flows less easily than does the upper mantle (chemical changes within the mantle may also be important). The source of heat that drives plate tectonics is the primordial heat left over from the planet's formation as well as the radioactive decay of uranium, thorium, and potassium in Earth's crust and mantle.

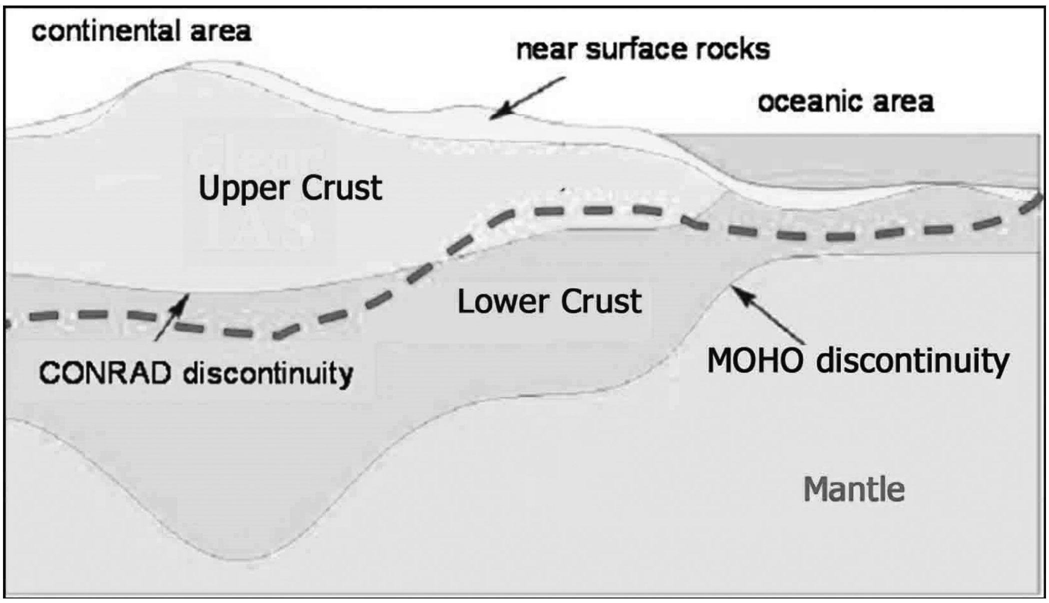
Core

The inner core was discovered in 1936 by Inge Lehmann and is generally believed to be composed primarily of iron and some nickel. It is the innermost layer surrounding the earths centre. Since this layer is able to transmit shear waves (transverse seismic waves), it must be solid. Experimental evidence has at times been critical of crystal models of the core. The core is also known as barysphere. It is separated from the mantle by a boundary called Weichart-Gutenberg discontinuity. The core is also divided into two parts. The Core consists of two sub-layers: the inner core and the outer core. (i) The outer core, which is rich in iron, is in liquid state. It extends between 2,900 – 5,150 km. (ii) the inner core, composed of Nickel and Ferrous (Nife), is solid in state. The central core has very high temperature and pressure. It extends from 5,150 km to 6,370 km.

The Inner core is in solid state and the outer core is in the liquid state (or semi-liquid). The discontinuity between the upper core and the lower core is called as **Lehmann Discontinuity. Barysphere** is sometimes used to refer the core of the earth or sometimes the whole interior.

The core is mostly iron, with some nickel and takes up 16% of Earth's total volume. The metallic core accounts for Earth's magnetic field. Earth behaves as though it has a simple straight bar magnet at its centre, with the 'south' pole just below Canada and the 'north' pole opposite, not quite coincident with the geographical poles. A compass needle's 'north' pole points northwards; because 'unlike' poles attract, Earth's magnetic pole in the Arctic must be the opposite type, 'south'. Evidence of Earth's change in magnetic polarity (direction of north–south line of magnetism) is found in the rocks. Scientists have found that rocks within Earth's crust formed at different times.

In early stages of Earth's formation about 4.6 billion years ago, melting would have caused denser substances to sink toward the center in a process called planetary differentiation, while less-dense materials would have migrated to the crust. The core is thus believed to largely be composed of iron (80%), along with nickel and one or lighter elements, whereas other dense elements, such as lead and uranium, either are too rare to be significant or tend to bind to lighter elements and thus remain in the crust. Some have argued that the inner core may be in the form of a single iron crystal. The liquid outer core surrounds the inner core and is believed to be composed of iron mixed with nickel and trace amounts of lighter elements.



Dynamo theory suggests that convection in the outer core, combined with the Coriolis Effect, gives rise to Earth's magnetic field. The solid inner core is too hot to hold a permanent magnetic field but probably acts to stabilize the magnetic field generated by the liquid outer core. The average magnetic field strength in Earth's outer core is estimated to be 25 Gauss (2.5 mT), 50 times stronger than the magnetic field at the surface.

Check your progress

3. Describe in short about basic structure of the earth.

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4. What your understand about the mantle layer of earth's interior

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5. What is asthenosphere?

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6. What is Moho Discontinuity?

3.6 TEMPERATURE, PRESSURE AND DENSITY OF THE EARTH'S INTERIOR

Temperature

- A rise in temperature with increase in depth is observed in mines and deep wells.
- These evidence along with molten lava erupted from the earth's interior supports that the temperature increases towards the centre of the earth.
- The different observations show that the rate of increase of temperature is not uniform from the surface towards the earth's centre. It is faster at some places and slower at other places.
- In the beginning, this rate of increase of temperature is at an average rate of 1^0C for every 32m increase in depth.
- While in the upper 100kms, the increase in temperature is at the rate of 12^0C per km and in the next 300kms, it is 20^0C per km. But going further deep, this rate reduces to mere 10^0C per km.
- Thus, it is assumed that the **rate of increase of temperature beneath the surface is decreasing towards the centre** (do not confuse rate of increase of temperature with increase of temperature. **Temperature is always increasing from the earth's surface towards the centre**).
- The temperature at the centre is estimated to lie somewhere between 3000^0C and 5000^0C, may be that much higher due to the chemical reactions under high-pressure conditions.
- Even in such a high temperature also, the materials at the centre of the earth are in solid state because of the heavy pressure of the overlying materials.

Pressure

- Just like the temperature, the **pressure is also increasing from the surface towards the centre** of the earth.
- It is due to the huge weight of the overlying materials like rocks.
- It is estimated that in the deeper portions, the pressure is tremendously high which will be nearly 3 to 4 million times more than the pressure of the atmosphere at sea level.
- At high temperature, the materials beneath will melt towards the centre part of the earth but due to heavy pressure, these molten materials acquire the properties of a solid and are probably in a plastic state.

Density

- Due to increase in pressure and presence of heavier materials like Nickel and Iron towards the centre, the **density of earth's layers also gets on increasing towards the centre**.
- The average density of the layers gets on increasing from crust to core and it is nearly 14.5g/cm3 at the very centre.

Check your progress

7. What do understand about temperature of the earth's interior.

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3.7. REALMS OF THE EARTH

The area near the surface of the earth can be divided into four interconnected spheres: lithosphere, hydrosphere, biosphere, and atmosphere. Think of them as four interconnected parts that make up a complete system, in this case, of life on earth. Environmental scientists use this system to classify and study the organic and inorganic materials found on the planet. The names of the four spheres are derived from the Greek words for stone (**litho**), air or vapor (**atmo**), water (**hydro**), and life (**bio**).

The Earth is the third planet from the Sun and the only known astronomical object to have life on it. Land, which consists of continents and islands, covers about 29.2 percent of the Earth's surface. Water covers the remaining 70.8 percent, mainly in the form of oceans, seas, gulfs, and other salt-water bodies, but also in the form of lakes, rivers, and other freshwater bodies.

All of the world's land masses, water sources, living organisms, and gases are contained within four overlapping subsystems. The spheres are the four subsystems. The world's air (atmosphere), water (hydrosphere), land (geosphere), and living organisms (biosphere) are divided into four spheres by geographers. There are three abiotic spheres and one biotic sphere in this set. Non-living materials are used to create abiotic compounds. Bacteria, birds, rodents, insects, and plants are examples of biotic organisms.

The Lithosphere

The lithosphere is made up of elements from the Earth's crust and upper mantle. This is the Earth's rough and rigid outer layer. The expression comes from the Greek word lithos, which means "rocky." Soil is found in this region of the Earth.

The lithosphere, sometimes called the geosphere, refers to all of the rocks of the earth. Lithosphere is the solid crust or the hard top part of the Earth. It is made up of rocks and minerals and covered with a thick layer of soil. It is not a smooth surface as you see on the globe but has high mountains, plateaus or high lands, low plains, deep valleys and very deep basins which are filled with water (oceans). It includes the planet's mantle and crust, the two outermost layers. The boulders of Mount Everest, the sand of Miami Beach and the lava erupting from Hawaii's Mount Kilauea are all components of the lithosphere.

The actual thickness of the lithosphere varies considerably and can range from roughly 40 km to 280 km. The lithosphere ends at the point when the minerals in the earth's crust begin to demonstrate viscous and fluid behaviours. The exact depth at which this happens depends on the chemical composition of the earth, and the heat and pressure acting upon the material.

The lithosphere is divided into 15 tectonic plates that fit together around the earth like a jagged puzzle: African, Antarctic, Arabian, Australian, Caribbean, Cocos, Eurasian, Indian, Juan de Fuca, Nazca, North American, Pacific, Philippine, Scotia and South American. These plates aren't fixed; they're slowly moving. The friction created when these tectonic plates push against one another cause's earthquakes, volcanoes and the formation of mountains and ocean trenches.

The Hydrosphere

The Earth's hydrosphere refers to all of the water on the planet. This is the water that can be found in the world's climate, soil, ice, seas, rivers, lakes, and streams. On Earth, water exists in all three states: gas, liquid, and solid.

All the waters on the earth's surface, such as lakes and seas, and sometimes including water over the earth's surface, such as clouds. The hydrosphere is composed of all of the water on or near the planet's surface. This includes oceans, rivers, and lakes, as well as underground aquifers and the moisture in the atmosphere. Scientists estimate the total amount at more than 1,300 million cubic feet.

More than 97 percent of the earth's water is found in its oceans. The remainder is fresh water, two-thirds of which is frozen within the earth's Polar Regions and mountain snow packs. It's interesting to note that even though water covers the majority of the planet's surface, water accounts for a mere 0.023 percent of the earth's total mass.

The planet's water doesn't exist in a static environment; it changes form as it moves through the hydrological cycle. It falls to the earth in the form of rain, seeps into underground aquifers, rises to the surface from springs or seeps from porous rock, and flows from small streams into larger rivers that empty into lakes, seas, and oceans, where some of it evaporates into the atmosphere to begin the cycle anew.

The Biosphere

Hydrosphere, atmosphere and lithosphere of earth together constitute the biosphere. **Hydrosphere**- It is the part of earth covered by 71% of water. Water is essential for supporting life's existence. **Lithosphere**- The surface of the earth is called as lithosphere. It supports the growth of microorganisms, plants and animals. **Atmosphere** - It is a mixture of gases that surrounds the earth. 78% of the atmosphere is nitrogen, 21% is oxygen and rest 1% consists carbon dioxide, argon and other gases.

The biosphere is made up of biomes, which are areas where plants and animals of a similar nature can be found together. A desert, with its cactus, sand, and lizards, is one example of a biome. A coral reef is another. *All living species on Earth are included in the biosphere. The world's species number between 20 million and 100 million, divided into the 100 phyla that make up the five kingdoms of life. These species can be found almost anywhere on the planet. On Earth, organisms can be found in the air, soil, and water.*

Most of the planet's terrestrial life is found in a zone that stretches from 3 meters below ground to 30 meters above it. In the oceans and seas, most aquatic life inhabits a zone that stretches from the surface to about 200 meters below. But some creatures can live far outside of these ranges: some birds are known to fly as high as 8 kilometres above the earth, while some fish have been found as deep as 8 kilometres beneath the ocean surface. Microorganisms are known to survive well beyond even these ranges.

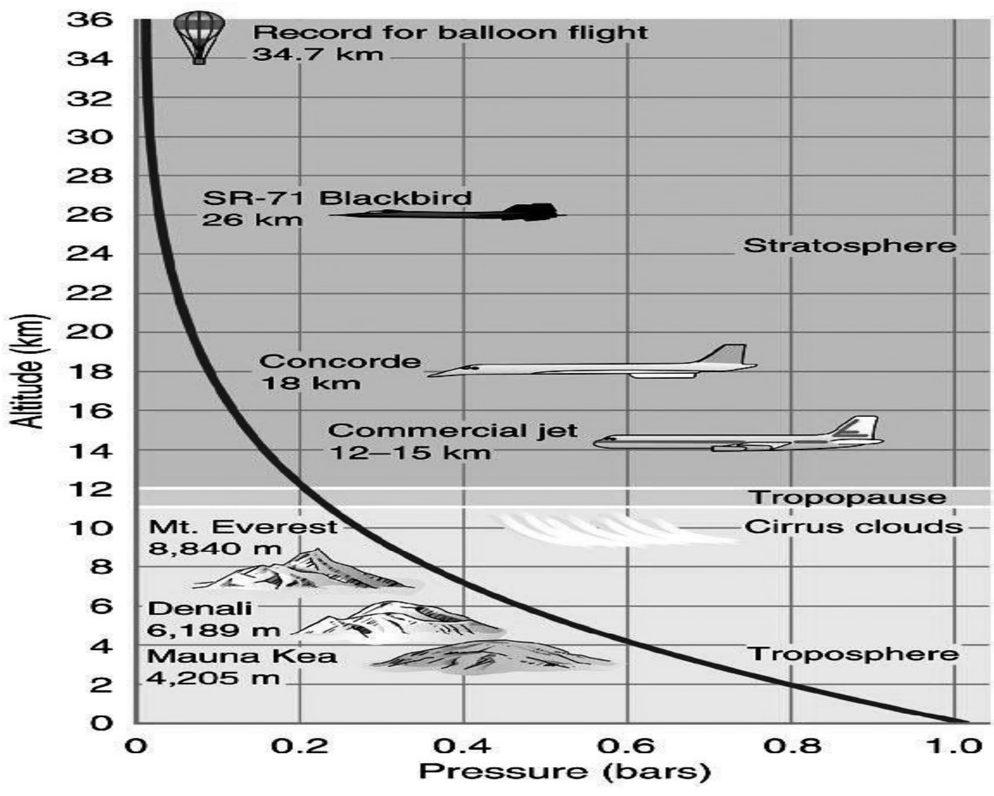
The Atmosphere

The ionosphere, which overlaps the mesosphere, thermosphere, and exosphere, is the sixth layer of the Earth's atmosphere. The densest of the five layers is the bottom layer, which is nearest to the Earth. The troposphere is the name for this layer. The layer of the Earth's atmosphere in which humans live and breathe is known as the ozone layer. The troposphere begins at ground level and extends to a height of 10 kilometers.

Earth's Atmosphere is divided into distinct layers based on altitude.

1. Exosphere (very thin ~500 km) - Atmosphere merges with space
Thermosphere (>90 km) - Where space shuttles orbit
Mesosphere (50-90 km) - Meteors burn up here
Stratosphere (12-50 km) - Stable air; good for jets
Tropopause (11-12 km)
Troposphere (0-11 km) - Mixing layer, All weather is limited to this layer, "Tropo" = Greek for "turning".

It is one of the four components of the Earth's ecosystem (the other three are biosphere, hydrosphere, and lithosphere). It is a band of gases enveloping the Earth's surface. Ninety-nine percent of its mass is concentrated within 20 miles of the earth's surface. The atmosphere is the body of gasses that surrounds our planet, held in place by earth's gravity. Most of our atmosphere is located close to the earth's surface where it is most dense. The air of our planet is 79 percent nitrogen and just under 21 percent oxygen; the small amount remaining is composed of argon, carbon dioxide, and other trace gasses.



The atmosphere itself rises to about 10,000 km in height and is divided into four zones. The troposphere, where about three-quarters of all atmospheric mass can be found, stretches from about 6 km above the earth's surface to 20 km. beyond this lies the stratosphere, which rises to 50 km above the planet. Next comes the mesosphere, which extends to about 85 km above earth's surface. The thermosphere rises to about 690 km above the earth, then finally the exosphere. Beyond the exosphere lies outer space.

Check your progress

8. What do understand about biosphere?

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9. What is lithosphere?

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10. Ozone layer?

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3.8 ORIGIN & EVOLUTION OF LIFE ON EARTH

Earth will always be the most accessible habitable planet for study. Consequently, studying the origin and earliest evolution of life, along with the long-term evolution of the Earth's environments, helps us understand why the Earth became habitable and why terrestrial life has persisted for billions of years. The earliest environments on Earth are also very unlike our modern-day environment, and serve as alternate examples of "habitable planets." Earth's climate has been influenced by the Sun, which has gradually brightened by 25-30% in the last 4 billion years, and by the presence of greenhouse gases, many of which are produced by microbial life.

- There are dozens of hypotheses proposed regarding the origin of the earth by different philosophers.
- However, one of the hypotheses namely **"Nebular Hypothesis"** given by Immanuel Kant and revised by Laplace became more popular.
- According to Nebular Hypothesis, the planets were formed out of a cloud of material associated with a youthful sun.
- **Big Bang Theory**, which is also known as **expanding universe hypothesis,** is the modern and the most accepted theory.
- **Edwin Hubble** was the first one who provided evidence that the universe is expanding, in 1920.
- It is believed that the event of Big Bang took place about 13.7 billion years from now.
- According to the **Big Bang** theory, the universe originated from an extremely dense and hot state and keeps expanding till date.
- **Galaxy** is a group of stars. Galaxies normally spread over vast distances, which are measured in thousands of light-years.
- A galaxy starts to form by the accumulation of hydrogen gas in the form of a very large cloud called **nebula**.

- One light year is the distance travelled by light in one year, which is equal to 9.4611012km
- Light travels at the speed of 300,000 km/second.
- The mean distance between the sun and the earth is about 149,598,000 km. And, in terms of light years, it is 8.311 minutes.

Check your progress

11. What do understand about nebular hypothesis?

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12. What is big bang theory?

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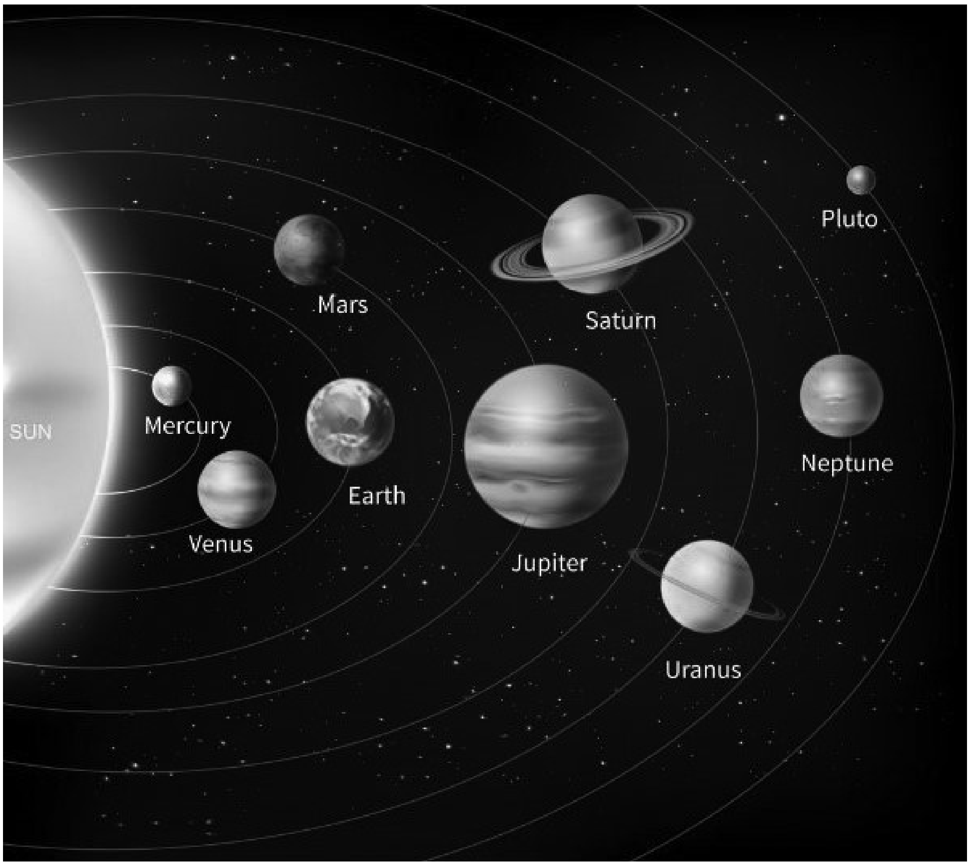
3.9 MILKY WAY

- Our Solar system (part of **"Milky Way"** galaxy) consists of eight planets, the sun, 63 moons, millions of smaller bodies like asteroids and comets and huge quantity of dust-particles and gases.
- The planets of Milky Way were formed about **4.6 billion** years ago.
- The planets, Mercury, Venus, Earth, and Mars are called the **inner planets** as they lie between the sun and the belt of asteroids and the rest four planets i.e. Jupiter, Saturn, Uranus, and Neptune are known as **outer planets**.



- In addition to this, the inner planets are also known as **"Terrestrial Planets,"** meaning earth-like as they are made up of rocks and metals, and have relatively high densities.
- On the other hand, the outer planets are known as **"Jovian"** (Jupiter like) or Gas Giant Planets.
- However, all the planets are formed in the same period i.e. about 4.6 billion years ago.
- The terrestrial planets were formed in the closer to the parent star where it was too warm for gases to condense to solid particles, whereas Jovian planets were formed at quite a distant location from the parent star.
- The solar wind was most intense nearer to the sun; so, it blew off lots of gas and dust from the terrestrial planets; however, the solar winds were not all that intense to cause similar removal of gases from the Jovian planets
- The **moon** is the only natural satellite of the planet earth.
- The earth has a layered structure and hence, from the surface to deeper depths (i.e. inner core), the earth has different zones/layers and each of these contains materials of different characteristics.
- The present composition of the earth's atmosphere is chiefly contributed by nitrogen and oxygen, as the primordial atmosphere with hydrogen and helium, is supposed to have been stripped off as a result of the solar winds.
- **Degassing** is the process through which the gases were outpoured from the interior of the earth.
- Further, continuous volcanic eruptions contributed water vapor and gases to the atmosphere.
- The earth's oceans were formed within 500 million years from the evolution of the earth.
- About 3,800 million years ago, life began to evolve and the process of photosynthesis got evolved about 2,500-3,000 million years ago.
- Primarily, life remained confined to the oceans for a long time.
- Oceans began to have the contribution of oxygen through the process of **photosynthesis**.
- Over a period of time, oceans were saturated with oxygen; however, about 2,000 million years ago, oxygen began to flood the atmosphere.

The continental crust contains the historical record of our planet. Its most ancient rocks are four billion years old, and the youngest ones are still forming today. Parts of the continental crust may be older than four billion years, but if so, they are not exposed, or have not been found, on the Earth's surface. The rocks of the crust convey the story of how the planet has been transformed between the period shortly after its formation and the way we see it today.

Check your progress

13. What is terrestrial planet?

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3.10 EARTH'S BEGINNINGS

The solar system was created from gas clouds and dust that remained from the Sun's formation some 6-7 billion years ago. This material contained only about 0.2% of the solar system's mass with the Sun holding the rest. Earth began to form over 4.6 billion years ago from the same cloud of gas (mostly hydrogen and helium) and interstellar dust that formed our sun, the rest of the solar system and even our galaxy. In fact, Earth is still forming and cooling from the galactic implosion that created the other stars and planetary systems in our galaxy. This process began about 13.6 billion years ago when the Milky Way Galaxy began to form.

As our solar system began to come together, the sun formed within a cloud of dust and gas that continued to shrink in upon itself by its own gravitational forces. This caused it to undergo the fusion process and give off light, heat and other radiation. During this process, the remaining clouds of gas and dust that surrounded the sun began to form into smaller lumps called planetesimals, which eventually formed into the planets we know today. A large number of small objects, called planetesimals, began to form around the Sun early in the formation of the solar system. These objects were the building blocks for the planets that exist today.

The Earth went through a period of catastrophic and intense formation during its earliest beginnings 4.6-4.4 billion years ago. By 3.8 to 4.1 billion years ago, Earth had become a planet with an atmosphere (not like our atmosphere today) and an ocean. This period of Earth's formation is referred to as the pre-Cambrian Period.

Earth's early atmosphere most likely resembled that of Jupiter's atmosphere, which contains hydrogen, helium, methane and ammonia, and is poisonous to humans. As Earth began to take solid form, it had no free oxygen in its atmosphere. It was so hot that the water droplets in its atmosphere could not settle to form surface water or ice. Its first atmosphere was also so poisonous, comprised of helium and hydrogen that nothing would have been able to survive.

Earth's second atmosphere was formed mostly from the out gassing of such volatile compounds as water vapour, carbon monoxide, methane, ammonia, nitrogen, carbon dioxide, nitrogen, hydrochloric acid and sulphur produced by the constant volcanic eruptions that besieged the Earth. It had no free oxygen.

About 4.1 billion years ago, the Earth's surface — or crust — began to cool and stabilize, creating the solid surface with its rocky terrain. Clouds formed as the Earth began to cool, producing enormous volumes of rainwater that formed the oceans. For the next 1.3 billion years (3.8 to 2.5 billion years ago), the Archean Period, first life began to appear and the world's landmasses began to form. Earth's initial life forms were bacteria, which could survive in the highly toxic atmosphere that existed during this time. Toward the end of the Archean Period and at the beginning of the Proterozoic Period, about 2.5 billion years ago, oxygen-forming photosynthesis began to occur. The first fossils were a type of blue-green algae that could photosynthesize.

Earth's atmosphere was first supplied by the gasses expelled from the massive volcanic eruptions of the Hadean Era. These gases were so poisonous, and the world was so hot, that nothing could survive. As the planet began to cool, its surface solidified as a rocky terrain, much like Mars' surface and the oceans began to form as the water vapour condensed into rain. First life came from the oceans.

Some of the most exciting events in Earth's history and life occurred during this time, which spanned about two billion years until about 550 million years ago. The continents began to form and stabilize, creating the supercontinent Rodinia about 1.2 billion years ago. Although Rodinia is composed of some of the same land fragments as the more popular supercontinent, Pangaea, they are two different supercontinents. Pangaea formed some 225 million years ago and would evolve into the seven continents we know today.

Free oxygen began to build up around the middle of the Proterozoic Period — around 1.8 billion years ago — and made way for the emergence of life as we know it today. This increased oxygen created conditions that would not allow most of the existing life to survive and thus made way for the more oxygen-dependent life forms. By the end of the Proterozoic Period, Earth was well along in its evolutionary processes leading to our current period, the Holocene Period, or Anthropocene Period, also known as the Age of Man. Thus, about 525 million years ago, the

Cambrian Period began. During this period, life "exploded," developing almost all of the major groups of plants and animals in a relatively short time. It ended with the massive extinction of most of the existing species about 500 million years ago, making room for the future appearance and evolution of new plant and animal species. About 498 million years later — 2.2 million years ago — the first modern human species emerged.

The first modern human being was called Homo habilis, the first of the homo genus. This species developed stone tools for use in daily life. Homo habilis means "Handy Man." He existed from about 2.2 to 1.5 million years ago. There are earlier species related to modern man, called hominids.

The Pre-Cambrian Period — accounts for about 90 percent of Earth's history. It lasted for about four billion years until about 550 million years ago. About 70 percent of the world's land masses were created in the Archean Era, between 3.8 and 2.5 million years ago. Rodinia, widely recognized as the first supercontinent, formed during the Proterozoic Era, about 2.5 billion years ago. It is believed that the oldest human family member was discovered in Ethiopia and lived 4.4 million years ago. It was named "Ardi," short for Ardipithecus ramidus.

3.11 CONCLUSION

All four spheres can be and often are present in a single location. For example, a piece of soil will contain minerals from the lithosphere. Additionally, there will be elements of the hydrosphere present as moisture within the soil, the biosphere as insects and plants, and even the atmosphere as pockets of air between soil pieces. The complete system is what makes up life as we know it on Earth.

3.12 SUMMARY

Thus, in this unit, studied and learnt the following concepts, key points and issues as highlighted below:

- The basic concepts like Earth as a solid body, Earth's interior, rock cycle, seismology and distinctive layering systems along with discontinuities and characteristics as well.
- the most prominent discontinuities of 'Mohorovicic discontinuity' lies between crust and mantle and that of 'Weichert-Gutenberg discontinuity' marks the boundary between lower mantle and upper parts of the core.

3.13 WHAT WOULD YOU UNDERSTAND ABOUT THE INTERIOR OF THE EARTH?

It is not possible to know about the earth's interior by direct observations because of the huge size and the changing nature of its interior composition. It is an almost impossible distance for the humans to reach till the centre of the earth (The earth's radius is 6,370 km). Through mining and drilling operations we have been able to observe the earth's interior directly only up to a depth of few kilometers. The rapid increase in temperature below the earth's surface is mainly responsible for setting a limit to direct observations inside the earth. But still, through some direct and indirect sources, the scientists have a fair idea about how the earth's interior look like.

What you learn

The Earth's interior structure is compared with that of an apple. The crust is the outer-most layer of the earth. The upper part of the earth crust is SIAL. The lower part of the earth crust is SIMA. The mantle is about 2900km thick. Earth is made up of layers: the core, mantle and crust. Earth's crust is divided into plates that move like bricks over freshly laid mortar. learnt about the various theories dealing with the Earth's internal structure. learnt about atmospheric and other variables such as temperature, pressure and density etc. along with their characteristics. In nutshell, you have learned about the Earth's interior structure and its composition. This information will definitely serve as a key and fundamental to further probe the same in more scientific ways.

3.14 CHECK PROGRESS – MODEL ANSWERS

1. The earth is made up of three layers. The crust, mantle and core. Beneath the earth the crust is extends 5 kms. Below the crust is mantle. Centre of the earth lies core.

2. The forces which act in the interior of the earth is called as endogenic forces and the forces that work on the surface of the earth called exogeneic forces.

3. The structure of the earth can be in two ways: Mechanically it is lithosphere, Asthenosphere, mesosphere. Chemically it is crust, mantle and core.

4. The mantle is the thickest layer of the earth. It extends up to 2900 km from the crust to earth's core. The mantle divided into upper and lower mantle.

5. Asthenosphere is the part of the mantle that flows and moves the plates of the earth.

6. The discontinuity between the crust and mantle is called Moho discontinuity.

7. The rate of temperature increase beneath the surface is decreasing towards the centre. Temperature is always increasing from earth's surface towards the centre.

8. The biosphere is made up of biomes, which are areas where plants and animals of a similar nature can found together. i.e. all living species on earth are included in the biosphere.

9. The lithosphere is made up of elements from the earth's crust and upper mantle. This is the earth's rough and rigid outer layer.

10. The layer of the earth's atmosphere in which humans live and breathe is known as ozone layer.

11. The nebular hypothesis given by Immanuel Kant. According to this hypothesis the planets were formed out of a cloud of material associated with youthful sun.

12. Big bang theory is also known as expanding universe hypothesis is the modern and most accepted theory.

13. Inner planets are known as terrestrial planets.

3.15 MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines

1. Describe in short the basic concepts pertaining to the interior of the Earth?
2. What do you understand by the mantle layer of the Earth's interior? Explain?
3. Write down a detailed account of any one theory of the Earth's interior?

II. Answer the following questions in about 10 lines

1. Write note on the core of the earth?
2. Distinguish between SIAL and SIMA
3. The earth's interior is very hot. Why?
4. Earth's crust
5. Milky way galaxy

3.16 GLOSSARY

Core: The inner most layer of the earth

Mantle: The second layer beneath the crust

Mohorovicic discontinuity: Boundary that separated the mantle from the crust

3.17 FURTHER READINGS

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BLOCK-II: THEORIES AND LAND FORMS

The positions of the continents and ocean bodies, as shown on the map, have not always been the same. Furthermore, it is now widely believed that seas and continents will not be able to maintain their current positions in the future. What were their previous positions? Why do people alter their minds and how do they do it? Even if it is true that the positions of the continents and oceans have changed and are changing, you may wonder how scientists know this. What has been your experience? The chapter will give answers on theories of continent drift.

The chapter on geological time scale will deal with chronological measuring system that defines the timing and correlations between events throughout Earth's history. The chapter deals with the Timeline of the events and incidents, Origin of the different organisms on earth, Geological events and Different time periods and their corresponding important events. Explain how scientists use different types of fossils to investigate Earth's historical environment and diverse life-forms. Explains how disasters have altered Earth's history, affecting the conditions on the planet and the diversity of its life-forms.

Because of the close relationship between rocks and landforms, and soils, a geographer must have a fundamental understanding of rocks. The crust of the earth is made up of rocks which is a mineral composition made up of one or more minerals. From the chapter on rocks and their types we will learn about the Formation of rocks, Life cycle of rocks, Types of rocks and their distribution.

This block contains 3 units. They are:

Unit 4: Theories: Isostasy, Continental drift theory and plate tectonics
Unit 5: Geological time Scale
Unit 6: Types of rocks and their Characteristics

UNIT- 4: THEORIES: ISOSTASY, CONTINENTAL DRIFT AND PLATE TECTONICS

Contents

4.0 Objectives
4.1 Introduction
4.2 Isostasy
    4.2.1 Pratt's Hypothesis
    4.2.2 Airy's Hypothesis
4.3 Continental drift theory
4.4 Plate tectonic theory
4.5 Summary
4.6 Check Your Progress-Model Answers
4.7 Model Examination Questions
4.8 Glossary
4.9 Further Readings

4.0 OBJECTIVES

The chapter speaks about the different theories which try to explain the formation of earth, continents and water bodies.

After reading this unit, you will be able to;

- Know the Concept of flotation of landforms in Pratt's and Airy's theory
- Explain the Formation of present shape of earth- its continents, water bodies and landforms
- Understand the Split of landmasses and Historical movement of different plates
- You will Know the Evidence to prove the theories
- Explain the Driving forces for the movement of plates, types of movements of plates and their resultant landform

4.1 INTRODUCTION

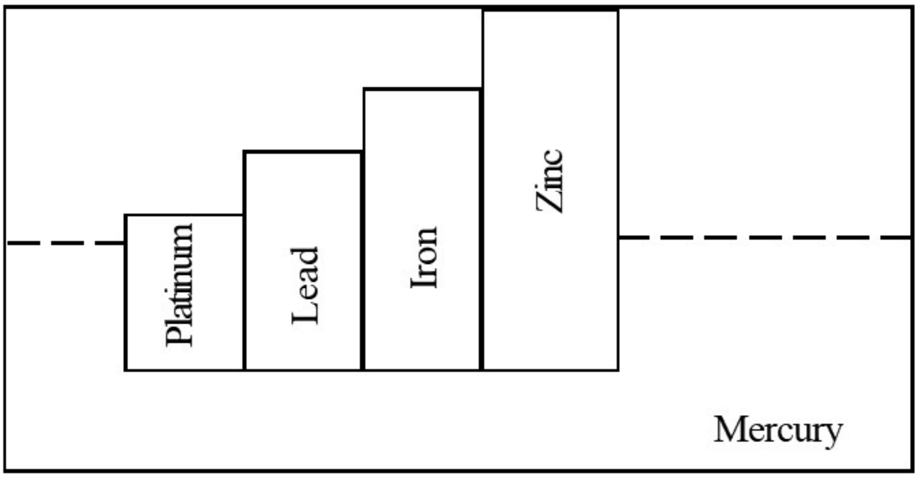
The globe map is something you're already familiar with. You may be aware that continents cover 29% of the earth's surface, with the remaining submerged beneath oceanic waters. The positions of the continents and ocean bodies, as shown on the map, have not always been the same. Furthermore, it is now widely believed that seas and continents will not be able to maintain their current positions in the future. If this is the case, it begs the question: what were their previous positions? Why do plates alter their paths and how do they do it? Even if it is true that the positions of the continents and oceans have changed and are changing, you may wonder how scientists know this. What has been your experience?

4.2 ISOSTASY

The term Isostasy is derived from the Greek word Iso and states which means Equipoise meaning equal standing. Although all the relief features like mountains, plateaus, plains, lakes, seas, oceans faults and rift valleys etc all are on the surface, but, there is a difference in density of relief features. It is evident that there is less density in mountains rather than the density on plains and ocean deeps. Here arises a question that, when all the relief features have different densities, how the Earth can sustain its equilibrium position. Geologists have given different perceptions and answers but none of them explain this phenomenon satisfactorily. In the year 1829 the geophysicist Hutton used the term "equilibrium" as the answer to the problem for the first time. Isostasy simply means a mechanical stability between the upper standing parts of the Earth and the lower lying basins.

Major landforms on earth surface like mountains have the density of 2.7 gram per cc which is made up of Sial and the Plains are made up of Sima with the density of 3.0. As Sial is lighter it floats over Sima. In this context two explanations have been found reliable which are mentioned below.

4.2.1. Pratt's hypothesis:
J.H.Pratt in 1859 gave an explanation regarding this concept without using the term Isostasy. According to his explanation, the density of various reliefs is different. For example the density of Ganga Yamuna plains is greater than the density of the mountains. To prove this, Pratt filled mercury in a glass tank with Mercury, and put some of the varieties of rods which have equal weight but differ in terms of density. According to Pratt a line of compensation above which there is a variation in density of different columns of land but there is no variation in the density below this level.

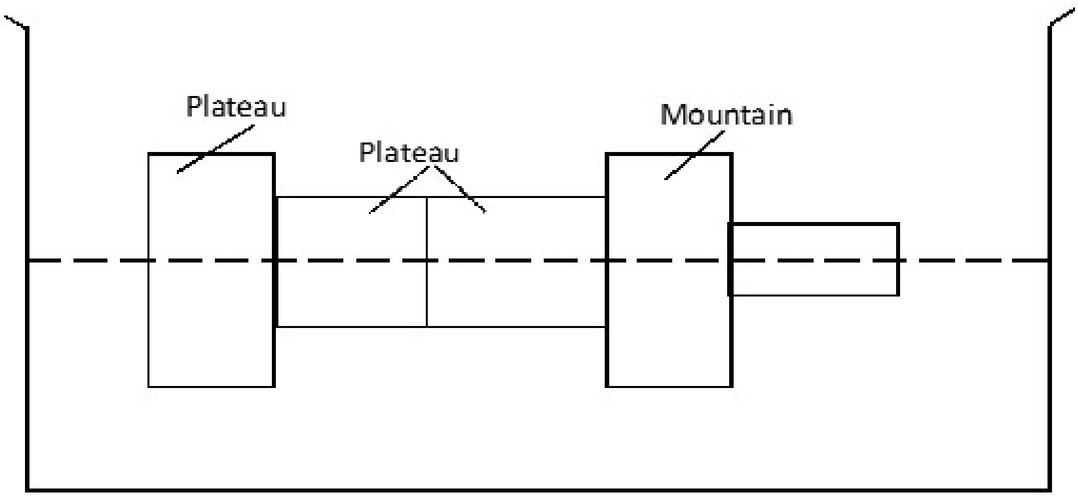


The central theme of the concept is expressed as **uniform depth with varying density**. According to Pratt equal surface area must underlie equal mass along the line of compensation. As we said earlier Pratt filled a glass with Mercury and put some of the varieties of equal weight rods in vertical position. Even though the weight of these rods is equal, the density is different from each other. All these rods are submerged in Mercury at uniform depth and all these rods have equal surface area but they have the difference in the height above the surface of the Mercury.

This can be explained with an example. The density of the zinc rod is 7.1, the density of the Lead rod is 11.4, the density of the iron rod is 7.9, and the density of the Platinum rod is 21.50. It can be observed that the density of the platinum rod is 3 times more than the density of the zinc rod due to which the height of the zinc rod is not sunk into the Mercury is three times greater than the height of the platinum rod. Thus Pratt's concept of inverse relationship between the height of different columns and the respective densities can be expressed in the following manner. Bigger the column, lesser the density and smaller the column, greater the density. According to Pratt, different relief features are standing only because of the fact that their respective mass is equal along the line of compensation because of their different densities.

4.2.2 Concept of Sir George Airy

Airy Contradicted the theory proposed by Pratt and give his new explanation along with his friend Heiskenen. According to Airy the inner part of the mountains is compensated by lighter materials below. According to Archimedes' principle he believes that a material floating on water means that a greater part of the material is submerged into the water. By applying this concept he tries to explain that the crust of relatively lighter material is floating in the subtraction of denser material in other words he says that Sial is floating on Sima.



This can be explained with an example. The relative density of ice is 0.9 and relative density of water is 1.0 so if an inch of ice is above the water level it means those 9 inches of ice is below the surface of the water. Similarly Himalayas are floating in the denser Magma with their maximum portion sunk in the magma in the same way as a boat floats in water with its maximum part drowned in the water. He says that the Himalayas are about 9 km above the earth, which means they extend up to 81 km below the surface of the earth. Thus for 8848 m part of Himalaya above the surface there must be downward projection of lighter material beneath the mountain reaching up to the depth of 80000 m.

Thus Airy postulated that if the land column above the surface is larger its greater part would be submerged below the surface and if the land column is lower its smaller part would be submerged below the surface. In other words mountains, plateaus and plains have varying depths depending on their length on the ground.

Thus, every landform above the surface of the earth must have a root below in accordance with its height. The density does not change with depth that is **uniform density with varying thickness**.

Pratt's does not believe in the law of floatation as stated by Sir George Airy, if we observe the concept of Pratt can observe the glimpse of law of floatation indirectly under the name of law of compensation. In a similar manner the Airy does not believe directly in the concept of root formation with very closely observation tells us that the concept of Isostasy does indicate the idea of root formation indirectly. The main difference between Airy's and Pratt's views is that area postulate and uniform density with varying thickness and Pratt's view is that of uniform depth with varying density.

Comparative study of Pratt and Airy concept:

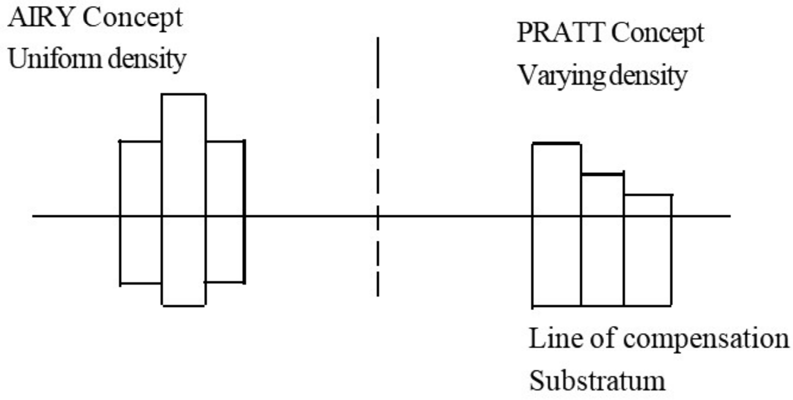


Fig. 3.3

4.3 CONTINENTAL DRIFT THEORY

It was proposed by a German geographer named Alfred Wegener. This theory helps us to know many facts related to the origin of earth and give solutions to many questions. This theory is essentially trying to know why it was produced and under what circumstances was it introduced?

4.3.1 Introduction

This theory was initially proposed by Abraham Ortelius in 1596. For the first time in 1620 the geographer name Francis Bacon discovered the matching coastline of South America and Africa. The other scientist named Antonio Sinder and pellegrin French drew a map which tried to represent that the American continent was fitting into the boundaries of Africa and Europe.

Another scientist JD Dana (1813-1895) proposed "permanent theory" based on the study of shapes and size of the continents. Just he told that the features like continents and islands, oceans or immovable things, that is they are constant since the date of their formation. But this theory was strongly criticized by Taylor in 1908. According to him there are two land masses named Lauratia and Gondwana in the Cretaceous period near the North and South poles respectively. He assumed that the continents were made of Sial which was absent in the ocean crust. He also said that the continents were moving towards the equator and the main driving force was the tidal force. According to Taylor, continents were displaced in two ways.

1. Equator ward movement and 2.Westward movement

He said that the driving force that was responsible for the both type of the movements was the tidal force of the moon. Thus he showed a new way to solve the problem of knowing the origin of continents and ocean basins.

After all the observations Alfred Wegener propounded his theory on continental drift in 1912 in his book named "Die Entstehung Der kontinente and ozeane", but this theory came to limelight only after 1922. It was translated into English in 1924.

Continental drift theory was based on works and findings of many scientists from different fields such as geologist, paleo-climatologist, paleontologists, geophysicist and others. The climatic change that has occurred on the globe can be explained in two ways.

1. If we consider the climatic zones remain stationary then the land masses might have been displaced and drifted.

2. In contrast to the above statement, if the continents remained stationary at the same place since the origin of the earth, the climatic zones might have shifted from one region to another region.

Wegener chose the first statement and rejected the second statement, that is, he rejected the idea of the permanency of continents and oceans.

4.3.2. Origin of the theory:

1. Around 300 million years ago (carboniferous period), there was a single United landmass, that is a large single continent named Pangaea and there was a mega ocean called Panthalasa surrounding it.

2. The continents witnessed horizontal displacement and shifted towards north word and westward during the period of Jurassic times (200million years ago).

3. Pangea was separated by Tethys Sea, a geosyncline which is a narrow and shallow elongated water body on the continent.

4. Laurasia or Angara land consists of the present continents of North America, Europe, and Asia formed the northern part of the Pangea, while Gondwana land has current Continents of South America, Africa, Madagascar, Peninsular India, Australia and Antarctica represented the southern part of the Pangea.

5. Pangea was located near the current south pole in the present southern hemisphere.

6. Thus, over a period of time Lauratia and Gondwanaland broke into many smaller continents that exist today as explained above. A variety of evidences was offered in support of the continental drift.

Check your progress

Note : (a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

1. Write about Pangea?

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2. Write about Panthalasa?

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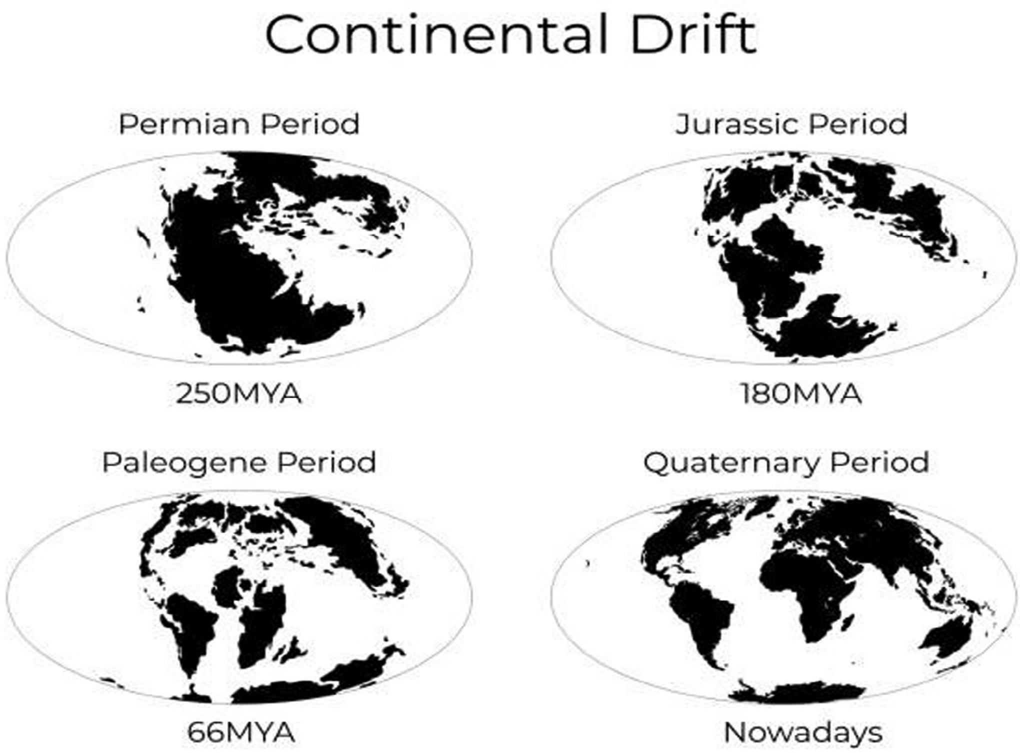


4.3.3 Evidence to prove the continental drift theory:

There are many evidences to prove as this and can be categorized as below:

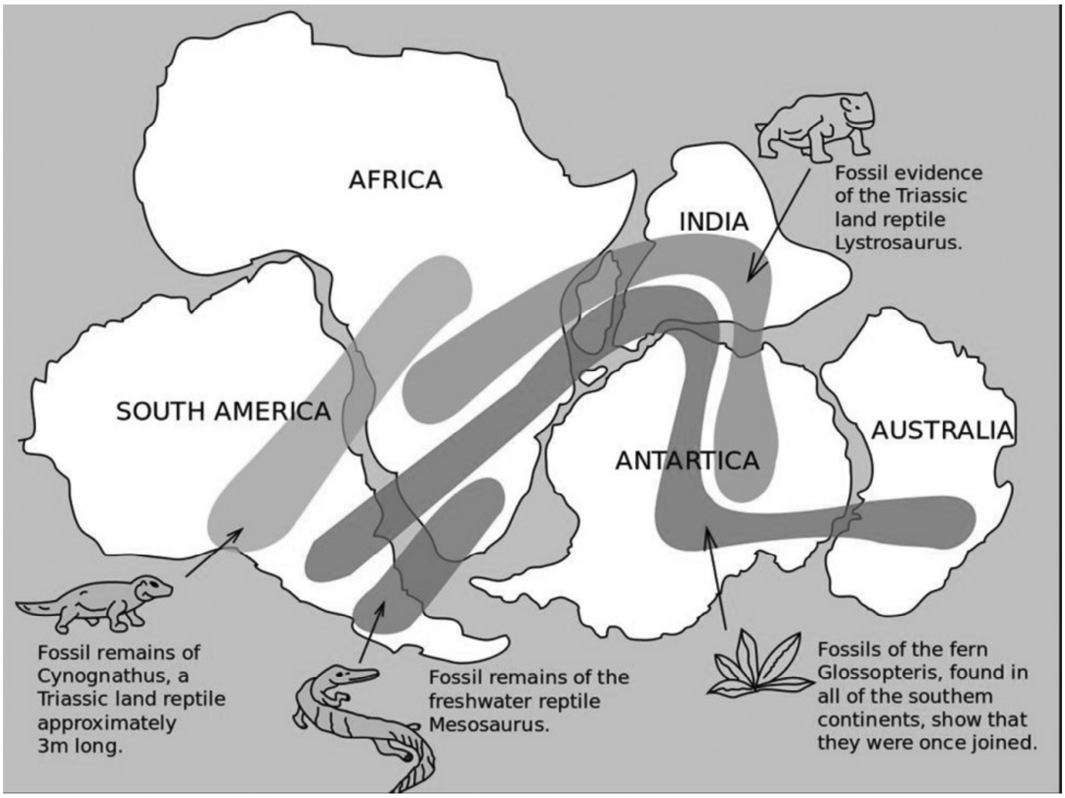
Geological evidences- matching of continents (Jig Saw fit)

1. Wegener said that there is a geographical similarity in the continents along the coast of the Atlantic Ocean. The shorelines of Africa and South America facing each other have a remarkable match in terms of rock type and geological structures.

2. In 1964, Bullard presented a digital map using computer program to find the best fit of the Atlantic margin. The match was tried at 1000 fathom line instead of the current shore line. The gulf coast of Africa found its counterpart and the Brazilian shield; the places where deposits of gold were found the Brazilian coast were also located at the same point and the Western African coast when both the continents were adjusted to fit into each other.

3. Geological evidences denote that the Santa Catherine plateau of South America and the Karoo plateau of Africa are similar and identical.

4. The Western and eastern coastal areas of the Atlantic which have the mountain systems of Caledonian and Hercynian are also similar and identical. The Appalachian of the North eastern region of North America which appeared to be disappearing into the sea water of the Atlantic resurfaced again on British Isles and on Scandinavia map.



Glacial evidence:

1. The evidence from the carboniferous glaciation of Brazil, Falkland, South Africa, Peninsular India, Australia and Antarctica further proved the unification of all landmass in one landmass during carboniferous period. Overall resemblance of the Gondwana type sediments clearly demonstrate that these land masses had remarkably similar histories. Other evidence includes existence of the large coal deposits in temperate regions of Europe and North America is another evidence of continental drift. Wegener questioned why coal deposits were found on cold temperature regions? And why glacial deposits were found near the equator?

2. Glacial deposits in the southern hemisphere indicate that it was covered with ice sheets around 200-300 million years ago. The glacial deposits have the same stratigraphic position but found in South Africa and South America as well as in India and Australia. Erratic of glacial Origin, striated and grooved bedrocks are also found in the different regions indicating location of continents nearer to Antarctica where it is presently located.

Biological evidences

1. The Fossil remains of both flora and fauna (animals and plants) support the continental drift theory as the first of similar structure and composition can be found on separate continents. Wegener cited many such organisms and fossils on different land masses.

2. Based on the study on fossil remains in the different continents. One such example is of the remains of Glossopteris fern which was found on the Brazilian coast and also found in Africa, India and Australia. Fossils of Manuscripts were also found in these continents.

3. An extinct reptile, Mesosaurus is adapted to shallow brackish water; its remains were found in two locations: South Africa and Brazil. As it is a freshwater animal, there was no possibility of them to swim across the salty Atlantic ocean, therefore their distribution in Africa and South America indicates that these continents were together (adjacent to each other) in the past.

Social evidence:
The Swiss Geophysist believes that 'Gonds' tribe is closely associated with the word 'Gondwana'.

Geodetic evidence:
The westward drift of Greenland at the rate of 20 cm per year is indicated by the geodetic evidence. For example the Greenland Island is travelling towards North America this phenomenon is confirmed by the Geodetic survey conducted by American Scientists in the year 1823, 1870, 1917, and 1970. In the year 1892 the England scientist proved that Greenland Island is moving away from England.

According to Taylor continents moved towards the equator. The main driving force for the drift was tidal force and the continents moved in two ways. Equator ward and Westward movement. He mentioned that the driving force responsible for both movement was tidal force of the moon.

Geophysical evidence:
According to geologist, the North and South poles are not constant they have been changing their position since many eras. Due to this the magnetic properties of the earth also keep changing accordingly. And this theory states that the north and south poles have changed their positions.

4.3.4 Criticism:

1. The forces that are leading to the drift in the continent cannot be adjusted.

2. The oceanic crust has less density than the continental crust, or it is not in such a physical condition to allow the slide of the continental crust.

3. His explanation of mountain formation on western edge of continents was unscientific.

4. He failed to provide a cohesive picture of the geological history of earth. He never explained the pre-carboniferous period.

5. He failed to explain the formation of all the young fold mountains of the world.

4.4 PLATE TECTONICS THEORY

The continental drift theory proposed by Alfred Wegener had brought revolution in geography to continue the explanation of this theory. Many geographers have made observations in depth and proposed subsequent theories. In 1967 Morgan, McKinzie and Parker Independently came out with another theory called Plate Tectonics Theory. According to them the rigid lithospheric slabs are the solid crustal layers of the continent which are technically called as plates. These tectonic plates are also called lithospheric plates. The tectonic plates are massive irregularly shaped slabs of solid Rock which are composed of both continental and oceanic lithosphere. The continental drift theory and plate tectonic theory criticize the permanence theory proposed by J.D.Dana.

4.4.1 Plate tectonics and its concepts:
It may be mentioned that the terms plate were used by the Canadian geographers JT Wilson in 1965 for the first time. McKenzie and Parker discussed the mechanism of plate motions in detail on the basis of Euler's geometrical theorem in 1967. They proposed the "paving stone hypothesis",

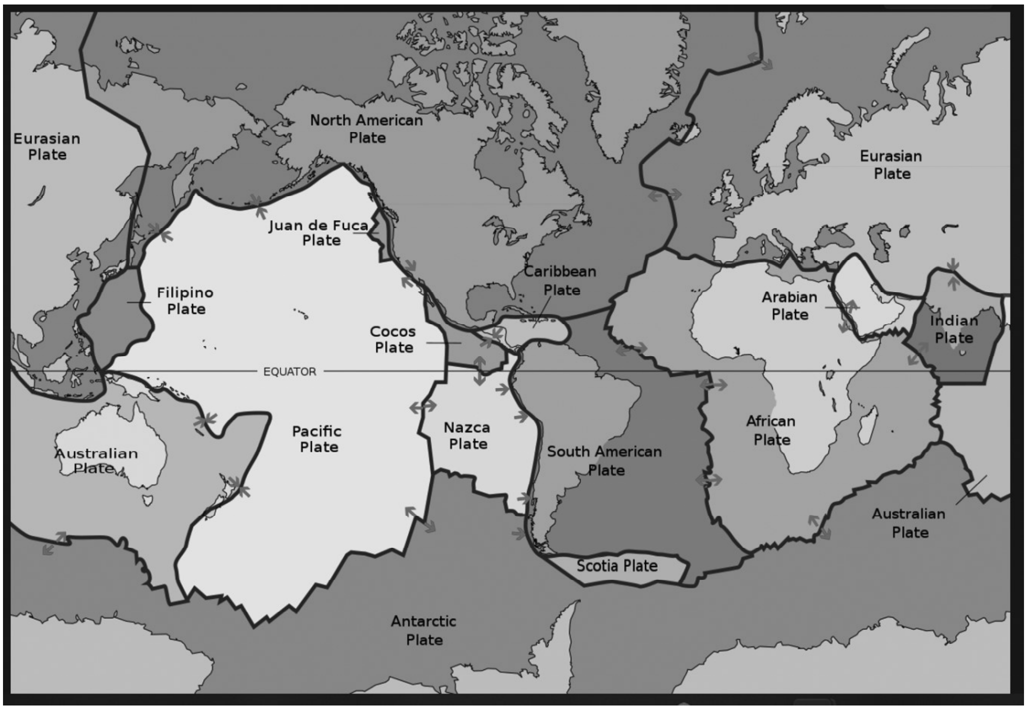
it said that the ocean crest was considered to be newly formed at mid oceanic ridges and said that it will be destroyed at the trenches. Isacks and Sykes have confirmed the paving stone hypothesis in 1967. Morjan.W.J and Lepichon explain the aspects of plate tectonics theory in detail in 1968.

According to this theory, lithosphere is made up of rigid plates. Plates may be either oceanic or continental depending on large portion of the plate. Eurasian plate is example of continental plate whereas pacific plate is example of oceanic plate. Alfred says that so far seven major and other minor plates have been identified. They are: Eurasian plate, Indian –Australian plate, north and South American plate, African plate and Antarctic plate. He called the lithosphere slabs as plates. The whole concept of mechanism of the evolution nature and motion of plates and its result is called plate tectonics. It can be said that the boundaries of the tectonic plates which are also known as plate margins are the most important because all the tectonic activities like seismic events, volcanicity, mountain building etc, occur along the plate margins.

Eurasian plate: This plate is a complete continental plate which includes parts of the current Europe and Asian continent excluding India.

North American plate: This plate is partly continental and partly oceanic. It contains Western Atlantic floor, which is separated from the South American plate along the Caribbean islands plate.

South American plate: It is also partly continental and partly oceanic plate. It contains the Western Atlantic floor which is separated from the North American plate along the Caribbean islands plate.



African plate: It is also made up of both the continent and ocean and plates. It contains eastern Atlantic floor plate and western Indian oceanic plate.

Indo Australian plate: This plate is also combination of continental and oceanic plate; it contains Western Indian oceanic plate.

Pacific plate: This plate is completely an oceanic plate. This is one of the largest plates it occupies the complete Pacific plane.

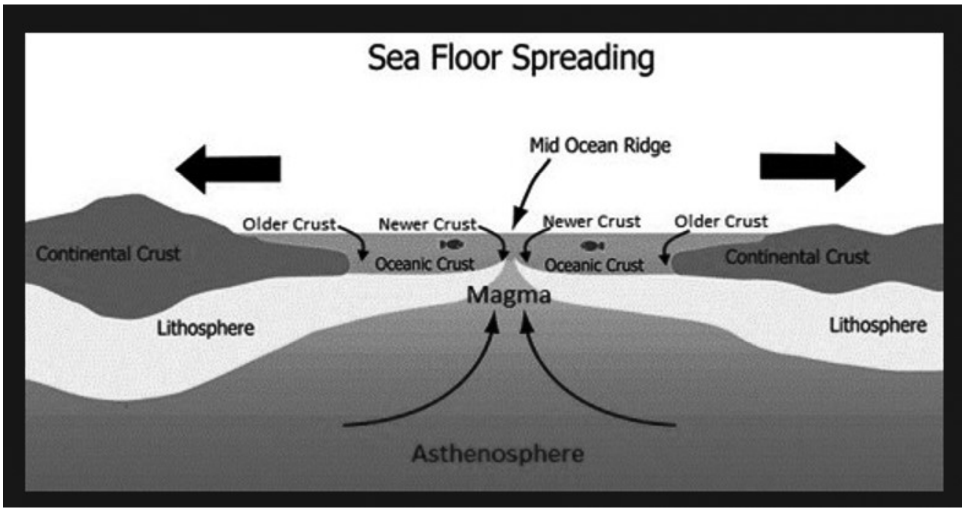
Antarctica plate: This plate is also partly oceanic and a partly continental plate. It covers the entire Antarctica continent and the surrounding oceanic plate.
Among the minor plates few important plates are listed below:
1. Coco's plate: it is situated between Central America and the Pacific plate.
2. Nazia plate: between South American and Pacific plate.
3. Arabian plate: it lies in the Saudi Arabian land mass.
4. Philippine plate: it is located between the Asiatic and the Pacific plate.
5. Fiji plate: it is situated on North East of Australia.
6. Carolina plate: it lies between Philippine and Indian plate.

These plates have been constantly moving over the flow throughout the history of the earth. Alfred Wegener believes that it is not the continent that moves but it is the plates which are moving and as the continents lie on the plate it appears as if the continents are moving. Since the birth of the earth it is evident that there is no exception for any plate it means all the plates have been moving constantly since the origin of the earth and they will continue to keep on moving in the future as well.

There are three types of plate movements they are;
1. Divergent movement
2. Convergent movement
3. Parallel movement

4.4.2 Divergent movement of boundaries: In this type of moment, plates move away from each other and so they are called as divergent boundaries. In such boundaries the activities will occur: 1. Seafloor spreading, 2. Origin of oceanic ridge.

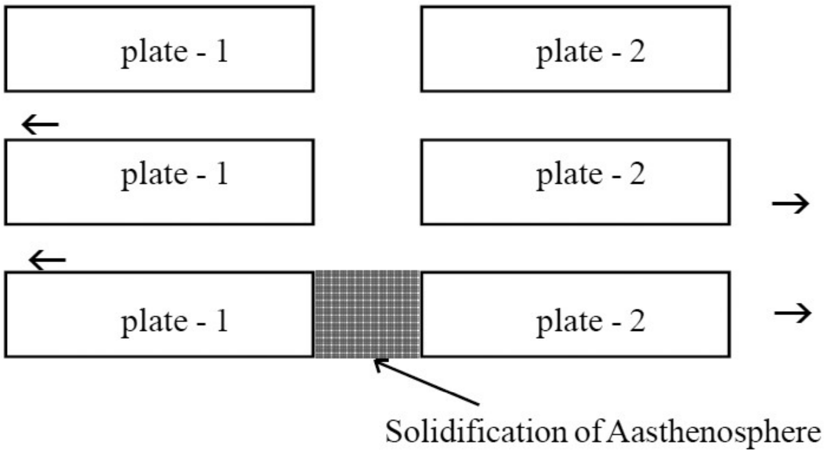
Seafloor spreading:
This activity takes place due to the divergent plate margins. At the place of divergence continuous up swelling of molten material and thus new oceanic crust is continuously formed.



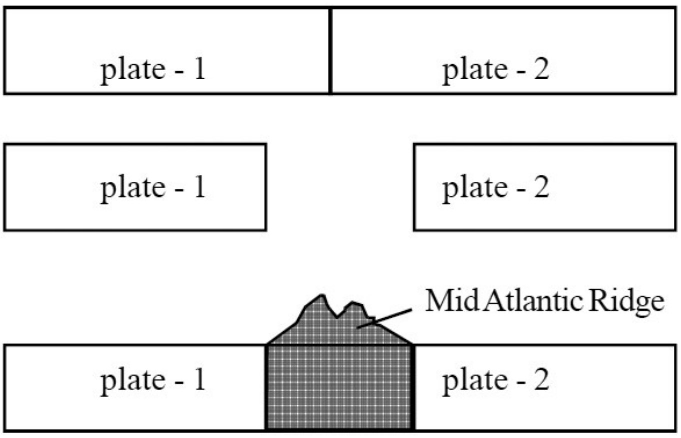
All the years have passed after the proposal of this there is no evidence of extension in seafloor. This tells us that when two plates are moving opposite to each other in one place simultaneously to balance this moment two other plates in some other place are moving towards each other.

When one plate overrides on the other plate the overriding plate is subdued and part of the crust is lost into the mantle. The part of the mantle which is subdued melts due to high temperature. This is a continuous cyclic process that keeps on happening.

Based on the mapping of the ocean floor and with the help of the paleomagnetic studies of rocks from oceanic regions, Harry Hess said that the mid oceanic ridges are situated on the rising thermal convection currents which are coming up from the mantle. The ocean crest moves in opposite direction from the mid oceanic ridges this creates continuous up swelling of molten materials along the oceanic ridges. This molten lava cools down and solidifies to form new crust along the margins of the divergent plates.



Hence according to Hess, it proves the fact that the seafloor spreading along the mid oceanic ridges and the expanding crust are destroyed along the ocean trenches. These facts prove that the continents and ocean basins are in motion continuously.



Evidences

1. It was realized that the volcanic eruptions along the mid oceanic ridges are common and they bring huge amount of Lava on to the surface of the earth.

2. The rocks which are equidistant on the other side of the crest of the mid oceanic ridges show remarkable similarities in terms of period of formation, chemical composition and magnetic properties. The rocks which are closer to the mid oceanic ridges have normal polarity and seem to be the youngest. As one moves away from the crust the age of the rocks increases.

3. The oceanic crust rocks are younger than that of the continental rocks.

4. The sediments on the ocean floor are very thin. Scientists expected that if the ocean floor were older than the continent they will have a complete sequence of sedimentary for a period of much longer duration. However no sediment column has been found which can be older than 200 million years.

5. The Deep trenches have earthquakes occurring in the mid oceanic ridge areas. The focus point of the earthquakes will have a shallow depth.

Check your progress

Note : (a) Space is given below for writing your answer
(b) Compare your answer with the one given at the end of this unit.

1. Write about Plate tectonic theory

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2. Write a few words about Sea floor spreading?

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4.4.3. Convergent moment or destructive plate margins:

When two plates move towards each other they are called convergent plates and their movement is called convergent movement. And the margins of those plates are called destructive plate margins. There are three ways in which convergent movement of the plates can happen. They are;

1. between Oceanic and continental plate
2. between two oceanic plates
3. between two continental plates

The above three types of convergent movements result in the following activities:

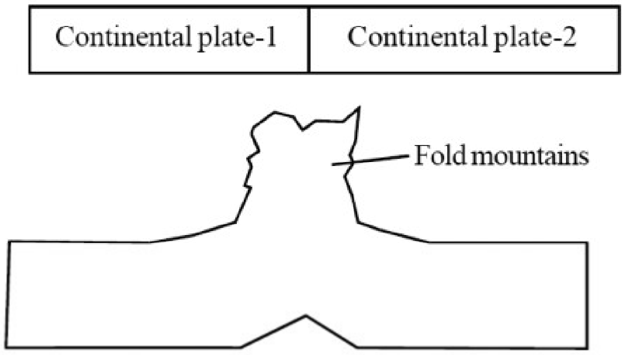
1. Origin of Fold Mountains
2. Origin of volcanoes
3. Origin of ocean trenches.

Origin of folded mountains:

When two continental plates move towards each other or when two plates converge along a line they form folded mountains.

To examine this we can consider Eurasian plate which is combined of both the continents of Europe and Asia excluding India. The Indian plate includes peninsular India and the Australian continental portions. When the Indo Australian plate moved into Eurasian plate the Himalayas were formed. The scientist still believes that this process still continuing due to which we can see the increase of height of Himalayas even to this day.

In similar way due to the convergent movement of European plate and African plate the mountain chain of Alps is formed.



Origin of volcanoes:

There is a close relationship between the plate margins and the volcanic activity. We can see that the world's most active volcanoes are located along the plate margins. And this is observed that 80% of the volcanoes are situated on destructive plate margins that are on the margins of the convergent plates. Some of the volcanoes which are found on intra plate regions are the Hawaiian volcanoes, the fault zone of East Africa etc.

When convergent plate boundaries collide and form a subduction zone the heavier plate margin bends completely and the lighter plate boundary slides over the heavier plate. When the subducted plate margin reaches a depth of a hundred km or more, then in the upper mantle it melts due to the high temperature and results in formation of magma. This magma due to intensive heat and pressure gushes out on earth surface in enormous volume along with explosive gases on the boundaries of the convergent plates. The convergent plate boundaries which are famous for volcanoes are circum Pacific belt and mid continental belt. The volcanoes of the islands like Fujiyama, Unzen, sakurajima, Kagoshia are caused due to some subduction of the Pacific plate below the Asiatic plate near Japan Trench. Due to the subduction of African plate below the Eurasian plate we can see the volcanoes like Etna, Vesuvius, and Stromboli near the Mediterranean Sea.

Origin of ocean trenches:

As discussed earlier when a high density plate is subducted over another low density plate at 100 km, this results in the formation of oceanic trench. Ex: Japan Trench, Philippine trench, Marian trench etc.

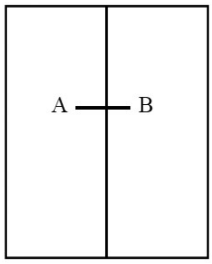
The plate tectonic theory states that there is a close relationship between the ocean trenches and the volcanoes. Ex: Japan Trench, Marian trench etc.

According to plate tectonic theory there are three major belts where volcanoes and earthquakes are closely associated: 1. Mid-Atlantic ridge zone; 2. Circum Pacific zone; 3. mid continental zone. All these zones are situated at the margins of plate boundaries.

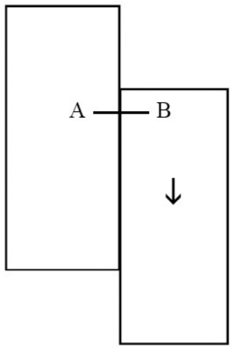
4.4.4 Parallel movement or conservative plate margins:

In this moment the two plates slide over one another side by side in a way that neither they collide nor they move away. Thus this type of plate movement neither creates nor destroys any landform and hence it is called as conservative plate margin or parallel movement.

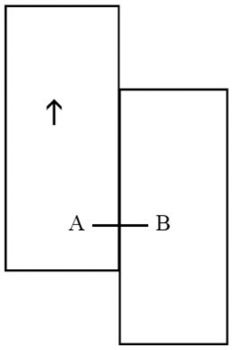
Ex: San Andreas Fault is the result of the parallel movement of the Pacific plate and North American plate.



Plates equal to each other



(2) Downward movement of plate-B



(3) Upward movement of plate -A

Source of energy for the moment of the plates:

The theories of seafloor spreading and plate tectonics theory prove that the surface of the earth and interior of the earth are dynamic in nature; there is a constant activity and motion on both.

1. The majority of the scientific community believes that the source of energy for this moment is the thermal conductive currents inside the earth. The belief that these convective currents provide the plates the required energy to move. These currents originate due to high temperature in the mantle which is covered by Magma. Sir Arthur Holmes postulated the concept of rising thermal convection currents from within the earth in 1928.

2. The majority of the scientist believe that the mechanism of thermal convective Currents on the basis of thermal and pressure conditions. The rising connective currents transport hot liquid materials upwards which upon reaching the point just below the crust split and diverge into the opposite direction in the form of horizontal slow which is find to the depth up to 200 kilometers.

Thus the divergence of conductive currents with hot and molten matter creates plate movement in opposite directions on one hand and in the same direction on the other hand. The scientist thinks that the plate motion is caused due to high gravitational force because of creation of additional matter on either side of the mid oceanic ridges.

Evidence:

There are ample of evidences to demonstrate plate tectonic theory.

1. The J shaped crack on the mid Atlantic ridge covering both the ends of the ridge is formed when both plates move in the opposite direction.

2. Scientists are of the opinion that due to the rise of Magma on crust from mantle the Island is formed besides the mid-Atlantic ridge.

4.5 SUMMARY

The term Isostasy is a Greek word which means equal standing. Pratt says that there is an inverse relationship between the height of the different columns and respective densities, the bigger the column the lesser the density and the smaller the column, the greater the density. Airy says if the column above land is lower its smaller part would be submerged below the earth's surface. The continental drift theory says that, initially, there was one single huge landmass called Pangea and one single water body called Tethys Sea which split into Laurasia and Gondwana continents, Tethys Sea. These land bodies further split to form the current form of Earth's surface. This was proved with various evidences. The plate tectonics theory says that the lithosphere is made of rigid plates out of which 7 are major plates and 20 are identified as minor plates. These plates move in divergent direction, convergent direction and parallel direction to each other. The movement of the plates results in formation of different types of landforms such as formation of mountains, valleys, ocean trenches, and occurrence of volcanoes etc.

4.6 CHECK YOUR PROGRESS-MODEL ANSWERS

1. Pangea
Around 300 million years ago (carboniferous period), there was a single United landmass. Pangea was separated by Tethys seas, a geosyncline which is a narrow and shallow elongated water body on the continent. Lauratia consists of the present continents of North America, Europe, and Asia formed the northern part of the Pangea while Gondwana has current Continents of South America, Africa Madagascar, Peninsular India, Australia and Antarctica represented the southern part of the Pangea.

2. Panthalasa
Around 300 million years ago (carboniferous period), there was a single United landmass, that is a large single continent named Pangaea and there was a mega ocean Panthalasa surrounding it.

3. Plate tectonic theory:
This theory tells us that when two plates are moving opposite to each other in one place simultaneously to balance this moment two other plates in some other place are moving towards each other. When one plate overrides on the other plate the overriding plate is subdued and part of the crust is lost into the mantle. The part of the mantle which is subdued melts due to high temperature. This is a continuous cyclic process that keeps on happening.

4. Sea floor spreading:
Based on the mapping of the ocean floor and with the help of the paleomagnetic studies of rocks from oceanic regions, the mid oceanic ridges are situated on the rising thermal convection currents which are coming up from the mantle. The ocean crest moves in opposite direction from the mid oceanic ridges this creates continuous up swelling of molten materials along the oceanic ridges. This molten lava cools down and solidifies to form new crust along the margins of the divergent plates. It proves the fact that the seafloor spreading along the mid oceanic ridges and the expanding crust are destroyed along the ocean trenches.

4.7 MODEL EXAMINATION QUESTIONS

1. Explain the types of plate movements.
2. Write a detailed note on criticism on Continental Drift theory
3. Explain the Origin of Volcanoes

Define the following words

- Tectonic plates
- Subduction zone

4.8 GLOSSARY

Ocean Ridges: these are **submarine mountain chain formed by plate tectonics**. In other words, it is an underwater longest mountain range in the world. It demarcates the boundary between two plates.

Mid-ocean ridge: it is a seafloor mountain system formed by plate tectonics. It typically has a depth of about 2,600 meters and rises about 2,000 meters above the deepest portion of an ocean basin.

Subduction: is a geological process in which the oceanic lithosphere is recycled into the Earth's mantle at convergent boundaries.

Geodesy is **the science of accurately measuring and understanding three fundamental properties of the Earth**: its geometric shape, its orientation in space, and its gravity field— as well as the changes of these properties with time

"Crust" describes **the outermost shell of a terrestrial planet**. Earth's crust is generally divided into older, thicker continental crust and younger, denser oceanic crust.

4.9 FURTHER READINGS

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UNIT - 5: GEOLOGICAL TIME SCALE

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5.3 Archaeozoic era

5.4 Proterozoic era

5.5 Paleozoic era

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5.9 Check your progress-Model Answers

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5.11 Glossary

5.12 Further Readings

5.0 OBJECTIVES

After reading this unit, you will be able to;

- Explain the Timeline of the events and incidents on earth
- Understand the Origin of the different organisms on earth
- Know the Geological events
- Explain the different time periods and their corresponding important events

5.1 INTRODUCTION

The geological time scale (GTS) is a chronological measuring system that defines the timing and correlations between events throughout Earth's history. The time scale was created by researching rock strata and fossils all throughout the world. The absolute divisions in the time scale were determined using radioactive dating. Applications demonstrate the tremendous diversity of life that has existed on Earth throughout history. Explain how scientists use different types of fossils to investigate Earth's historical environment and diverse life-forms. Explains how disasters have altered Earth's history, affecting the conditions on the planet and the diversity of its life-forms.

5.2 GEOLOGICAL TIME SCALE

The geological time scale summarizes the information about the earth right from the origin of the earth to till date. The earth formed around 4.25 billion years ago on the rocks formed around 3600 million years ago and life on Earth came in around 600 million years ago. We have eras, periods and epochs in case of a geological time scale. This is explained in the table below.

Eons	Era	Period	Epoch	Age/years before present	Life/ major events
	Cenozoic (from 65 million years to the present times)	Quaternary	Holocene Pleistocene	0-10000 10000-2 million	Modern man Homo sapiens
		Tertiary	Pliocene Miocene Oligocene Eocene Palaeocene	2-5 million 5-24 million 24-37 million 37-58 million 58-65 million	Early human ancestor Ape: flowering plants and trees Anthropoid ape Rabbits and hare Small mammals: rats- mice
	Mesozoic 65-245 million	Cretaceous Jurassic Triassic		65-144 million 144-208 million 208-245 million	Extinction of dinosaurs Age of dinosaurs Frogs and turtles mammals
	Palaeozoic 245- 570 million	Permian Carboniferous Devonian Silurian Ordovician Cambrian		245-286 million 286-360 million 360-408 million 408-438 million 438-505 million 505-570 million	Reptile dominate- replace amphibians First reptiles: vertebrates: coral beds Amphibians First trace of life on land: plant First fish No terrestrial life: marine invertebrate
Proterozoic Archean Hadean	Pre-Cambrian 570 million – 4800 million			570- 2500 million 2500-3800 million 3800-4800 million	Soft bodied arthropods Blue green algae: unicellular bacteria Oceans and continents form- ocean and atmosphere are rich in carbon dioxide
Origin of stars Super nova Big bang	5000-13700 million			5000 million 12000 million 13700 million	Origin of the sun Origin of the universe

Source: NCERT

Now let's try to discuss a few other important points of the eras listed in the table.

5.3 ARCHAEOZOIC ERA

This era is also called the Archean or Azoic era. This term was coined by J.D.Dana for the first time in 1872. It is believed that the earth has been formed during the era by the collision in joint disc shaped cloud material that also forms the sun. Due to the gravitational force the gas and dust gathered slowly in two clubs that became asteroids and small planets called planetesimals. It is also believed that the Earth was initially in a gaseous state when it was separated from the sun and gradually over a period it cooled down and attained the solid state. The entire process of formation of primary rocks and promotional atmosphere is believed to have been undertaken 1000 million years ago. The revenant of these rocks in present can be seen in metamorphic rocks like Archean gneisses which are generally called shield areas. Few of the important shield areas are Baltic shield in Europe, Siberian shield, China shield, Indian shield, Australian shield, African shield, Canadian Shield, South American shield and Antarctica shield.

Check your progress

Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

1. What do you understand about Archaeozoic Era?

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5.4 PROTEROZOIC ERA

The Precambrian era witnessed the formation of Earth volcanic activity and other Earth movements along with development of oxygen rich terrestrial atmosphere. It saw the origin of life rise of multi-cellular organisms the water vapor was added to the atmosphere from volcanic Lava that eventually resulted in the formation of clouds due to torrential rains and condensation of clouds low lying areas of earth turned into water bodies. The flowing water bodies resulting in the formation of streams and rivers etc., the rocks were subjected to weathering denudation and transportation resulting in the formation of new states of rocks due to fluvial and wind action.

In the Indian peninsula two major groups of rocks were formed during this era. They are the dharwar group of rocks and the purana group of rocks. The purana groups of rocks are again divided into two important Rock groups: Kadapa system and Vindhyan system.

The Kadapa super groups of rocks have been deposited in Kadapa basins which are spread over few of the districts of Andhra Pradesh and Telangana. Brindavan group of rocks having divided into lower Vindhyan formation and upper Vindhyan formation. The Vindhyan group of rocks occurs in parts of Jharkhand, Bihar, Chittorgarh, parts of Chhattisgarh, parts of Kurnool district in Andhra Pradesh and also beneath the Himalayan ranges.

5.5 PALEOZOIC ERA

As mentioned in the table this Era is divided into five periods. They are Permian, Carboniferous, Devonian, Silurian, Ordovician and Cambrian. Weathering and denudation of pre-existing rocks has increased significantly in the Devonian period. Early in the carboniferous period Earth's climate was warm, later glaciers formed at poles and equatorial regions were often warm and humid. Since the process of coal formation took place in the carboniferous period and so it got its name.

Cambrian Period: In Latin language the whales region in Britain is called Cambrian. In the Cambrian period many Fossil forms of shells, coiled shells, sponges and other forms of invertebrate have been recorded; most of the fauna is of marine origin. The famous coral reefs, the barrier reef of the east coast of Australia, the coral reefs of Morocco are believed to have formed in this period.

Ordovician Period: During the Ordovician period the area of the northern tropics was almost entirely ocean and most of the world's land was collected into Southern supercontinent Gondwana. The second largest mass extinction of all time ended this period.

Silurian Period: The Silurian period got its name from one of the old tribes that lived during the Roman period in the Wales region of England. The centipod, like animals, Millopods evolved better during this period. Due to the drastic climatic changes arid conditions prevailed. Apart from the iron manganese many other minerals like oil and natural gas lead copper formed extensively during this period.

Devonian Period: The Devonian period got its name as the Rock formations are well developed in the Devonshire area of England and so the period got this name. The first significant adaptive radiation of life and triland occurred during this period. By the middle of the Devonian period several group of plants have evolved leaves and true roots and by the end of this era the first seed bearing plants have appeared. The ancestors of all forelimb vertebrates began adapting to walk on land as their pelvic fins gradually evolved into legs. The ammonites' species of mollusca have appeared in this period.

Carboniferous Period: The name carboniferous means coal bearing and this word is derived from the word carbo in Latin language. It is called so as most of the coal deposits over world formed during this period. This period is divided into upper and Lower Carboniferous periods. The Upper Carboniferous period is called Pennsylvanian and the Lower Carboniferous period is called Mississippian by the American Geoscientist. Meganeura a variety of butterflies whose wings measured around 70 to 80 CM also existed during the period.

Permian period

The Permian period witnessed the diversification of early amniotes into the ancestor groups of mammal's turtles and other reptiles as lizards, snakes, and amphibians of frog species evolved and flourished during this period.

The world at this time was dominated by two continents known as Pangea and Siberia surrounded by a global Ocean called Panthalasa. The Permian ended with the Permian Triassic extinction event the largest mass extinction in Earth's history. In this event nearly 90% of marine species and 70% of terrestrial species were wiped out. By the end of the Permian period mammals appeared on the globe.

5.6 MESOZOIC ERA

Mesozoic means middle life which is derived from the Greek. This error is subdivided into three major periods: the Triassic Jurassic and cretaceous. This Era has witnessed the gradual rifting of supercontinent Pangea into separate land masses that would eventually move into their current positions. It also witnessed flora and fauna. 80% of flora and fauna which we found today have roots in this era except monkeys and human beings. The first mammals also updated during this period but they were still small and weighed less than 15 kgs until the Cenozoic era. The climate of this period varied alternatively between warming and cooling periods. Overall the earth was hotter than what it is today.

Triassic Period: The Triassic period was named after the three distinct Rock layers that were found throughout Germany and North Western Europe. The three layers were red beds, capped by marine limestone, followed by a series of terrestrial mud and sandstone called Trias. The best supercontinent of Pangea existed until the mid-Triassic period after which it began to gradually rift into two separate land masses called Laurasia on the northern side and Gondwana onto the southern side.

Jurassic Period: This is also known as age of reptiles. The start of this period is marked by major Triassic Jurassic extinction event. Two other extinction events occur during this period they are the Pliensbachian or Toarcian event in early Jurassic and Tithonian event at the end. However these events do not rank among the five big mass extinctions. At the beginning of the patriot the supercontinent Pangea lifted into two land masses. This created more coastal lines Gulf of Mexico and shift of the continental climate from drive to humid and many of the arid deserts of the Triassic were replaced by lush rainforest.

Cretaceous Period: this period was relatively warm resulting in high ecstatic sea levels that created numerous shallow inland seas. The oceans and seas were populated with many types of marine reptiles, ammonites which are extinct now while the land was dominated by the dinosaurs. During this period new groups of mammals and birds as well as flowering plants appeared. The famous Deccan traps of the Western India are formed as a result of volcanic eruptions that took place during this period. This period ended with the large mass extinction in which many groups including non-avian dinoceros and large Marine reptiles became extinct.

Check your progress:

Note : (a) Space is given below for writing your answer
(b) Compare your answer with the one given at the end of this unit.

2. Write about the major events of the Mesozoic era.

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5.7 CENOZOIC ERA

The Cenozoic era is derived from the Greek word which means life. This is the current and most recent of all the eras. Cenozoic Era is also known as age of mammals because the large mammals that dominated the earth were fully developed in this era. The extinction of many large tap set groups such as dinosaurs, plesiosauria and pterosauria allowed the animals and birds to grow, diversify and become dominant species on earth.

The Cenozoic era is divided into two periods namely tertiary and quaternary. Literature is further divided into five epochs which are Paleocene, Eocene, Oligocene, Miocene and Pliocene. Whereas the quaternary is subdivided into the Pleistocene and Holocene epochs. By the end of the tertiary period Himalayan fold mountain ranges were formed because of the origin IQ moments in Tethys Sea.

5.8 SUMMARY

The time period of the earth can be divided into eons, eras, periods, epochs. The origin of the supernova big bang has happened around 5000-13700 million years ago during which the sun and universe originated. In the Proterozoic, Archean, hadean eons during 570-2500 million years, 2500-3800 million years, 3800-4800 million years, the major events were origin of soft bodied arthropods, blue green algae, formation of oceans and continents, occurrence of carbon dioxide in atmosphere respectively. In a similar way in the Paleozoic era we can see reptiles dominate and replace amphibians. In the Mesozoic era the dinosaurs were extinct and frogs and turtles came to life. The modern man, Homo sapiens, originated in the Cenozoic era.

5.9 CHECK YOUR PROGRESS-MODEL ANSWERS

1. This era is also called the Archean or Azoic era. It is believed that the earth has been formed during the era by the collision in joint disc shaped cloud material that also forms the sun. The Earth was initially in a gaseous state when it was separated from the sun and gradually over a period it cooled down and attained the solid state. The entire process of formation of primary rocks and promotional atmosphere is believed to have been undertaken 1000 million years ago. The revenant of these rocks in present can be seen in metamorphic rocks like Archean gneisses which are generally called shield areas. Few of the important shield areas are Baltic shield in Europe, Siberian shield, China shield, Indian shield, Australian shield, African shield, Canadian shield, South American shield, Antarctica shield.

2. The climate of this period varied alternatively between warming and cooling periods. Overall the earth was hotter than what it is today. The famous Deccan traps of the Western India are formed as a result of volcanic eruptions that took place during this period. This period ended with the large mass extinction in which many groups including non-avian dinoceros and large Marine reptiles became extinct. 80% of flora and fauna which we found today have roots in this era except monkeys and human beings. The first mammals also updated during this period but they were still small and weighed less than 15 kgs until the Cenozoic era.

5.10 MODEL EXAMINATION QUESTIONS

I. Write about the following terms in less than 50 words

1. Permian
2. Carboniferous
3. Devonian
4. Silurian

II. Answer the following questions

1. Explain in detail about the Cenozoic era.
2. Write about the major events of the Paleozoic era

5.11 GLOSSARY

Crust: In geology, crust is the outermost solid shell of a rocky planet, dwarf planet, or natural satellite. It is usually distinguished from the underlying mantle by its chemical makeup;

Era: a fixed point in time from which a series of years is reckoned. A memorable or important date or event especially: one that begins a new period in the history of a person or thing.

Shield: is that part of a craton in which Precambrian basement rocks crop out extensively at the surface. By contrast, in a platform the basement is overlain by horizontal or sub horizontal sediments.

Craton: the term is used to distinguish the stable portion of the continental crust from regions that are more geologically active and unstable. Cratons can be described as shields.

5.12 FURTHER READINGS

1. Chorley R J., 1972: Spatial Analysis in Geomorphology, Harper and Row, London.

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UNIT-6: TYPES OF ROCKS AND THEIR CHARACTERISTICS

Contents

6.0 Objectives
6.1 Introduction
6.2 Rocks
6.3 Igneous rocks
6.4 Sedimentary rocks
6.5 Metamorphic rocks
6.6 Rock cycle
6.7 Summary
6.8 Check your Progress-Model Answers
6.9 Model Examination Questions
6.10 Glossary
6.11 Further Readings

6.0 OBJECTIVES

After reading this chapter you will be able to;

- Explain the Formation of rocks
- Understand the Life cycle of rocks
- Explain the types of rocks
- Give a brief note on distribution of rocks

6.1 INTRODUCTION

The crust of the earth is made up of rocks. A rock is a mineral composition made up of one or more minerals. Rock can be firm or soft, and it comes in a variety of colours. Granite, for example, is a hard stone, but soapstone is a soft one. Quartzite can be milky white while gabbros can be black. Mineral constituents do not have a specific composition in rocks. The most prevalent minerals found in rocks are feldspar and quartz. Because of the close relationship between rocks and landforms, and soils, a geographer must have a fundamental understanding of rocks. There are many distinct types of rocks, which are divided into three categories based on their development mechanism. They are:

(i). Igneous Rocks solidified from magma and lava; (ii) Sedimentary Rocks, formed by the deposition (sedimentation) of rock fragments: (iii) Metamorphic Rocks, which are produced from existing rocks that are recrystallizing.

6.2 ROCKS

Rocks can be defined as natural substances which are a solid aggregate of one or more minerals. Example granite is a rock with a combination of minerals like quartz feldspar and biotite. Earth's outer layer, which is called the lithosphere, is made up of Rock. The bedrock which is usually covered by a layer of weathered Rock fragments is called a regolith. Petrology is the science of rocks. Under this branch studies on rocks are conducted in all aspects like mineral composition, texture, structure, origin, occurrence, alteration and relationship with other rocks. There are different kinds of rocks which can be grouped into three types on the basis of their origin. They are igneous rocks, sedimentary rocks and metamorphic rocks.

6.3 IGNEOUS ROCKS

The source of these rocks is Magma which is below the surface of the earth or the Lava which comes on to the surface and solidifies to form a rock. The igneous rocks are the first form on earth's surface and hence they are called primary rocks. They are also the base for the formation of other types of rocks, sedimentary and metamorphic rocks and so they also called parent rocks. The types of rocks which they formed depend upon the chemical composition of the magma. If the Magma is acidic in nature then acidic igneous rocks are formed, if the Magma is basic in nature the basic igneous rocks are formed.

6.3.1 Characteristics of igneous rock

As these rocks are formed due to solidification and crystallization of hot liquid magma the shape of grains or crystals can be seen on the rocks. The shape of grains is angular but not spiracle because these properties largely depend upon the rate and place of cooling and solidification of Magma or Lava. They don't have any stratification. They do not contain fossils. But they contain Ferro magnesium minerals besides silica aluminum sodium calcium magnesium etc. As these rocks are volcanic in origin they are generally found in volcanic zones. 90% of the earth crust comprises igneous rocks.

6.3.2 Classification of igneous rocks:

On the basis of the mineral composition of igneous rocks they are classified as:

1. Acidic Igneous rocks which have light minerals light quartz and feldspar which are rich in silica
2. Mafic igneous rocks which have dark mineral groups such as pyroxenes, amphiboles and olivine's which are rich in magnesium and iron.
3. Ultramafic igneous rocks which have abundance of pyroxenes and olivine minerals ex: peridotite.

On the basis of the amount of silica rocks they contain can be divided into 2 groups.

1. Igneous rocks which have more silica, example: granite.
2. Basic igneous rocks which have less amount of silica, example: gabbro

On the basis of the place where igneous rocks are formed these rocks can also be classified into two groups; they are extrusive igneous rocks and intrusive igneous rocks.

Extrusive igneous rocks: The rocks which are formed due to solidification of Lava on the surface of the earth are called as extrusive igneous rocks. Ex: Basalt, Andesit, Rhyolite and obsidian.

Intrusive igneous rocks: These types of rocks are formed if the Magma is solidified deep within the earth. Based on the level that is depth at which solidification of Magma takes place. The intrusive igneous rocks are further classified into two: they are; the plutonic rocks and hypabyssal rocks.

Plutonic rocks: If the Magma is solidified at greater depth than such types of rocks are called as plutonic rocks. The size of the crystal or grain varies from big to very big.

Hypabyssal rocks: the rocks that are formed at medium to shallow that's within the crust and have intermediate grain size are called hypabyssal rocks.

6.3.3. Distribution of igneous rocks in India:

These rocks are abundantly distributed in the states of Telangana, Andhra Pradesh, Orissa, Madhya Pradesh, Chhattisgarh, Maharashtra, Kerala, Tamil Nadu etc.

Check your progress

Note :(a) Space is given below for writing your answer
(b) Compare your answer with the one given at the end of this unit.

1. Briefly write a note on Intrusive igneous rocks

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6.4 SEDIMENTARY ROCKS

These rocks are formed by the deposition and subsequent cementation of the material on the earth surface and within the water bodies. Sedimentation is the collective name given to settle in place and further form a rock due to accumulation of the sediment. Sedimentary rocks are also called secondary rocks. These rocks cover 75% of Earth's crust. Sedimentary rocks are deposited in layers as tracts forming a structure called bedding and this process is called stratification. This unconsolidated sediment will be consolidated over a period of time due to the pressure exerted and turn into a rock; this process is called lithification. The process of cementation, compaction and hardening of sediments into a rock is called lithification.

6.4.1 Characteristics of Sedimentary rocks

These rocks are formed due to the process of weathering erosion and deposition of igneous and metamorphic rocks. As they are formed layer by layer or strata by strata they are called stratified rocks. Patterns of folds are not regular in these rocks. As these rocks are formed in fluvial Marine and Aeolian conditions that contain ripple marks. When compared to igneous and metamorphic rocks these rocks are soft and brittle in nature. They have high permeability and porosity and so they are prone to maximum weathering. 75% of the Earth's surface is covered by sedimentary rocks in spite of this these rocks constituted only 5% of the composition of crust and the other 95% is composed by the igneous and metamorphic rocks. These rocks are poorly consolidated and hence the nature of cementing depends upon the elements which participate in the rock formation. Most of the sedimentary rocks are formed due to the deposits of hematite and magnetite, base metals, manganese, coal, rock salt, gypsum etc.

6.4.2 Classification of sedimentary rocks.

Sedimentary rocks can be classified on the basis of two aspects: one on the basis of the process formed and the second is on the basis of the transporting agent.

On the basis of process

Sedimentary rocks can be formed in three processes. They can be formed mechanically, chemically or organically.

In the mechanical formation the rocks are broken into smaller pieces without much change in the chemical composition of the parent rock. Ex: conglomerate, sandstone, shale, clay, loess etc.

Due to excessive rains, high temperature and variant pressure conditions the rocks are responsible for chemical weathering. The sedimentary rocks which are the result of this process are said to be formed chemically.

The rocks are deposited due to the activity of different types of organisms in huge quantities and undergo lithification resulting in the formation of sedimentary rocks such rocks are called as organically formed.

On basis of the transporting agent

- If the sediments are deposited by the water are called aqueous rocks. Ex: clay, dolomite and limestone.
- If the weathered rock particles are transported by wind they are called Aeolian rocks.
- The weathered Rock material is transported by glaciers that are called till. All deposits are called moraines.

6.4.3 Distribution of sedimentary rocks:

The entire indo-Gangetic plain in India, the parts of Delhi, Bengal, Bihar, Uttar Pradesh, Orissa, Madhya Pradesh and coastal regions of Kerala, Andhra Pradesh are occupied by sedimentary rocks.

6.5 METAMORPHIC ROCKS

Metamorphic rock is a result of transformation of already existing rock. When the original rock is subjected to high temperature and high pressure causing physical and/or chemical changes metamorphic rocks are formed. Ex: slate, gneiss, schist, marble

If the igneous rocks undergo metamorphosis they called as orthomorphic rocks, if the sedimentary rocks undergo metamorphosis they are called as poly metamorphic rocks.

Metasomatism is the chemical alteration of Rock by hydrothermal and other fluids; it is the process of replacement of one drug by another which has different mineralogical and chemical compositions.

6.5.1 Characteristics of metamorphic rocks:

As the source of the metamorphic rocks is sedimentary rocks or igneous rocks they have the characteristics of the parent rocks. In general folds and faults are prominent in metamorphic rocks of high-pressure origin structures. When already formed metamorphic rocks undergoes a process of metamorphism again then that process is called ReMetamorphoism. This is possible only when the temperature becomes exceedingly high and the pressure exerted is enormous due to orogenic moments.

6.5.2 Types of metamorphism

Based on factors the metamorphic rocks are classified into the following types.

1. Thermal metamorphism:

Thermal or contact metamorphism in which the country rock which is surrounded by hot magma intrusion is metamorphosed by the high heat flow coming from intrusion.

2. Contact metamorphism: it occurs typically around intrusive igneous rocks as a result of temperature increases caused by intrusive igneous rocks, as a result of temperature increase caused by the intrusion of magma into cooler rock. The area surrounding the intrusion where the contact metamorphism effects are visible is called the metamorphic aureole.

Pyro metamorphism is a type of metamorphism in which rocks are changed by heat coming from fossil fuel fire. Anthropogenic pyro metamorphic rocks are found in burning coal mining dumps.

Optalic metamorphism: this term is used for indurating, baking and fitting effects produced by Lava flows are small dykes on their contact rocks. This process is categorized by incipient fusion without melting, thus marking a boundary with pyro metamorphism.

Pneutolytic metamorphism: contact metamorphism in which the composition of a rock has been altered by introduction of gaseous magnetic material.

Dynamic metamorphism is catalectic metamorphism: Under this process the fragmentation and recrystallization of rocks happens in narrow zones such as faults where strong deformation has already occurred.

Check your progress

Note:(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

1. Define the term ReMetamorphoism?

Rocks are ground to a fine powder in the zone of the formation and due to their fine grain size recrystallization happens effectively under the extreme directional stress and the release of frictional heat during the deformation.

6.5.3 Types of metamorphic rocks

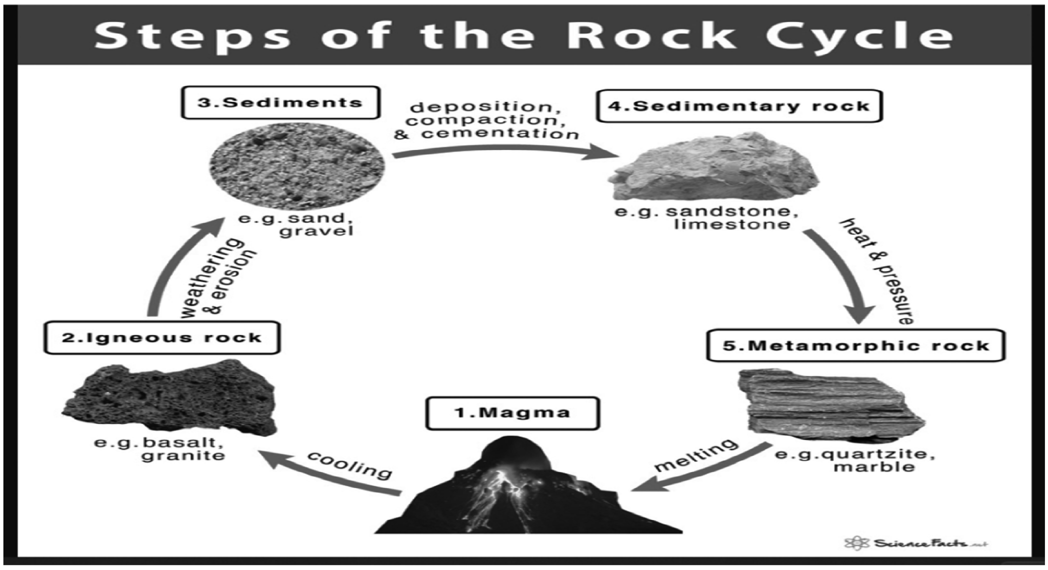
Metamorphic rocks are broadly classified into thermal metamorphic rocks and dynamic metamorphic rocks.

Thermal Metamorphic rocks: The metamorphic rocks which are formed due to high temperature changes are called thermal metamorphic rocks. Examples are limestone changing into marble, sandstone changing into quartzite, shale changing into slate and coal changing into graphite.

Dynamic metamorphic rocks are formed when rocks are subjected to high pressure. Examples gneiss from granite, schist from shale, hornblende from augite etc.

6.6 ROCK CYCLE

As any other activity on earth, the formation of rocks and transformation of rocks from one form to the other form is a continuous cyclic process. They always changed from one form to the other form.



The igneous rocks which are also known as primary rocks and the sedimentary and metamorphic rocks are formed from the primary rocks and vice versa. The fragments derived from igneous and metamorphic rocks can form sedimentary rocks. Sedimentary rocks can be turned into fragments and again form another type of sedimentary rock. When a crystal rock is formed it can be again carried down into the mantle through the process of subduction and the same meltdown due to increase in temperature in the interior and again form molten magma, the original source of the rock formation. In this way, the rock formation from one form to the other and from Rock to its liquid state of Magma which is its origin is a cyclic process which never stops or pauses.

Check your progress

Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

3. Explain the Rock cycle

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6.7 SUMMARY

Rocks are the solid aggregate of one or more minerals. The rocks are of mainly three types- igneous, sedimentary and metamorphic rocks. The igneous rocks are the basic types of rocks which are formed due to solidified lava, they can be extrusive or intrusive. They are distributed in India in areas of. Telangana, Andhra Pradesh, Orissa, Madhya Pradesh, Chhattisgarh, Maharashtra etc. The sedimentary rocks are formed due to the process of sedimentation which can happen either mechanically, chemically or organically. Depending on the agents of transport sedimentary rocks can be of 3 types- aqueous, Aeolian, till. They are found in parts of Delhi, Bengal, Bihar, Uttar Pradesh, Orissa, Madhya Pradesh, coastal regions of Kerala, Andhra Pradesh etc. The metamorphic rocks are formed when the other types of rocks undergo extreme heat and pressure for a considerable period of time. There are different types of metamorphosis - thermal, pyro metamorphism, optalic, pneutolutic, cataclastic, dynamo, plutonic. The process of changing of one form of rock into another rock is called rock cycle.

6.8 CHECK YOUR PROGRESS-MODEL ANSWERS

1. Intrusive igneous rocks: these types of rocks are formed if the Magma is solidified deep within the earth. Based on the level that is depth at which solidification of Magma takes place the intrusive igneous rocks are further classified into two. They are the plutonic rocks and hypabyssal rocks.

2. ReMetamorphoism: When already formed metamorphic rocks undergoes a process of metamorphism again then that process is called ReMetamorphoism

3. Explain the Rock cycle.

As any other activity on earth the formation of rocks and transformation of rocks from one form to the other form is a continuous cyclic process. The igneous rocks known as primary rocks and the sedimentary and metamorphic rocks are formed from the primary rocks and vice versa. The sedimentary rocks can be turned into fragments and again form another type of sedimentary rock. When a crystal rock is formed it can be again carried down into the mantle and meltdown due to increase in temperature in the interior and again form molten magma. In this way the rock formation from one form to the other and from Rock to its liquid state of Magma is a cyclic process which never stops or pauses.

6.9 MODEL EXAMINATION QUESTIONS

I. Answer the following Questions?

1. Write about primary rocks
2. State the differences between Characteristics of the three major forms of rocks.
   Characteristics of igneous rock:

II. Answer the following Questions?

Define the following words

a. Lithification
b. Regolith
c. Aqueous rocks
c. Aeolian rocks
d. Plutonic rocks:
e. Hypabyssal rocks:

6.10 GLOSSARY

Orogenic movements, also called horizontal earth movements, are **slow movements of the lithospheric plates**. When two plates push against each other, it causes the strata's to fold upwards which causes formation of mountains. This process is also called oogenesis.

Magma is extremely hot liquid and semi-liquid rock located under Earth's surface. Earth has a layered structure that consists of the inner core, outer core, mantle, and crust. Much of the planet's mantle consists of magma. This magma can push through holes or cracks in the crust, causing a volcanic eruption.

Lava (molten rock) emerging as a liquid onto Earth's surface. The term lava is also used for the solidified rock formed by the cooling of a molten lava flow.

Fault is a fracture or zone of fractures between two blocks of rock. Faults allow the blocks to move relative to each other.

Stratification, the layering that occurs in most sedimentary rocks and in those igneous rocks formed at the Earth's surface, as from lava flows and volcanic fragmental deposits.

6.11 FURTHER READINGS

1. Chorley R J., 1972: Spatial Analysis in Geomorphology, Harper and Row, London.

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BLOCK - III: GEOMORPHIC PROCESS – I

The physical and chemical interactions between the Earth's surface and the natural forces acting upon it to produce landforms. The processes are determined by such natural environmental variables as geology, climate, vegetation and base level, to say nothing of human interference. The nature of the process and the rate at which it operates will be influenced by a change in any of these variables are known as geomorphic processes.

The geomorphic process means **bringing about changes in the configuration of the Earth's surface, due to physical stresses and chemical actions on materials present on earth**. The physical and chemical action are due to endogenic and exogenic forces.

Endogenic forces are those internal forces which derive their strength from the earth's interior and play a crucial role in shaping the earth crust. Examples – mountain building forces, continent building forces, earthquakes, volcanism etc.

After learning about how the earth was born, how it evolved its crust and other inner layers, how its crustal plates moved and are moving, and other information on earthquakes, the forms of volcanism and about the rocks and minerals the crust is composed of, it is time to know in detail about the surface of the earth on which we live.

This block have 3 units:

7. Earth Quakes and Volcanoes

8. Weathering, Erosion, Denudation and Mass-wasting.

9. Fluvial Landforms- Cycle of Erosion and depositional features.

Unit 7: EARTHQUAKES

After reading this unit, you will be able to understand;
About Earthquakes and types of earthquakes
To understand causes of earthquakes

Contents

7.0 Objectives
7.1 Introduction
7.2 Identification of Earthquakes
7.3 Distribution of Earthquakes
7.4 Classification of Earthquakes
7.5 Causes of Earthquakes
7.6 Earthquake zones
7.7 Volcanoes
7.8 Classification of volcanoes
7.9 Summary
7.10 What you learnt
7.11 Model Answers
7.12 Model Examination questions
7.13 Glossary

7.0 OBJECTIVES

- How earthquakes are caused by a buildup of strain in Earth's crust.
- Compare and contrast primary, secondary, and surface waves.
- Recognize earthquake hazards and how to prepare for them.

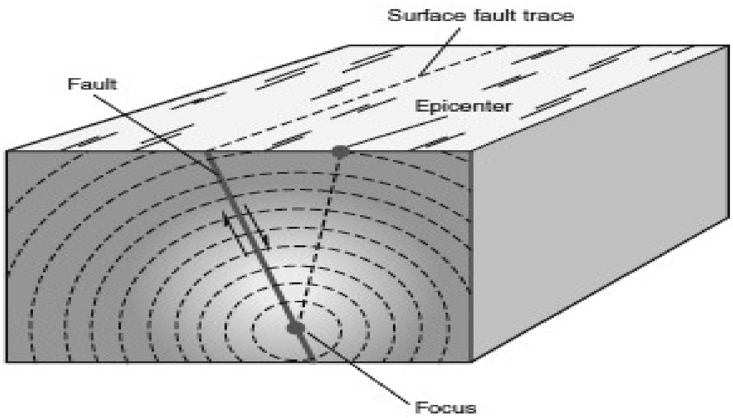
Why it is important
Studying earthquakes will help you learn where they might occur and how you can prepare for their hazards.

7.1 INTRODUCTION

The mother earth, where we live, it is continuously shaking without our notice. There are studies which indicating that eight to ten thousand earthquakes are identifying annually on the Globe. Every one hour we can find one earthquakes surrounded by us. In stable water if we through a stone, a continuous series of waves will get and it reaches to surface. Same way if sudden disturbances happen is bellow earth it will reaches to surface with vibrations. It is the movement of internal rocks among one another and reaches to surface with vibrations is called earthquakes. Earthquakes are the sudden movement which is created below the earth because of internal forces and it reaches to surface.

An **earthquake** is a weak to violent shaking of the ground produced by the sudden movement of rock materials below the earth's surface.

Rocks usually change shape, or deform, slowly over long periods of time. As they are strained, potential energy builds up in them. This energy is released suddenly by the action of rocks breaking and moving. Such breaking, and the movement that follows, causes vibrations that move through rock or other earth materials. If they are large enough, these vibrations are felt as ***earthquakes***.



Where do the forces come from that cause rocks to deform by bending or breaking? Why do faults form and why do earth-quakes occur in certain areas? As you'll learn later in this chapter, forces inside Earth are caused by the constant motion of plates, or sections, of Earth's crust and upper mantle.

The earthquakes originate in tectonic plate boundary. The focus is point inside the earth where the earthquake started, sometimes called the **hypocenter**, and the point on the surface of the earth directly above the focus is called the **epicenter**.

Earthquake Focus and Epicenter Movement along a fault releases strain energy. Strain energy is potential energy that builds up in rock when it is bent. When this potential energy is released, it moves outward from the fault in the form of seismic waves. The point inside Earth where this movement first occurs and energy is released is called the ***focus*** of an earthquake. The point on Earth's surface located directly above the earthquake focus is called the ***epicente**r* of the earthquake.

The origin point of earthquake is focus point which is located inside of earth. The focus point varies from place to place. The Himalayan earthquakes are generated at the depth of 700 km inside of earth. The epicenter is quite perpendicular to the focus point and also called hypocenter. The seismic waves which are generated from focus point first will hit to the epicenter only.

7.4 CLASSIFICATION OF EARTHQUAKES

There are two ways by which we can measure the strength of an earthquake: magnitude and intensity. **Magnitude** is proportional to the energy released by an earthquake at the focus. It is calculated from earthquakes recorded by an instrument called **seismograph**. It is represented by Numbers. Intensity on the other hand, is the strength of an earthquake as perceived and felt by people in a certain locality. It is a numerical rating based on the relative effects to people, objects, environment, and structures in the surrounding. The **intensity** is generally higher near the epicenter. It is represented by Roman Numerals.

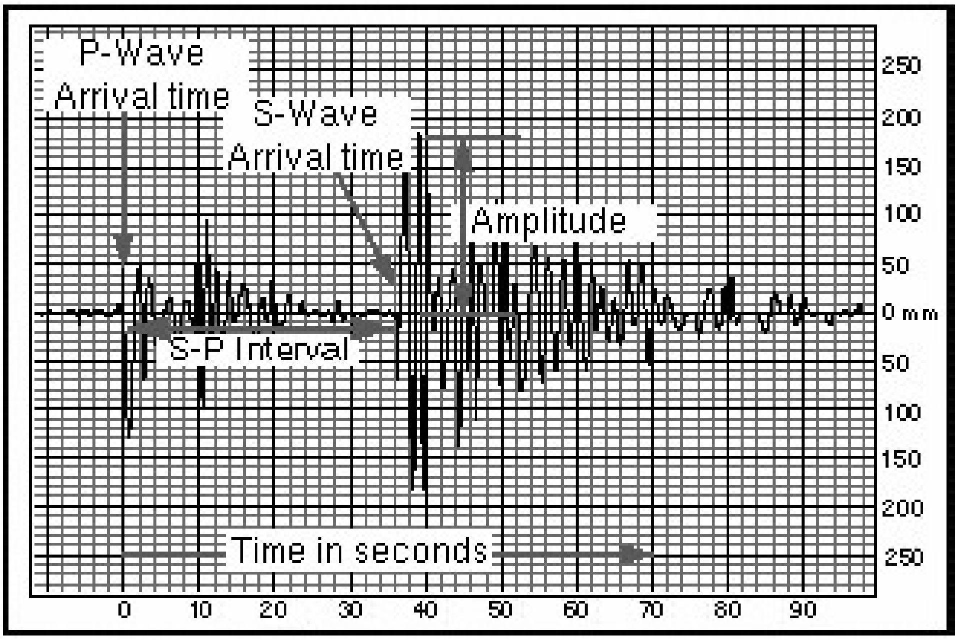
Check your progress

Note: a) Space is given below for writing your answer
b) Compare your answer with one given at the end of this Unit

1. What is the difference between an earthquake's epicenter and focus?

Earthquakes also release waves. Earthquake waves are transmitted through materials in Earth and along Earth's surface. Earthquake waves are called seismic waves. Seismic Waves After they are produced at the focus, seismic waves travel away from the focus in all directions. Some seismic waves travel throughout Earth's interior, and others travel along Earth's surface. The surface waves cause the most damage during an earthquake event.

Primary waves, also known as P-waves, travel the fastest through rock material by causing particles in the rock to move back and forth, or vibrate, in the same direction as the waves are moving. Secondary waves, known as S-waves, move through rock material by causing particles in the rock to vibrate at right angles to the direction in which the waves are moving. P- and S-waves travel through Earth's interior. Studying them has revealed much information about Earth's interior.



Surface waves are the slowest and largest of the seismic waves, and they cause most of the destruction during an earthquake. The movements of surface waves are complex. Some surface waves move along Earth's surface in a manner that moves rock and soil in a backward rolling motion. They have been observed moving across the land like waves of water. Some surface waves vibrate in a side-to-side, or swaying, motion parallel to Earth's surface. This motion can be particularly devastating to human-built structures Earthquake Measurements Seismologists are scientists who study earthquakes and seismic waves. The instrument they use to obtain a record of seismic waves from all over the world is called a seismograph.

Check your progress

Note: a) Space is given below for writing your answer
b) Compare your answer with one given at the end of this Unit

2. What are the characteristics of a primary seismic wave?

Epicenter Location: When seismic-wave arrival times are recorded at a seismograph station, the distance from that station to the epicenter can be determined. The farther apart the arrival times for the different waves are, the farther away the earthquake epicenter is. Major earthquakes cause much loss of life. For example, on September 20, 1999, a major earthquake struck Taiwan, leaving more than 2,400 people dead, more than 8,700 injured, and at least 100,000 homeless.

Sometimes earthquakes are felt and can cause destruction in areas hundreds of kilometers away from their epicenters. The Mexico City earthquake in 1985 is an example of this. The movement of the soft sediment underneath Mexico City caused extensive damage to this city, even though the epicenter was nearly 400 km away. The Richter scale magnitude is based on measurements of amplitudes, or heights, of seismic waves as recorded on seismographs. Richter magnitude describes how much energy an earthquake releases.

Earthquake Damage: Another way to measure earthquakes is available. The modified Mercalli intensity scale measures the intensity of an earthquake. Intensity is a measure of the amount of structural and geologic damage done by an earthquake in a specific location. The range of intensities spans Roman numerals I through XII. The amount of damage done depends on several factors—the strength of the earthquake, the nature of the surface material, the design of structures, and the distance from the epicenter. An intensity-I earthquake would be felt only by a few people under ideal conditions. An intensity-VI earthquake would be felt by everyone. An intensity-XII earthquake would cause major destruction to human-built structures and Earth's surface.

The 1994 earthquake in Northridge, California was a Richter magnitude 6.7, and its intensity was listed at IX. An intensity-IX earthquake causes considerable damage to buildings and could cause cracks in the ground.

Tsunamis: Most damage from an earthquake is caused by surface waves. Buildings can crack or fall down. Elevated bridges and highways can collapse. However, people living near the seashore must protect themselves against another hazard from earthquakes. When an earthquake occurs on the ocean floor, the sudden movement pushes against the water and powerful water waves are produced. These waves can travel outward from the earthquake thousands of kilometers in all directions.

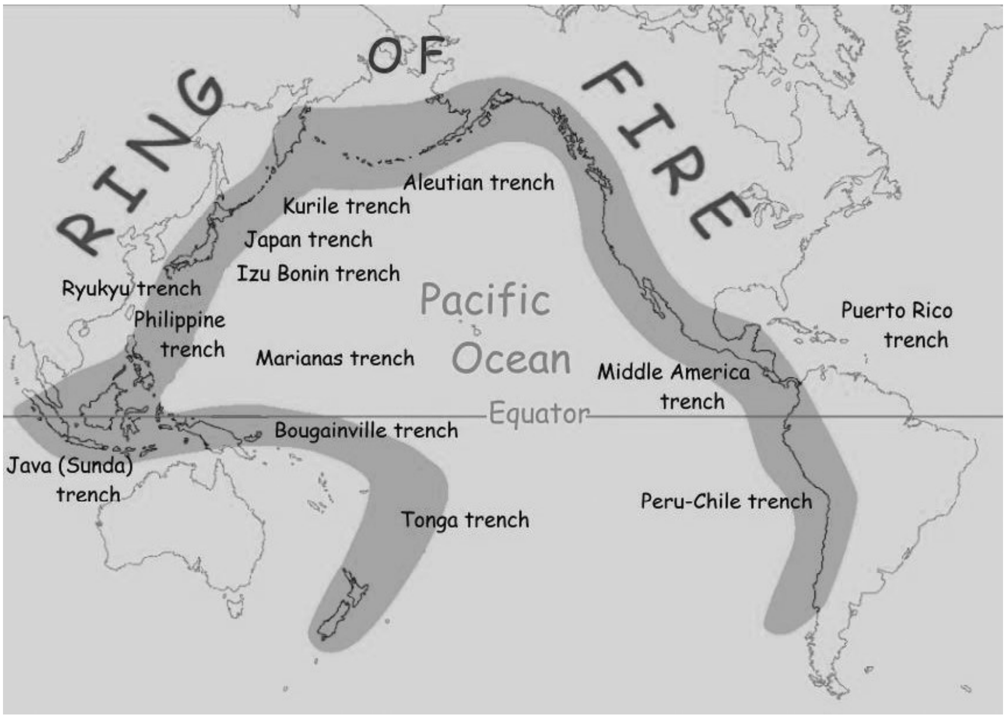
When these seismic sea waves, or tsunamis, are far from shore, their energy is spread out over large distances and great water depths. The wave heights of tsunamis are less than a meter in deep water, and large ships can ride over them and not even know it. In the open ocean, the speed of tsunamis can reach 950 km/h. However, when tsunamis approach land, the waves slow down and their wave heights increase as they encounter the bottom of the seafloor. This creates huge tsunami waves that can be as much as 30 m in height. Just before a tsunami crashes to shore, the water near a shoreline may move rapidly out toward the sea. If this should happen, there is immediate danger that a tsunami is about to strike.

Types of earthquakes

There are two types of earthquakes: tectonic and volcanic earthquakes. Tectonic earthquakes are produced by sudden movement along faults and plate boundaries. Earthquakes induced by rising lava or magma beneath active volcanoes is called volcanic earthquakes.

The term seismology is derived from Greek. Seismology meaning earthquakes. The instrument which is records earthquakes is called seismograph. The energy released by the earthquakes is measured by the Richter scale and the intensity and magnitude of the earthquakes recorded device is discovered by Charles F. Richter in 1935.

Fig: Ring of fire



Largest Earthquakes in the World

No.	Mag	Location	Alternative Name	Date (UTC)	Time (UTC)	Latitude	Longitude	References
1.	9.5	Bio-Bio, Chile	Valdivia Earthquake	1960-05-22	19:11	38.14°S	73.41°W	Kanamori & Anderson, 1975
2.	9.2	Southern Alaska	1964 Great Alaska Earthquake, Prince William Sound Earthquake, Good Friday Earthquake	1964-03-28	03:36	60.91°N	147.34°W	Kanamori & Anderson, 1975
3.	9.1	Off the West Coast of Northern Sumatra	Sumatra-Andaman Islands Earthquake, 2004 Sumatra Earthquake and Tsunami, Indian Ocean Earthquake	2004-12-26	00:58	3.30°N	95.98°E	Duputel et al., 2012
4.	9.1	Near the East Coast of Honshu, Japan	Tohoku Earthquake	2011-03-11	05:46	38.30°N	142.37°E	Duputel et al., 2012
5.	9.0	Off the East Coast of the Kamchatka Peninsula, Russia	Kamchatka, Russia	1952-11-04	16:58	52.62°N	159.78°E	Kanamori, 1976
6.	8.8	Offshore Bio-Bio, Chile	Maule Earthquake	2010-02-27	06:34	36.12°S	72.90°W	Duputel et al., 2012
7.	8.8	Near the Coast of Ecuador	1906 Ecuador–Colombia Earthquake	1906-01-31	15:36	0.96°N	79.37°W	Kanamori, 1977
8.	8.7	Rat Islands, Aleutian Islands, Alaska	Rat Islands Earthquake	1965-02-04	05:01	51.25°N	178.72°E	Kanamori & Anderson, 1975
9.	8.6	Eastern Xizang-India border region	Assam, Tibet	1950-08-15	14:09	28.36°N	96.45°E	Kanamori, 1977
10.	8.6	Off the West Coast of Northern Sumatra		2012-04-11	08:39	2.33°N	93.06°E	Duputel et al., 2012
11.	8.6	Northern Sumatra, Indonesia	Nias Earthquake	2005-03-28	16:10	2.09°N	97.11°E	NEIC
12.	8.6	Andrean of Islands, Aleutian Islands, Alaska		1957-03-09	14:23	51.50°N	175.63°W	Johnson et al., 1994
13.	8.6	South of Alaska	Unimak Island Earthquake, Alaska	1946-04-01	12:29	53.49°N	162.83°W	Lopez & Okal, 2006
14.	8.5	Banda Sea		1938-02-01	19:04	5.05°S	131.61°E	Okal & Reymond, 2003
15.	8.5	Atacama, Chile	Chile-Argentina Border	1922-11-11	04:33	28.29°S	69.85°W	Kanamori, 1977
16.	8.5	Kuril Islands		1963-10-13	05:18	44.87°N	149.48°E	Kanamori & Anderson, 1975

No.	Mag	Location	Alternative Name	Date (UTC)	Time (UTC)	Latitude	Longitude	References
17.	8.4	Near the East Coast of Kamchatka Peninsula, Russia	Kamchatka, Russia	1923-02-03	16:02	54.49°N	160.47°E	Okal, 1992
18.	8.4	Southern Sumatra, Indonesia		2007-09-12	11:10	4.44°S	101.37°E	NEIC
19.	8.4	Near the Coast of Southern Peru	Arequipa, Peru Earthquake	2001-06-23	20:33	16.27°S	73.64°W	Duputel et al., 2012
20.	8.4	Off the East Coast of Honshu, Japan	Sanriku, Japan	1933-03-02	17:31	39.21°N	144.59°E	Kanamori, 1971

7.5 CAUSES OF EARTHQUAKES

Earthquakes are mainly generated below the crust because of changes in equilibrium position. The major factors responsible for earthquakes are; eruption of volcanos, movement of plates like down warping, up warping , folding , faulting , expansion of gases inside the earth , manmade features like reservoirs and lakes. Most of the world earthquakes are distributed nearby weaker zone and plate boundaries areas of the globe.

Volcanic activity

The volcanic earthquakes are caused by eruption of lava is an active state or dormant state, and which are extinct. In their area the lava flow is in a vertical movement as well as in a horizontal movement. There explosion lava will have the movement of crust and caused earthquakes. At a magnitude of 6, earthquakes will cause items to fall off of shelves. House wall may crack, and windows may break. A magnitude 7 earthquake will destroy weaker structures.

Classification of earthquakes

Earthquakes are classified depending on the depth ranges like deep, intermediate and shallow.

1. Deep earthquake

There is very deep ranging from 288 to 640 km range. These quakes are occurred deep but there is no shocks will identify on surface of the earth but it will record on seismographs.

2. Intermediate

The generated of earthquakes or focus point ranging from 48 km to 288km deep from surface. These are few earthquakes which are recorded when it composed to deep earthquakes. There is accord in upper bounding of earth.

3. Shallow earthquakes

It is extending from 48km to surface of is earth. There are most destructive earthquakes and it has most of the earthquakes are generated this categories only. The earthquakes are classified depending on frequency in India and it is divided from zone I to zone VI. It is from low frequency to high frequency.

7.6 EARTHQUAKE ZONES

As we know that, these days frequent tremors of the earthquake are occurring in Delhi-NCR and nearby regions. It is said that Delhi-NCR belt, mainly areas near Yamuna River etc., comes under high-risk seismic zones. Do you know about seismograph and division of seismic zones in India? Let us find out!

An earthquake is a vibration of the surface of the earth that is caused due to the elasticity or the isostatic adjustment of the rocks under the surface of the earth. It may be caused via human as well as natural activities. The point where the seismic (earthquake) waves originate is called the 'focus' of the earthquake, it takes place below the surface of the earth. Whereas, the place which perpendicularly above the focus, on the surface of the earth where the tremors of the earthquake are felt for the first time is called the 'epicenter'. The energy that is dissipated from the focus is known as the 'Elastic Energy'.

What are Seismic Waves: The waves which are generated during an **earthquake** are known as seismic waves. They are classified into 3 types:

1. Primary or Longitudinal waves are also known as P-Waves: These are longitudinal waves analogous to the sound waves.

2. Secondary or Transverse Waves are also known as S-Waves: These are transversal waves analogous to the light waves.

3. Surface or Long-period Waves are also known as L-Waves: They originate when 'P' wave hits the surface.

What is Seismograph: The instrument which is sensitive to the seismic waves and helps to measure the intensity of the earthquake is called Seismograph. There are different scales that are used to measure the intensity of earthquakes namely: Rossi-Forel Scale, Mercalli Scale, and Richter scale.

Earthquake (Seismic) Zones in India:

Earthquakes can strike any location at any time, but history shows they occur in the same general patterns year after year, principally in **three large zones** of the earth:

The world's greatest earthquake belt, the **Circum-Pacific seismic belt**, is found along the rim of the Pacific Ocean, where about 81 percent of our planet's largest earthquakes occur. It has earned the nickname "Ring of Fire". Earthquakes in the Circum-Pacific seismic belt include the M9.5 Chilean Earthquake [Valdivia Earthquake] (1960) and the M9.2 Alaska Earthquake (1964).

The **Alpide earthquake belt** extends from Java to Sumatra through the Himalayas, the Mediterranean, and out into the Atlantic. This belt accounts for about 17 percent of the world's largest earthquakes, including some of the most destructive, such as the 2005 M7.6 shock in Pakistan that killed over 80,000 and the 2004 M9.1 Indonesia earthquake, which generated a tsunami that killed over 230,000 people.

The third prominent belt follows the submerged **mid-Atlantic Ridge**. The ridge marks where two tectonic plates are spreading apart (a divergent plate boundary). Most of the mid-Atlantic Ridge is deep underwater and far from human development, but Iceland, which sits directly over the mid-Atlantic Ridge, has experienced earthquakes as large as at least M6.9. The remaining shocks are scattered in various areas of the world.

Seismic zones in Indian subcontinent is divided into four seismic zones (II, III, IV, and V) based on scientific inputs relating to seismicity, earthquakes occurred in the past and tectonic setup of the region. The Indian subcontinent has a history of earthquakes. The reason for the intensity and high frequency of earthquakes is that the Indian plate driving into Asia at a rate of approximately 49 mm/year. Previously, earthquake zones divided into five zones with respect to the severity of the earthquakes, but Bureau of Indian Standards [IS 1893 (Part I):2002], has grouped the country into four seismic zones; the first and second seismic zones were unified. The bureau of Indian standards is the official agency for publishing the seismic hazard maps and codes. It has brought out versions of seismic zoning map: a six zone map in 1962, a seven zone map in 1966, and a five zone map 1970/1984.

Seismic Zone	**Intensity on M.M Scale**
Zone-II (Low-Intensity Zone)	6 (or less)
Zone-III (Moderate Intensity Zone)	7
Zone-IV (Severe Intensity Zone)	8
Zone-V (Very Severe Intensity Zone)	9 (and above)

Seismic Zone V: Area determines by pro seismically of certain major fault systems. It is seismically the most active region, and comprises entire northeastern India, parts of Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Rann of Kutch in Gujarat, part of North Bihar and Andaman & Nicobar Islands.

Seismic Zone IV: Major damage corresponding to intensity VII and higher of **MM** scale. It covers remaining parts of Jammu and Kashmir and Himachal Pradesh, National Capital Territory (NCT) of Delhi, Sikkim, Northern Parts of Uttar Pradesh, Bihar and West Bengal, parts of Gujarat and small portions of Maharashtra near the west coast and Rajasthan.

Seismic Zone III: Moderate damage corresponding to intensity VII of **MM** scale. It comprises Kerala, Goa, Lakshadweep islands, remaining parts of Uttar Pradesh, Gujarat and West Bengal, Parts of Punjab, Rajasthan, Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh, Maharashtra, Orissa, Andhra Pradesh, Tamilnadu and Karnataka.

Seismic Zone II: Area with minor damage (i.e., causing damages to structures with fundamentally periods greater than 1.0 second) earthquakes corresponding to intensities V to VI of **MM** scale (MM - Modified Mercalli Intensity scale). It covers the areas which are not covered by other three seismic zones discussed below.

Earthquake zone V is the most vulnerable to earthquakes, where historically some of the country's most powerful shock have occurred. Earthquakes with magnitudes in excess of 7.0 have occurred in these areas, and have had intensities higher than IX.

So now you may have come to know about the Earthquake (Seismic) Zones in India

Summary

The sudden release of energy in rock and the resulting movement causes an earthquake.

Faults are breaks in rocks along which movement occurs.

The focus is where an earthquake occurs. The epicenter is directly above it. Earthquakes generate seismic waves.

The Richter scale measures magnitude. The modified Mercalli scale measures intensity.

What you learn

An Earthquake forms when two or more large pieces of the Earth's crust bump into each other and unexpectedly drops or breaks. Lucky the chunks of Earth are moving very slow. You may notice that certain locations of the world are likely to experience quakes. These locations are where the edges of the Earth's crust are located, they are called faults. Pressure and heat (under the surface) build up over time causing repeated ruptures. Scientists use a device called a seismograph to measure the power of a quake. A seismograph measures the value on the Moment Magnitude Scale (MMS). The larger the value on this scale, the greater the damage caused by the quake. The damage caused to the surface by an Earthquake is a result of how close to the surface the fault event occurs and the makeup of the fault.

Test your knowledge Answers

1. **Epicenter**: where seismic waves (Surface waves) of an earthquake are released on Earth's surface.

Focus: where seismic waves (P- and S-waves) of an earthquake are released under the Earth's surface

2. Can travel through any state of matter. First and Fastest seismic wave, Comes from the Focus

GLOSSARY

***Caldera**:* is a large cauldron-like hollow that forms shortly after the emptying of a magma chamber in a volcanic eruption.

The Ring of Fire: also referred to as the Circum-Pacific Belt, is **a path along the Pacific Ocean characterized by active volcanoes and frequent earthquakes**.

The majority of Earth's volcanoes and earthquakes take place along the Ring of Fire

Seismic wave: is **an elastic wave generated by an impulse such as an earthquake or an explosion**. Seismic waves may travel either along or near the earth's surface or through the earth's interior (P and S waves).

7.7 VOLCANOES

What you will learn from this chapter

- The chapter explains how volcanoes can affect people.
- Describe how types of materials are produced by volcanoes.
- Compare how three different volcano forms develop.

Why it is important

Volcanic eruptions can cause serious consequences for humans and other organisms.

How do volcanoes form?

Volcanos are a process where the heated or molted lava material ejected from interior of the earth through crust weak zones. The ejected material will eject from vent where lava material erupted from it.

A volcano is a mountain that opens downward to a pool of molten rock below the surface of the earth. When pressure builds up, eruptions occur. A volcano is a weak spot in the crust where molten material, or magma, comes to the surface. Magma is a molten mixture of rock-forming substances, gases, and water from the mantle. When magma reaches the surface, it is called lava. When lava has cooled, it forms solid rock. Lava released during volcanic activity builds up Earth's surface.

Molten rock material, or magma, is forced upward toward Earth's surface by denser surrounding rock. Rising magma eventually can lead to an eruption, where magma, solids, and gas are spewed out to form cone-shaped mountains called volcanoes. As magma flows onto Earth's surface through a vent, or opening, it is called lava. Volcanoes have circular holes near their summits called craters. Lava and other volcanic materials can be expelled through a volcano's crater. Some explosive eruptions throw lava and rock thousands of meters into the air. Bits of rock or solidified lava dropped from the air are called tephra. Tephra varies in size from volcanic ash to cinders to larger rocks called bombs or blocks.

Where Plates Collide Some volcanoes form because of collision of large plates of Earth's crust and upper mantle. This process has produced a string of volcanic islands, which includes Montserrat. These islands are forming as plates made up of oceanic crust and mantle collide. The older and denser oceanic plate subducts, or sinks beneath, the less dense plate. When one plate sinks under another plate, rock in and above the sinking plate melts, forming chambers of magma. This magma is the source for volcanic eruptions that have formed the Caribbean Islands.

Volcanoes occur in belts that extend across continents and oceans. One major volcanic belt is the Ring of Fire, formed by the many volcanoes that rim the Pacific Ocean. Volcanic belts form along the boundaries of Earth's plates. At plate boundaries, huge pieces of the crust spread apart or collide. As a result, the crust often fractures, allowing magma to reach the surface. Most volcanoes form along spreading plate boundaries such as mid-ocean ridges and along colliding plate boundaries where subduction takes place. Along the rift valley, lava pours out of cracks in the ocean floor, gradually building new mountains.

Many volcanoes form near colliding plate boundaries where oceanic plates return to the mantle. Volcanoes may form where two oceanic plates collide or where an oceanic plate collides with a continental plate. Many volcanoes occur near boundaries where two oceanic plates collide. Through subduction, the older, denser plate sinks into a deep-ocean trench down into the mantle. Some of the rock above the sub ducting plate melts and forms magma. Because the magma is less dense than the surrounding rock, it rises toward the surface. Eventually, the magma breaks through the ocean floor, creating volcanoes. The resulting volcanoes create a string of islands called an island arc. Volcanoes also occur where an oceanic plate is sub ducted beneath a continental plate.

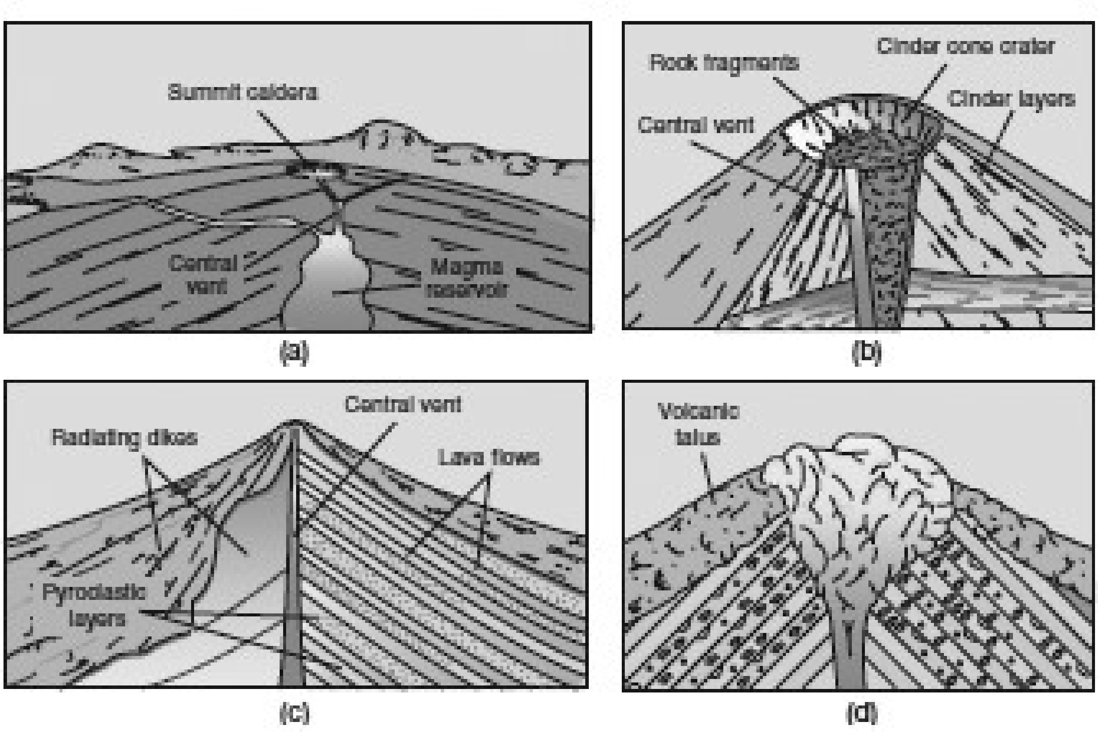
Some volcanoes result from "hot spots" in Earth's mantle. A hot spot is an area where material from within the mantle rises and then melts, forming magma. A volcano forms above a hot spot when magma erupts through the crust and reaches the surface. A hot spot on the ocean floor can gradually form a series of volcanic mountains. The Hawaiian Islands formed one by one over millions of years as the Pacific plate drifted over a hot spot. Hot spots can also form under the continents. Yellowstone National Park in Wyoming marks a hot spot under the North American plate.

Volcanic Eruptions

Lava begins as magma deep beneath Earth's surface. Magma flows upward through cracks in the rock until it becomes trapped or reaches the surface to form a volcano. Inside a volcano, magma collects in a pocket called a magma chamber. The magma moves through a pipe, a long tube that connects the magma chamber to Earth's surface. There, the magma leaves the volcano through an opening called a vent. The area covered by lava as it pours out of a vent is called a lava flow. Lava may collect in a crater, a bowl-shaped area around a volcano's central vent. As magma rises toward the surface, the pressure decreases and the dissolved gases begin to expand and exert an enormous force. When a volcano erupts, the force of the expanding gases pushes magma from the magma chamber through the pipe until it flows or explodes out of the vent.

What determines how a volcano erupts? Some volcanic eruptions are violent, while during others lava flows out quietly around a vent. The composition of the magma plays a big part in determining the manner in which energy is released during a volcanic eruption. Lava that contains more silica, which is a compound consisting of silicon and oxygen, tends to be thicker and is more resistant to flow. Lava containing more iron and magnesium and less silica tends to flow easily. The amount of water vapor and other gases trapped in the lava also influences how lava erupts.

Geologists classify volcanic eruptions as quiet or explosive. Silica is a material found in magma that is made of oxygen and silicon. If the magma has a low silica content, it flows easily and the volcano erupts quietly. The gases bubble out gently and the lava oozes quietly. Quiet eruptions can produce both fast-moving, hot lava that is thin and runny (pahoehoe) and slower-moving, cool, thicker lava (aa). A volcano erupts explosively if its magma is high in silica. The thick magma does not flow out of the chamber, but builds up in the pipe. The trapped gases build up pressure until they explode with incredible force. A pyroclastic flow occurs when an explosive eruption hurls out ash, cinders, and bombs. Volcano hazards include lava flows, clouds of ash and deadly gases, landslides, and avalanches of mud, snow, or rock.



Geologists often use the terms active, dormant, or extinct to describe a volcano's stage of activity. An active volcano is one that is erupting or has shown signs that it may erupt in the near future. A dormant volcano is not active now but may become active in the future. An extinct volcano is unlikely to erupt again. Geologists monitor changes in and around volcanoes to try to predict eruptions. But geologists cannot be certain about the type of eruption or how powerful it will be. Hot springs and geysers are often found in areas of present or past volcanic activity. Hot springs collect in a natural pool. A geyser is a fountain of water and steam that erupts from the ground.

Check your progress

Note: a) Space is given below for writing your answer
b) Compare your answer with one given at the end of this Unit

1. What is pyroclastic material?

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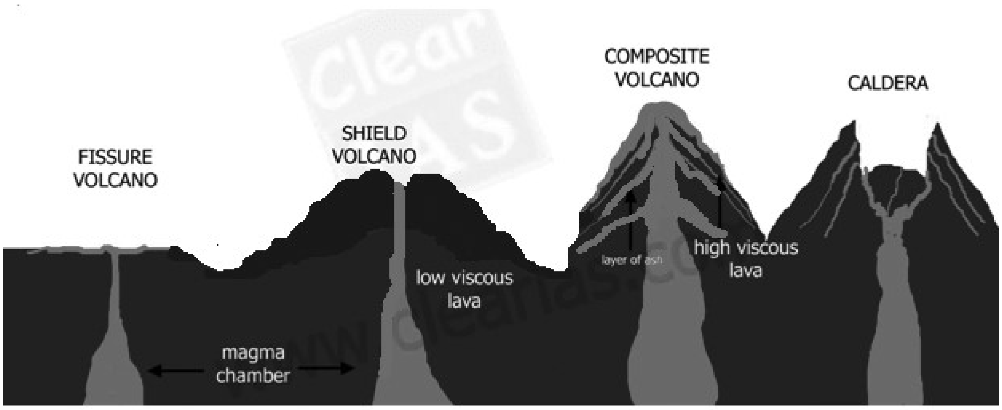
Forms of Volcanoes

As you have learned, volcanoes can cause great destruction. However, volcanoes also add new rock to Earth's crust with each eruption. The way volcanoes add this new material to Earth's surface varies greatly. Different types of eruptions produce different types of volcanoes.

7.8 TYPES OF VOLCANOES

Volcanoes are classified on the basis of nature of eruption and the form developed at the surface.



In general, Volcanoes can be divided on the basis of **Type of Eruption** & **Periodicity of Eruption**.

Based on Type of Eruption: The nature of the eruption mainly depends on the viscosity of the magma and are of two types:

Basic: The basic magma are dark colored like basalt, rich in iron and magnesium but poor in silica. They travels far and generates broad shield volcanoes.

Acidic: These are light-colored, of low density, and have a high percentage of silica and therefore it makes a familiar cone volcano shape.

Based on **frequency of Eruption**:

Active volcanoes: They erupt frequently and mostly located around Ring of Fire. E.g.: Mount Stromboli is an active volcano and it produces so much of Gas clouds that it is called Light house of Mediterranean.

Dormant Volcano: These are not extinct but have not erupted in recent history. The dormant volcanoes may erupt in future. E.g. Mount Kilimanjaro, located in Tanzania also the highest mountain in Africa is known to be a dormant Volcano.

Extinct or inactive volcanoes have not worked in distant geological past. In most cases the crater of the Volcano is filled with water making it a lake. E.g.: Deccan Traps, India.

Landforms associated with Volcanoes are broadly of two types:

Intrusive Landforms: The commonest intrusive landforms are:

Sills: When an intrusion of molten magma is made horizontally along the bedding plains of sedimentary rocks, the resultant intrusions is called a sill.

Dykes: Intrusions when injected vertically as narrow walls igneous rocks within the sedimentary layers are termed as dykes.

Laccolith: It is large blister of igneous mound with a dome-shaped upper surface and a level base fed by a pip-like conduit from below.

Lopolith: A lopolith is another variety of igneous intrusions with a saucer shape.

Phacolith: It is a lenses-shaped mass of igneous rocks occupying the crest of an anticline or the bottom of a syncline and being fed by a conduit from beneath.

Batholith: It is a huge mass of igneous rocks, usually granite, which after removal of the overlying rocks forms a massive and resistant upland region.

Check your progress

Note: a) Space is given below for writing your answer
b) Compare your answer with one given at the end of this Unit

2. What are the required factors for an explosive volcanic eruption?

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List of Largest Volcanoes in the World

largest volcanoes in the world that also highlights the location and heights of the volcanoes along with prominent features of various volcanoes in the world.

Volcanoes	Location & Feature	Metres	Feet
Mouna Loa	Hawaii, U.S.A	9170	30085
Haleakalâ	Hawaii, U.S.A	9144	30000
Teide	Canary Islands, Spain	7500	24606
Piton des Neiges	Reunion, France	7071	23199
Ojos del Salado	Argentina/Chile – Highest active volcano on Earth	6893	22615
Llullaillaco	Argentina/Chile – Second highest active volcano on Earth	6739	22110
Nevado Sajama	Bolivia – The highest peak of Bolivia	6542	21463
Chimborazo	Ecuador – Farthest point from Earth's centre	6267	20561
Cotopaxi	Ecuador – Second highest in Ecuador	5897	19347
Kilimanjaro	Tanzania – Highest volcano outside South America; the highest peak in Africa	5895	19341

Volcanoes	Location & Feature	Metres	Feet
Cayambe	Ecuador – Third highest in Ecuador	5790	18996
Mount Elbrus	Russia – Highest volcano in Eurasia; the highest peak in Russia	5642	18510
Pico de Orizaba	Mexico – Highest volcano in North America; the highest peak in Mexico	5636	18491
Mount Damavand	Iran – Highest volcano within Asia; the highest peak in Iran	5610	18406
Popocatepetl	Mexico – Second highest volcano in North America	5426	17802
Iztaccíhuatl	Mexico – Third highest volcano in North America	5230	17159
Mount Kenya	Kenya – Second highest volcano in Africa; the highest mountain in Kenya	5199	17057
Mount Ararat	Turkey/Armenia – The highest mountain in Turkey	5137	16854
Mount Kazbek	Georgia – Highest volcano in Georgia	5047	16558
Mount Bona	Alaska – highest volcano in the United States	5005	16421
Mount Karisimbi	Rwanda/Democratic Republic of Congo – highest mountain in Rwanda	4507	14787
Mount Rainier	Washington – highest volcano in the contiguous United States	4392	14409
Mount Giluwe	Papua New Guinea – highest volcano in Australasia and Pacific islands	4368	14331
Volcán Tajumulco	Guatemala – highest mountain in Central America	4220	13845
Mauna Kea	Hawaii, United States – World’s tallest mountain from base to summit	4205	13796
Mount Sidley	Antarctica – Highest volcano in Antarctica	4181	13717
Mount Cameroon	Cameroon – highest mountain in Cameroon	4095	13435
Mount Aragats	Armenia – highest mountain in Armenia	4095	13435
Mount Kerinci	Sumatra, Indonesia – Highest volcano in Indonesia; the highest mountain in Sumatra	3805	12484
Mount Fuji	Chûbu Region, Honshû – highest mountain in Japan	3776	12388
Mount Rinjani	Lombok, Indonesia – Second-highest volcano in Indonesia	3726	12224
Teide	Tenerife, Canary Islands – the highest peak in the Atlantic Islands and Spain	3718	12198
Semeru	Java, Indonesia – highest mountain in Java	3676	12060
Emi Koussi	Chad – the highest mountain in Chad & the Sahara	3415	11204
Mount Etna	Sicily – active; highest volcano in Western Europe; the highest peak in Italy south of the Alps	3329	10922
Haleakalâ	Maui, Hawaii – the highest peak of Maui	3055	10023
Mount Agung	Bali, Indonesia – highest mountain in Bali	3031	9944
Mount Zuqualla	Oromia Region – highest volcano in Ethiopia	2989	9806
Mount Apo	Mindanao – highest mountain in the Philippines	2954	9692
Mount Shishaldin (Sisquk)	Unimak Island, Alaska – highest mountain in the Aleutian Islands	2857	9373
Mount Ruapehu	North Island – highest volcano in New Zealand	2797	9177
Mawson Peak	Heard Island – the highest mountain in Australia	2745	9006
Pico	Azores – highest mountain in Portugal	2351	7713
Beerenberg	Jan Mayen, Norway – highest volcano in Norway	2277	7470
Taal Volcano	Batangas, Philippines – Smallest volcano on earth	311	1020

Reference – Wikipedia

Extrusive Landforms:

Cinder Cone Volcanoes: rising magma accumulates gases on its way to the surface. When the gas builds up enough pressure, it erupts. Moderate to violent eruptions throw volcanic ash, cinders, and lava high into the air. The lava cools quickly in midair and the particles of solidified lava, ash, and cinders fall back to Earth. This tephra forms a relatively small cone of volcanic material called a cinder cone volcano. Cinder cones are usually less than 300 m in height and often form in groups near other larger volcanoes.

Cinder cones are of low height and are formed of volcanic dust and ashes etc pyroclastic material. Falling under the influence of gravity, these particles accumulate around the vent, in a large pile. The form of a cinder cone is very distinctive, with steep straight sides and a crater (depression) at the top of the hill. E.g.: Volcano Paricutin, Mexico

Composite cones Volcanoes: Steep-sided Mountains composed of alternating layers of lava and tephra are composite volcanoes. They sometimes erupt violently, releasing large quantities of ash and gas. This forms a tephra layer of solid materials. Then a quieter eruption forms a lava layer. Composite volcanoes form where one plate sinks beneath another. Soufriere Hills volcano is an example of a composite volcano. Another volcanic eruption from a composite volcano was the May 1980 eruption of Mount St. Helens in the state of Washington. It erupted explosively, spewing ash that fell on regions hundreds of kilometers away from the volcano.

Shield volcanoes: Basaltic lava, which is high in iron and magnesium and low in silica, flows in broad, flat layers. The buildup of basaltic layers forms a broad volcano with gently sloping sides called a shield volcano. Shield volcanoes, shown in Figure 13A, are the largest type of volcano. They form where magma is being forced up from extreme depths within Earth, or in areas where Earth's plates are moving apart. The separation of plates enables magma to be forced upward to Earth's surface.

When numerous successive basaltic lava flow occur in a given region they can eventually pile up into the shape of a large mountain called a shield volcano. E.g.: Mauna Loa, Hawaii

Calderas: A caldera is a large, basin shaped depression formed at the volcanic mouth. It forms when summit material on a volcanic mountain collapses inward after an eruption or other loss of magma. E.G.: Crater Lake, USA.

Fissure Eruptions Magma that is highly fluid can ooze from cracks or fissures in Earth's surface. This is the type of magma that usually is associated with fissure eruptions. The lava that erupts has a low viscosity, which means it can flow freely across the land to form flood basalts. Flood basalts that have been exposed to erosion for millions of years can become large, relatively flat landforms known as lava plateaus. The Columbia River Plateau in the northwestern United States was formed about 15 million years ago when several fissures erupted and the flows built up layer upon layer.

Check your progress

Note: a) Space is given below for writing your answer
b) Compare your answer with one given at the end of this Unit

3. Identify the three types of volcanoes and be able to describe their appearance.

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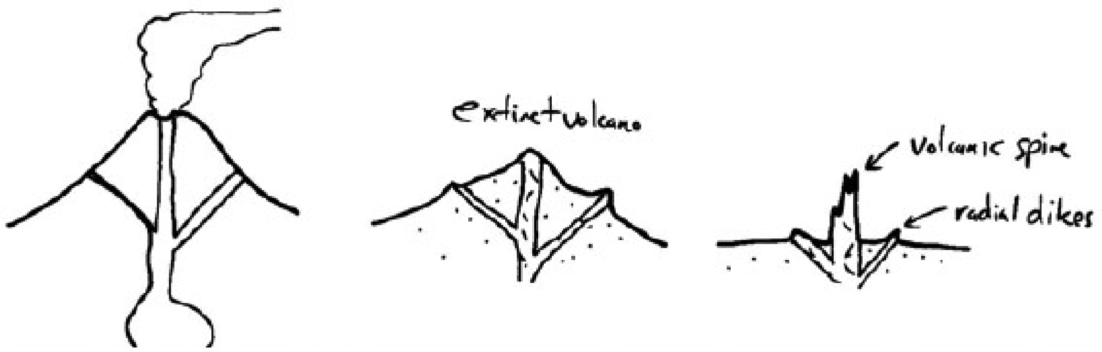
Volcanic Landforms

Some volcanic landforms are formed when lava flows build up mountains and plateaus on Earth's surface. Volcanic eruptions create landforms made of lava, ash, and other materials. These landforms include shield volcanoes, cinder cone volcanoes, composite volcanoes, and lava plateaus. At some places on Earth's surface, thin layers of lava pour out of a vent. More layers of such lava harden on top of previous layers. The layers gradually build a wide, gently sloping mountain called a shield volcano. If a volcano's lava is thick, the lava may explode into the air and harden into ash, cinders, and bombs. These materials pile up around the vent, forming a steep, cone-shaped hill or mountain called a cinder cone. Sometimes lava flows alternate with explosive eruptions of ash, cinders, and bombs. The alternating layers form a tall, cone-shaped mountain called a composite volcano. Some eruptions of thin, runny lava flow out of cracks and travel a long distance before cooling and hardening. Over millions of years, these layers of lava build up over a large area to form a lava plateau.

An enormous eruption may empty a volcano's main vent and magma chamber. With nothing to support it, the top of the mountain collapses inward. The huge hole left by the collapse of a volcanic mountain is called a caldera. Over time, the hard surface of a lava flow breaks down to form soil. Some volcanic soils are among the most fertile soils in the world. People have settled close to volcanoes to take advantage of the fertile soil. Sometimes magma rises upward through cracks in the crust but does not reach Earth's surface. The magma cools and hardens into rock beneath the surface. Features formed by magma include volcanic necks, dikes, sills, and batholiths. A volcanic neck forms when magma hardens in a volcano's pipe. The softer rock around the pipe wears away, exposing the hard rock of the volcanic neck. A dike forms when magma forces itself across rock layers and hardens. A sill forms when magma squeezes between layers of rock and hardens. Dikes and sills are examples of igneous intrusions. An intrusion forms when magma hardens underground to form igneous rock. When a large body of magma cools inside the crust, a mass of rock called a batholith forms. Smaller bodies of hardened magma can form Dome Mountains.



7.9 SUMMARY

How do volcanoes form? Some volcanoes form as two or more large plates collide.

The Caribbean Islands formed from volcanic eruptions as one plate sinks under another plate. Lava high in silica produces explosive eruptions, lava low in silica but high in iron and magnesium produces more fluid eruptions.

The amount of water vapor and gases impact show volcanoes erupt.

The types of volcanoes include shield, cinder cone and composite volcanoes, and fissure eruptions.

7.10 TEST YOUR KNOWLEDGE ANSWERS

1. Forms when magma explodes into the air and hardens to create rock fragments
2. Thick magma/lava, High water content/concentration and High gas pressure
3. Shield: gently sloping sides, wide base

Composite: tall, mountain-like with snow cap
Cinder Cone: small base with steep sides

Short answer questions
In how many ways does the Earthquakes can occur?
What is a fault line?
In magma formation, what are the temperature and pressure requirements?
What are the required factors for an explosive volcanic eruption?
What are the characteristics of an extinct volcano?

7.11 GLOSSARY

Energy: the ability to cause change
Seismograph: Seismographs are **instruments used to record the motion of the ground during an earthquake**.
Epicenter: the point on the earth's surface vertically above the focus of an earthquake.
Focus: The *focus* is the place inside Earth's crust where an *earthquake* originates

UNIT - 8: WEATHERING, EROSION, DENUDATION AND MASS WASTING

Content

8.0. Objectives
8.1. Introduction
8.2 Weathering
8.3 Erosion
8.4 Denudation
8.5 Mass wasting
8.6 Summary
8.7 Model answers

8.0 OBJECTIVES

Learning outcomes

To know the basic processes, functions, and influences of weathering.
To understand the main influences of weathering.
To know the main influences of mass wasting.
To know the various types of mass wasting processes.

8.1 INTRODUCTION

The geomorphic processes on the earth's crust or its surface brought down by the **forces emanating from above the earth's surface** (wind, water) are called exogenic geomorphic process. Exogenic geomorphic process gives rise to exogenic geomorphic movements or simply exogenic movements such as **weathering** and **erosion**. The effects of most of the exogenic geomorphic processes are small and slow but will, in the long run, affect the rocks severely due to continued fatigue.

Weathering, erosion, mass-wasting, and depositional processes occur at or near the Earth's surface and produce changes to the landscape that influence surface and subsurface topography and landform development.

8.2 WEATHERING

Weathering is the physical disintegration or chemical alteration of rocks at or near the Earth's surface.

Erosion is the physical removal and transportation of weathered material by water, wind, ice, or gravity.

Mass wasting is the transfer or movement of rock or soil down slope primarily by gravity.

Deposition is the process by which weathered and eroded materials are laid down or placed in a location that is different from their source.

These processes are all very important to the rock cycle because over geologic time weathering, erosion, and mass wasting transform solid rock into sediments and soil that result in the redeposition of material forming new sedimentary rocks.

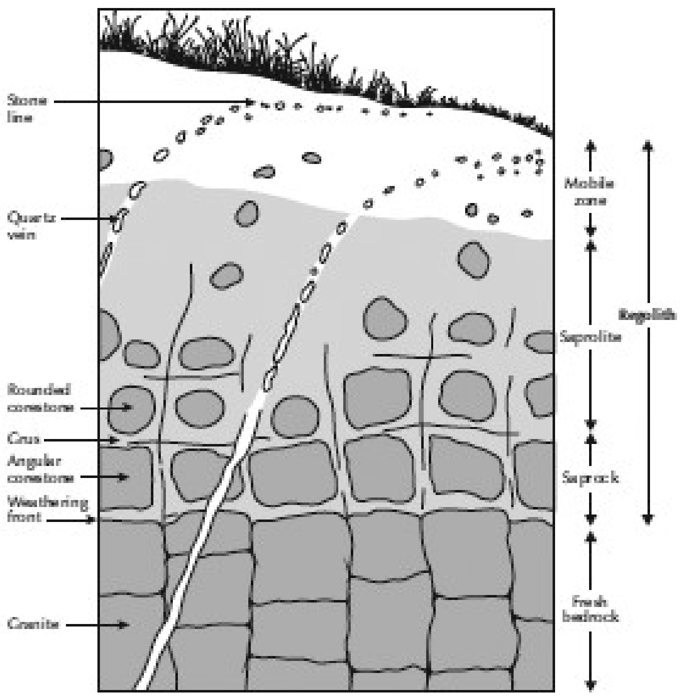
Weathering is the process that changes solid rock into sediments. With weathering, rock is disintegrated into smaller pieces. Once these sediments are separated from the rocks, **erosion** is the process that moves the sediments away from its original position. The four forces of erosion are water, wind, glaciers, and gravity. Water is responsible for most erosion. Water can move most sizes of sediments, depending on the strength of the force. Wind moves sand-sized and smaller pieces of rock through the air. Glaciers move all sizes of sediments, from extremely large boulders to the tiniest fragments. Gravity moves broken pieces of rock, large or small, downslope. These forces of erosion will be covered later.

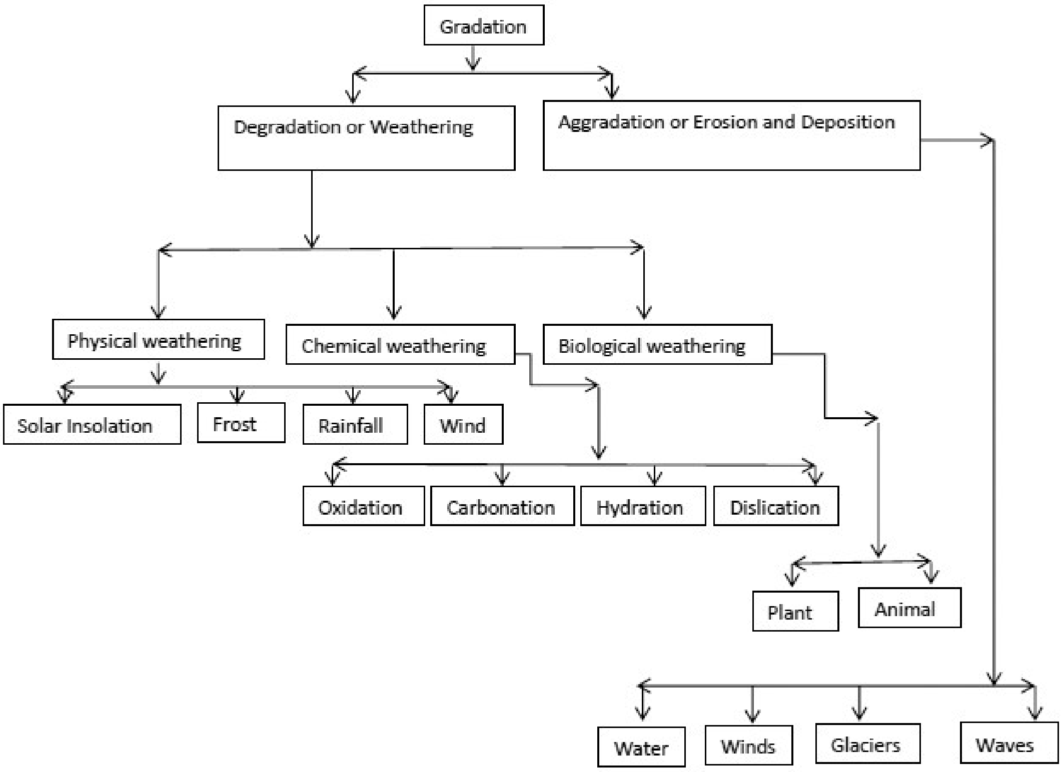
While plate tectonics forces work to build huge mountains and other landscapes, the forces of weathering and mass wasting gradually wear those rocks and landscapes away, called **denudation**. Together with erosion, tall mountains turn into hills and even plains. The Appalachian Mountains along the east coast of North America were once as tall as the Himalayas.

No human being can watch for millions of years as mountains are built, nor can anyone watch as those same mountains gradually are worn away. But imagine a new sidewalk or road. The new road is smooth and even. Over hundreds of years, it will completely disappear, but what happens over one year? What changes would you see? What forces of weathering wear down that road, or rocks or mountains over time?

Weathering and Erosion act over the earth's floor and essentially involve the procedure of "gradation", which in flip is done via the simultaneous process of "degradation" and "aggradation". The surface changes which are act on rock by chemical and physical weathering assisting of rain water by dissolved gases and surrounding air. The exogenetic forces involve two ranges – firstly, the landforms weaken, breakup, as soon as the newly created landform is exposed to the have an effect on of weather. This stage is called weathering. Scraping, scratching and grinding on the surface rock, which consists of elimination or transportation of the weathered rock fabric from one area to any other is known as "Erosion".

Erosion is a cellular system while weathering is a static process because the disintegrated cloth and the products do no longer involve any motion without the falling down of the material by means of the pressure of gravity. The reverse process of filling up of depressions on the earth's floor by using the material deposited with the aid of the equal retailers of erosion is known as "aggradation or deposition". Weathering can also be physical, chemical or biological depending on the nature of retailers and the techniques concerned and the merchandise created.





Weathering is a universal activity which has taken place all parts of the earth surface, so there is no escape of rocks either it may be hard or resistant in nature. As per weathering phenomena it is divided in 3 kinds of weathering. 1. Physical weathering; 2. Chemical weathering; 3.Biological weathering. These are the Gradational agents which are acted on surface of the earth.

Check your progress

Note: a) Space is given below for writing your answer
b) Compare your answer with one given at the end of this Unit

1. What is weathering?

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Physical weathering

Mechanical weathering, also called **physical weathering,** breaks rock into smaller pieces. These smaller pieces are just like the bigger rock, just smaller. That means the rock has changed physically without changing its composition. The smaller pieces have the same minerals, in just the same proportions as the original rock. This type of mechanical pressure produces fantastic particles from large rock with the aid of the exertion of stresses sufficient to fracture the rock, however does now not trade its chemical composition. Physical weathering may additionally take place in many ways. The expiation and contraction of rocks by suns heat and cooling in evening will lead to rock breaking and cracking on surface of the earth. This kind of activity is very predominant in hot deserts where we can find huge temperature changes. Wind also plays a major role in Physical weathering.

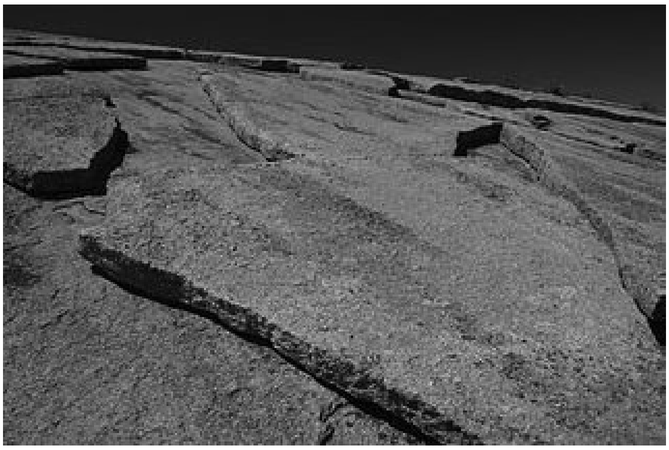
There are many ways that rocks can be broken apart into smaller pieces. The main factor in physical or mechanical weathering is atmosphere. The factors which are basically controlling physical or mechanical weathering are; 1.Temperature, 2.Rainfall; 3.Frost; 4.Wind.

- Gravity causes abrasion as a rock tumbles down a mountainside or cliff.
- Moving water causes abrasion as particles in the water collide and bump against one another.
- Strong winds carrying pieces of sand can sandblast surfaces.
- Ice in glaciers carries many bits and pieces of rock. Rocks embedded at the bottom of the glacier scrape against the rocks below.

Abrasion makes rocks with sharp or jagged edges smooth and round. If you have ever collected beach glass or cobbles from a stream, you have witnessed the work of abrasion.

Ice wedging, also called **freeze-thaw weathering**, is the main form of mechanical weathering in any climate that regularly cycles above and below the freezing point. Ice wedging works quickly, breaking apart rocks in areas with temperatures that cycle above and below freezing in the day and night, and also that cycle above and below freezing with the seasons.

Ice wedging breaks apart so much rock that large piles of broken rock are seen at the base of a hillside called **talus**. Ice wedging is common in Earth's Polar Regions and mid latitudes, and also at higher elevations, such as in the mountains. **Abrasion** is another form of mechanical weathering. In abrasion, one rock bumps against another rock.



Exfoliation: A rock mass disintegrates layer by means of layer leaving at the back of successively smaller spheroidal bodies and forming curved rock shells by disintegration .This kind of rock breakup is also known as spalling. These layers separate due to successive cooling and heating with modifications in temperature.

Frost Action: This type of weathering is common in bloodless climates. During the heat season, the water penetrates the pore spaces or fractures in rocks. During the bloodless seasons the water freezes into ice and its quantity expands as a result. This exerts great pressure on rock partitions to tear aside even big rocks.

Block separation: This kind of disintegration takes place in rocks with severe joints acquired via mountain-making pressures or by using shrinkage due to cooling. This kind of disintegration in rocks can be carried out by way of comparatively weaker forces.

Shattering: A huge rock might also bear disintegration along weak zones to produce fantastically angular pieces with sharp corners and edges through the manner of shattering.

Mass Wasting: Since gravity exerts its pressure on all matters, each bedrock and the merchandise of weathering have a tendency to slide , roll , drift and creep down slopes in distinctive kinds of earth and rock movements grouped below the term "mass wasting ". This may additionally take region in a variety of approaches

Talus cones: Rocks particles created through tactics of mechanical weathering go down high mountain slopes and steep rock partitions of gorges. These particles have a tendency to get deposited in a special landform, the talus cone.

Earth drift : In the humid local weather areas the place there are steep slopes , the masses of soil saturated with water, overburden a week bedrock and might also slide down slope for the duration of a duration of a few hours in the structure of earth waft .

Land slide: This is rapid sliding of rock mass alongside hill slopes. It may additionally take region both by rockslide along a relatively flat inclined rock aircraft or by way of stoop mechanism involving a rotating motion of the sliding rock mass on a slightly curved slope.

Soil creep: This is an extremely gradual down slope movement of soil on almost all somewhat steep soil – protected slopes. Soil creep occurs as a result of some disturbances of the soil and mantle precipitated by means of heating and cooling of the soil, increase of frost needles, alternating drying and wetting of the soil, trampling and burrowing via animals and shaking by using earth quake. Because gravity exerts a down hills pull on each such rearrangement, the particles are entreated regularly down slope.

Mudflow: In areas with sparse vegetation, the unexpected flow of water due to rain acquires a muddy character on its trip down slope. As it follows the circulate course, it receives thicker and thicker till it turns into so overburdened as to come to end. It may additionally elevate massive boulders on its way.

Solifluction: This form of mass losing is common in the arctic areas. In late spring and early summer, the water penetrates and saturates the upper few toes of the soil, however is unable to go deeper because of frozen stipulations below. The upper saturated soil mass starts off evolved flowing alongside slopes. This movement causes the formation of terraces and lobes due to punctuated deposition.

Mechanical weathering increases the rate of chemical weathering. As rock breaks into smaller pieces, the surface area of the pieces increases. With more surfaces exposed, there are more surfaces on which chemical weathering can occur.

Now that you know what mechanical weathering is, can you think of other ways it could happen? Plants and animals can do the work of mechanical weathering. This could happen slowly as a plant's roots grow into a crack or fracture in rock and gradually grow larger, wedging open the crack. Burrowing animals can also break apart rock as they dig for food or to make living spaces for themselves.

Check your progress

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b) Compare your answer with one given at the end of this Unit

2. What is exfoliation?

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Chemical weathering

Chemical weathering is the other important type of weathering. Chemical weathering causes rocks to i.e., to decompose instead of disintegrating. The minerals contained in the structure of rocks endure chemical changes when they get in contact with atmospheric water and air. These chemical adjustments purpose rock particles to destroy up due to decomposition. Atmospheric water consists of oxygen, carbon, Sulphur, hydrogen and Carbon dioxide. High degrees of temperature and water content beautify the tempo of chemical reactions.

Chemical weathering is different from mechanical weathering because the rock changes, not just in size of pieces, but in composition. That is, one type of mineral changes into a different mineral. Chemical weathering works through chemical reactions that cause changes in the minerals. Most minerals form at high pressure or high temperatures deep in the crust, or sometimes in the mantle. When these rocks reach the Earth's surface, they are now at very low temperatures and pressures. This is a very different environment from the one in which they formed and the minerals are no longer stable. In chemical weathering, minerals that were stable inside the crust must change to minerals that are stable at Earth's surface.

Remember that the most common minerals in Earth's crust are the silicate minerals. Many silicate minerals form in igneous or metamorphic rocks deep within the earth. The minerals that form at the highest temperatures and pressures are the least stable at the surface. Clay is stable at the surface and chemical weathering converts many minerals to clay. There are many types of chemical weathering because there are many agents of chemical weathering. Water is the most important agent of chemical weathering. Two other important agents of chemical weathering are carbon dioxide and oxygen. Chemical weathering takes places in the following ways.

Carbonation: Carbon dioxide (CO_2) combines with water as raindrops fall through the atmosphere. This makes a weak acid, called **carbonic acid**. It takes place in rocks containing calcium, sodium, magnesium etc., when they come in contact with rain water contains dissolved carbon dioxide. This technique is frequent in decrease latitude humid climates. Carbonic acid is a very common in nature where it works to dissolve rock. Pollutants, such as sulfur and nitrogen, from fossil fuel burning, create sulfuric and nitric acid. Sulfuric and nitric acids are the two main components of acid rain, which accelerate chemical weathering.

Chlorination: It takes area when chloride salts are shaped as a result of chemical reaction of water on sure rock sorts.

Oxidation is a chemical reaction that takes place when oxygen reacts with another element. Oxygen is very strongly chemically reactive. The atmospheric oxygen present in rain water unites with mineral grains in the rock, especially with iron compounds. The most familiar type of oxidation is when iron reacts with oxygen to create rust. Minerals that are rich in iron break down as the iron oxidizes and forms new compounds. Iron oxide produces the red color in soils. This procedure is called oxidation.

Hydration: The chemical action of water detaches the outer shell of aluminium- bearing rocks through the manner of hydration. **Hydrolysis** is the name of the chemical reaction between a chemical compound and water. When this reaction takes place, water dissolves ions from the mineral and carries them away. These elements have undergone leaching. Through hydrolysis, a mineral such as potassium feldspar is leached of potassium and changed into a clay mineral. Clay minerals are more stable at the Earth's surface.

Desilication: Removal of silica rocks also leads to their weathering and eventual disintegration due to Desilication.

Solution: Some minerals, such as rock salt and gypsum are eliminated via the procedure of solution in water.

Now that you know what chemical weathering is, can you think of some other ways chemical weathering might occur? Chemical weathering can also be contributed to by plants and animals. As plant roots take in soluble ions as nutrients, certain elements are exchanged. Plant roots and bacterial decay use carbon dioxide in the process of respiration.

Check your progress

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b) Compare your answer with one given at the end of this Unit

3. What is oxidation?

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Biological weathering

This refers to disintegration, breakup and decomposition of rock hundreds by plants, animals and things to do of man. Plant roots penetrate the cracks in rocks or at the rock base and dislodge large blocks from the cliffs. Roots may also motive breakup of the rock. The burrowing by using earthworms, ants, rats and the like make channels via the rock and contribute to their destruction.

Man activities such as mining, quarrying, deforestation and und unscientific agricultural practices etc. add to the weathering of rocks. Biological weathering may additionally be bodily or chemical in nature. Directly or indirectly animals and plants are contributing towards disintegration of rocks. Work of plants and Work of animals.

Questions a region's climate strongly influences weathering. Climate is determined by the temperature of a region plus the amount of precipitation it receives. Climate is weather averaged over a long period of time. Chemical weathering increases as:

Temperature increases: Chemical reactions proceed more rapidly at higher temperatures. For each 10 degrees C increase in average temperature, the rate of chemical reactions doubles.

Precipitation increases: More water allows more chemical reactions. Since water participates in both mechanical and chemical weathering, more water strongly increases weathering.

So how do different climates influence weathering? A cold, dry climate will produce the lowest rate of weathering. A warm, wet climate will produce the highest rate of weathering. The warmer a climate is, the more types of vegetation it will have and the greater the rate of biological weathering. This happens because plants and bacteria grow and multiply faster in warmer 8/ temperatures.

8.3 EROSION

Objectives

After reading this unit, you will be able to understand
About Erosion and types of Erosion
You can understand causes of Erosion

Introduction

The rocks are blanketed with regolith through weathering. Winds, walking water, transferring ice, etc., material accumulated from transport rock waste from one vicinity to another. The system is regarded as Transportation or moving of eroded materials. In this process of transportation, the rocks which are effected by all these action will continue to disintegrate. Winds, running water, moving ice, etc., scour, scratch and wear away rocks. This procedure is regarded as Erosion.

Running water has a prominent and important place in erosion. The disintegrated rock pieces in water act as equipment in crushing other rock pieces. These tools smoothen the rock with the aid of corrosion, abrasion, grinding, etc., so that the edges of rock are rounded off.

Weathering is one of the important factor in erosion work because the rocks itself get disintegrated by all kinds of weathering process and it will be easier to erosion of a disintegrated material. The erosion is a loosening and removal materials from its existing position to some other place by action of winds, water, glaciers etc.

Cycle of erosion/geographical cycle

The thinking of geographical cycle of erosion acknowledges the opportunity of obliteration of relief, or plantation, throughout the lifestyles history of a landscape, via the system of erosion, happening in a sequence of orderly changes, ultimately reducing the landscape remedy to a minimum. The earth scientists have attempted to interpret geomorphological tactics or forces on the groundwork of this cycle of erosion.

Views of W.M.Davis

Davis defined a geographical cycle of erosion acknowledges the possibility of adjustments which an uplifted block has to bear before it gets decreased to the base degree or peneplane. He postulated that a geographical cycle is a feature of the factors;

1. Structure – which includes 'nature' and altitude of rocks.
2. Process- which implies the factors or agents responsible for weathering and erosion.
3. Time- implies the stage at which the cycle is – youth, maturity or old age.

Davisian cycle of Erosion – The major assumption which Davis made was that the erosion stars only after the uplift has stopped.

Youth – The uplift is entire and stopped. Immediately erosion of the uplifted block units in. The streams comply with initial irregularities on hand barring adjusting to the structure. These are consequent streams. The flooring of the valley suffer down cutting whilst the summits stay nearly unaffected. Increased relief heralds the commencing of mature age, indicated by widening of the gap between traces 'A' & 'B'.

Maturity: A this stage, the vertical erosion slows down and the horizontal action increases. A attribute function is the erosion of mountain tops at a quicker fee than decreasing of the valley floor. The coming closer of strains "A"&"B" indicates emergence of a mild slope. The subsequent streams gain importance.

Old Age: A mild gradient, eventuated through horizontal action and deposition reduces the erosion depth. A thick layer of sediment represents the formerly erosion recreation. The landforms gets mellowed – lines "A"&"B" run parallel to each other. Relicts of mountains or monad rocks are dotting the water divides and a featureless plain – peneplane is produced.

Views of Penck

Penck made certain deviations from the views of Davis. One , the erosion does no longer stay suspended till the uplift is entire .In fact, he said, the geomorphic varieties are an expression of the segment and price of uplift in relation to the price of degradation, and that interaction between the two factors , uplift and degradation, is continuous. Two, the rate of the uplift continues changing. Penck proposed three types of valley slopes on the groundwork of erosional intensity acting on crustal movements.

1. Straight slope indicating uniform erosion depth and a uniform improvement of landforms.

2. Convex slope indicating waxing erosion intensity and a waning improvement of landforms.

3. Concave slope indicating waning erosion depth and a waning improvement of landforms.

4. Penck's cycle of Erosion – The cycle of erosion has various stages.

Stage 1: In low flow conditions straight river channels have bars of sediment on their beds. Flowing water weavers around these bars of sediment. This creates deeper pathways where most of the water flows called pools and shallow areas where less water flows called riffles. This causes the river flow to swing from side to side.

Stage 2: Where the river swings towards the bank lateral (sideways) erosion causes undercutting. On the opposite side of the channel where the velocity (speed of the flow of water) is lowermaterial is deposited. Therefore the river does not get any wider. The image below shows evidence of undercutting on the outer bank and deposition on the inner bank of the meander.

Stage 3: Continued erosion along the outer bank, as the result of hydraulic action and abrasion, creates a river cliff or bluff. A point bar forms on the inner bank. This is a gently sloping deposit of sand, gravel and pebbles. The image below shows a point bar.

Meanders are perpetuated through a process called helicoidally flow. As the surface flow of water hits the outer bank it corkscrews, flows along the river bed then deposits eroded material on the inner bank.

Stage 4: Eventually the neck of the meander will be breached by the river creating an ox-bow lake. The aerial photograph below shows a meander in the River which will soon be breached. Once this occurs an ox-bow lake will form.

Fig: delta

Check your progress

Note: a) Space is given below for writing your answer
b) Compare your answer with one given at the end of this Unit

4. What is erosion?

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Water erodes rocks and the landscapes by transporting weathered materials from their source to another location where they are deposited.

Wind erodes materials by picking them up and temporarily transporting them from their source to another location where they are deposited.

• Fluvial erosion (water)
• Aeolian (wind) erosion
• Rocks falls or landslides (mass-wasting) erosion

Ice erosion occurs when particles are plucked up or incorporated by moving ice, such as a glaciers, and are transported downhill. Gravity facilitates the down slope transportation of loosened, weathered materials and enables them to move without the aid of water, wind, or ice. Gravity related erosion is a major component of mass-wasting events.

Water (Fluvial): 3 distinct categories:

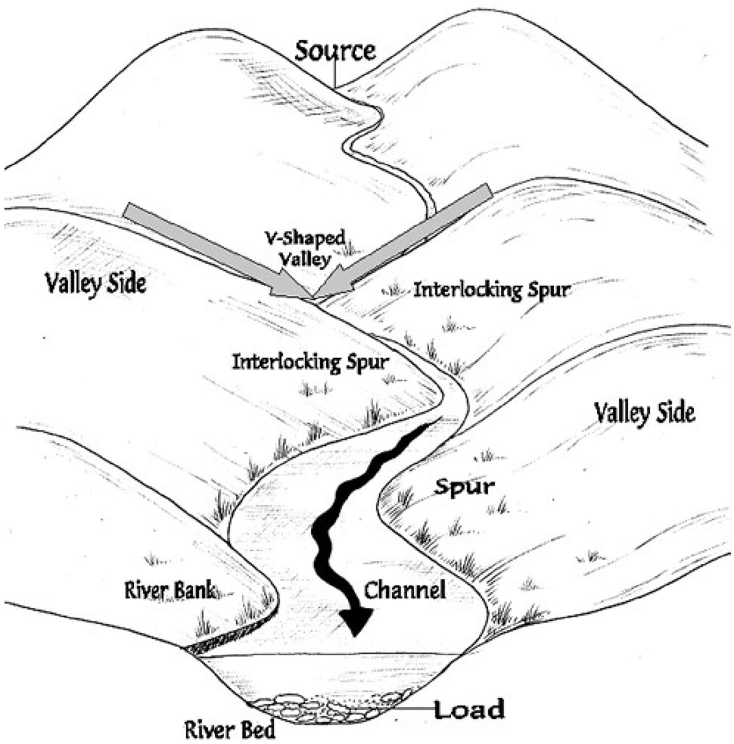
Rain splash erosion occurs when the impact of a rain drop loosens and mobilizes particles.

Sheet erosion is a process where particles loosened buy rain-splash erosion are transported by runoff water down the slope of a surface.

Rill erosion occurs when water concentrates during sheet erosion and erodes small rills or gullies into the surface that channel flow down slope.

Rainfall events, melt-water runoff, or ground water percolation. Transported as suspended load, bed load (rolling along the bottom), or bounced by saltation. The accumulation of fluvial erosion and associated processes over a large area forms pathways for surface and groundwater flow and carves v-shaped river valleys that continue to erode, transport, and deposit weathered sediments across the landscape.

Fig: Upper course of a river

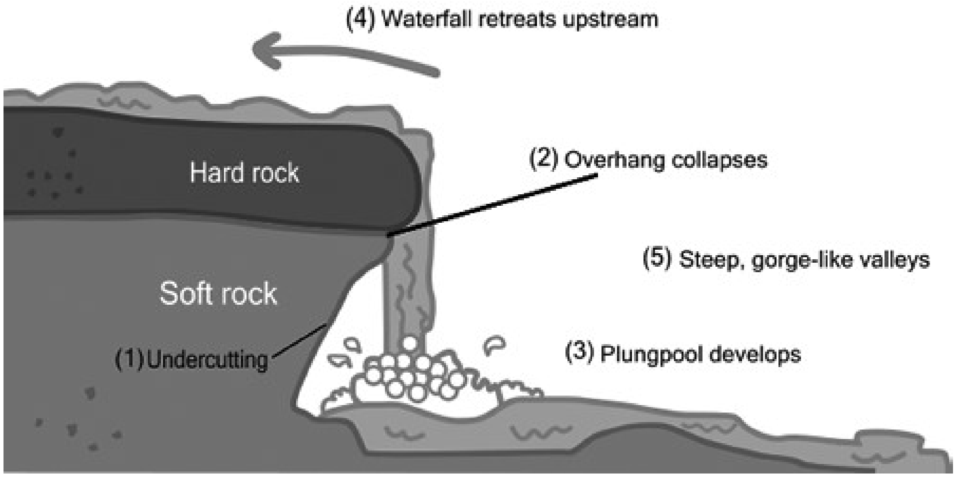


In the upper course of a river gradients are steep and river channels are narrow. Vertical erosion is greatest in the upper course of a river. As the result of this typical features include steep valley sides, interlocking spurs, rapids, gorges and waterfalls. When a river runs over alternating layers of hard and soft rock, rapids and waterfalls may form.

Waterfalls commonly form where water rushes down steep hillsides in upland areas and quickly erodes the rocks. The height and number of waterfalls along a stream or river depends upon the type of rocks that are being eroded by the water. Some types of rocks (shale, for example) wear away more easily than others (such as sandstone or limestone).

As the river or stream wears away the weak rocks, they travel across the surface of stronger rocks. These more resistant rocks become the capstones to waterfalls. The number and thickness of these stronger rock units in a vertical sequence of rocks controls how many water falls there are and how much vertical drop there is on each waterfall.

The diagram shows the formation of a waterfall. Soft rock is undercut (1). This leaves a layer of hard rock which overhangs the layer of soft rock (2). The water flows over the overhang and creates a plunge pool in the soft rock below (3). Eventually the overhang will collapse due to the erosion of the soft rock beneath it. The waterfall then retreats up stream (4). This creates a steep, gorge-like valley.



Middle course of a river: The middle course of a river has more energy and volume then in the upper course. The gradient is gentler and lateral (sideways) erosion has widened the channel. The river channel has also become deeper. Meanders are typical landforms found in this stage of the river.

Meanders

A meander is a winding curve or bend in a river. They are typical of the middle and lower course of a river. This is because vertical erosion is replaced by a sideways form of erosion called lateral erosion, plus deposition within the floodplain.

The image below shows a series of meanders. Notice the deposition on the inside of the meanders (pale material) and the river cliffs or bluffs (indicated by dark shadows) on the outside of the meanders.

Erosion, transportation and deposition are all processes that create the characteristic features of meanders shown in the images above. There are several stages involved in the creation of meanders. These are discussed below.

Check your progress

Note: a) Space is given below for writing your answer
b) Compare your answer with one given at the end of this Unit

5. Briefly discuss about meanders?

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Lower course of a river

The volume of water in a river is at its greatest in the lower course. This is due to the contribution of water from tributaries. The river channel is deep and wide and the land around the river is flat. Energy in the river is at its lowest and deposition occurs. Deltas are often found at the mouth of large rivers. Deltas are formed when a river deposits material faster than the sea can erode it.

Erosion

Rivers erode in four ways:

Abrasion or corrosion - This is when large pieces of bed load material wear away the river banks and bed.

Attrition - This is when the bed load itself is eroded when sediment particles knock against the bed or each other and break, becoming more rounded and smaller.

Hydraulic Action - This is when the force of water erodes softer rock.

Solution or corrosion - This is when acidic water erodes rock. **Solution** - minerals are dissolved in the water and carried along in solution. This typically occurs in areas where the underlying bedrock is limestone.

River Transportation: Rivers transport material in four ways:

Suspension - fine light material is carried along in the water.

Saltation - small pebbles and stones are bounced along the river bed.

Traction - large boulders and rocks are rolled along the river bed.

Deposition

Deposition is the processes where material being transported by a river is deposited. Deposition occurs when a river loses energy. This can be when a river enters a shallow area (this could be when it floods and comes into contact with the flood plain) or towards its mouth where it meets another body of water.

Rivers flood on a regular basis. The area over which they flood is known as the floodplain and this often coincides with regions where meanders form. Meanders support the formation of flood plains through lateral erosion.

When rivers flood the velocity of water slows. As the result of this the river's capacity to transport material is reduced and deposition occurs. This deposition leaves a layer of sediment across the whole floodplain. After a series of floods layers of sediment form along the flood plain.

Larger material and the majority of deposition occurs next to the river channel. This is the result of increased friction (with the flood plain) causing the velocity of the river to slow and therefore rapidly reduce its ability to transport material. This leaves a ridge of higher material next to the river channel on both banks of the river known as a levee.

Chemical action includes corrosion or solution: This action of running water might also either be in vertical direction or in lateral/horizontal direction. Where chemical modified water denudes the rock surface; causing subsequent slumming.

Drainage patterns

The regular form of a river course as it completes its erosional cycle is referred to as the drainage sample of a stream. A drainage pattern reflects the structural of basal rocks, resistance and strength; cracks or joints and tectonic irregularity, if any.

There are quite a number sorts of drainage patterns.

Dendritic: This is an irregular tree department formed pattern Eg: Indus, Godavari, Mahanadi, Kaveri, and Krishna

Trellis : In this type of pattern the short tributary streams meet the principal stream at proper angles , and differential erosion via gentle rocks paves the way for tributaries Examples:- Siene and its tributaries in Paris basin(France).

Rectangular: The predominant movement bends at right angles and tributaries be a part of a proper angles growing rectangular patterns e.g. Colorado River (USA).

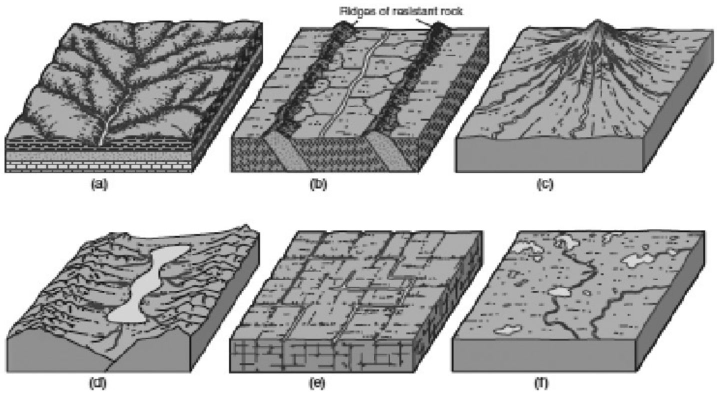
Parallel: The tributaries seem to ne strolling parallel to every other in a uniformly sloping region.

Angular: The tributaries be part of the most important circulate at an acute angle. This pattern is frequent in foothill regions.

Radial: The tributaries from a submit comply with the slope downwards and drain down in all directions E.g., streams of Saurashtra, etc.

Annular: when the upland has an outer gentle stratum, enhance subsequent which strive to observe a circular drainage around the summit.

Centripetal: In a low lying basin, the streams converge from all sides e.g. The streams of Ladakh, Tibet and the Baghmati and its tributaries in Nepal.



Check your progress

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b) Compare your answer with one given at the end of this Unit

6. Briefly discuss about trellis pattern of drainage?

8.4 Denudation

Introduction

We have been discussing geomorphic processes in this section. We have already seen that geomorphic processes are classified into endogenic processes and exogenic processes. As endogenic processes are already covered in detail, we focus on exogenic forces and exogenic processes. Exogenic (Exogenetic) processes are a direct result of stress-induced in earth materials due to various forces that come into existence due to the sun's heat. Force applied per unit area is called stress. Stress is produced in a solid by pushing or pulling. The basic reason that leads to weathering, erosion, and deposition in the development of stresses in the body of the earth's materials. Temperature and precipitation are the two important climatic elements that control various processes by inducing stress in earth materials.

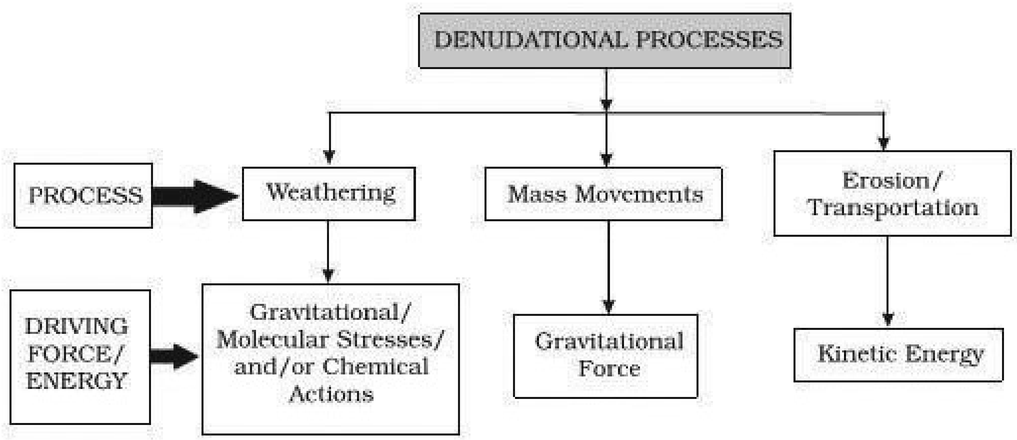
Denudation: All the exogenic geomorphic processes are covered under a general term, denudation. The word 'denude' means to strip off or to uncover. Weathering, mass wasting/ movements, erosion, and transportation are included in denudation. Denudation is the name for the processes of erosion, leaching, stripping, and reducing the mainland due to removal of material from higher to lower areas like valleys, river valleys, lakes and seas with a permanent filling of low lands.

Denudation, or **surface lowering of the land by mass wasting and erosion**, was understood in principle by 1800 and has since been refined. Planation implies that denudation continues until land is reduced to a low plain just above the base level of erosion, generally the sea. Denudation mainly depends on rock type and its structure that includes folds, faults, orientation and inclination of beds, presence or absence of joints, bedding planes, hardness or softness of constituent minerals, chemical susceptibility of mineral constituents; permeability, or impermeability, etc.

All the exogenic processes (weathering and erosion) are covered under a general term, denudation. The word 'denude' means to strip off or to uncover. Denudation depends on physical (folds, faults, orientation and inclination of beds, presence or absence of joints, bedding planes, hardness or softness of constituent minerals, permeability) and chemical (chemical susceptibility of mineral constituents to corrosion) properties of the rocks.

The effects of most of the exogenic geomorphic processes are small and slow but will, in the long run, affect the rocks severely due to continued fatigue. Denudation has 4 phases; Weathering; Erosion; Transportation; Deposition.

Denudation refers to processes that lead to the chemical and physical disintegration of rocks, which eventually results in the wearing away of the Earth's surface. There are three denudation processes: erosion, weathering, and mass wasting. While weathering involves the decomposition of rocks, erosion refers to the removal of soil particles, rocks, and other earth materials from one location to another caused by wind and water. Mass wasting is the movement of soil, sand, rock, and residue down a slope driven by gravitational force. In most cases, there are also debris flows and mudflow during mass wasting.



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7. Define denudation?

Differences between Weathering and Denudation

- Weathering is a short-term process, while denudation is a long-term process that takes years to occur.
- The weathering process causes the disintegration of rock, while denudation results in the wearing of all parts of the Earth's surface.
- Weathering is just one part of the denudation process, along with erosion and mass wasting, and can be considered as the first stage of denudation.
- Weathering is caused by temperature changes, wind, rain, bacteria, and plants, whereas denudation is caused by volcanoes, earthquakes, and plate tectonics.

8.5 MASS WASTING

In this lesson, you will learn about a process called mass wasting and the factors that cause this movement of material.

Learning outcomes

- Explain the main influences of weather determine the main influences of mass wasting.
- Describe the various types of mass wasting processes.
- Compare the difference between fast and slow subsidence.
- Determine ways mass wasting processes may be limited.

Mass wasting is natural phenomena characterized by the mass movement of rock, soil, and debris downward as a result of gravity. Learn about the definition, types, causes, and overall process of mass wasting. If a rock slides off of a mountain and no one is around to hear it, does it make a sound? Well, I don't know about the noise this activity would create, but I do know that mountains erode and that rocks and debris can slide and fall down mountain slopes in massive amounts.

Mass wasting, which is sometimes called mass movement or slope movement, is defined as the large movement of rock, soil and debris downward due to the force of gravity. In other words, the earth's outer crust is being 'wasted' away on a 'massive' scale and falling to lower elevations.

Mass wasting is a type of erosion, and it is capable of making big changes to the side of a mountain. These changes can happen suddenly, as in one minute the rock is there and the next it is gone, or it can happen more slowly over time. You might think of this process as a landslide, and this term is sometimes used interchangeably with mass wasting. However, the term landslide is a bit limiting and does not allow for a description of the many different triggers and types of erosion that can happen on this large of a scale.

Causes of Mass Wasting

Now, we mentioned that mass wasting is mainly due to gravity. So, we see that mountains have an ongoing tug-of-war with gravity. Gravity is constantly trying to pull rock and debris down the slope of a mountain. At the same time, the resistive forces of the mountain, including the cohesive strength and internal friction between the materials, referred to as the mountain's **shear strength**, constantly pulls back against gravity.

The shear strength works to maintain the slope's stability and keep the materials in place. This is a lot like a mountain climber gripping onto the side of a mountain and resisting gravity. The climber uses his grip strength to resist gravity, like the mountain uses its shear strength.

With this understanding, we see that the causes of mass wasting occur when gravitational force overcomes the resistive forces of the mountain. And, since gravitational pull is always constant, then we see that mass wasting occurs when something changes the mountain's ability to resist gravity.

For instance, an increased slope steepness increases mass wasting simply because the gravitational force acting on a steep slope is greater than the force acting on a gentle slope. Increasing the steepness of a slope is one way man can increase mass wasting. For example, if a road crew cuts away a slope to make room for a new road but makes the angle of the slope too steep, the slope will be prone to mass wasting.

Increased water is another factor that plays an important role in mass wasting. Water can wash away small particles that help keep the mountainside intact. This is similar to what happens

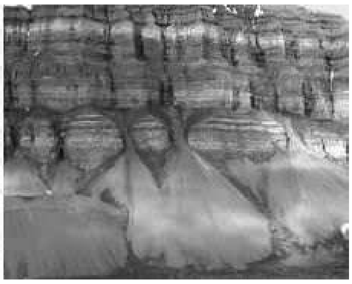
Increased water is another factor that plays an important role in mass wasting. Water can wash away small particles that help keep the mountainside intact. This is similar to what happens when a wave comes ashore and washes away a sandcastle. The abundant water breaks apart the small sand particles and destroys the structural stability of the castle you spent the afternoon building.

If an area has decreased vegetation, it will be more prone to mass wasting. Vegetation stabilizes soil particles on the surface and anchors soil under the surface through its root system. This is much like comparing two sand dunes on a beach. If one sand dune has grasses growing on it, it will resist the erosion of water and wind better than a sand dune without vegetation.

Another factor that plays a role in mass wasting is earthquakes. The violent shaking that occurs in a region where an earthquake takes place has the ability to break off sections of mountains or hills, causing them to slide down the slope.

Mass wasting is the mass movement of unconsolidated soil, sand, rocks, regolith (the layer of unconsolidated solid material covering the bedrock of a planet), etc. along a slope under the influence of gravity. Mass wasting occurs when the gravitational force acting on a slope exceeds its resisting force leading to **slope failure** (mass wasting). Timescales of the mass wasting process may be a few seconds (debris flows and mudflows) or hundreds of years (mass wasting along the slopes of stable mountains leaving behind alluvial fan like structures).





There are several factors that influence mass wasting, but ultimately it is a battle between friction and gravity. If the friction on a rock is stronger than gravity for a particular slope, the rock material will likely stay. But if gravity is stronger, the slope will fail.

The steeper the slope, the stronger the friction or rock strength must be to resist downslope motion. The steepest angle a slope can be before the ground will slide is about 35 degrees, called the angle of repose. Many times we will cut through a slope to make room for a road or other forms of development. So to help prevent the slope from sliding along these cut areas, retaining walls must be build. More on this later.

Check your progress

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b) Compare your answer with one given at the end of this Unit

8. causes of mass wasting?

Factors determining mass wasting

One of the factor that determines mass wasting is the slope's materia. Mass wasting is more prone on slopes that contain clay and shale. Without going into great detail here, the shape and composition of individual clay particles can absorb water and prevent water from peculating through the ground. A layer of clay on a slope can prevent water from filtering through the slope. Instead, the water stays near the surface and saturates the ground. This can cause the surface layers to lose friction and slide.

Weight and friction of slope: A third factor that influences whether a slope will fail is the load or weight of that slope. Adding weight to a weakened slope can obviously cause it to slide easier, especially on steep slopes. This added weight tends to occur by building on top of weak slopes, increasing the steepness of the slope, or over-saturating the slope.

Friction has been mentioned as a factor several times already, but there are a few more things must be said here. As already noted, as long as the friction along the slope is stronger than gravity, the ground is unlikely to slide. But if that friction is weakened, slope fail becomes more likely. There are several other ways friction can be reduced along a slope: wildfires, removal of vegetation, or adding too much water.

Gravity is probably the ultimate driving force of mass wasting. The force of gravity pulls all things on the planet toward the center of the Earth. Without gravity, mass wasting would not occur. But unlike many of the other factors, humans have no influence or control on gravity.

Regional climate conditions

A region's climate can also determine the likelihood of a landslide. Climate is based on temperature and precipitation. Mass wasting is prone in the spring-time when snowmelt, water saturation, and runoff is greatest. Also the type of climate will help determine the type of mass wasting. Humid climates tend to have slides, where water-saturated slopes fail and fall. Drier climates tend to have rocks that fall; especially early spring. Canyons and places prone to wildfires tend to have debris flows.

Water content within slopes

The amount of water in the soil is a major factor in the stability of a slope. When you build a sand castle, water is needed to build the walls and towers. That is because water has surface tension and is attracted to each other. So a little water can actually prevent slopes from sliding. But too much water lubricates the individual grains of sediment decreasing friction between each grain, so the possibility of mass wasting increases. The increase of water within the soils can come from over watering, pipe or swimming pool leaks, or prolonged stormy weather.

Finally, gravity is the driving force of mass wasting. The force of gravity pulls all things on the planet toward the center of the Earth. But unlike many of the other factors, humans have no influence or control on gravity.

Check your progress

Note: a) Space is given below for writing your answer
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9. What are the Factors determine the mass wasting?

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Types of Mass Wasting

Rock fall: A rock fall are the fastest of all landslide types and occurs when a rock *falls* through the air until it comes to rest on the ground - not too complicated. In Utah, they are common in the spring and fall because of what is called freeze-thaw weathering. In the daytime, temperatures in the spring and fall tend to be above freezing, which allows liquid water to enter cracks within rocks.

At night, the temperatures cool below freezing and the water within the rocks freezes and expands which causes the rock to break more. The following morning, the ice will melt and go deeper within the crack to refreeze later that night. This freeze-thaw action over time can cause rocks to break off and fall to the ground. The debris accumulates at the base of these steep slopes is called talus. But rock falls can also occur when heavy precipitation is falling on a steep slope, causing the rocks to lose friction and fall.

Rotational slides: Rotational slides occur when a landslide occurs in a curved manner concave to the sky. When this type of slide occurs, the upper surface of the slide tilts backwards toward the original slope and the lower surface moves away from the slope. They are common when the soil tends to be deep in clay or soft sediment deposits.

Translational slides: Rather than rotating, a translational slide occurs when slope failure occurs parallel to the slope. Often times the slope failure occurs on soil composed of clay or shale, or along old fault lines, or previous slide areas. What makes translational slides dangerous is that they tend to flow faster and travel farther than rotational slides.

Debris flows: Debris flows are one of the most common, but most dangerous of the various types of landslides because of their speed and consistency. Debris flows tend to be a mixture of rock and water with two to three times the density of flooding streams. That density allows debris flows strip away the land and pick up objects as large as school buses. Debris flows are most common at the mouth of canyons along alluvial fans. Now once the debris flow reaches the mouth of a canyon, the sediment gets deposited in a fan-shaped delta called an alluvial fan. The problem is that people like to live along alluvial fans because of their scenic view on the canyon. Another influence of debris flows is wildfires. When a wildfire strips an area of its vegetation, the bare soil is easily eroded away in either a thunderstorm or snow melt creating these debris flows.

Volcanic mass wasting: Lahars were mentioned in the module on volcanoes, but in essence they are volcanic landslides. Recall that volcanoes eject pyroclastic material ranging in size from ash to boulders. Now there tends to be two ways lahars occur. One is if a thunderstorm precipitates large amounts of moisture on the pyroclastic material and the pyroclastic flow downslope. The other option is if a volcano is snow-capped and the heat from the volcano causes some of the snow to melt and mix with the pyroclastic material. What makes lahars so dangerous is that they have the consistency of concrete and can travel hundreds of miles.

Check your progress

Note: a) Space is given below for writing your answer

b) Compare your answer with one given at the end of this Unit

10. What are the types of mass wasting?

8.6 SUMMARY

Weathering is the **first step in the formation of soil** from rocks. Weathering weakens soil and rocks and makes it easy to exploit natural resources. Weathering leads to **natural soil enrichment**. Weathering leads to **mineral enrichment** of certain ores by leaching unwanted minerals leaving behind the valuable ones.

8.7 CHECK YOUR PROGRESS MODEL ANSWERS

1. **Weathering** is the process that changes solid rock into sediments. With weathering, rock is disintegrated into smaller pieces.

2. A rock mass disintegrates layer by means of layer leaving at the back of successively smaller spheroidal bodies and forming curved rock shells by disintegration .This kind of rock breakup is also known as spalling.

3. **Oxidation** is a chemical reaction that takes place when oxygen reacts with another element. Minerals that are rich in iron break down as the iron oxidizes and forms new compounds. Iron oxide produces the red color in soils. This procedure is called oxidation.

4. **Erosion**: In this process of transportation, the rocks which are effected by all these action will continue to disintegrate. Winds, running water, moving ice, etc., scour, scratch and wear away rocks. This procedure is regarded as Erosion.

5. **Meanders:** Meanders are typical landforms found in the middle course stage of the river. A meander is a winding curve or bend in a river. This is because vertical erosion is replaced by a sideways form of erosion called lateral erosion, plus deposition within the floodplain.

6.**Trellis**: In this type of pattern the short tributary streams meet the principal stream at proper angles, and differential erosion via gentle rocks paves the way for tributaries Examples:- Siene and its tributaries in Paris basin(France).

7. Denudation is the name for the processes of erosion, leaching, stripping, and reducing the mainland due to removal of material from higher to lower areas like valleys, river valleys, lakes and seas with a permanent filling of low lands.

8. The causes of mass wasting occur when gravitational force overcomes the resistive forces of the mountain. And, since gravitational pull is always constant, then we see that mass wasting occurs to resist gravity. Increased slope steepness increases mass wasting simply because the gravitational force acting on a steep slope is greater than the force acting on a gentle slope. Increased water is another factor that plays an important role in mass wasting. Decreased vegetation, will be more prone to mass wasting. Another factor that plays a role in mass wasting is earthquakes.

9. Mass wasting is more prone on slopes that contain clay and shale. This can cause the surface layers to lose friction and slide. Friction has been mentioned as a factor several times already, but there are a few more things must be said here. There are several other ways friction can be reduced along a slope: wildfires, removal of vegetation, or adding too much water. Gravity is probably the ultimate driving force of mass wasting.

10. A rock fall are the fastest of all landslide types and occurs when a rock *falls* through the air until it comes to rest on the ground. Rotational slides occur when a landslide occurs in a curved manner concave to the sky. Debris flows are one of the most common, but most dangerous of the various types of landslides because of their speed and consistency. Lahars were mentioned in the module on volcanoes, but in essence they are volcanic landslides. Recall that volcanoes eject pyroclastic material ranging in size from ash to boulders.

Long answer questions

1. Discuss about different types of mass wasting.

2. What are the factors determine mass wasting

3. Discuss about penk cycle of erosion

4. Discuss about differences between weathering and denudation

Short answer questions

1) What is weathering?

2) What is Chemical weathering?

3) What are the active Types of weathering?

4. Write about volcanic mas wasting.

UNIT 9: FLUVIAL LAND FORMS – CYCLE OF EROSION AND DEPOSITIONAL FEATURES

Contents

9.0 Objectives
9.1 Introduction
9.2 Drainage patterns
9.3 Fluvial Landforms
9.4 River valleys - Young Stage
9.5 Middle course of river - Youth Stage
9.6 Depositional Landforms - Old age Stage
9.7 Fluvial Cycle of Erosion
9.8 Check your progress answers
9.9 Model Examination Questions

9.0 OBJECTIVES

After reading this unit, you will be able to understand

About fluvial landforms

You can understand depositional landforms

9.1 INTRODUCTION

Fluvial Landforms: The landforms created as a result of degradation action (erosion) or aggradation work (deposition) of running water are called fluvial landforms. The fluvial processes may be divided into three physical phases – erosion, transportation and deposition.

Various Aspects of Fluvial Erosive Action: Running water may carry out erosion through any one or more of the following ways:

Mechanical action include the solid river load striking against rocks and wearing them down (corrosion or abrasion), or the force of running water wearing down rocks (hydration) or the river load particles striking, colliding against each other and breaking down in the process (attrition).

Chemical action includes corrosion or solution: This action of running water may either be in vertical direction (down cutting leading to valley deepening) or in lateral/horizontal direction (causing valley broadening). The lowest level to which a valley can be eroded by running water is called its base level. J.W. Powell had given the concept of base level in 1875.

The sea level is considered to the Ultimate or Grand Base Level below which a dry-land cannot be eroded anywhere on earth. There may be many temporary base levels during the course of a stream because of a variety of factors, such as at the confluence of a tributary and the master stream, which is the base level for the tributary and presence of a lake or enclosed water body, etc.

Antecedent Drainage: A part of a river slope and the surrounding area gets uplifted and the river sticks to its original slope, cutting through the uplifted portion like a saw, and forming deep gorges: this type of drainage is called Antecedent drainage. Example: Indus, Satluj, Brahmaputra.

Superimposed drainage: When a river flowing over a softer rock stratum reaches the harder basal rocks but continues to follow the initial slope, it seems to have no relation with the harder rock bed and seems unadjusted to the base. This type of drainage is called superimposed drainage. Examples: rivers of eastern USA and southern France.

9.2 DRAINAGE PATTERNS

The typical shape of a river course as it completes its erosional cycle is referred to as the drainage pattern of a stream. A drainage pattern reflects the structure of basal rocks, resistance and strength, cracks or joints and tectonic irregularity, if any.

There can be various types of drainage patterns. (Fig)

Dendric or Pinnate: This is an irregular tree branch shaped pattern. Examples: Indus, Godavari, Mahanadi, Cauveri, Krishna.

2. Trellis: In this type of pattern the short subsequent streams meet the main stream at right angles, and differential erosion through soft rocks paves the way for tributaries. Examples: Seine and its tributaries in Paris basin (France).

3. Rectangular: The main stream bends at right angles and the tributaries join at right angles creating rectangular patterns. This pattern has a subsequent origin. Example: colorado River (USA).

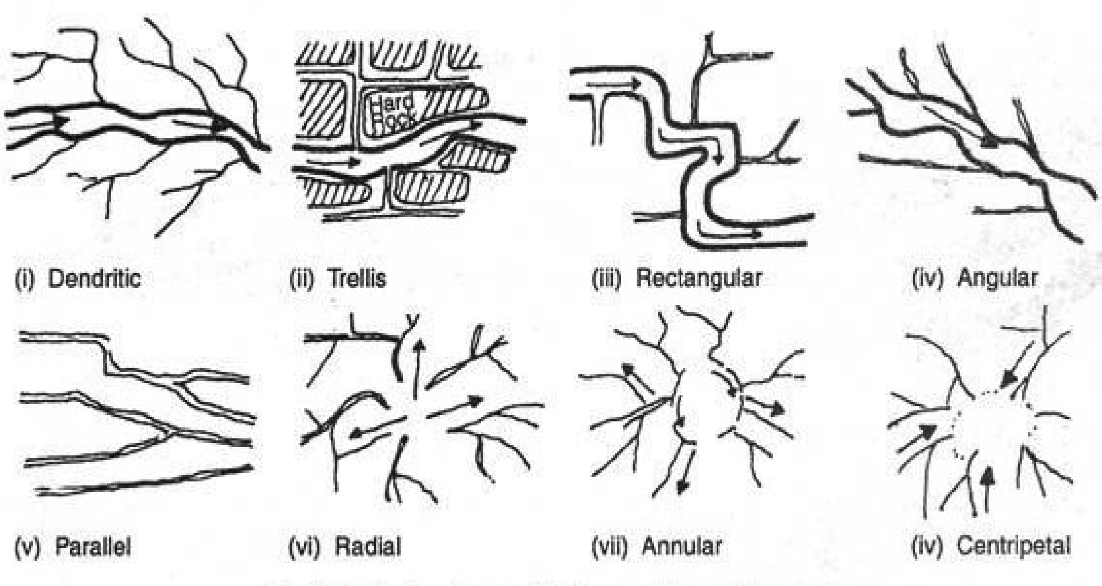
4. Angular: The tributaries join the main stream at acute angles. This pattern is common in foothill regions.

5. Parallel: The tributaries seem to be running parallel to each other in a uniformly sloping region. Example: rivers of lesser Himalayas.

6. Radial: The tributaries from a summit follow the slope downwards and drain down in all directions. Examples: streams of Saurashtra region and the Central French Plateau.

7. Annular: When the upland has an outer soft stratum, the radial streams develop subsequent tributaries which try to follow a circular drainage around the summit. Example: Black Hill streams of South Dakota.

8. Centripetal: In a low lying basin the streams converge from all sides. Examples: streams of Ladakh, Tibet, and the Baghmati and its tributaries in Nepal.



Various types of drainage patterns of a stream

9.3 FLUVIAL LANDFORMS

The landforms created by a stream can be studied under erosional and depositional categories.

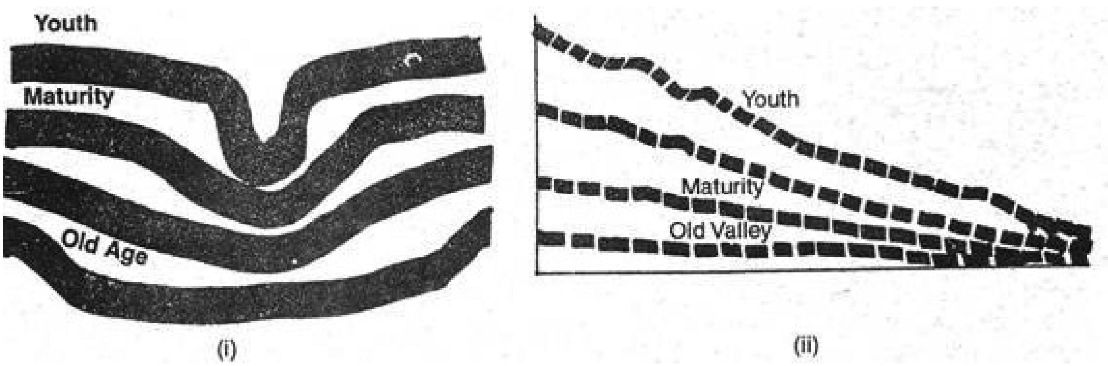
River Valleys: The extended depression on ground through which a stream flows throughout its course is called a river valley. At different stages of the erosional cycle the valley acquires different profiles.

At a young stage, the valley is deep, narrow with steep wall-like sides and a convex slope. The erosional action here is characterized by predominantly vertical down cutting nature. The profile of valley here is typically 'V' shaped. As the cycle attains maturity, the lateral erosion becomes prominent and the valley floor flattens out. The valley profile now becomes typically 'U' shaped with a broad base and a concave slope.

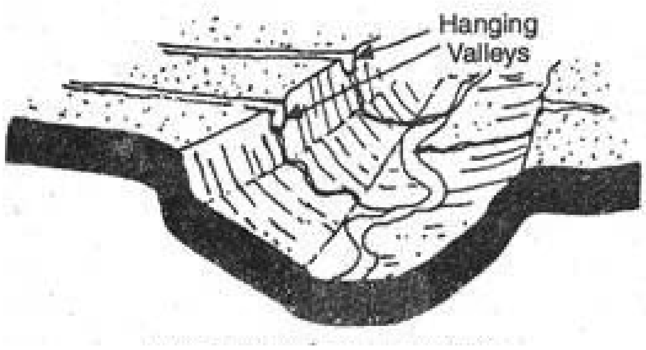
9.4 RIVER VALLEYS - YOUNG STAGE

A deep and narrow V shaped valley is also referred to as gorge and may result due to down cutting erosion and because of recession of a waterfall. Most Himalayan Rivers pass through deep gorges (at times more than 500 metres deep) before they descend to the plains. An extended form of gorge is called a canyon. The Grand Canyon of the Colorado River in Arizona (USA) runs for 483 km and has a depth of 2.88 km. A tributary valley lies above the main valley and is separated from it by a steep slope down which the stream may flow as a waterfall or a series of rapids.

Waterfalls: A waterfall is simply the fall of an enormous volume of water from a great height, because of a variety of factors such as variation in the relative resistance of rocks, relative difference in topographic reliefs, fall in the sea level and related rejuvenation, earth movements etc. For example, Jog or Gersoppa falls on Sharavati (a tributary of Cauveri) has a fall of 260 metres.

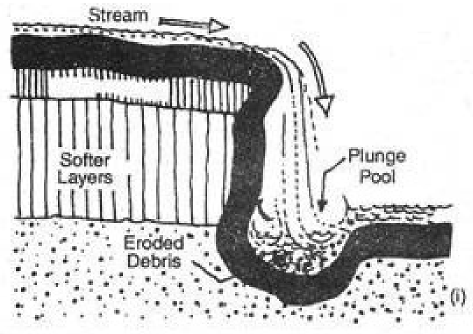


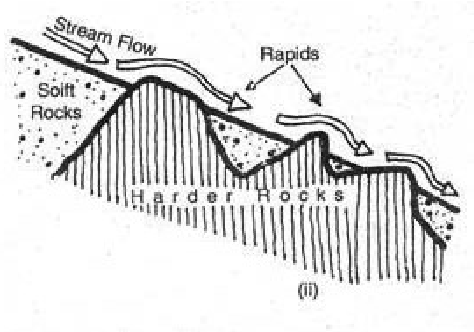
Stages in valley formation: (i) cross profile (ii) longitudinal profile



A Hanging Valley

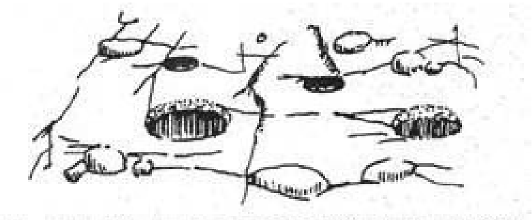
A rapid, on the other hand, is a sudden change in gradient of a river and resultant fall of water (Fig.).



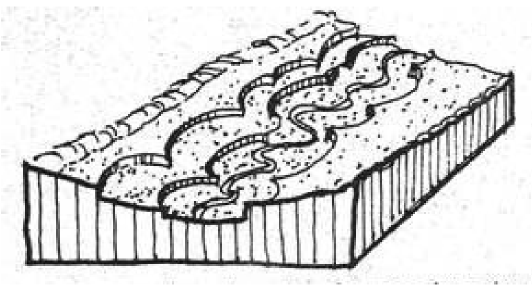


Formation of - (i) waterfall, and (ii) rapids

Pot Holes: The kettle-like small depressions in the rocky beds of the river valleys are called pot holes which are usually cylindrical in shape. Pot holes are generally formed in coarse-grained rocks such as sandstones and granites. Potholing or pothole-drilling is the mechanism through which the grinding tools (fragments of rocks, e.g. boulders and angular rock fragments) when caught in the water eddies or swirling water start dancing in a circular manner and grind and drill the rock beds of the valleys like a drilling machine. They thus form small holes which are gradually enlarged by the repetition of the said mechanism. The potholes go on increasing in both diameter and depth. (Fig)



Patholes in a river bed with hard rock base



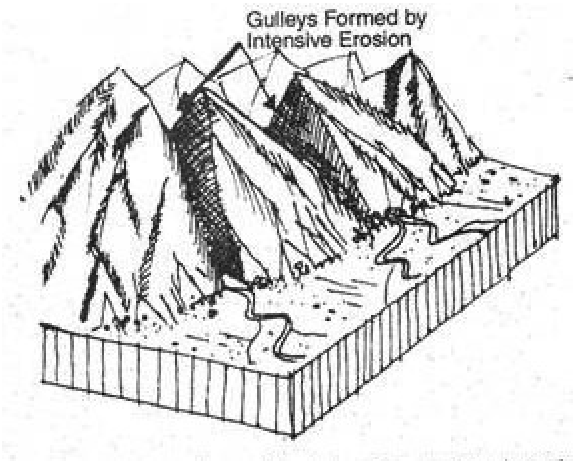
Formation of a series of terraces by a river

Terraces: Stepped benches along the river course in a flood plain are called terraces. Terraces represent the level of former valley floors and remnants of former (older) flood plains. (Fig.)

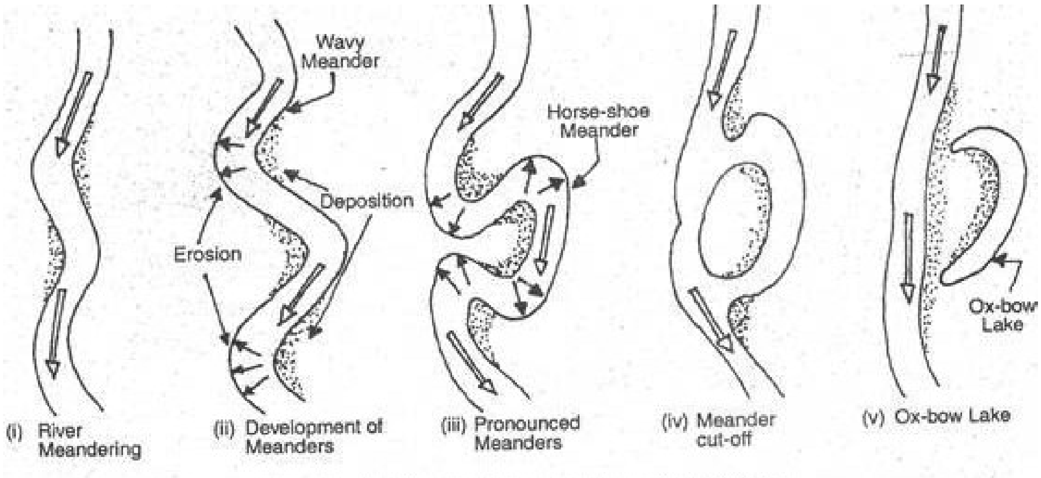
Gulley's /Rills: Gulley is an incised water- worn channel, which is particularly common in semi-arid areas. It is formed when water from overland-flows down a slope, especially following heavy rainfall, is concentrated into rills, which merge and enlarge into a gulley. The ravines of Chambal Valley in Central India and the Chos of Hoshiarpur in Punjab are examples of galleys. (Fig.).

Meanders: A meander is defined as a pronounced curve or loop in the course of a river channel. The outer bend of the loop in a meander is characterized by intensive erosion and vertical cliffs and is called the cliff-slope side. This side has a concave slope. The inner side of the loop is characterized by deposition, a gentle convex slope, arid is called the slip-off side. Morphologically, the meanders may be wavy, horse-shoe type or ox-bow/ bracelet type.

7. Ox-Bow Lake: Sometimes, because of intensive erosion action, the outer curve of a meander gets accentuated to such an extent that the inner ends of the loop come close enough to get disconnected from the main channel and exist as independent water bodies. These water bodies are converted into swamps in due course of time. In the Indo-Gangetic plains, southwards shifting of Ganga has left many ox-bow lakes to the north of the present course of the Ganga.



Gulleys formed by intensive erosion through a soft stratum, particularly under arid conditions



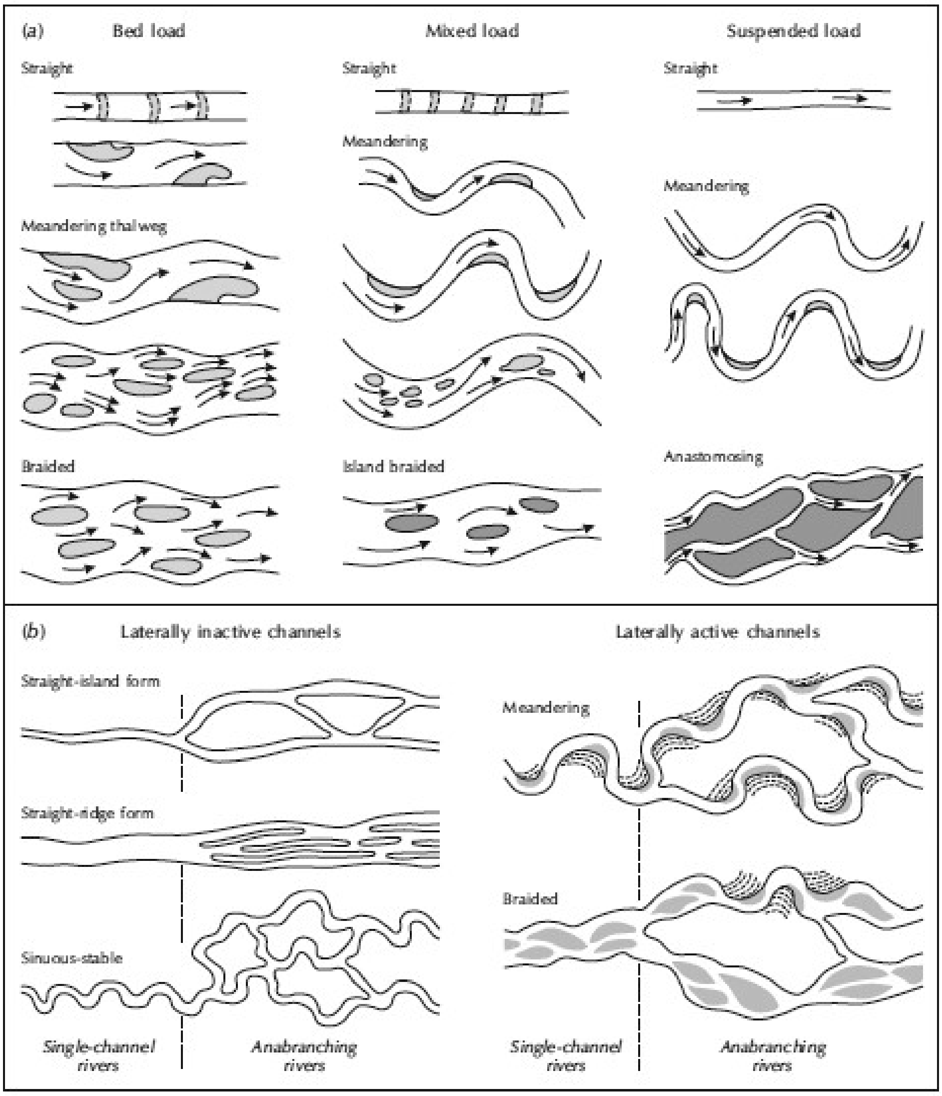
Development of a meander and ox-bow lake

8. Peneplane (Or peneplane): This refers to an undulating featureless plain punctuated with low- lying residual hills of resistant rocks. According to W.M. Davis, it is the end product of an erosional cycle.

9.5. MIDDLE COURSE OF RIVER - YOUTH STAGE

The prolonged despair on floor via which a circulation flows throughout its route is referred to as a river valley. At exclusive ranges of the erosional cycle the valley acquires specific profiles. At a young stage, the valley is deep, slim with steep wall – like aspects and a convex slope. The erosional motion right here is characterized by means of a predominantly vertical down cutting nature. The profile of a valley right here is typically ‘V’ fashioned. At the cycle attains maturity, the lateral erosion will become outstanding and the valley floor flatters out. The valley profile now turns into normally ‘U’ fashioned with a broad base and a concave slope.

A deep and slender ‘V’ formed valley is additionally referred to as a ‘gorge’ and may additionally result due to down cutting erosion and recession of a water fall. A prolonged from of gorge is known as a canyon. The Grand Canyon of the Colorado River in Arizona (USA) runs for 483km and has a depth as a waterfall and is separated from it through a steep slope down which the stream can also drift as a water fall or a sequence of rapids.



Waterfalls: A waterfall is the fall of a vast extent of water from a brilliant peak due to the fact of a variety of factors such as version in the relative resistance of rocks, relative difference in relief, fall in the sea level and associated rejuvenation, earth actions etc.

A fast on the different hand is a surprising exchange in gradient of a river and resultant fall of water

Potholes: The kettle like small depressions in the rocky beds of the river valleys are called pot holes, which are commonly cylindrical in form. Pot holes are usually shaped in coarse – grained rocks such as sandstones and granites.

Terraces: Stepped benches alongside the river path in flood undeniable are known as terraces. Terraces symbolize the level of former valley floors and remnants of former flood plains.

Gulleys / rills: These are include water worn channels, which are mainly frequent in semi – arid areas. They are formed when water from overland- flows down a slope, specifically following heavy rainfall, is targeted into rills which merge and extend into a gulley.

Meanders: A menders is described as a pronounced curve or loop in the direction of a river channel. The outer bend of the loop in a mender is characterized by way of intensive erosion and vertical cliffs and is known as the cliff slope side. This facet has a concave slope. The internal side of the slope is characterized by deposition, a gentle convex slope, and is referred to as the slip – off side. Morphologically, the meanders may additionally be wavy, horse shoe kind or ox-bow type.

Ox- Bow Lake: Sometimes, due to the fact of intensive erosive action, the other curve of a meander receives accentuated to such an extent that the inner ends of the loop come close adequate to get disconnected from the predominant channel and exist as unbiased water bodies. These water our bodies are converted into swamps in due route of time.

Peneplant: This refers to an undulating, featureless simple punctuated with low- mendacity residual hills of resistant rocks.

Check your progress

Note: a) Space is given below for writing your answer

b) Compare your answer with one given at the end of this Unit

1. Discuss about ox Bow Lake.

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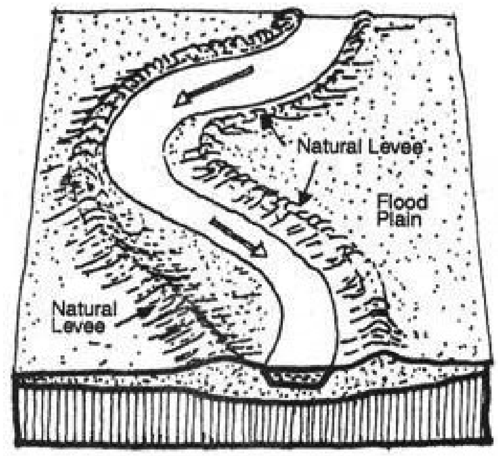
9.6 DEPOSITIONAL LANDFORMS (OLD AGE STAGE)

The depositional action of a stream is influenced by stream velocity and the volume of river load. The decrease in stream velocity reduces the transporting power of the streams which are forced to leave additional load to settle down. Increase in river load is effected through (i) accelerated rate of erosion in the source catchment areas consequent upon deforestation and hence increase in the sediment load in the downstream sections of the rivers; (ii) supply of glacio-fluvial materials; (iii) supply of additional sediment load by tributary streams; (iv) gradual increase in the sediment load of the streams due to rill and gully erosion. Various landforms resulting from fluvial deposition are as follows:

1. Alluvial Fans and Cones: When a stream leaves the mountains and comes down to the plains, its velocity decreases due to a lower gradient. As a result, it sheds a lot of material, which it had been carrying from the mountains, at the foothills. This deposited material acquires a conical shape and appears as a series of continuous fans. These are called alluvial fans. Such fans appear throughout the Himalayan foothills in the north Indian plains. (Fig.)

An alluvial fan or cone



Natural levees in a flood plain

2. Natural Levees: These are narrow ridges of low height on both sides of a river, formed due to deposition action of the stream, appearing as natural embankments. These act as a natural protection against floods but a breach in a levee causes sudden floods in adjoining areas, as it happens in the case of the Hwang Ho river of China. (Fig)

3. Delta: A delta is a tract of alluvium usually fan-shaped, at the mouth of a river where it deposits more material than can be carried away. The river gets divided into two or more channels (distributaries) which may further divide and rejoin to form a network of channels.

A delta is formed by a combination of two processes:

(i) Sediment is deposited when the load-bearing capacity of a river is reduced as a result of the check to its speed as it enters a sea or lake, and

(ii) At the same time fine clay particles carried in suspension in the river coagulate in the presence of salt water and are deposited. The finest particles are carried farthest to accumulate as bottom-set beds; coarser material is deposited in a series of steeply sloping wedges forming the forest beds; and the coarsest material is deposited on the braided surface of the delta as top set beds. (Fig)

The depositional motion of a flow is influenced by way of movement pace and the quantity of river load. The limit in flow speed reduces the transporting power of the streams which are forced to leave extra load to settle down. Increase in river load is effected via (1) accelerated charge of erosion in the supply or catchment areas consequent upon deforestation and consequently extend in the sediment load in the downstream part the rivers. (2) Supply of glacio fluvial materials (3) grant of extra sediment load with the aid of tributary streams (4) gradual increase in the sediment load of the streams due to rill and gully erosion.

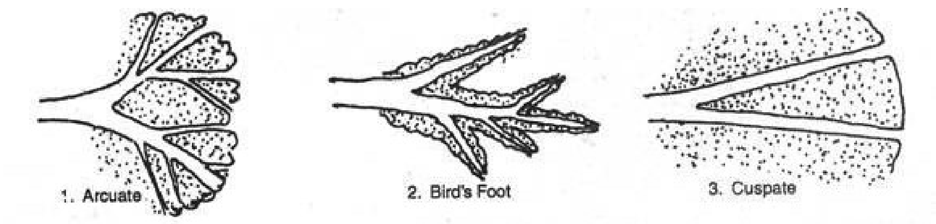
Depending on the conditions under which they are formed, deltas can be of many types.

1. Arcuate or Fan-shaped: This type of delta results when light depositions give rise to shallow, shifting distributaries and a general fan-shaped profile. Examples: Nile, Ganga, Indus.

2. Bird's Foot Delta: This type of delta emerges when limestone sediment deposits do not allow downward seepage of water. The distributaries seem to be flowing over projections of these deposits which appear as a bird's foot. The currents and tides are weak in such areas and the number of distributaries lesser as compared to an arcuate delta. Example: Mississippi river.

3. Estuaries: Sometimes the mouth of the river appears to be submerged. This may be due to a drowned valley because of a rise in sea level. Here fresh water and the saline water get mixed. When the river starts 'filling its mouth' with sediments, mud bars, marshes and plains seem to be developing in it. These are ideal sites for fisheries, ports and industries because estuaries provide access to deep water, especially if protected from currents and tides. Example: Hudson.

4. Cuspate Delta: This is a pointed delta formed generally along strong coasts and is subjected to strong wave action. There are very few or no distributaries in a cuspate delta. It has curved sides because of an even deposition of material on either side of the mouth. **Example:** Tiber river on west coast of Italy. (Fig.)



Different types of delta

Check your progress

Note: a) Space is given below for writing your answer
b) Compare your answer with one given at the end of this Unit

2. Briefly discuss about types of deltas.

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9.7.FLUVIAL CYCLE OF EROSION

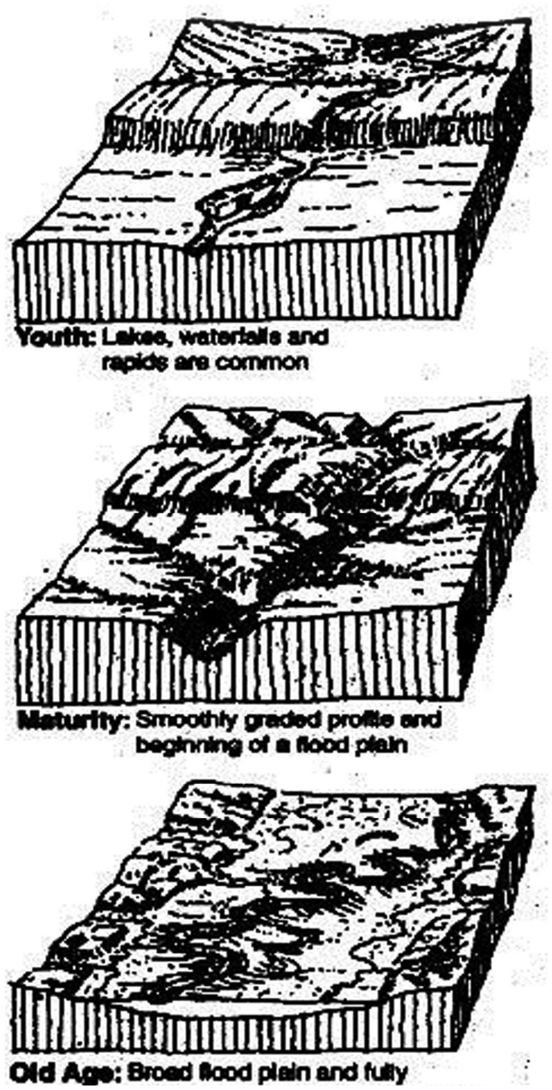
Three distinct stages of youth, maturity and old age can be identified during the lifetime of a stream.

Youth: A few consequent streams exist and a few subsequent streams are trying to develop valleys by random head ward erosion. These valleys may be "V shaped. The depth of these valleys depends on the height above sea level. The inter- stream divides are broad, extensive, irregular and may have lakes. Rapids, water-falls, gorges, river capture are characteristic features. Floodplain is generally absent, but may exist along the trunk stream. Overall, a highly uneven relief exists.

Maturity: This stage is marked by well- integrated drainage system with a few streams trying to adjust through softer beds. Broad valleys result from continuous horizontal erosion. Meanders are a characteristic feature and valley floor width is more than the meander belt width. The inter-stream divides are sharp and the upland is reduced. Rapids and waterfalls are absent.

Floodplain development is a prominent feature. Maximum relief exists overall.

Old Age: The streams are more numerous than in youth but less as compared to maturity. With increasing deposition valley broadening dominates. Meanders are highly developed with ox-bow lakes, and floor width is more than the meander belt width. The inter-stream divides are highly reduced. Lakes and marshes may be present. The successive floodplains join to form a pen plain. Delta formation is characteristic of old age at the mouth of the river. Mass wasting is dominant and, overall, minimum relief is evident. (Fig.).



Different stages in fluvial cycle of erosion

Check your progress

Note: a) Space is given below for writing your answer

b) Compare your answer with one given at the end of this Unit

3. What are the stages in the Fluvial Cycle of Erosion?

9.8 CHECK YOUR PROGRESS ANSWERS

1.Ox-Bow Lake: because of intensive erosion action, the outer curve of a meander gets accentuated to such an extent that the inner ends of the loop come close enough to get disconnected from the main channel and exist as independent water bodies. These water bodies are converted into swamps in due course of time. In the Indo-Gangetic plains, southwards shifting of Ganga has left many ox-bow lakes to the north of the present course of the Ganga.

2. Types of deltas: Arcuate or Fan-shaped; Bird’s Foot Delta: Estuaries and Cuspate Delta:

3. Three distinct stages of youth, maturity and old age can be identified during the lifetime of a stream.

9.9 MODEL EXAMINATION QUESTIONS

1) What is cycle of erosion?

2) What are the fluvial landforms?

3) What are potholes?

BLOCK - IV: GEOMORPHIC PROCESS - II

We know that the surface of the earth is not a plain platform. It is distributed unevenly with a variety of landforms like mountains, hills, plateaus, plains, ravines, cliffs etc. Why is the surface of the earth uneven? What make changes in the earth's surface? What process makes mountains and hills? The answer to all the questions above – Geomorphic Processes.

The formation and deformation of landforms on the surface of the earth are a continuous process which is due to the continuous influence of external and internal forces. The internal and external forces causing stresses and chemical action on earth materials and bringing about changes in the configuration of the surface of the earth are known as geomorphic processes.

The geomorphic process means **bringing about changes in the configuration of the Earth's surface, due to physical stresses and chemical actions on materials present on earth**. The physical and chemical action are due to endogenic and exogenic forces.

Endogenic forces are those internal forces which derive their strength from the earth's interior and play a crucial role in shaping the earth crust. Examples – mountain building forces, continent building forces, earthquakes, volcanism etc.

Exogenic forces are those forces which derive their strength from the earth's exterior or are originated within the earth's atmosphere. Examples of forces – the wind, waves, water etc. Weathering, mass wasting, erosion and deposition are exogenic geomorphic processes. These exogenic processes are dealt with in detail in this chapter.

The actions of exogenic forces result in wearing down (**degradation**) of relief/elevations and filling up (**aggradation**) of basins/ depressions, on the earth's surface. The phenomenon of wearing down of relief variations of the surface of the earth through erosion is known as **gradation**. Running water, groundwater, glaciers, the wind, waves, and currents, etc., can be called geomorphic agents.

This block have 3 units:

Unit 10: Aeolian Topography
Unit 11: Karts Topography
Unit 12: Glacial Topography

UNIT 10: AEOLIAN TOPOGRAPHY

Contents

10.0 Objectives
10.1 Introduction
10.2 Mechanism of Arid Erosion
10.3 Erosional Landforms: Rock Pedestal or Mushroom Rock
10.4 Depositional work of Wind
10.5 Summary
10.6 Check Your Progress – Model Answers
10.7 Model Examination Questions
10.8 Glossary
10.9 Further readings

10.0. OBJECTIVES:

At the end of this lesson you will be able to understand

- ❖ The formation and movement of Arid and desert landforms.
- ❖ The process of wind erosion and the landforms that wind erosion produces.
- ❖ The processes of Aeolian deposition.

10.1 INTRODUCTION

All the deserts are confined within the 15^0 to 30^0 parallels of latitude North or South at the equator. Deserts as a land area characterized by sparse and infrequent rainfall. Deserts can conveniently be classified into three kinds they are High-latitude deserts, Mid-latitude deserts and Low latitude deserts. The wind is the main geomorphic agent in the hot deserts. Winds in hot deserts have greater speed which causes erosional and depositional activities in the desert. The work of winds and water in eroding elevated uplands, transporting the worn-off materials and depositing them elsewhere, has given rise to five distinctive kinds of desert landscapes. The landforms which are created by erosional and depositional activities of wind are called as Aeolian Landforms.

10.2 MECHANISM OF ARID EROSION

Insufficient rainfall, very high temperature and rapid rate of evaporation. Sub aerial denudation – weathering, action of wind are the main factors of responsible for erosion. Wind erosion occurs in three ways viz. 1. Deflation 2. Abrasion or Sand blasting and 3. Attrition

Deflation is the process by which wind moves particles that are loose from one area to another.

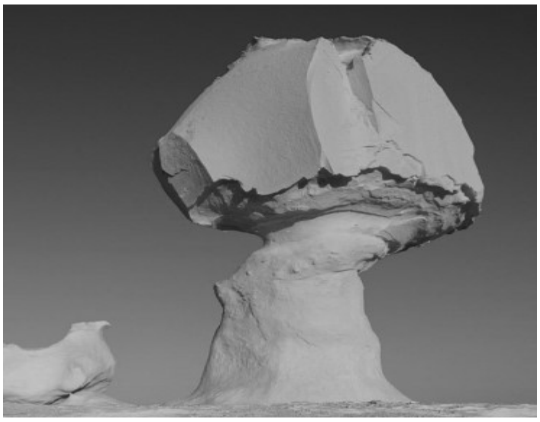
Abrasion is when an area is eroded directly by airborne particles blowing in the wind.

Attrition is the process of erosion that occurs during rock collision and transportation. The transportation of sediments chips and smooth's the surface of bedrock by water or water. In this process attrition responsible for turning boulders into smaller rocks and eventually to sand.

When the wind moves loose soil and dirt particles, this would be an example of deflation. When airborne particles cause landmass to wear away or erode, on the other hand, this is an example of abrasion.

10.3 EROSIONAL LANDFORMS: ROCK PEDESTAL OR MUSHROOM ROCK

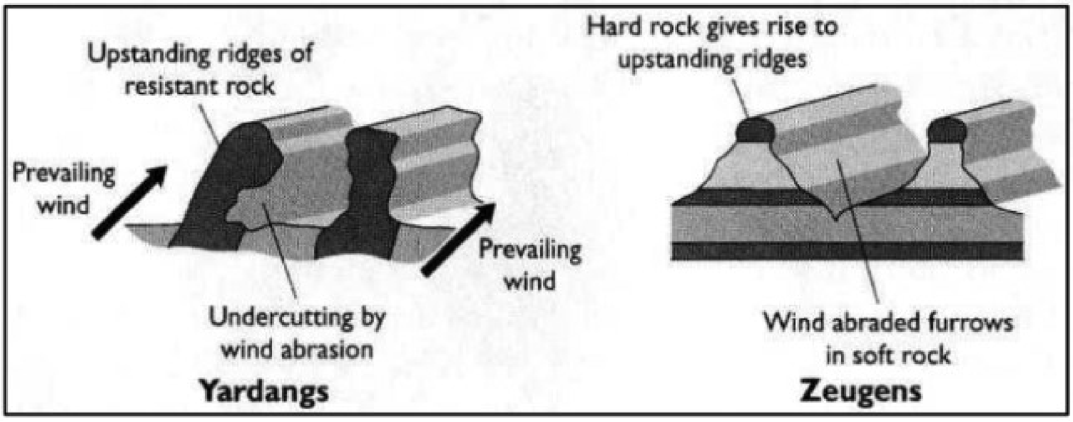
The rocks have broad upper portion in contrast to their narrow base where the friction is greatest and this process of under-cutting produces rocks of mushroom shape called mushroom rocks. They are the products of abrasion from all sides caused by variable directions of wind. **(Fig.)**



Mushroom Rock

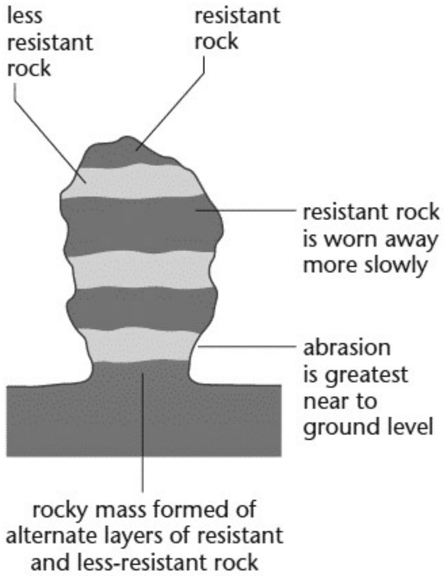
Zeugen: Wind abrasion turns a desert surface which a layer of resistant rock has underlain by a layer of weak rock into a 'ridge and furrow' landscape. The ridges are called Zeugen. Eventually, they are undercut and worn away (Fig.).

Yardang: When strata of resistant and weak rocks lie parallel to the prevailing winds, wind abrasion produces another type of 'ridge and furrow' landscape. The belts of resistant rock stand up as sloping ridges, varying in height from 5m to 15 m but having lengths of up to 1000m. These ridges are called Yardangs.



Yardangs and Zeugens

Inselbergs: Inselbergs are rising residual hills above the flat surfaces, in South Africa. Such residual hills and mounds of relatively resistant rocks in the arid regions are also called bornhardts.



Inselbergs

Transportation works of wind: wind transports the material through the mechanism of suspension, saltation and traction.

Check your progress

Note: a) Space is given below for writing your answer

b) Compare your answer with one given at the end of this Unit

1. Explain the various mechanism of wind erosion?

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2. Differentiate between the Yardang and Zeugen

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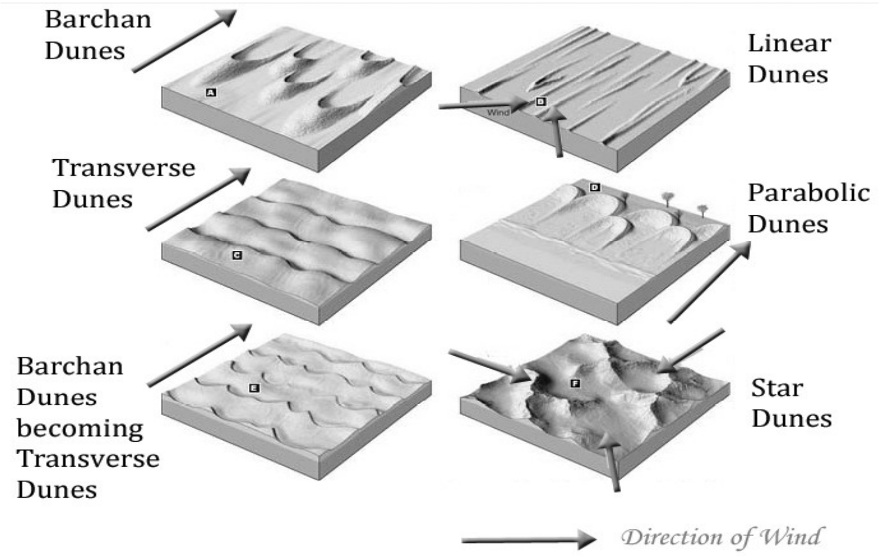
10.4 DEPOSITIONAL WORK OF WIND

After erosion, transportation, there will be deposition of materials in situ. Those landforms namely sand dunes, Loess and etc. will be explained.

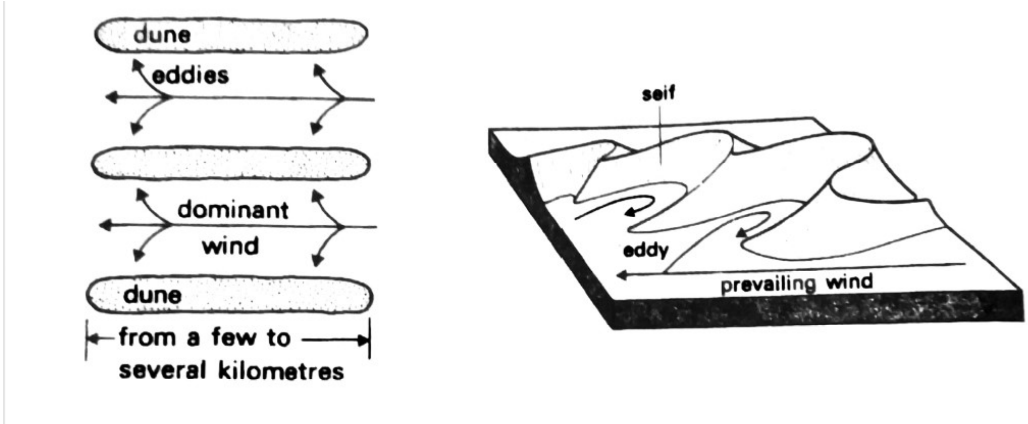
Sand dunes: heaps or mounds of sand are generally called sand dunes. Formation of sand dunes requires abundance of sand, high velocity wind, huge quantity of sand may blow and transported to form dunes. Obstacles of trees, bushes and forest etc., Suitable places for the accumulation of sands. Sand dunes can be classified into following types Head Dunes, Tail dunes, longitudinal dunes, transverse dunes, star dunes and pyramidal dunes. However, the following two types of common dunes, Barchans and Seifs.

Barchans: These are crescentric or moon shaped dunes which occur individually or in groups. These are initiated probably by a chance accumulation of sand at an obstacle, such as patch of grass or heap of rocks. The migration of the barchans may be a threat to desert life for they may encroach on an Oasis burying palm trees or houses.



Types of Dunes

Seifs is an Arabic word meaning 'Sword'. They are long, narrow ridges of sand, often over an hundred miles long lying parallel to the direction of the prevailing winds.



Loess: The fine dust blown beyond the desert limits is deposited on neighbouring lands as Loess.

Check your progress

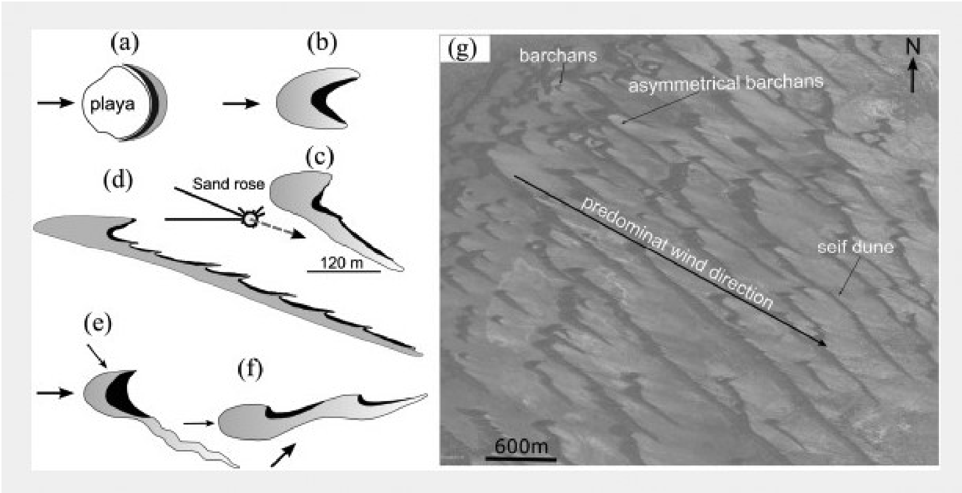
Note: a) Space is given below for writing your answer

b) Compare your answer with .one given at the end of this Unit

3. Give an account on Barchans?

Landforms due to water action in desert:

Playa when rainwater percolates in porous areas composed of pebbles and cobbles and seeps underground. A lake is formed whenever a depression exists; such lakes are called playa lakes



Bolson: if the rivers of an extensive desert surrounded by a mountain bring sediment in times of floods towards the lower portion of the desert, the floor of the basin is filled up with aluminum, such basins are called bolsons.

10.5 SUMMARY

Deflation, abrasion and attrition are three ways of wind erosion in arid topography. Rock Pedastral, Zeugen, Yardang, inselbergs are some of erosional landforms, sand dunes, Barchans, Bajadas, playas, Basins are the depositional landforms in arid topography.

10.6 CHECK YOUR PROGRESS - MODEL ANSWERS

1. Ans Deflation, Abrasion and attrition are the main wind erosion process in deserts which is characteristics of High temperature, insufficient rainfall, rapid rate evaporation and etc.

2. Wind abrasion produces 'ridge and furrows' landscape where strata of resistant and weak rocks lie parallel to the prevailing winds. The resistant rock stand up as sloping ridges these ridges are called Yardangs. Wind abraded furrows in soft rock are called Zeugens.

3. The word Barchans comes from Russian word "Barchans". It is a U-shaped type of sand dune that consists of horns or tips that point downwind or against the wind the face of a barchan is a very steep, extending further backward and meeting the desert floor. And generally crescent shape called barchans. These are up to 100 feet high.

10.7 MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each

1. Explain the main landforms formed by wind action with a neat diagrams

2. Discuss the depositional landforms of Aeolian topography.

II. Answer the following questions in about 10 lines each

1. Explain the Characteristics deserts

2. Explain about on erosional landforms of produced by wind.

10.8 GLOSSARY

Rock Pedastral: A rock pedestal is a typical mushroom shaped landform that is formed by the action of wind. Hard rocks are arranged horizontally over a soft rock resulting in such erosion by abrasion is called rock pedestal.

Yardangs: elongated grooves or furrows which are carved from relatively weak materials and are formed in the direction of the wind. These are mainly caused by sand blasting called abrasion.

Sand dunes: These are large mounds of sand. They occur in variety of shapes, depending on the wind direction and velocity.

10.9 FURTHER READINGS

Certificate Physical and Human Geography, by Gohchengleong

Physical geography by Savindra Singh

Fundamentals of Physical Geography 5th Ed. by Husain Majid (Author)

UNIT 11: KARST TOPOGRAPHY

Contents

11.0 Objectives
11.1 Introduction
11.2 Karst Topography
11.3 Erosional Landforms
11.4 Depositional Landforms
11.5 Summary
11.6 Check Your Progress – Model Answers
11.7 Model Examination Questions
11.8 Glossary
11.9 Further reading

11.0 OBJECTIVES

At the end of this lesson you will be able to

- ❖ Know the conditions for formation of Karst landforms.
- ❖ Understand the process of underground water erosion and the formation of various erosional landforms.
- ❖ Know the formation of karst deposition.

11.1 INTRODUCTION

Karst topography is named after the typical topography developed in limestone rocks of Karst region in the Balkans adjacent to the Adriatic Sea. Karst topography includes typical landforms in any limestone or dolomitic region, produced by the action of groundwater through the processes of solution and deposition. Limestone is made up of calcite or calcium carbonate but where magnesium is also present it is termed as dolomite.

Conditions for the formation of Karst Topography

- A region with a large stretch of water-soluble rocks such as limestone at the surface or sub-surface level
- Limestone's should not be porous
- These rocks should be dense, thinly bedded and well jointed
- A perennial source of water and a low water table to allow the formation of conspicuous features.
- Moderate to abundant rainfall to cause the solvent action of water i.e. solution of rocks

11.2 MECHANISM FOR THE FORMATION OF KARST TOPOGRAPHY

Water falls as rain or snow and soaks into the soil. The water becomes weakly acidic because it reacts chemically with carbon dioxide that occurs naturally in the atmosphere and the soil. This acid is named carbonic acid and is the same compound that makes carbonated beverages taste tangy. Rainwater seeps downward through the soil and through fractures in the rock responding to the force of gravity. The carbonic acid in the moving ground water dissolves the bedrock along the surfaces of joints, fractures and bedding planes, eventually forming cave passages and caverns.

Cracks and joints that interconnect in the soil and bedrock allow the water to reach a zone below the surface of the land where all the fractures and void spaces are completely filled (also known as saturated) with water. This water-rich zone is called the saturated zone and its upper surface is called the **water table.**

11.3 EROSIONAL LANDFORMS

Karst landforms created by downward movement of water accompanied by dissolution of rock and mass transport of sediments in stream channels. In tropical areas with thick massive limestone's, a remarkable and distinctive landscape of jagged hills and narrow gorges completely dominates the landscape. Movement of solution along fractures and joints etches the bedrock and leaves limestone blocks as isolated spires or pinnacles. Pinnacles range from small features a few inches tall to intermediate forms a few feet tall to large pinnacles hundreds of feet tall. Besides the etching of pinnacles and residual hills, sheets of flowing water move down sloping surfaces creating a variety of etched surface features.

Doline karst is the most widely distributed type of karst landscape. The landscape is dotted with sinkholes (dolines) which can vary widely in number and size.

Sink Holes: A sinkhole is a surface depression in a region of limestone. They develop where the limestone is more susceptible to solution, weathering or where an underground cover near the surface has collapsed. For the Sinkhole Plain in central Kentucky, there are approximately 5.4 sinkholes per square kilometer over a 153 square kilometer area.

Swallow Holes: They are cylindrical in shape lying underneath the sinkholes at some depth. In limestone regions, the surface streams often enter the sinkholes and then disappear underground through swallow holes. It is so, because these holes are connected to the underground caverns on their other side.

When a number of swallow holes coalesce, a larger hollow is formed and is called a Doline. Several dolines may merge as a result of subsidence (gradual caving) to form an even larger depression called an Uvala. A single Uvala typically contains numerous sinkholes within it. In Yugoslavia, some very large depressions called Polje, may be as large as 100 square miles, but produced partly due to faulting.

Caverns: Caverns are interconnected subterranean cavities in bedrock formed by the corrosions action of circulating underground water on limestone. They are found near Dehradun in Uttarakhand and in Almora in Kumaon Himalayas. The caves of Kotamsar in the tribal district of Bastar in Chhattisgarh are famous caverns of India.

Check your progress

Note :a) Space is given below for writing your answer
b) Compare your answer with one given at the end of this Unit

1. Explain the characteristics of Karst Topography?

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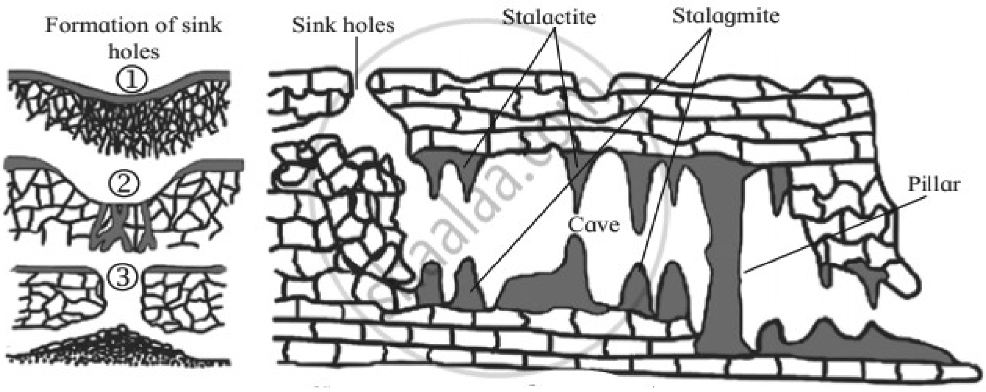
11.4 DEPOSITIONAL LANDFORMS

They are the major depositional features formed in the caverns in limestone regions. The water containing limestone in solution, seeps through the roofs of the caverns in the form of a continuous chain of drops. A portion of the water dropping from the ceiling gets evaporated and a small deposit of limestone is left behind on the roof. This process continues and deposit of limestone grows downwards like pillars. These beautiful forms are called stalactites.

When the remaining portion of the water dropping from the roof of the cavern falls on the floor, a part of it is again evaporated and a small deposit of limestone is left behind. This deposit grows upward from the floor of the cavern. These type of depositional features are called stalagmites. As the process grows, both stalactite and stalagmite often join together to form vertical columns in the caverns.

Dripstones: The calcareous deposits from dripping of water in dry caves are called dripstones. Beside this, all types of deposits in the caverns are collectively called speleothems of which calcite is the common constituent.

Drapes: Numerous needle-shaped dripstones hanging from the cave ceiling are called drapes or curtains.



Check your progress

Note :a) Space is given below for writing your answer
b) Compare your answer with one given at the end of this Unit

2. Explain the depositional landforms of Karst topography?

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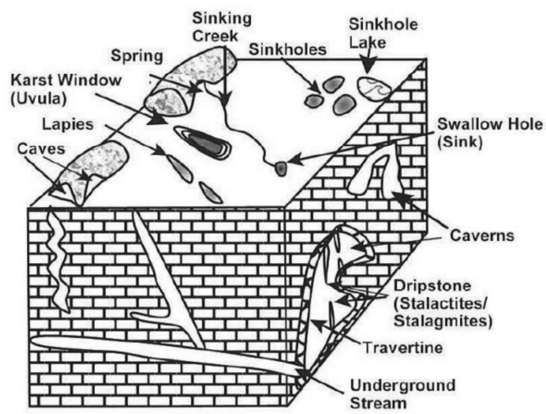


Flowstones: Floor deposits caused by seepage water and water flowing out of stalagmites are called flowstones.

Travertines: Banded calcareous deposits are called travertines whereas the calcareous deposits, softer than travertine, at the mouth of the caves are called tufa or calc-tufa.

11.5 SUMMARY

This is a type of landscape that forms when water dissolves and erodes soft rock (like limestone) and leaves landscapes behind such as caves, surface sinkholes, and tall, steep rock cliffs. The rock itself may be worn away from the surface by rainwater, or it may be eroded from the inside. The depositional landforms of karst topography are stalactites and stalagmites.

11.6 CHECK YOUR PROGRESS - MODEL ANSWERS

1. Karst is a type of landscape where the dissolving of the bedrock has created sinkholes, sinking streams, caves, springs, and other characteristic features. Karst is associated with soluble rock types such as limestone, marble, and gypsum. In general, a typical karst landscape forms when much of the water falling on the surface interacts with and enters the subsurface through cracks, fractures, and holes that have been dissolved into the bedrock. After traveling underground, sometimes for long distances, this water is then discharged from springs, many of which are cave entrances. When the water dropping from roof of the cavern falls on the floor, a part of it evaporated and small deposit of of limestone this type of depositional features are called stalagmites and stalagmites

2. Depositional characteristic features of karst topography are stalactite, stalagmites and columns. A portion of the roof hangs on the roof and on evaporation of water, a small deposit of limestone is left behind contributing to the formation of a stalactite, growing downwards from the roof. The remaining portion of the drop falls to the floor. This also evaporates, leaving behind a small deposit of limestone aiding the formation of a stalagmite, thicker and flatter, rising upwards from the floor and sometimes, stalactite and stalagmite join together to form a complete pillar known as the column.

11.7 MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each

1. What are the suitable conditions for Karst formation?
2. How erosion takes place in Karst region

II. Answer the following questions in about 10 lines each

3. Give an account on Sink holes and caverns
4. Explain the Difference between stalactites and stalagmites

11.8 GLOSSARY

Columns: Stalactite and stalagmite join together to form a complete pillar known as the column.

Doline When a number of swallow holes coalesce, a larger hollow is formed & is called a Doline

Karst topography: Karst is a topography formed from the dissolution of soluble rocks such as limestone, dolomite, and gypsum. It is characterized by underground drainage systems with **sinkholes and caves.**

Stalactite: The columns of dripstones hanging from the cave ceiling are called stalactites.

Stalagmite: The calcareous columns of dripstones growing upward from the cave floor are known as stalagmites. Pillars/Columns: When stalactites and stalagmites meet together, they form pillars/columns.

Uvala: Several dolines may merge as a result of subsidence (gradual caving) to form an even larger depression called an.

11.9 FURTHER READINGS

Certificate Physical and Human Geography, by Goh Cheng Leong

Physical Geography by Savindra Singh

Fundamentals of Physical Geography 5th Ed. by Husain Majid (Author)

UNIT 12: GLACIAL TOPOGRAPHY

Contents

12.0 Objectives

12.1 Introduction

12.2 Glacial Types

12.3 Erosional Glacial Landforms

12.4 Depositional Glacial Landforms

12.5 Summary

12.6 Check Your Progress – Model Answers

12.7 Model Examination Questions

12.8 Glossary

12.9 Further reading

12.0 OBJECTIVES

At the end of this lesson you will be able to understand

- ❖ The formation and movement of glaciers.
- ❖ The types of Glaciers.
- ❖ The process of glacial erosion and the landforms that glacial erosion produces.
- ❖ The processes of glacial deposition.

12.1 GLACIAL LANDFORMS

A glacier is a moving mass of ice. The conditions necessary to form a glacier are (a) Cold local climate (polar latitudes or high elevation). (b) Snow must be abundant; more snow must fall than melts, and (c) snow must not be removed by avalanches or wind. Glaciers can only form at latitudes or elevations above the ***snowline***, which is the elevation above which snow can form and remain.

12.2 TYPES OF GLACIERS

Glaciers are classified as Continental glaciers, ice caps, piedmont glaciers and valley glaciers.

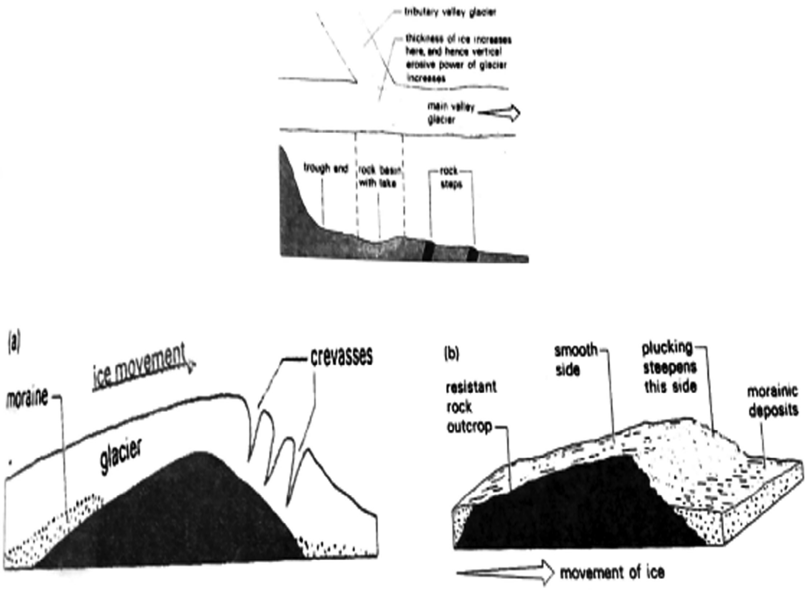
1) Continental glaciers are the largest types of glaciers on Earth. They cover large areas of the land surface, including mountain areas. Modern ice sheets cover Greenland and Antarctica. These two ice sheets comprise about 95% of all glacial ice currently on Earth.

2) Ice shelves are sheets of ice floating on water and attached to land. They usually occupy coastal embayments, may extend hundreds of km from land and reach thicknesses of 1000 m.

3) Piedmont glaciers occur when steep valley glaciers flow onto relatively flat plains, where they spread out into fan or bulb shapes (lobes). The Malaspina Glacier in Alaska is the largest piedmont glacier in the world.

4) The valley glaciers, also known as Alpine glaciers, are found in higher regions of the Himalayas in our country and all such high mountain ranges of the world. The largest of Indian glaciers occur in the Karakoram Range, viz. **Siachen (72 km),** while Gangotri in Uttar Pradesh (Himalayas) is 25.5 km long.

A glacier is charged with **rock debris** which are used for erosional activity by moving ice and it creates various landforms which may be classified into erosional and depositional landforms. Erosion by glaciers is tremendous because of friction caused by sheer weight of the ice. The material plucked from land by glaciers get dragged along the floors or sides of the valleys and cause great damage through abrasion and plucking. Glacial can cause significant damage to even un-weathered rocks and can reduce high mountains into low hills and plains.



Mechanism of erosion of Glacier

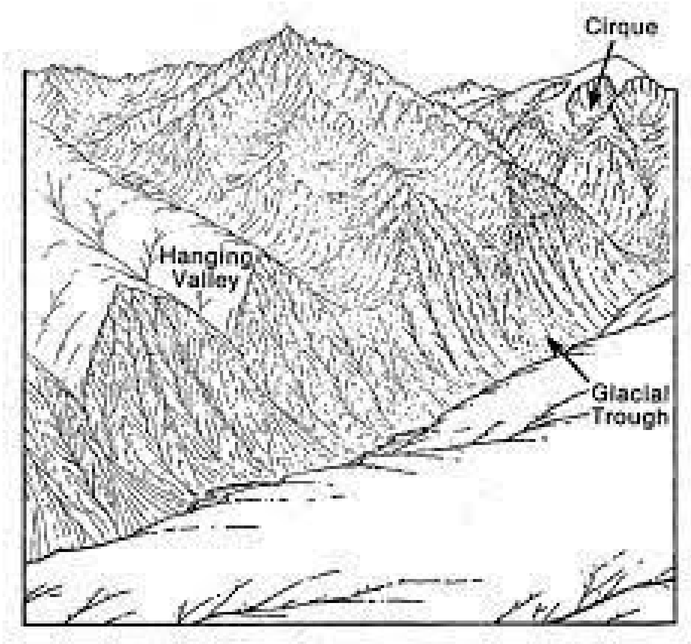
As glaciers flow downhill from mountains to the lowlands, they erode, transport, and deposit materials, forming a great array of glacial landforms.

12.3 EROSIONAL GLACIAL LANDFORMS

Cirque or Corris: a bowl-shaped depression formed near-mountain top ridges where snow accumulates and forms the head of an alpine glacier due to the erosional activity of glaciers (Figure). They are deep, long and wide troughs or basins with very steep concave to vertically dropping high walls at its head as well as sides. When these depressions are filled with water, they are called as **Cirque Lake or Corrie Lake or Tarn Lakes**.

Glacial trough: Glacial mass is heavy and areas moving, erosional activity is uniform – horizontally as well as vertically. A steep sided and flat bottomed valley results, which has a 'U' shaped profile.

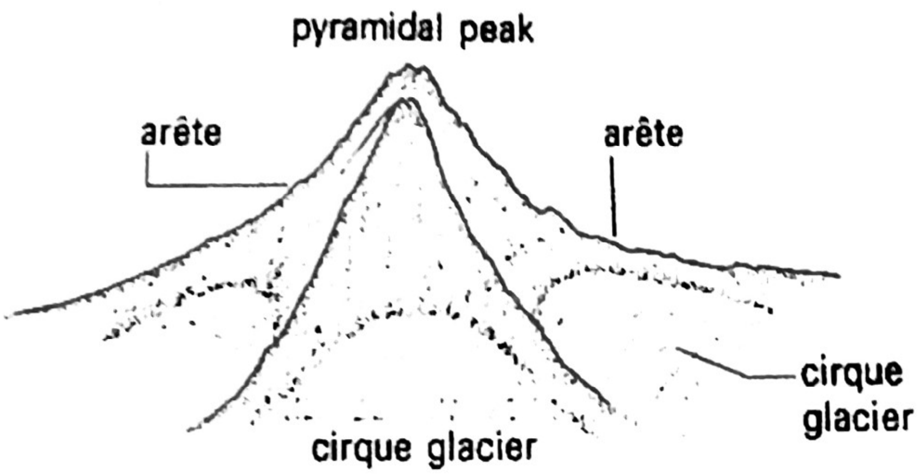
Hanging valley: Formed when smaller tributaries are unable to cut as deeply as bigger ones and remain 'hanging' at higher levels than the main valley as **discordant tributaries**. Hanging valleys are revealed when the glacier melts.



Cirque, Hanging valley and Glacial Trough

Horns and Aretes: Ridge that acquires a 'horn' shape when the glacial activity cuts it from more than two sides**.** These are formed by head ward erosion of cirque wall.

Arete : Steep-sided, sharp-tipped summit with the glacial activity cutting into it from **two** cirque walls gets narrow, it results in A**rete (**Figure**)** .



Arete

Check your progress

Note: a) Space is given below for writing your answer
b) Compare your answer with one given at the end of this Unit

1. Give an account on Tarn Lake?

U-shaped Valleys, Fjords/fiords: These valleys, which are formed by the glacial erosions assume the shape of letter 'U' and hence are called as U-shaped Valleys

Fjords: Steep-sided narrow entrance-like feature at the coast where the stream meets the coast. Fjords are common in Norway, Greenland and New Zealand. These are formed when a glacier cuts a U-shaped valley by ice segregation and abrasion of the surrounding bedrock and this valley gradually gets filled with the seawater (formed in mountains nearby sea).

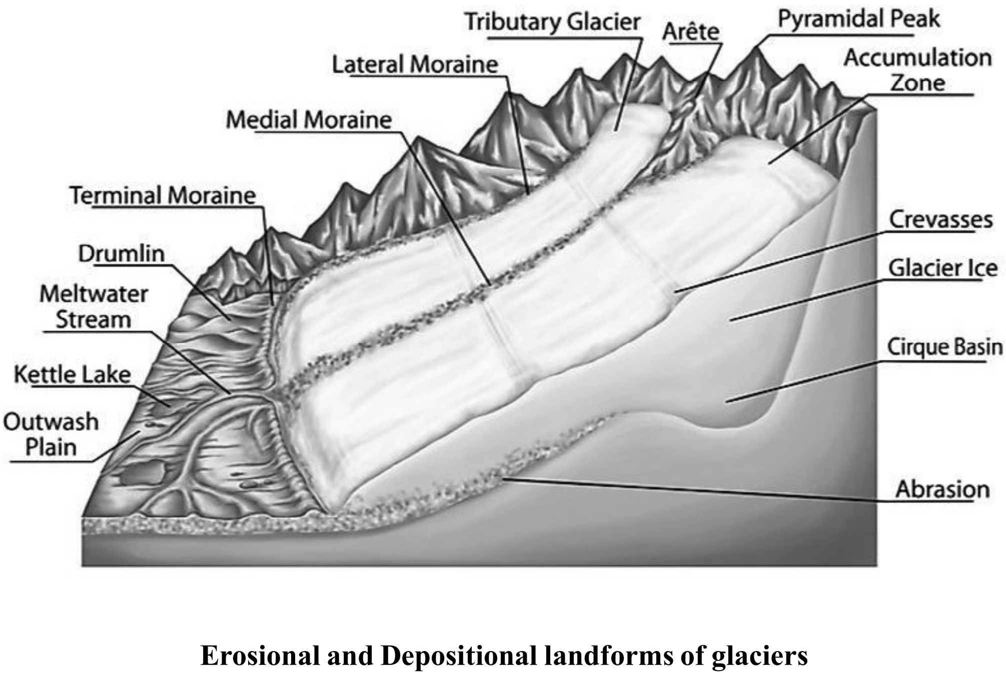
As the glacier continue to move, debris gets removed, divides get lowered and eventually the slope is reduced to such an extent that glaciers will stop moving leaving only a mass of low hills and outwash plains along with the depositional landforms.

12.4 DEPOSITIONAL GLACIAL LANDFORMS

Outwash plain: When the glacier reaches its lowest point and melts, it leaves behind a stratified deposition material, consisting of rock debris, clay, sand, gravel etc. This layered surface is called till plain or an outwash plain (Fig.).

Eskers: When glaciers melt in summer, the water which formed as a result of melting accumulates beneath the glacier and flows like streams in channels beneath that ice. Very coarse material like boulders, blocks and some minor fractions of rock debris are carried away by these streams. They later get deposited in the valleys itself and once the ice melts completely, they are visible to the surface as sinuous ridges. These ridges are called as Eskers. The eskers resemble the features of an embankment and are often used for making roads.

Kame Terraces: Broken ridges or un-assorted depositions looking like hump in a till plain.



Erosional and Depositional landforms of glaciers

Drumlins: Large glaciers and ice sheets can deposit great swathes of sands and gravels, forming, smooth oval-shaped ridge-like structures composed mainly of swarms of hills called drumlins (Figure)

Moraines: General term applied to rock fragments, gravel, sand, etc. carried by a glacier. Depending on its position, the moraine can be ground moraine and end moraine. Moraines are long ridges of deposits of glacial till (rock fragments, gravel, sand, etc) as the glacier melts. When these deposits are at the end of a glacier, they are called as **Terminal moraines** and when they are deposited on both sides, they are called as **Lateral moraines**. When lateral moraines of two glaciers join together, they form **Medial moraines** (Figure 12.4). When the lateral moraines of both sides of a glacier join together, it forms a horse-shoe shape. Ground moraines are deposits left behind in areas once covered by glaciers.

Check your progress

Note: a) Space is given below for writing your answer
b) Compare your answer with one given at the end of this Unit

2. Discuss about Eskers?

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3. Explain types of Moraines?

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12. 5 SUMMARY

In the processes of movement of glacier, the material plucked from land glaciers fragments are dragged along the floors sides of the valleys causing erosional landforms like Cirques, Hanging valleys, Arete, Fjords As glaciers continue to move, debris get removed, divides get lowered and eventually the slope is reduced and finally deposition landforms like moraines, Eskers, outwash plains and drumlins are formed.

12.6 CHECK YOUR PROGRESS ANSWERS

1. They are deep, long and wide troughs or basins with very steep concave to vertically dropping high walls at its head as well as sides. When these depressions are filled with water, they are called as Cirque Lake or Corrie Lake or Tarn Lakes.

2. Eskers are long, narrow and sinous ridges of sands and gravels and are situated in the middle of ground moraines and extend for kilometres in length. The sides of eskers are very steep. They vary in height and width ranging from a few meters to tens of meters

3. Moraines are generally divided into 4 main categories on the basis of locational aspect of glacial deposits. Viz 1. Terminal moraines, 2. Lateral moraines, 3. Medial moraines and 4. Ground moraines.

12.7 MODEL EXAMINATION QUESTIONS

I answer the following in about 30 lines each

1. Explain the process of erosional landforms formed by glacial.
2. Discuss the depositional landform process of glaciers.

II. Answer the following in about 10 lines each

1. Write about the different types of glaciers.
2. Give an account on Moraines?

12.8 GLOSSARY

Cirque: the arm chair shaped steep walled depression representing a glaciated valley head is called cirque

Drumlins: the swarns or clusters of rounded hummocks resulting from the deposition of glacial till are called drumlins .which looks like inverted boat or spoon.

Kames: are small hills or irregular mounds of bedded sands and gravels which are deposited by melt water near edge of retreating ice sheets. Kames are classified into cone kames and delta kames.

12.9 FURTHER READINGS

Certificate Physical and Human Geography, by Goh Cheng Leong

Physical Geography by Savindra Singh

Fundamentals of Physical Geography 5th Ed. by Husain Majid (Author)

BLOCK - V: ELEMENTS OF MAPPING

The units in the block will focus on map elements and design principles. The cartographic process will be covered which explains why one would want to create a map and for what purpose. The units will identify and explain elements that should be considered and added when creating a quality map. Cartographer will outline and to aid in understanding how to organize a map. The units concludes with an example maps which highlights issues and identifies solutions to make the map sound.

Unit 13: Introduction to Maps

Unit 14: Elements and Characteristics of Maps

Unit 15: Types of Maps

UNIT-13: INTRODUCTION TO MAPS

Contents

13.0 Introduction
13.1 History of map making
13.2 Why people need Maps?
13.3 Essentials of map making
13.4 Importance and Uses of Maps
13.5 Check your progress Answers
13.6 Model Examination questions
13.7 Further Readings

13.0 INTRODUCTION

You may be familiar with maps that you have seen in most of your books of social sciences representing the earth or any of its parts. You may also know that the shape of the earth is geoid (three-dimensional) and a globe can best represent it (Fig. 1).

A **map** can be simply defined as a graphic representation of the real world. This representation is always an abstraction of reality. Because of the infinite nature of our Universe it is impossible to capture all of the complexity found in the real world. For example, topographic maps abstract the three-dimensional real world at a reduced scale on a two-dimensional plane of paper.

A map, is a simplified depiction of whole or part of the earth on a piece of paper. In other words, it is a two-dimensional form of the three-dimensional earth. Hence, a map can be drawn using a system of map projections. As it is impossible to represent all features of the earth's surface in their true size and form, a map is drawn at a reduced scale. Hence, maps are drawn at a scale and projection so that each point on the paper corresponds to the actual ground position. Besides, the representation of different features is also simplified using symbols, colours and shades. A map is, therefore, defined as selective, symbolized and generalized representation of whole or a part of the earth's surface on a plane surface at a reduced scale. It may also be understood that a simple network of lines and polygons without a scale shall not be called a map. It is only referred to as "the sketch". In the present chapter, we will study the essential requirements of maps, their types and the uses.

India as it is seen on the globe

How this lesson relates to the geographic themes

Location—where things are—is the most fundamental geographic concept.

The first task in geography is to locate places. Maps are the tools students need to accomplish this task. This lesson also helps students understand that there are many different kinds of maps.

Place—-physical and human characteristics— is another key concept in geography. All places on Earth have distinctive characteristics that give them meaning and character, and that help distinguish them from other places.

As students learn about Salt Lake City, a city near both a lake and mountains, they will start to understand that physical characteristics make a place unique.

Geography involves not only learning the location of places, but analyzing *why* the place is there: the interaction of physical, climatic, economic, and historical factors. Spatial analysis is the cornerstone of geography, and maps are the principal tools in performing that analysis.

Maps are a 2-D representation of a 3-D world. They are a 'bird's eye' view – as if the viewer is 'flying' above the land surface and looking down on it. They show how objects are distributed and their relative size. Maps are a very useful way of visualizing all sorts of data and they are a key tool.

Maps are everywhere—on the Internet, in your car, and even on your mobile phone. Moreover, maps of the twenty-first century are not just paper diagrams folded like an accordion. Maps today are colorful, searchable, interactive, and shared. This transformation of the static map into dynamic and interactive multimedia reflects the integration of technological innovation and vast amounts of geographic data. The key technology behind this integration, and subsequently the maps of the twenty-first century, is *geographic information systems* or GIS.

Put simply, GIS is a special type of information technology that integrates data and information from various sources as maps. It is through this integration and mapping that the question of "where" has taken on new meaning. From getting directions to a new restaurant on your mobile device to exploring what will happen to coastal cities if oceans were to rise due to global warming, GIS provides insights into daily tasks and the big challenges of the future.

Essentials of Geographic Information Systems integrates key concepts behind the technology with practical concerns and real-world applications. Recognizing that many potential GIS users are non-specialists or may only need a few maps. In today's world, learning involves knowing how and where to search for information. In some respects, knowing where to look for answers and information is arguably just as important as the knowledge itself. Because *Essentials of Geographic Information Systems* is concise, focused, and directed, readers are encouraged to search for supplementary information and to follow up on specific topics of interest on their own when necessary.

Maps are used to display both cultural and physical features of the environment. Standard **topographic maps** show a variety of information including roads, land-use classification, elevation, rivers and other water bodies, political boundaries, and the identification of houses and other types of buildings. Some maps are created with very specific goals in mind. The intended purpose of this map is considerably more specialized than a topographic map.

A map is the fundamental tool of the geographer. With a map, one can illustrate the spatial distribution (i.e., geographic pattern) of almost any kind of phenomena. Maps provide a wealth of information. The information collected to create a map is called spatial data. Any object or characteristic that has a location can be considered spatial data.

Maps can depict two kinds of data. Qualitative map data is in the form of a quality and expresses the presence or absence of the subject on a map, like the kind of vegetation present occupying a region. Quantitative map data is expressed as a numerical value, like elevation in meters, or temperature is degrees Celsius. There are many different kinds of maps that serve quite different purposes. A map is a conventional representation of the earth (whole or part of it) drawn to scale on a flat surface.

The art of map construction is called **cartography**. People who work in this field of knowledge are called cartographers. The construction and use of maps has a long history. Some academics believe that the earliest maps date back to the fifth or sixth century BC. Even in these early maps, the main goal of this tool was to communicate information. Early maps were quite subjective in their presentation of spatial information. Maps became more objective with the dawn of Western science. The application of **scientific method** into cartography made maps more ordered and accurate. Today, the art of map making is quite a sophisticated science employing methods from cartography, engineering, computer science, mathematics, and psychology.

Cartographers classify maps into two broad categories: **reference maps** and **thematic maps**. Reference maps normally show natural and human-made objects from the geographical environment with an emphasis on location. Examples of general reference maps include maps found in atlases and topographic maps. Thematic maps are used to display the geographical distribution of one phenomenon or the spatial associations that occur between a numbers of phenomena.

Check your progress

Note: a) Space is given below for writing your answer

b) Compare your answer with one given at the end of this Unit

1. Defne Map.

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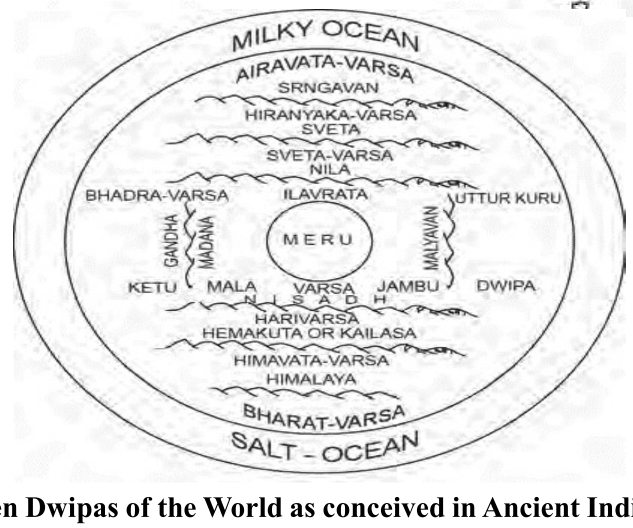
13.1 HISTORY OF MAP MAKING

People have been making maps or pictures of places for a very long time, purposes that were different than maps today. The earliest maps were carved on rocks and they illustrated beliefs and rituals connected with wider cosmologies.

The history of map making is as old as the history of mankind itself. The oldest map was found in Mesopotamia drawn on a clay tablet that belongs to 2,500 B.C. Figure 1.4 shows Ptolemy's Map of the World. Greek and the Arab geographers laid the foundation of modern cartography. The measurement of the circumference of the Earth and the use of the system of geographical coordinates in map-making are some of the significant contributions of the Greeks and the Arabs. The art and science of map making was revitalized in early modern period, with extensive efforts made to minimize the effects of the transformation of the geoid onto a plane surface. The maps were drawn on different projections to obtain true directions, correct distances and to measure area accurately. The aerial photography supplemented the ground method of survey and the uses of aerial photographs stimulated map-making in the nineteenth and twentieth centuries.

Babylonian clay tablet world map, 600 B.C

The foundation of map-making in India was laid during the Vedic period when the expressions of astronomical truths and cosmological revelations were made. The expressions were crystallized into 'sidhantas' or laws in classical treaties of Arya Bhatta, Varahamihira and Bhaskara, and others. Ancient Indian scholars divided the known world into seven 'dwipas' (Fig.). Mahabharata conceived a round world surrounded by water (Fig).



Seven Dwipas of the World as conceived in Ancient India

Todarmal pioneered land surveying and map-making as an integral part of the revenue collection procedure. Besides, Sher Shah Suri's revenue maps further enriched the mapping techniques during the medieval period. The intensive topographical surveys for the preparation of up–to–date maps of the entire country, were taken up with the setting up of the Survey of India in 1767, which culminated with the map of Hindustan in 1785. Today, the Survey of India produces maps at different scales for the entire country.

Check your progress

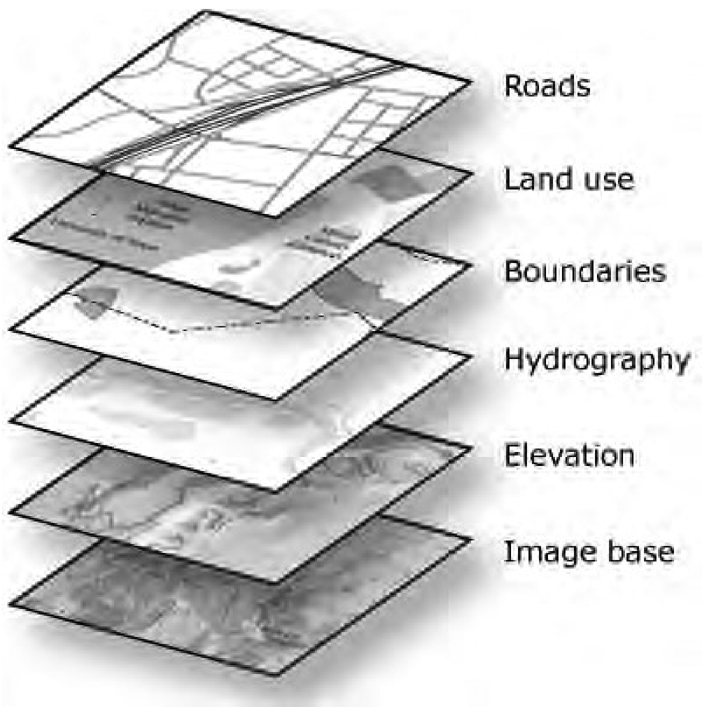
Note: a) Space is given below for writing your answer

b) Compare your answer with one given at the end of this Unit

2. Where the first map discovered and when?

13.2 WHY PEOPLE NEED MAPS?

As nations expanded military ventures demanded, the need for maps became more evident. Maps are used as tools for planning (i.e. dams, highways, urban development). To help us find our way to different areas. Show us where major places. To Show us distribution of resources. And bring out relationship amongst geographic elements.



13.3 ESSENTIALS OF MAP MAKING

The cartographic process is the process you should follow when you want to go from having unmapped data to a map formed by the data. The cartographic process is not a rigid processing you need to follow step-by-step, however, it is a recommended set of steps that you should follow in order to properly create a map.

The Cartographic process is composed of five steps. Step one is to define purpose and meaning of the map. Step two is to choose the scale of the map. The third step is to determine the map format, printing limitations you may have, and the economics of production and reproduction of the map. Step four is to abstract and generalize the data. And finally step five is to design the layout of the map.

In view of the variety of maps, we may find it difficult to summarize what they all have in common. Cartography, being an art and science of map-making, does include a series of processes that are common to all the maps. Designing a map is often a dynamic and iterative process which requires you to bounce back and forth between steps in order to produce a cartographically sound map. We will now go over each one of the five steps in the cartographic process in more detail.

These processes that may also be referred to as essentials of maps are: Scale; Map Projection; Map Generalization; Map Design; Map Construction and Production

Map Scale: We know that all maps are reductions. The first decision that a map-maker has to take is about the scale of the map. The choice of scale is of utmost importance. The scale of a map sets limits of information contents and the degree of reality with which it can be delineated on the map.

Maps are rarely drawn at the same scale as the real world. Most maps are made at a scale that is much smaller than the area of the actual surface being depicted. The amount of reduction that has taken place is normally identified somewhere on the map. This measurement is commonly referred to as the **map scale**. Conceptually, we can think of map scale as the ratio between the distances between any two points on the map compared to the actual ground distance represented.

Projection: Representing the true shape of the Earth's surface on a map creates some problems, especially when this depiction is illustrated on a two-dimensional surface. To overcome these problems, cartographers have developed a number of standardized transformation processes for the creation of two-dimensional maps. All of these transformation processes create some type of distortion artifact. The nature of this distortion is related to how the transformation process modifies specific geographic properties of the map. Some of the geographic properties affected by projection distortion include: distance; area; straight line direction between points on the Earth; and the bearing of cardinal points from locations on our planet.

We also know that maps are a simplified representation of the three-dimensional surface of the earth on a plane sheet of paper. The transformation of all-side-curved-geoidal surface into a plane surface is another important aspect of the cartographic process. We should know that such a radical transformation introduces some unavoidable changes in directions, distances, areas and shapes from the way they appear on a geoid. A system of transformation of the spherical surface to the plane surface is called a map projection. Hence, the choice, utilization and construction of projections is of prime importance in map-making.

Generalization: Every map is drawn with a definite objective. For example, a general purpose map is drawn to show information of a general nature such as relief, drainage, vegetation, settlements, means of transportation, etc. Similarly, a special purpose map exhibits information pertaining to one or more selected themes like population density, soil types or location of industries. It is, therefore, necessary to carefully plan the map contents while the purpose of the map must be kept in the forefront. As maps are drawn at a reduced scale to serve a definite purpose, the third task of a cartographer is to generalize the map contents. In doing so, a cartographer must select the information (data) relevant to the selected theme and simplify it as per the needs.

Map Design: The fourth important task of a cartographer is the map design. It involves the planning of graphic characteristics of maps including the selection of appropriate symbols, their size and form, style of lettering, specifying the width of lines, selection of colours and shades, arrangement of various elements of map design within a map and design for map legend. The map design is, therefore, a complex aspect of map- making and requires thorough understanding of the principles that govern the effectiveness of graphic communication.

Map Construction and Production: The drawing of maps and their reproduction is the fifth major task in the cartographic process. In earlier times, much of the map construction and reproduction work used to be carried out manually. Maps were drawn with pen and ink and printed mechanically. However, the map construction and reproduction has been revolutionalised with the addition of computer assisted mapping and photo-printing techniques in the recent past.

Check your progress

Note: a) Space is given below for writing your answer

b) Compare your answer with one given at the end of this Unit

3. What are important elements in making map?

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13.4 IMPORTANCE AND USES OF MAPS

Maps are the tools of Geographers. No other science is so much dependent upon maps as geography though all use maps and diagrams to illustrate their facts and data. As all sciences are directly or indirectly connected with the science of the earth, all types of maps may be regarded geographic in one sense or the other. Our planet is so big and presents such a variety of scenery that it is very difficult for any individual to have personal observation of things all the world over. Not unlike books, maps are also records of various facts regarding the earth; but they are something more in that they make a direct appeal to the mind and even the unknown and unseen lands may be unfolded in their original form. In a certain sense they are pictorial and as such a glance at them is more pleasant and easily brings home even a set of complex facts in their proper relationship.

For example, a population map with towns of various sizes not only acquaints us with factual data regarding the distribution of man in rural and urban areas, but it explains .their causal relationship also. They at once present a concrete idea about other parts and peoples. Good maps furnish us with a wealth of information in its true perspective and so they are as good as pages of descriptions. With the help of topographical maps regional geography of a country may be systematically described. It is with the help of maps and diagrams that many complicated landforms may be explained in a simplified manner.

Thus, few academic purposes maps are very essential. But for personal observation, maps are true guides not only to geographers but to other individuals too. They are useful to travellers and tourists in that they may guide them to their destination without their being under the necessity of enquiring about it from other local perches, It is needless to mention the importance of navigational charts for sea or air use. In military operations the services of maps — topographical maps or "topo sheets" in short — can hardly be exaggerated. In unmapped areas advances are not free from risks and dangers. During operations, maps render much help by indicating various routes and possible enemy positions. This is why the public use of the topographical maps is restricted during war.

Businessmen, industrialists and managers of factories and workshops also need maps and charts. The manager of a cotton mill by casting a glance over the production graphs, may at once understand whether his production is falling or rising and take further action, without incurring the trouble of going over a long list of daily production data. The government badly need maps for administrative purposes. Besides, maps are useful for planning and conservation of natural resources of a country.

In conclusion, it may be noted that while the map is a guide and help to individuals in general and the government in particular, it is a "shorthand script" of geographers, which cannot be thoroughly followed without proper training and practice.

13.5 CHECK YOUR PROGRESS ANSWERS

1. A map can defined as a graphic representation of the world.

2. The oldest map was found in Mesopotania on a clay tablet in 2500 B.C.

3. Important elements in map making are:

   Scale, Projections, Generalisation, Design, Structure, Title, direction etc.

13.6 MODEL EXAMINATION QUESTIONS

1. What are the essential things in making of maps

2. Write about importance and uses of maps

3. Define map. Discuss about Two broad categories of maps.

Write your answers in 10 lines

a) What are the important elements in preparation of map?

b) Write about importance of Maps and its uses.

c) Define Map. Discuss about two types.

13.7 FURTHER READINGS

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UNIT - 14: ELEMENTS AND CHARACTERISTICS OF MAPS

Contents

14.0 Introduction
14.1 Elements of Maps
14.2 Map Design - Parts of Map
14.3 Conventional Symbolic Signs
14.4 Check your Progress Answers
14.5 Model Examination Questions
14.6 Further Readings

14.0 INTRODUCTION

Maps are drawn to represent the Earth on a piece of paper. Maps are used widely to represent the Earth. Maps use signs and symbols in different colours. All areas can be seen on the with equal clarity.

Most maps contain the same common elements: main body, legend, title, scale and orientation indicators, inset map, and source notes. Not all are necessary or appropriate for every map, but all appear frequently enough that they're worth covering which are necessary to read and understand them. The acronym DOGSTAILS makes it easy to remember the important parts of a map:

Date	D	When the map was made
Orientation	O	Directions (north arrow)
Grid	G	Locates places on the map
Scale	S	what the map distance is
Title	T	What, where, and when
Author	A	Who made the map
Index	I	Map address of places
Legend	L	what the symbols mean
Sources	S	Basis for map information

14.1 ELEMENTS OF MAPS

The title and sub title are the basic elements of a map.

The title of the map indicates the place for which the map is drawn. Example India.

Sub title gives information about the purpose of the map. Example Physical or political.

Direction as per the international convention every map identifies the north direction with the help of an arrow pointing to the north or with the alphabet 'N'.

Some object like mountains, buildings or forests etc. are represented on a map by using signs, symbols pictures or letters due to limited space. These are called Conventional signs and symbols.

Particularly Topographical maps contain symbols, signs and pictures. In India such maps show the standard symbols set by the Indian survey department. For example: A plus sign (+) indicates spring. A symbol of two parallel horizontal lines (=) indicates a metal road.

Small scale maps like wall maps and atlas maps show relief features through colors.

The scale of a map is the ratio or proportion between the distances on the ground. Maps represents the surface of the Earth on a small scale on a piece of paper.

Elements of Maps

Maps are the primary tools by which spatial relationships and geographic data are visualized. Maps therefore become important documents. There are several key elements that should be included each time a map is created in order to aid the viewer in understanding the communications of that map and to document the source of the geographic information used.

What makes a good map? When done well, a map is a vehicle for effective communication. There are many cartographic principles to help guide effective map making. Below are ten common considerations that all cartographers should incorporate as part of their map making process? This list isn't meant to be a comprehensive list but rather a starting point of things to contemplate. Different cartographic presentations will require additional points of consideration and techniques.

Check your progress

Note: a) Space is given below for writing your answer

b) Compare your answer with one given at the end of this Unit

1. Describe elements of Map.

14.2 MAP DESIGN - PARTS OF MAP

What are the parts of a map? A map is composed of multiple parts known as map elements. Map elements that may be included on the map are a neat line, map body, graticule, insets, title, legend, label, ancillary text, ancillary object, scale bar, directional indicator, and metadata. It is important to note that not all map elements are required for every map. In fact, the only map element required to create a map is the map body which is what shows the data. Below is the descriptions of cartographic elements that are commonly found on a map layout. Some maps have all eight elements while other maps may only contain a few of them.

Geographic Bounds

The extent of the geographic area mapped will affect a whole slew of cartographic choices from the map projection used to data and symbology choices. The geographic area of the map should be restricted to the extent of the map's subject data.

Data Elements and Data Frame

There are two main reasons to include data on a map: to support the subject matter of the map and to provide orientation (e.g. streets, cities, points of interest). It's important to choose data that is relevant and current to the map. For example, choosing an out of date street layer for an area that has recently undergone change can be confusing. Cluttering the map with too much background data can lead to excess noise and dilute the actual message of the map.

The data frame is the portion of the map that displays the data layers. This section is the most important and central focus of the map document.

Title

The first map element to discuss is the title. The title is important because it instantly gives the viewer a succinct description of the subject matter of the map. The title quickly tells the viewer the subject matter and location of the data. The purpose of the title is to focus attention on the purpose of the map; therefore, it is dominant in size and is typically placed at the top of the map and centered. A good map title is brief and will typically include where, what, and when as related to the map's topic. Every map should have a map title.

Map Body: The map body map element is the main focus of the map and should be visually dominant in every case. The map body contains the features important to the message of the map. The map body should be made as large as possible on the medium but should also leave room for other map elements and should not crowd the edges so that the map has a little "breathing room". The map body is the only map element that is absolutely required when composing a map.

Inset Map: An inset map element is a small ancillary map that is typically larger in scale than the map body. The purpose of the inset map is to show more detail in the map body. To learn where the inset map is covering, an outline of the extents of the inset map may be shown on the main map body. Another use for an inset map to show other areas related to the primary map body, but at a different scale or location.

Map Scale: The next map element is the map scale. The purpose of the map scale is to measure linear relationships and distances on the map. Map scale should use a unit of measure that is appropriate for the audience and its purpose. The scale should be noticeable but not stand out too much as map readers are expected to search for the map scale when required. The scale explains the relationship of the data frame extent to the real world. The description is a ratio. This can be shown either as a unit to unit or as one measurement to another measurement. Therefore a scale showing a 1:10,000 scale means that everyone paper map unit represents 10,000 real world units. For example 1:10,000 in inches means that a measurement of one inch on the map equals 10,000 inches in real life. The graphic scale uses a graphic element, typically a bar or line, to represent a certain distance on the map. The graphic scale bar is often divided at meaningful intervals to assist the map reader in measuring.

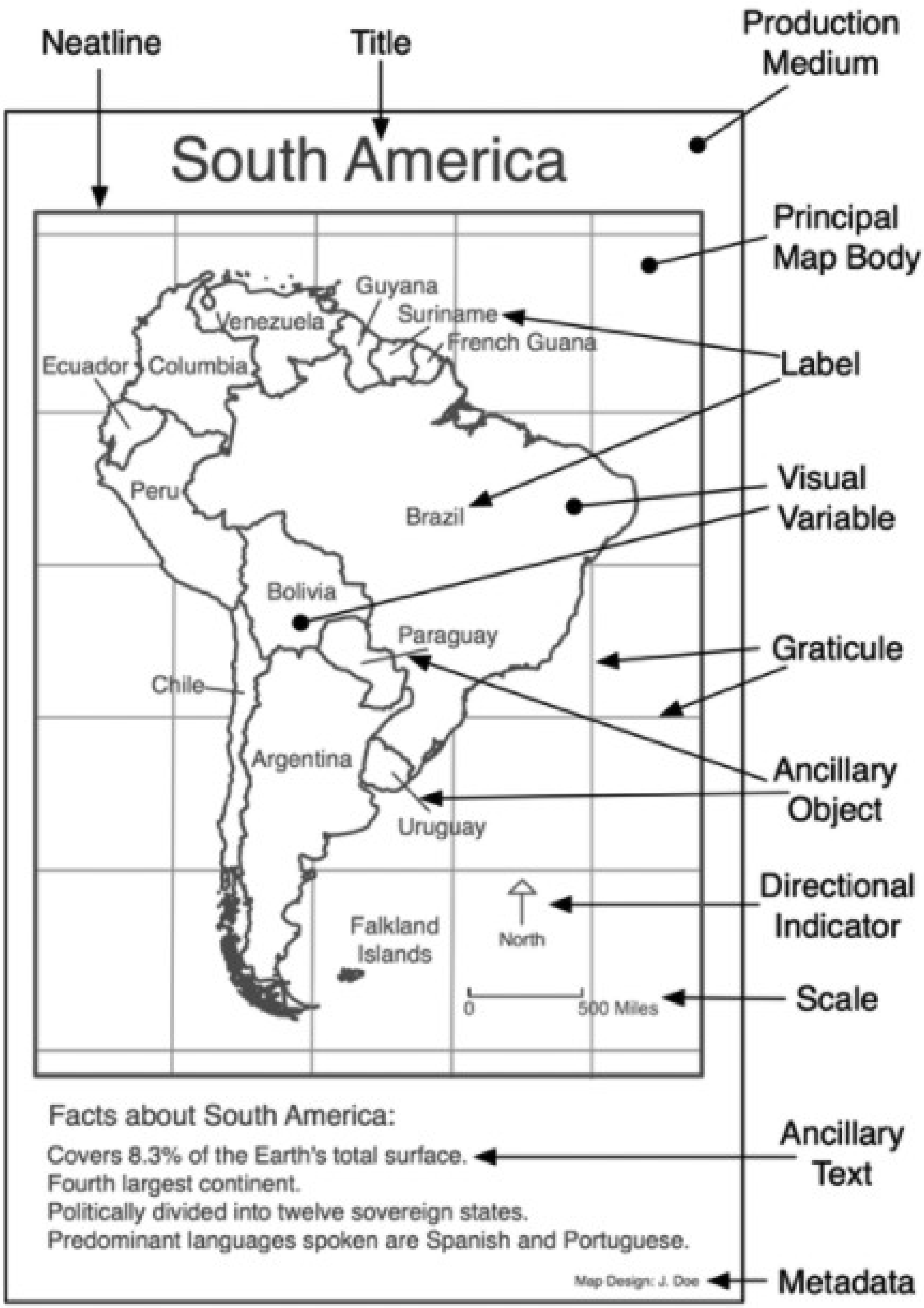
Graphic Scale

The second type of scale is the verbal scale. The verbal scale is a sentence that describes the relationship of the distance on the ground to the distance on the map. For instance, in the verbal scale it reads "1 inch on the map equals 20 feet on the ground".

Legend: The purpose of the legend is to identify unknown or unique map features. This means that a map legend does not need to include a representation of all map features that are self-evident such as water features, or roads. However, general reference maps traditionally define all symbols. Legends are the key used to decipher the symbology on the map. They need to be legible, not overly cluttered, and easy to understand the data frame. Therefore, it is also commonly known as the key. Descriptions detailing any color schemata, symbology or categorization is explained here. Without the legend, the color scheme on the map would make no sense to the viewer. The legend tells the viewer that the lighter the color, the longer the last recorded date of fire has been. When color ramping is used, care must be taken to using colors that are easily discernible from each other with the naked eye.

Symbolization / Labels

The choices of symbology can make or break a map. The color choices, line widths, icons, and labeling (more on labels next) all affect the readability, and hence message, of the map. Consider the intended audience of the map when selecting design choices. A map aimed at children might involve brighter colors and less complexity in the symbology. The purpose of the label map element is the communicate attribute or ancillary information to the map user. A label helps orient the user to the map and the features are shown on the map.



A sample map showing the different elements in a map layout.

While it may be tempting to label all features shown on a map, doing so can block underlying features, create a cluttered looking map, and create confusion. In the example below, the use of labels creates a lot of noise on the map. The use of what feels like every label type clutters the map, making the map hard to read. The labels overlap and cover the roadway network, making it hard to see the actual data on the map. Labels should be used sparingly to identify important aspects of the matter. Since the map below was created to show the major roadway system, only major cities and regions should be labeled.

North Arrow / Directional Indicator: The purpose of the north arrow is for orientation. The directional indicator is typically a North arrow. The purpose of a directional indicator is to indicate a direction on a map. Map readers are used to most maps showing North as up. This allows the viewer to determine the direction of the map as it relates to due north. Most maps tend to be oriented so that due north faces the top of the page. There are exceptions to this and having the north arrow allows the viewer to know which direction the data is oriented.

Grid and Index:

Not all maps use a grid and index, but it really helps in finding locations. A grid and index are common in an atlas and on roadmaps. A grid represents a series of horizontal and vertical lines running across the map whereas index helps the map reader find a particular location by following the numbers and letters in the grid.

Incorporating Map Elements

Making sure that all map elements are properly applied is important for providing readers with the context of the map. Most maps should have a clear and concise title, a notation on the scale (or if the map is not to scale), and, when needed for orientation, a north arrow.

Latitude and Longitude / Graticule: A graticule is a visual representation of a coordinate system or location scheme used on the map. You should include graticule on a map if the map reader will be referencing coordinate locations throughout the map. The feature critical to all maps falls into the ability to label a specific location on the planet in such a way that can be described verbally or written down. To achieve this, cartographers use an agreed-upon imaginary grid of lines. The numbering of this grid increases with the distance from each of these starting points, up to 180 degrees from either side, creating a complete 360-degree circle around the planet in any direction.

Map Layout

Choice in map orientation (portrait versus landscape) and placement of map elements affects the visual appeal of the map.

Locator Map

Unless the map is aimed at a very specific knowledgeable audience or is of a geographic breadth (such as a countrywide map or a global map), it can be very helpful to include a smaller inset map showing the location of the mapped area. This helps to further orient the viewer in placing the geographic context of the map.

Citation

The citation portion of a map constitutes the metadata of the map. This is the area where explanatory data about the data sources and currency, projection information and any caveats are placed. The citation tells the source and date of the data. Citations help the viewer determine the use of the map for their own purposes.

Other elements such as a border, and inset map can be placed on the map to further aid the viewer.

Metadata

All maps should document all sources of data, currency of those datasets, and any other information helpful to the viewer. Also include the map projection and datum used. Lastly, be sure to add the author of the map so that the map can be properly referenced in other documents.

Check your progress

Note: a) Space is given below for writing your answer

b) Compare your answer with one given at the end of this Unit

2. Discuss about parts of Maps?

Learning these map making basics will help to get you on your way. Once you've learned the fundamentals, you can start exploring map-based platforms and complex maps. The main takeaway here is simple. When it comes to map making, clarity is key.

14.3 CONVENTIONAL SYMBOLIC SIGNS

Map is made up of different conventional signs such as roads, railways, rivers, settlements, canals, hills, mountains, plateaus, plains, seas, vegetaion etc.

Characteristics of Maps

The word ‘Map’ is derived from the Latin word ‘Mappe’ which means Napkin of cloth cover. The whole or part of the earth can be represented on a map.

What are characteristics of maps?

1. A map is much smaller than the earth that it represents. Altitudes, Longitudes and Scales are very essential to draw maps.

2. Every map should have a bold title on the top. There is an arrow mark in one corner of the map showing north. With the help of this mark other directions are known.

3. Index or legend is necessary for every map. Universally accepted conventional symbols are used on every map like RF (Reserved Forest), etc.

4. Maps are shaded with different colours also. White indicates ice caps, Blue for water, Green for forest, Yellow for agricultural belt, etc.

Some common features of maps include **scale, symbols, and grids**. All maps are scale models of reality. A map’s scale indicates the relationship between the distances on the map and the actual distances on Earth. This relationship can be expressed by a graphic scale, a verbal scale, or a representative fraction.

Types of maps are classified on the basis of two characteristics:

(i) Large scale and Small scale maps; (ii) Thematic maps.

Large Scale Maps

Fields, gardens, estates, tanks, wells and buildings are shown on large-scale maps. These maps are very useful. The local administrations like city survey, taxation, management of estates, etc., are done on large-scale maps. These maps cover less area and give more details. The scale may be 1 cm = 1 km or so.

Small Scale Maps

These maps cover vast area and represents broad features. Large mountains appear as spots. Rivers are shown as black or blue lines. Towns appear as black dots. While small villages, streams and roads are not shown. These maps are very useful for Atlas and wall maps are prepared on small scale.

Thematic Maps

These maps are used for different purposes. Relief, drainage climate, population distribution and land use patterns are shown on thematic maps. This will discuss in detail in the next chapter.

Summary

This chapter focused on map elements, design principles, and the cartographic process. In this chapter, you learned about why one would want to create a map and for what purpose. The planar and hierarchical organization were outlined which are important concepts that help to guide how one would determine the organization of a map. The chapter concluded with an example of a map critique which highlights issues and identifies solutions to make the map more attractive and useful.

14.4 CHECK YOUR PROGRESS ANSWERS

1. Title, sub title, direction, scale, latitudes, longitudes, conventionl signs and colour.
2. Geographical boundaries, data, legend, title, symbolisation, direction, scale, index, latitudes and longitudes.

14.5 MODEL EXAMINATION QUESTIONS

Answer the following questions in about 30 lines.

1. What are the important elements for making of a map?
2. What are the chief characteristics of thee maps – discuss.

Answer the following short questions in about 5-10 lines.

1. Write about scales
2. Write about large scale maps
3. Write about small scale maps

14.6 FURTHER READINGS

Monk house F. J. and Wilkinson H. R. (1968): Maps and Diagrams, Methuen, London

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UNIT - 15: TYPES OF MAPS

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15.0 Introduction
15.1 Types of Maps
15.2 Diagram and Diagrammatic Maps
15.3 Thematic Maps
15.4 Importance of Thematic Maps
15.5 Check your progress Answers
15.6 Model Examination Questions
15.7 Future Readings

15.0 INTRODUCTION

This chapter covers various types of maps and their features. Many types of maps exist so that cartographers can visualize spatial phenomenon in the most advantageous way. It is important that you be aware of all the different map types available to you so that you can visualize your data in the format that will be most appropriate for the content of your map and your map user. This chapter covers three map types: choropleth maps, proportional symbol maps, and dot-density maps.

Maps are among the most compelling forms of information for several reasons. Maps are artistic. Maps are scientific. Maps preserve history. Maps clarify. Maps reveal the invisible. Maps inform the future. Regardless of the reason, maps capture the imagination of people around the world. As one of the most trusted forms of information, map makers and geographic information system (GIS) practitioners hold a considerable amount of power and influence. Therefore, understanding and appreciating maps and how maps convey information are important aspects of GISs. The appreciation of maps begins with exploring various map types.

So what exactly is a map? There are probably just as many definitions of maps as there are people who use and make them. For starters, we can define a map simply as a representation of the world. Such maps can be stored in our brain (i.e., mental maps), they can be printed on paper, or they can appear online. Notwithstanding the actual medium of the map (e.g., our fleeting thoughts, paper, or digital display), maps represent and describe various aspects of the world.

Definition: Map - A set of points, lines, and areas all defined both by position with reference to a coordinate system and by their non-spatial attributes.

A map is a conventional representation of the earth (whole or part of it) drawn to scale on a flat surface. Maps are the world reduced to points, lines, and areas, using a variety of visual resources: size, shape, value, texture or pattern, color, orientation, and shape. A thin line may mean something different from a thick one, and similarly, red lines from blue ones.

A map is the fundamental tool of the geographer. With a map, one can illustrate the spatial distribution (i.e., geographic pattern) of almost any kind of phenomena. Maps provide a wealth of information. The information collected to create a map is called spatial data. Any object or characteristic that has a location can be considered spatial data.

15.1 TYPES OF MAPS

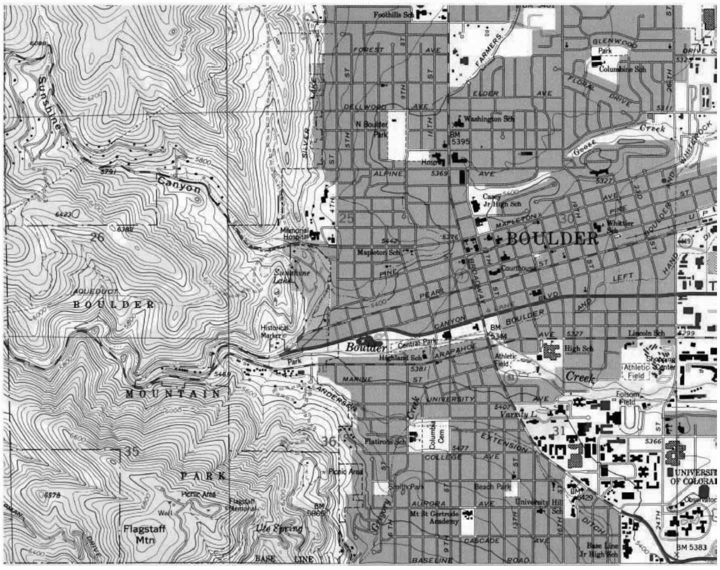
For purposes of clarity, the three types of maps are **the reference map, the thematic map, and the dynamic map**. Maps are divided into general purpose Maps and Thematic Maps.

Reference Maps

The primary purpose of a reference map is to deliver location information to the map user. Geographic features and map elements on a reference map tend to be treated and represented equally. In other words, no single aspect of a reference map takes precedent over any other aspect. Moreover, reference maps generally represent geographic reality accurately. Examples of some common types of reference maps include topographic maps such as those created by survey of India and image maps obtained from satellites or aircraft that are available through online mapping services. General Purpose Maps - Also known as reference or location maps.

The accuracy of a given reference map is indeed critical to many users. For instance, local governments need accurate reference maps for land use, zoning, and tax purposes. National governments need accurate reference maps for political, infrastructure, and military purposes. People who depend on navigation devices like global positioning system (GPS) units also need accurate and up-to-date reference maps in order to arrive at their desired destinations.

USGS Topographic Map



Thematic Maps

Contrasting the reference map are thematic maps. As the name suggests, thematic maps are concerned with a particular theme or topic of interest. While reference maps emphasize the location of geographic features, thematic maps are more concerned with how things are distributed across space. Such things are often abstract concepts such as life expectancy around the world, per capita gross domestic product (GDP), or literacy rates across India. One of the strengths of mapping, and in particular of thematic mapping, is that it can make such abstract and invisible concepts visible and comparable on a map.

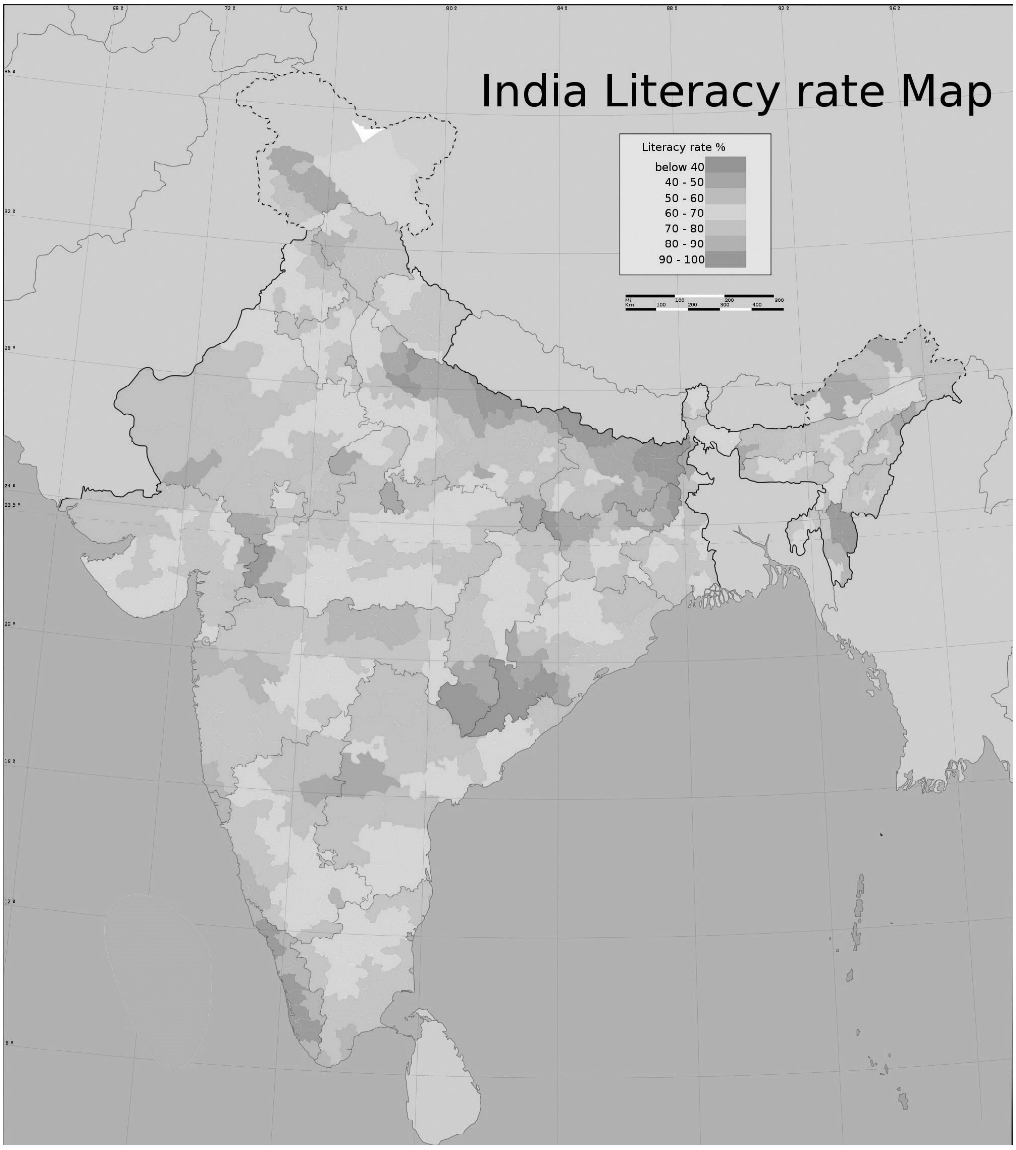
Thematic maps also known as Special Purpose maps. The Thematic maps subdivided into Qualitative Maps and Quantitative maps. Qualitative thematic maps also known as descriptive maps. Quantitative thematic maps indicate the quantity of a data attribute at different locations on a map.

It is important to note that reference and thematic maps are not mutually exclusive. In other words, thematic maps often contain and combine geographical reference information, and conversely, reference maps may contain thematic information. What is more, when used in conjunction, thematic and reference maps often complement each other.

For example, public health officials in a city may be interested in providing equal access to emergency rooms to the city's residents. Insights into this and related questions can be obtained through visual comparisons of a reference map that shows the locations of emergency rooms across the city to thematic maps of various segments of the population (e.g., households below poverty, percent elderly, underrepresented groups).

Within the context of a GIS, we can overlay the reference map of emergency rooms directly on top of the population maps to see whether or not access is uniform across neighborhood types. Clearly, there are other factors to consider when looking at emergency room access (e.g., access to transport), but through such map overlays, underserved neighborhoods can be identified. The integration of GISs with other forms of information technology like the Internet and mobile telecommunications is rapidly changing this view of maps and mapping, as well as geography at large.

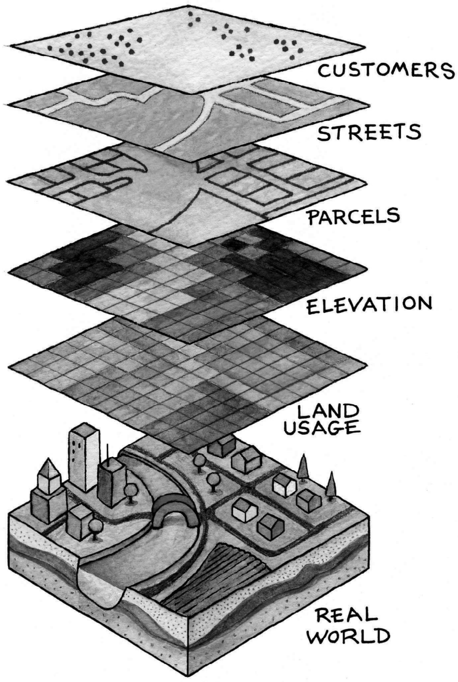
Indian Literacy Rates



A choropleth map is a map where colored or shaded areas represent the magnitude of an attribute.

For example, this map shows the population density.

Figure: Map Overlay Process



Dynamic Maps

The diffusion of GISs and the popularity of online mapping tools and applications speak to this shift in thinking about maps and map use. In this regard, it is worthwhile to discuss the diffusion of dynamic maps. ***Dynamic maps*** are simply changeable or interactive representations of the earth. Dynamic mapping refers more to how maps are used and delivered to the map user today (e.g., online, via mobile phone) than to the content of the map itself. Both reference and thematic maps can be dynamic in nature, and such maps are an integral component to any GIS. The key point about dynamic maps is that more and more people have access to such maps.

Unlike a hardcopy map that has features and elements users cannot modify or change, dynamic maps encourage and sometimes require user interaction. Such interaction can include changing the scale or visible area by zooming in or zooming out, selecting which features or layers to include or to remove from a map (e.g., roads, imagery), or even starting and stopping a map animation.

Just as dynamic maps will continue to evolve and require more user interaction in the future, map users will demand more interactive map features and controls. As this democratization of maps and mapping continues, the geographic awareness and map appreciation of map users will also increase. Therefore, it is of critical importance to understand the nature, form, and content of maps to support the changing needs, demands, and expectations of map users in the future.

Key Take ways

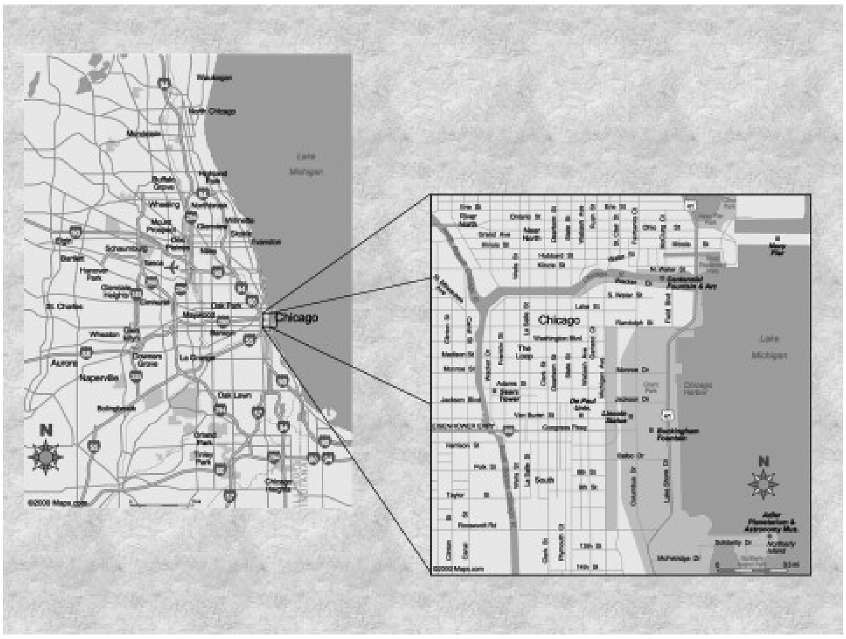
- The main purpose of a reference map is to show the location of geographical objects of interest.
- Thematic maps are concerned with showing how one or more geographical aspects are distributed across space.
- Dynamic maps refer to maps that are changeable and often require user interaction.
- The democratization of maps and mapping is increasing access, use, and appreciation for all types of maps, as well as driving map innovations

Maps can depict two kinds of data. Qualitative map data is in the form of a quality and expresses the presence or absence of the subject on a map, like the kind of vegetation present occupying a region. Quantitative map data is expressed as a numerical value, like elevation in meters, or temperature is degrees Celsius. There are many different kinds of maps that serve quite different purposes. On the basis of scale, maps may be classified into large-scale and small-scale.

Large Scale Maps

Large scale maps are drawn to show small areas at a relatively large-scale in greater detail. For example, the topographical maps drawn at a scale of 1: 250,000, 1:50,000 or 1:25,000 and the village maps, the zonal plans of the cities and house plans prepared on a scale of 1:4,000, 1:2,000 and 1:500 are large scale maps. Details of cities, towns, villages are shown. The scale may be 1 cm = 50 m or 1 km.

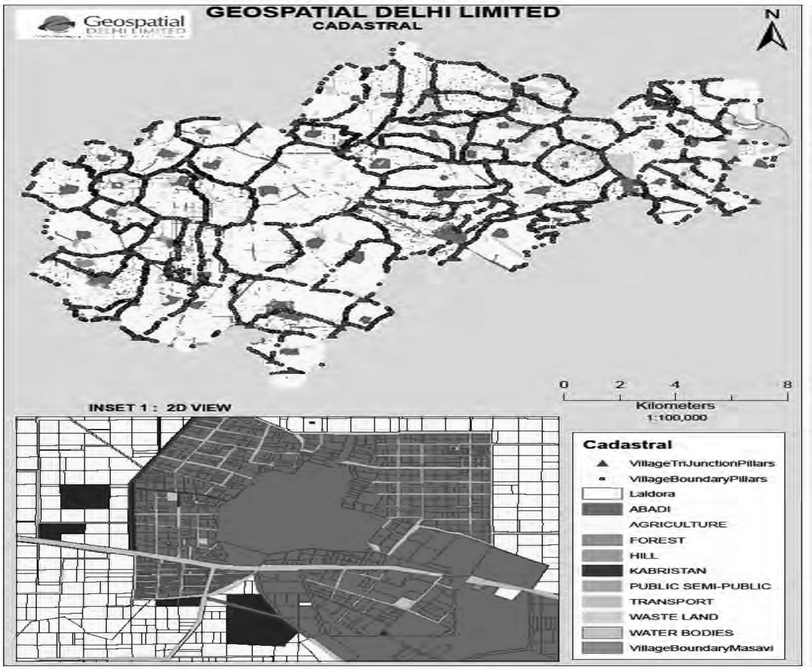
Small-scale Map **Large-scale Map**



Large-scale maps are further divided into the following types:

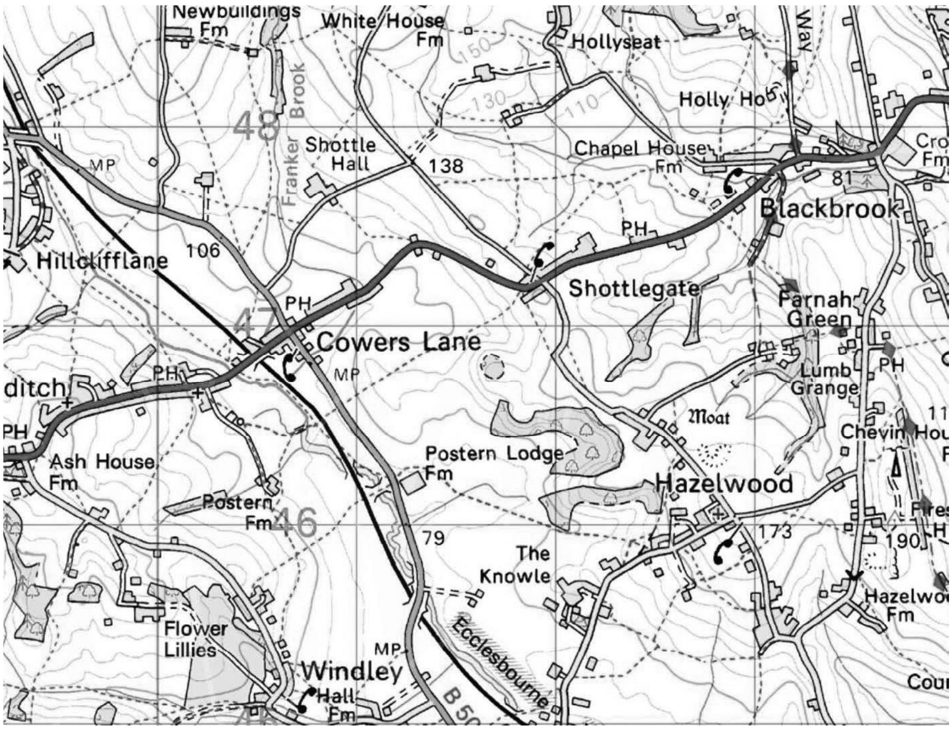
Cadastral maps and Topographical maps

Cadastral Maps*:* These maps are drawn to show the ownership of landed property by demarcating field boundaries of agricultural land and the plan of individual houses in urban areas. The cadastral maps are prepared by the government agencies to realize revenue and taxes, along with keeping a record of ownership. These maps are drawn on a very large scale, such as the cadastral maps of villages at 1 : 4,000 scale and the city plans at a scale of 1 : 2,000 and larger.



Topographical Maps: These maps are also prepared on a fairly large scale. The topographical maps are based on precise surveys and are prepared in the form of series of maps made by the national mapping agencies of almost all countries of the world. For example, the Survey of India undertakes the topographical mapping of the entire country at 1: 250,000, 1: 50,000 and 1: 25,000 scale. These maps follow uniform colours and symbols to show topographic details such as relief, drainage, agricultural land, forest, settlements, and means of communication, location of schools, post offices and other services and facilities.

A topographic map of 1: 50000 scale map, showing individual buildings, minor roads and contours are evident



Small-scale Maps:

On the other hand, small-scale maps are drawn to show large areas in less detail. For example, atlas maps, wall maps, etc. They show important features like mountains, plateaus, con-tinents and countries, and Scale may be 1 cm =100 km. Small-scale maps are further divided into the following types:

Wall Maps and Atlas Maps

Wall Maps: These maps are generally drawn on large size paper or on plastic base for use in classrooms or lecture halls. The scale of wall maps is generally smaller than the scale of topographical maps but larger than atlas maps.

Atlas Maps: Atlas maps are very small-scale maps. These maps represent fairly large areas and present highly generalized picture of the physical or cultural features. These maps provide a wealth of generalized information regarding location, relief, drainage, climate, vegetation, distribution of cities and towns, population, location of industries, transport-network system, tourism and heritage sites, etc.

Broadly, maps based on their functions may be classified into physical maps and cultural maps.

Physical Maps: Physical maps show natural features such as relief, geology, soils, drainage, elements of weather, climate and vegetation, etc.

Isopleth Maps: lines joining points of equal value. This value on topographic maps is height (or elevation/altitude) above mean sea level (MSL). Each successive contour line represents an increase or decrease in constant value. Often every 5th contour will be in bold to help identification. Contours are normally associated with changes in height, but they can represent any parameter (e.g. thickness, pressure, rainfall). They can also be called iso-lines (e.g. isopachs, isobars, isohyets)

Cultural Maps: Cultural maps show man-made features. These include a variety of maps showing population distribution and growth, sex and age, social and religious composition, literacy, levels of educational attainment, occupational structure, location of settlements, facilities and services, transportation lines and production, distribution and flow of different commodities.

Check your progress

Note: a) Space is given below for writing your answer

b) Compare your answer with one given at the end of this Unit

1. Discuss about types of Maps?

____

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15.2 DIAGRAM AND DIAGRAMMATIC MAPS

A diagram may be defined as the representation of statistical data, or a geographic element in a highly abduct and conventionalized form by laying emphasis on one selected clement. Thus, two types may be distinguished; (i) statistical diagrams; (ii) geographical diagrams. Daily, monthly and annual production figures of pig iron, steel ingots, etc., of Tata & Co., may be shown by diagrams which will be purely statistical diagrams; while the production figures of India, U.S.A.

and U.K., etc., may be diagrammatically shown together so as to give comparative idea. In this sense even statistical diagrams may be called geographic diagrams as the figures do refer to certain places which are pivotal points in geography. When some geographical facts in respect to location, relief, etc. arc represented in a greatly, abducted form to success some-particular point it becomes a diagrammatic map or, sometimes called a sketch-map. From Fig. it is obvious that the position of Delhi is such that 'I has attracted all means of communication and also the flow of human energy through them so much so that it has become a capital town. Thus, it is to emphasize one geographic fact, i.e., geographical location, a primary cause in the development of the town, that the scale and detailed relief features have been purposely omitted. Similarly, soil profiles, mountain ranges, river basins, routes, etc., may be diagrammatically simplified so that they may be more impressive and illustrative and their main Idea may be easily visualized. All such simplified representations may be regarded as geographical diagrams or diagrammatic maps.

Based on the elements of distribution, the following important types of distribution maps may be distinguished:

(i) Population maps; (ii) Stock maps; (iii) Crop maps; (iv) Climatic maps —Isotherm, Isobar and Isohyet or Isopluve maps; (v) Industrial maps; (vi) Mineral maps. The distribution maps may be classified on the basis of methods used for their drawing such as: (i) Chorochromatic maps; (ii) Choro-schematic Maps; (iii) Isopleth maps; (iv) Choropleth maps; (v) Dot maps; (vi) Diagrammatic maps. Political maps; Physical maps; Statistical / Distribution maps; Topographic maps; Geological maps; Geomorphological maps ; Town plan maps ; Cadastral maps; Weather maps; Bathymetric maps / Navigational maps; and Aeronautical maps. The application of any one method for all the types of distribution maps is not possible. One method may be applied to one or two types only.

Administrative map:

Colour or Tint Method

This is also known as chorochromatic method. This method, in general, makes use of different.

colours to make the distribution of various features distinct on the map; for instance, in a vegetation map forests may be shown by green colour, grasslands by yellow and desert vegetation by brown.

Isopleth, Choropleth and so on. Here a colour index is necessary to be shown in a comer of the map. At the same time, the distribution of a single element may also be shown with different colours; for example, the distribution of various types of forests may be shown with different colours. In this case, if different tints of the same colour, say green, are used, the map will produce better effect. This tinting method may also be called layering method which is commonly used in relief maps to show different elevation. The main defect of this method lies in the fact that it entirely obliterates all other features. It may be advantageously utilized for showing density of population. Tints may be used to make the isopleth maps more effective, i.e., colours may be put in the interval between -two isopleth.

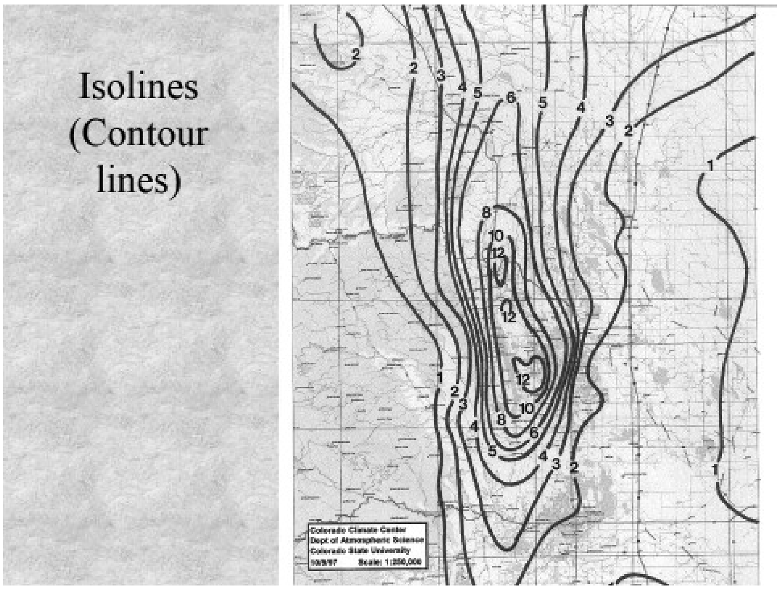
Region Map: In which geographic shapes have been grouped into larger regions, with each region appearing as a single entity usually with the same colour.

2. Symbol or Choro-schematic Method

One or more elements may be shown by conventionally selected symbols of equal size or varying sizes as the case may be. Initial letter of an element may be adopted as a symbol to represent that; for instance, W for wheat, C for cotton, etc., in the case of crop distribution maps; S for sheep, C for cattle in stock maps; G for gold, C for coal, etc., in mineral maps. When only one element is shown on the map, the letter of uniform size may be used as a unit and the number of letters may be found out with reference to the quantity to be represented. Then these letters may be distributed over respective districts. Such a map may be easily commensurable. Sometimes, to emphasize the relative importance of different areas with regard to different elements shown on one map, each element may be shown by a letter of varying size — the size varies in proportion to the quantity represented, that is, the height of the letters roughly corresponds to the square root of the quantity. Some of the letters may appear smaller than others; for instance, 'I showing iron looks smaller than C showing coal. The chief advantage of this method is that many elements may be shown together on one map.

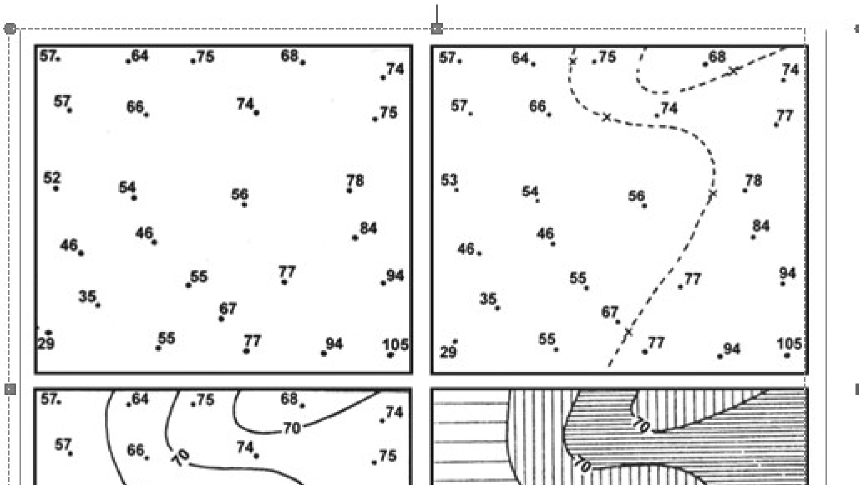
3. Isopleth Method

The term isopleth — isos+ plethron; isos meaning same and plethron means measure. Thus, isopleths are lines, of equal value in the form of quantity, intensity and density; they are drawn as contour lines. That some selected interval. The spacing of lines expresses the rate of variation. If the lines appear much' apart, variation is gentle and when they are closely set, variation is sharp. Each line is labelled according to the quantity or number it indicates. Their use is limited by the amount of information or data, and the extent of transitional belt when the data in detail are not available, the isopleths cannot be drawn and even if they are drawn, they will give a highly generalized or erroneous picture of the facts. When the transitional belt is not extensive, that is, when variability is great, such as in the case of the distribution of population, the isopleths lose their significance. It is due to this reason that this method has been commonly used for isotherm, isobar and isohyet maps because these elements are uniformly distributed over wide areas. The isopleth method is also used in ratio or percentage maps. Contours can show the distribution and relative size of any measured value.



Isopleth Map

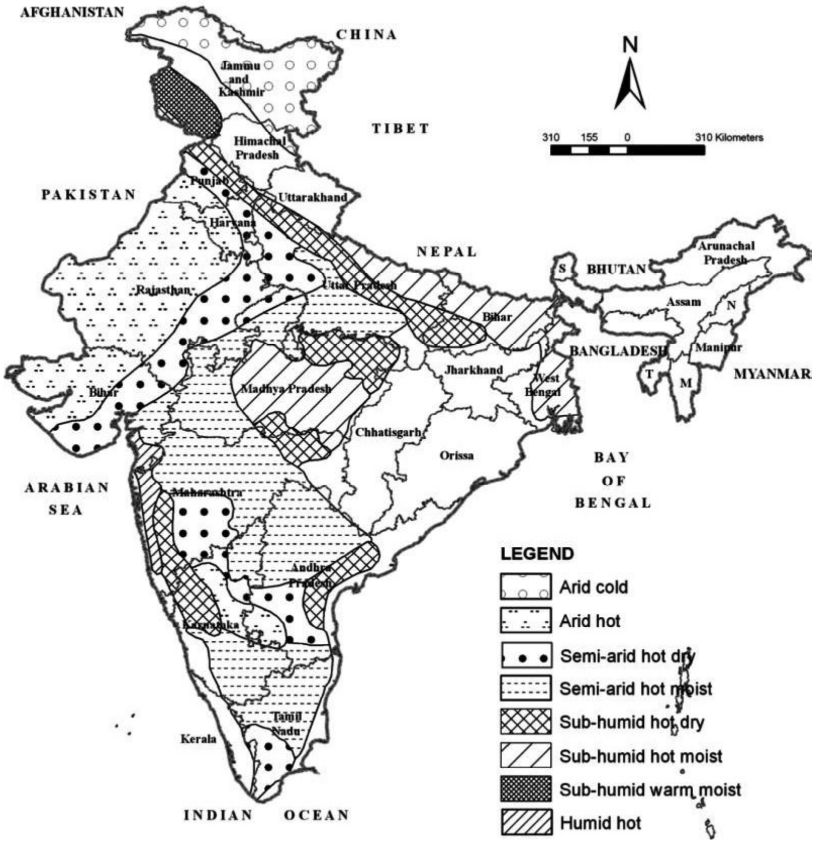
We have seen that the data related to the administrative units are represented using choropleth maps. However, the variations within the data, in many cases, may also be observed on the basis of natural boundaries. For example, variations in the degrees of slope, temperature, occurrence of rainfall, etc. possess characteristics of the continuity in the data. These geographical facts may be represented by drawing the lines of equal values on a map. All such maps are termed as Isopleth Map. The word Isopleth is derived from Iso meaning equal and pleth means lines. Thus, an imaginary line, which joins the places of equal values, is referred as Isopleth. The more frequently drawn isopleths include Isotherm (equal temperature), Isobar (equal pressure), Isohyets (equal rainfall), Isonephs (equal cloudiness), Isohels (equal sunshine), contours (equal heights), Isobaths (equal depths), Isohaline (equal salinity), etc.



4. Shading or Choropleth Method: A choropleth map is a map where colored or shaded areas represent the magnitude of an attribute. For example, this map shows the climatic regions.

Why Create a Choropleth Map? There are many reasons why you would want to create a choropleth map. Choropleth maps are relatively easy to create and easy to interpret by map readers. A choropleth map excels at displaying variables overall geographic pattern. As each color or shade is assigned a value or range of values the map reader can ascertain the values displayed on the map easily.

The distribution of one element is shown by different shades to represent varying intensity or density. A suitable scheme of shades of various intensities may be prepared and shown in some corner of the map. The lighter shades, show lower densities and deeper or darker shades, show higher densities. The shading generally follows the administrative boundaries, because the very data are available in reference to them Moreover, the element may not be distributed uniformly over large areas; so some very small areas showing a higher density will be obliterated by areas of moderate density.



Check your progress

Note: a) Space is given below for writing your answer

b) Compare your answer with one given at the end of this Unit

1. Based on distribution discuss about important types of Maps.

15.3 THEMATIC MAPS

This part of the chapter covers proportional symbol maps, and dot-density maps. These maps show selected features only. These are help-ful in studying relationships between two variables in a region. They are more important than general maps in studying environmental relationships e.g., weather map, population map, road map, vegetation, etc.

Classification of Thematic Maps based on Method of Construction

The thematic maps are, generally, classified into quantitative and non-quantitative maps. The quantitative maps are drawn to show the variations within the data. For example, maps depicting areas receiving more than 200 cm, 100 to 200 cm, 50 to 100 cm and less than 50 cm of rainfall are referred as quantitative maps. These maps are also called statistical maps. The non-quantitative maps, on the other hand, depict the non-measurable characteristics in the distribution of given information, such as a map showing high and low rainfall-receiving areas. These maps are also called qualitative maps. It would not be possible to discuss drawing these different types of thematic maps under the constraint of time. We will, therefore, confine to discuss the methods of the construction of the following types of quantitative maps:

(a) Dot maps

(b) Choropleth maps

(c) Isopleth maps

Dot Maps: The dot maps are drawn to show the distribution of phenomena such as population, cattle, types of crops, etc. The dots of same size as per the chosen scale are marked over the given administrative units to highlight the patterns of distributions.

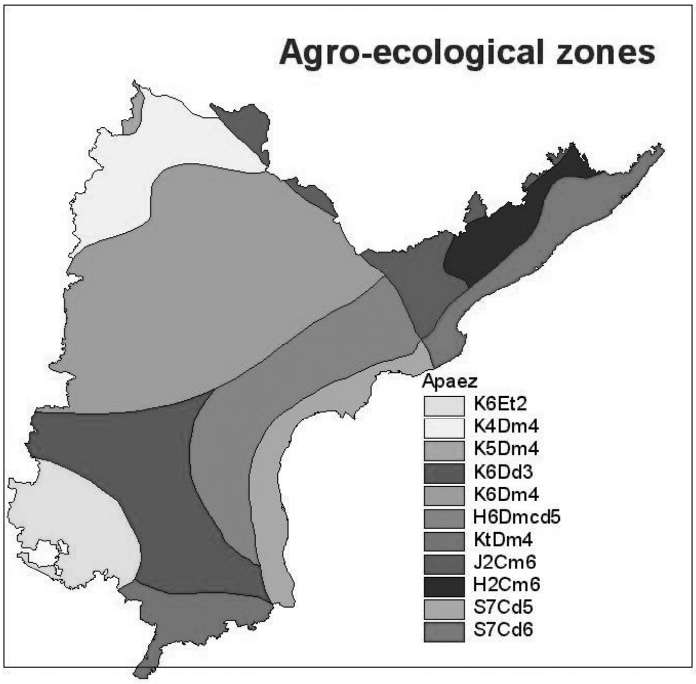
Dot Density Maps: A dot density map is as a map type that uses a dot symbol to show the presence of a feature or phenomenon. Dot density maps are a simple yet highly effective way to show density differences in geographic distributions across a landscape. Dot density maps have been popular for 150 years because they are easy to understand and, at a glance, show us intuitively where things clump or cluster. There are two basic types: *one-to-one dot density maps* (one dot represents one object or count) and *one-to-many dot density maps* in which one dot stands for a number of things or a value (e.g., 1 dot = 1,000 acres of wheat production).

Not only are natural features like mountains, valleys, streams and glaciers portrayed, but cultural features as well, like houses, schools, streets, and urbanized areas. Examine a topographic symbol sheet (pdf file) from the USGS to see how a variety of features are symbolized on a topographic map.

Proportional or graduated circle maps are another way of depicting geographic information on a map. Figure 1.15 is a map that shows population density of Canada as colored polygons and the distribution of major earthquakes felt throughout the country. Graduated circles indicate the area over which the earthquakes were felt. This map was created using a *geographic information system* which has the capability of overlying different kinds of spatial data to show the relationships between them.

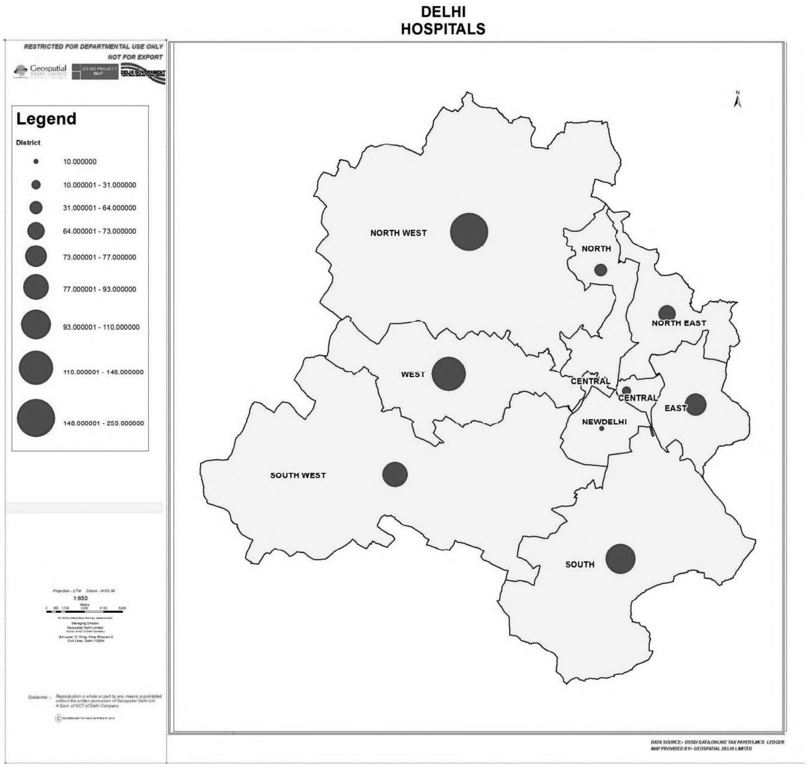
Dot maps use dots to illustrate the presence of the phenomenon on a map. A dot may equate to one or several units of measurement. Dot maps are especially useful in visualizing the frequency of occurrence or density of a mapped variable.

Choropleth maps: Maps use colour shading to represent different quantities or values. The choropleth maps are also drawn to depict the data characteristics as they are related to the administrative units. These maps are used to represent the density of population, literacy/growth rates, sex ratio, etc.



This defect may, however, by minimized by increasing the number of shades, that is, by decreasing the gradation of scale so that the interval of variation becomes small. Further, little consideration is possible regarding unused or waste lands such as deserts, marshes, rugged and rocky areas, hills, mountains, etc.; they all disappear beneath the shading. Such lands have been called negative areas by some authors.

Circle maps: Use symbols of different sizes placed within an area to show the value or quantity associated with it.



A map that displays the spatial distribution of an attribute that relates to a single topic, theme, or subject of discourse. Usually, a thematic map displays a single attribute (a 'univariate map') such as soil type, vegetation, geology, land use, or landownership. For attributes such as soil type or land use ("nominal" variables), shaded maps that highlight regions ("polygons") by employing different colors or patterns is generally wanted. For other attributes (like population density - a "metric" variable), a shaded map in which each shade corresponds to a range of population densities is generally wanted.

Thematic maps are used to display geographical concepts such as density, distribution, relative magnitudes, gradients, spatial relationships and movements. Also called geographic, special purpose, distribution, parametric, or planimetric maps. Thematic maps are used to communicate geographic concepts like the distribution of densities, spatial relationships, magnitudes, movements etc. World climate or soils maps are notable examples of thematic maps. There are five common techniques for depicting geography data on a thematic map. The most common is a choropleth map that uses color to show variations in quantity, density, percent, etc. within a defined geographic area. Each color usually depicts a range of values.

15.4 IMPORTANCE OF THEMATIC MAPS

(a) Thematic maps only show the selected features. For example, weather map or maps showing only crops, population, and vegetation.

(b) Thematic maps are useful in studying the relationship between two or more variables in a region.

(c) Thematic maps are more useful than the general maps in studying envi-ronmental relationship.

The map is, however, named after its content when only one aspect or feature is shown. For example, if only means of communication — roads, railways, airways, etc., — are shown it may be called communication map.

A population map denotes distribution of man over an area. When many features are shown on a map, it may be named either after the main idea reflected by it or according to the total aspect shown by it. For instance, the map showing the distribution of important agricultural, mineral and industrial products, with important centres linked by various means of communication may be termed economic map because from it the nature of economic development of the region may be interpreted.

Maps displaying the distribution of different objects of definite value may be grouped under the head the 'Distribution maps'. These present one characteristic feature of a certain area, even ignoring the exact location of the object if necessary. The item may be natural, like temperature, pressure, rainfall, flora and fauna, or, it may be cultural, showing agricultural and industrial products, etc. It may be contrasted with location maps or physiographic maps in which the features marked on the map exactly correspond with those on the earth-surface.

The distribution maps may be further sub-divided according to the method of construction. The data may be presented by: (i) colour, (li) symbol, (iii) regular lines, (iv) dots, (v) shading, (vi) bars, (vii) block, (viii) circles, and (ix) spheres.

When different objects are shown by various colours the map is known as chorochromatic. The representation of density of population, forest types, amount and intensity of rainfall, etc., may be done by different colours or different shades of one colour.

In a map showing the distribution of crops cotton may be shown by C, wheat by W, maize by M and rice by R. Likewise, the distribution of coal may be shown by C, iron by F and gold by G, etc. Such maps may be termed Choro-schematic.

Statistical data may also be shown by lines of equal value. Thus regular lines may be drawn on a map to show equal amount of rainfall, temperature and pressure, etc. These lines are called isohyets, isotherms and isobars, etc. respectively. All those maps in which lines of equal values are shown are called isopleth maps.

The distribution of sheep or horse or any other object may be shown by putting dots of uniform size, each dot representing a definite number or quantity; these are called dot maps.

Similarly, different shading by horizontal, vertical and slanting lines or in check forms may be adopted to show different density of population, location factor for industries, forest types, etc., such maps may be termed choropleth maps.

Bars, blocks, circles, spheres and other forms of representation arc also included in cartographic and diagrammatic representation of geographical data.

Basic issues in map design:

- Considering the purpose of and audience for the map. What to make—who will use.
- Choosing a map type.
- Choosing an appropriate map projection.
- Selecting a title that represents what is shown:
- Ex: Resources in India / Resource Map of India / India Resource Map.
- Selecting and placing text — Ex: Map Title, Map Scale, Legend, North Direction, Map source and date.
- Designing an overall layout for easy understanding

Check your progress

Note: a) Space is given below for writing your answer

b) Compare your answer with one given at the end of this Unit

3. Discuss about importance of Thematic Maps.

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Importance and Uses of Maps

Maps are the tools of Geographers. No other science is so much dependent upon maps as geography though all use maps and diagrams to illustrate their facts and data. As all sciences are directly or indirectly connected with the science of the earth, all types of maps may be regarded geographic in one sense or the other. Our planet is so big and presents such a variety of scenery that it is very difficult for any individual to have personal observation of things all the world over. Not unlike books, maps are also records of various facts regarding the earth; but they are something more in that they make a direct appeal to the mind and even the unknown and unseen lands may be unfolded in their original form. In a certain sense they are pictorial and as such a glance at them is more pleasant and easily brings home even a set of complex facts in their proper relationship.

For example, a population map with towns of various sizes not only acquaints us with factual data regarding the distribution of man in rural and urban areas, but it explains .their causal relationship also. They at once present a concrete idea about other parts and peoples. Good maps furnish us with a wealth of information in its true perspective and so they are as good as pages of descriptions. With the help of topographical maps regional geography of a country may be systematically described. It is with the help of maps and diagrams that many complicated landforms may be explained in a simplified manner.

Thus, few academic purposes maps are very essential. But for personal observation, maps are true guides not only to geographers but to other individuals too. They are useful to travellers and tourists in that they may guide them to their destination without their being under the necessity of enquiring about it from other local perches, It is needless to mention the importance of navigational charts for sea or air use. In military operations the services of maps — topographical maps or “topo sheets” in short — can hardly be exaggerated. In unmapped areas advances are not free from risks and dangers. During operations, maps render much help by indicating various routes and possible enemy positions. This is why the public use of the topographical maps is restricted during war.

Businessmen, industrialists and managers of factories and workshops also need maps and charts. The manager of a cotton mill by casting a glance over the production graphs, may at once understand whether his production is falling or rising and take further action, without incurring the trouble of going over a long list of daily production data. The government badly need maps for administrative purposes. Besides, maps are useful for planning and conservation of natural resources of a country.

In conclusion, it may be noted that while the map is a guide and help to individuals in general and the government in particular, it is a “shorthand script” of geographers, which cannot be thoroughly followed without proper training and practice.

Summary

This chapter covered various types of maps and their features. Choropleth, Dot Density, and Proportional Symbol Maps were exhibited and explained. You learned about appropriate and inappropriate data as well as data classifications and symbolization for each map type. Map legends and the elements that should be considered when using this feature were also covered.

15.5 CHECK YOUR PROGRESS ANSWERS

1. Based on scale Maps can be classified as qualitative maps and quantitative maps, small scale maps and large scale maps, cadastral maps, topographical, wall maps, atlas maps and physical maps are important.

2. Based on distribution maps can be divided as population maps, crops, climate maps, isobars, isopleths, industrial maps, economic maps and mineral maps.

3. Thematic maps show only selected feature. Thematic maps are useful in studying the relationship between any two are more variables in a region. These maps are more useful than general maps.

15.6 MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines

1. Discuss about the importance of the thematic maps
2. Write about importance and uses of maps.

II. Answer the following questions in about 10 lines

1. Choropleth map
2. Classification of thematic map based on method of construction
3. Isopleth maps

15.7 FURTHER READINGS

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GLOSSARY

Abiotic components: These include all the non-living elements of the biosphere

Abrasion: This is caused by boulders, pebbles and sand being hurled against the base of a cliff by breaking waves which results in undercutting and rock break-up.

Abyssal plain: These lie between the continental margins and mid-oceanic ridges.

Advection: This process of transfer of heat through horizontal movement of air (wind) is called advection.

Attrition: As boulders and rocks are hurled against the shore and against each other by breaking waves, they gradually break up into smaller pieces.

Attrition: When Erosional tools like boulders, cobbles and pebbles etc. moving with water, they collide against each other and (tear and wear) fragmented into smaller and finer pieces in the transit.

Bar: This is a ridge of sediment which is parallel to the coast. It may be exposed at both high and low tides, or only at low tides or not at all.

Barchans: Crescent-shaped Dune lying at right angles to the prevailing wind with the horns pointing downwind. A barchans usually develops from the accumulation of sand caused by a small obstruction such as a rock or piece of vegetation.

Batholith: This is a very large mass of magma which accumulates in the crust: Sometimes it forms the root or core of a mountain.

Biomes: The structure of an ecosystem is defined by its soil, climate, flora and fauna. A large geographic region characterized by a certain type of ecosystem is known as a biome.

Block Mountains: Faults usually occur in series and their formation is sometimes accompanied by an upward or a downward movement of blocks of the crust. The upraised blocks are fault-bordered. They are called Block Mountains.

Braided river: A river with a heavy load becomes overloaded if its discharge decreases. This can happen if surface run-off into the river basin decreases. When the discharge falls deposition takes place in the form of sandbanks and islands of alluvium that cause the channel to braid.

Celestial bodies: The objects shining in the night sky.

Cirque: A semi-circular, steep-sided basin cut into the side of a mountain, or at the head of a valley. Such a feature is called a corrie in Scotland, a cwm in Wales, and a cirque in France.

Cirque glacier: This is a small mass of ice which accumulates in a rock hollow either at the head of a valley or on the side of a mountain.

Corrosion: It involves the dissolution of soluble materials through the process of disintegration and decomposition of carbonate rocks.

Crust: The outer most solid part of the earth.

Denudation: the word is derived from a Latin word which means ‘to lay bare’, and it is the name given to those external agents who break down the rocks at the earth’s surface.

Diamond Dust: Diamond dust is extremely small ice crystals usually formed at low levels and at temperatures below -30 °C.

Disaster: it is an undesirable occurrence resulting from forces that are largely outside human control, strikes quickly with little or no warning, which causes or threatens serious disruption of life and property including death and injury to a large number of people.

Dissected Plateau: Vertical erosion is the dominant action of some rivers that cross a plateau. These rivers carve deep valleys which break up the surface into many steep sided pieces. A plateau of this type is called a dissected plateau.

Droughts: an extended period when there is a shortage of water availability due to inadequate precipitation, excessive rate of evaporation and over-utilisation of water from the reservoirs and other storages, including the ground water.

Dyke: When a mass of magna cuts across bedding planes, it forms a wall-like feature called a dyke.

Earthquake: Shaking of the earth which is a natural phenomenon caused due to release of Energy, which generates waves that travel in all directions.

Earthquakes: These are sudden movements or vibrations in the earth’s crust. They cause the ground to shake violently, making the walls of buildings crack or bulge or even tumble down.

Ecology / Ecosystem: Scientific study of the habitats characteristic of species.

Ecosystem: it is a fundamental functional unit occupying spatial dimension of earth spaceship characterized by total assemblage of biotic community and abiotic components and their mutual interactions within a given time unit

Ecological balance: “The natural state of dynamic equilibrium prevailing within a community of organisms in which the genetic, species and ecosystem diversity remain relatively stable, subject to gradual changes through ecological succession” or natural.

Economic Geography: It studies economic activities of the people including agriculture, industry, tourism, trade, and transport, infrastructure and services, etc.

Endogenetic forces: These are slow and steady movements that are constructive in nature (diastrophic). These forces are those which operate from the interior of the Earth. Volcanism and Earth quakes are two such forces.

Epicentre: The place of occurrence of an earth quake which experiences the seismic event first is called ‘epicentre’, which is located on the earth’s surface.

Erosion: it is a process by which soils and rocks are removed from the earth’s surface by exogenic forces such as wind or water flow and then transported and deposited in other locations.

Erosional plain: Over millions of years the agents of denudation smooth out and lower the surfaces of highlands, and if they operate uninterrupted for a sufficiently long time, the highlands will be reduced to an undulating low lying landform.

Exfoliation: In well-jointed rocks, flat or curved plates of rock, (sometimes called shells), break away from the main rock body. When curved plates of rock peel off in this way, it is called exfoliation.

Exosphere: It is the outermost layer of the atmosphere. The zone where molecules and atoms escape into space is mentioned as the exosphere.

Front: weather occurs along the periphery of these air masses at boundaries called fronts. Where two different types of air mass meet is known as a front. Fronts are boundaries between air masses. Front is the transition zone between air masses with distinctly different properties.

Galaxy: A huge System of billions of stars.

Geography: Geography is the description of the earth

Geography: "The inter-relational study between physical and human features of the earth surface with spatial dimension".

Geomorphology: It is the study of landforms, their evolution and related processes.

Geomorphology: "The science that deals with all the changes that take place in the interior as well as on the surface of the Earth".

'**Greenhouse effect**': An increase in the concentration of greenhouse gases in the atmosphere leading to an increase in the amount of infrared or thermal radiation near the surface. Greenhouse effect is not some peripheral phenomenon only of importance to global warming; rather it is at heart of the Earth's natural climatic systems.

Hamada, or rocky desert: An extensive areas of bare rocks from which all fine materials have been removed by deflation (includes lifting and removal of dust and smaller particles from the surface of rocks), while abrasion polishes and smoothes the rock surfaces.

Hanging valley: A tributary valley of a U-shaped valley which ends abruptly, high above the floor of the U-shaped valley and separated from it by an almost vertical slope.

Historical Geography: Historical processes through which the space gets organized.

Horizontal distribution: Distribution of temperature across the latitudes over the surface of the earth is called its horizontal distribution. On maps, the horizontal distribution of temperature is commonly shown by isotherms.

Horse latitudes: The descending air currents feed the winds blowing towards adjoining low pressure belts. A calm condition with variable and feeble winds is created in these high pressure belts.

Horse latitudes: The air after being heated near the equator ascends and after blowing in opposite direction to the surface trade winds descends in the latitudinal zone of 30°-35°. Thus, the descent of winds from above causes high pressure on the surface which in turn causes anticyclonic conditions. This is why the anticyclonic conditions cause atmospheric stability, dry condition and very weak air circulation. This zone (30°- 35°) is characterized by weak and variable winds and calm. This belt of calm is very popularly known as *horse latitudes.*

Hot spot: is a pocket of magma beneath the Earth's crust that erupts onto the Earth's surface.

Indian Standard Time (IST): **82** ½^{O} E longitudes are taken as standard meridian, and the local time is taken as standard time for the whole country, which is known as Indian Standard Time (IST**)**. It is **5½** hours ahead of Greenwich Meridian.

Infiltration: Some portions of the water from the precipitation is observed by the soil and some by the previous rocks and aquifers. Thus the process of passage of the surface water into the ground is known as the infiltration

Inner planets: Mercury, Venus, Earth and Mars

Ionosphere or Thermosphere: The lower Thermosphere is called the Ionosphere.

This layer is found above Mesopause from 80 to 400 km.

Jovian or **Gas giant planets:** Jupiter, Saturn, Uranus and Neptune

Kame: An irregular-shaped mass of stratified material formed as a delta on the surface of a stationary glacier or at its margin

Lava: Magma sometimes reaches the surface through a vent (hole), or a fissure (crack) in the surface rocks. When magma emerges at the surface it is called lava.

Loo: In tropical regions particularly in northern India during the summer season, local winds called **'Loo'** is the outcome of advection process.

Mantle: The portion of the interior beyond the crust

Mass wasting: It refers to the movement of regolith on slopes by creeping, flowing, sliding, slumping and falling, effected by the three factors i.e., angle of slope, gravity and water.

Mesosphere: The Mesosphere is found above the stratosphere.

Moraines: A glacier is capable of transporting a vast amount of rock waste called moraine. Glacial erosion on the floor and sides of a valley produces a part of this rock waste.

Mountain: "a natural rise of earth's surface that usually has a summit".

Oxidation: It is one of the varieties of chemical weathering in which oxygen dissolved in water reacts with certain rock minerals, especially iron, to form oxides. This manifests itself in brownish or yellowish staining of rock surface, which ultimately disintegrates.

Outer planets: Jupiter, Saturn, Uranus and Neptune

Parallels: The geographic grid consists of a set of as meridians and a set of east-west lines running parallel with the equator

Peneplain: Over millions of years the agents of denudation smooth out and lower the surfaces of highlands, and if they operate uninterrupted for a sufficiently long time, the highlands will be reduced to an undulating low lying landform.

Physical geography: The study of the natural characteristics of the earth.

Piedmont glacier: When valley glaciers extend on to the plains they sometimes join together to form vast lobes of ice- called piedmont glaciers.

Plant Geography: It studies the spatial pattern of natural vegetation in their habitats.

Plucking: The tearing away of blocks of rock which have become frozen into the sides or bottom of a glacier;

Polar High: The lowest temperatures are found over the poles, which cause subsidence of air and hence the polar highs. The polar highs are small in area and extend around the poles.

Population geography: It studies population growth, distribution, density, sex ratio, migration and occupational structure etc.

Political Geography: It studies boundaries, space relations between neighbouring political units, delimitation of constituencies, election scenario and develops theoretical framework to understand the political behaviour of the population.

Precipitation: It is a form of water in the atmosphere that falls on the earth; precipitation is a long-term, predictable factor of a region's makeup which is formed as a result of rapid condensation of moisture.

Primary Consumers: Organisms or animals, which feed on green plants (autotrophs) to obtain energy for survival, are called primary consumers.

Prime meridian: The meridian that passes through the old Royal Observatory at Greenwich, near London, England. It is often referred as Greenwich Meridian

Radiation: Radiation is the process by which solar energy reaches the earth and the earth loses energy to outer space. When the source of heat transmits heat directly to an object through heat waves, it is known as radiation process.

Revolution: The motion of the earth in its travel path or orbit around the Sun

Ria: This is the lower part of a river's valley which is not filled with sediment but which has been submerged by the sea.

Rock or **stone**: Is a natural substance, a solid aggregate of one or more minerals or mineraloids.

Rochemountonnee: small feature, few metres high, or large feature, more like a small hill.

Rock Pedestal: The weaker strata in a mass of rocks are shaped by wind abrasion and weathering to give tower-like structures of various shapes

Sapta Rishi: It is a group of seven Stars.

Seismology: It is the science which studies various aspects of seismic waves generated during the occurrence of earthquakes. Seismic waves are recorded with the help of an instrument known as seismograph.

Settlement Geography: It studies the characteristics of rural and urban settlements.

Sleet (Ice Pellets): Sleet takes place in freezing atmospheric conditions. Sleet, also known as ice pellets, form when snow falls into a warm layer then melts into rain and then the rain droplets falls into a freezing layer of air that is cold enough to refreeze the raindrops into ice pellets.

Sill: When a sheet of magma lies along a bedding plane forms a structure.

Social/Cultural Geography: The study of society and its spatial dynamics as well as the cultural elements contributed by the society.

Soil Geography: It is the study of the processes of soil formation, soil types, their fertility status, distribution and use.

Soil creep: There is a continuous but slow down slope movement on all slopes. This movement is called soil creep.

Solar system: The congregation of stars and planets

Solar Radiation: The sun is the primary source of energy on the earth. This energy is radiated in all directions into space through short waves. This is known as **solar radiation**.

Solifluction: Mudflows also occur in tundra regions during the early summer when the frozen soil thaws and turns into a semi liquid state thus enabling it to slide over the still frozen subsoil. This is called Solifluction.

Spit: A spit is a low, narrow ridge of pebbles or sand joined to the land at one end, with the other end terminating in the sea. It is formed by longshore drift.

Stratosphere: It is the second layer of the atmosphere found above the troposphere.

Stalactites: Develop in caves, and sometimes they join together to form natural pillars. Water containing calcium hydrogen carbonate constantly drips from the roofs of caves. As the water evaporates, it leaves behind calcium carbonate. In time the calcium carbonate forms long, slender needle-shaped features which hang down from the cave roofs. These features are called stalactites.

Stalagmites: Some of the drops of water fall to the floors of caves where similar features develop. These grow upwards are called stalagmites.

Terrigenous Deposits: Terrigenous deposits are derived from the wear and tear of land and volcanic and organic products

Terrestrial planets: Mercury, Venus, Earth and Mars.

Terrestrial radiation: When the earth's surface after being heated up by the insolation (in the form of short waves), it becomes a radiating body. The earth's surface starts to radiate energy to the atmosphere in the form of **long waves** is called as terrestrial radiation.

Tombolo: A bar joins an island to the mainland it is called a tombolo.

Transpiration: after utilizing water for conducting their biological activities, plants discharge it in the form of water vapour through the small openings present in their leaves into the atmosphere(Stomata) this natural process is called transpiration.

Troposphere: It is the lowermost layer in the structure of the atmosphere.

Volcano / Volconic Mountains: a vent or opening on the Earth's crust through which molten rock (lava), ash and gasses reach the Earth's surface from below. The ejected lava and ash accumulate around the vent and forms a high, nearly conical mountain with a crater in the summit area. It is generally called a volcano or a volcanic mountain.

Waves: Waves represent the oscillatory motions of the ocean surface induced by the force of winds. Waves may travel thousands of kms

Yardang: Bands of resistant and weak rocks lie parallel to the prevailing winds, wind abrasion produces another type of 'ridge and furrow' landscape. The belts of resistant rock stand up as sloping ridges are called yardangs.

Zoo Geography: Deals the spatial patterns and geographic characteristics of animals and their habitats.

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