150 BRANCHES OF GEOLOGY(EARTH SCIENCES)

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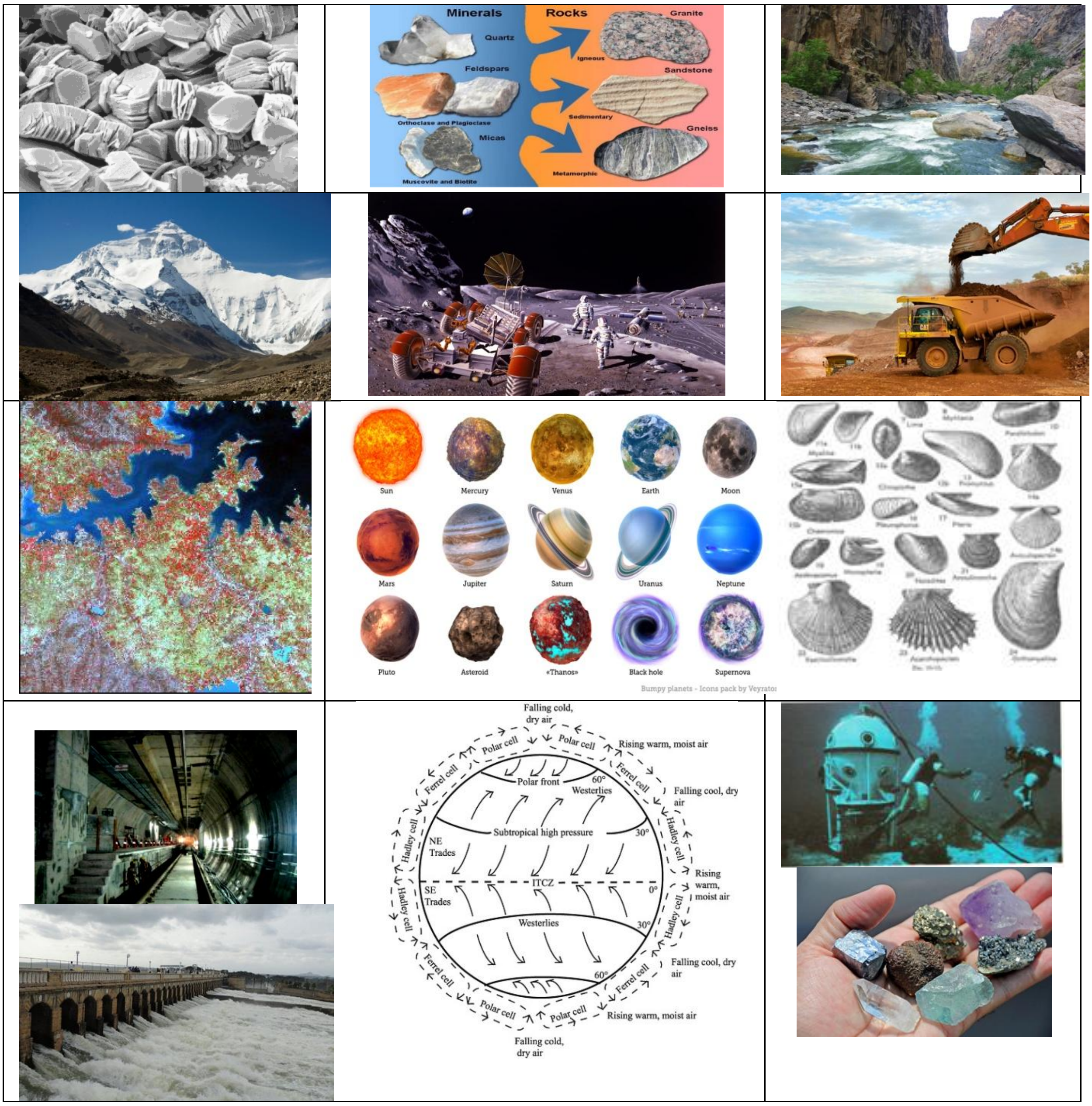

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Introduction:

Geology is the scientific study of the all constituents of planets, their internal and external forms and processes. More precisely, it is the study of nature, structure and history of the planet. Earth is the home to all life, well known to the humankind. Geology, itself, is a major part of The Earth and atmospheric sciences, which were born as twins . The subject of geology encompasses all aspects including the composition, structure, physical properties, and history of a planets'(like Earth's) inter-related components and the processes that are shaping the features on the surface. Geologists are the scientists who study the origin, occurrence, distribution and utilities of all materials(metallic, non-metallic, inorganic, etc), minerals, rocks, sediments, soils, water, oil and all other inorganic natural resources. It is a very vast subject covering a wide spectrum of scientific principles and holding hundred and fifty plus scientific branches. This report enumerates and highlights most of them, in a nutshell, for all those who intends to know for planning their career path. Some more branches could be added as and when needed.

The Subject of Geology:

The word "Geology" is derived from the Greek word "geo" means globe and "logos" means logical discourse. Hence, geology is defined as the logical study of all of the globe. Today, geology does not restrict its domain to the study of the planet earth alone. It also includes the study of the other planets and moons of the entire solar system. Geology is a very vast subject. It has several branches. In the olden days, people divided it into two broad areas, as physical geology and historical geology. The subject of Physical geology deals with the study of Earth's materials, such as minerals and rocks, as well as the processes that are operating on and within the Earth and on its surface. The subject of Historical geology focuses on the origin and evolution of life on the Earth, its continents, oceans, atmosphere, and the life of all ecosystems. Historical geology is more than just concentrating on the past events in geological history. It is the study of the sequential changes that have happened and evolved continuously during the past 4.6 billion years on the planet. Geology is a grand parent subject comprising four levels of grand children branches. Some of the notable ones are only discussed in this report.

1. Physical Geology:

Physical geology is the fundamental study of the earth's lithospheric components like rocks, minerals, and soils and how they got originated over a period of time. Many geological processes are active on the surface of the earth. They are called as exogenous processes. The highly complex internal processes such as plate tectonics and mountain-building have also formed the crustal rocks and brought them to the earth's surface. These are called as endogenous processes. All these processes are capable of creating both constructional and destructional landforms. The agents that are responsible for these actions are called as geological agents. The notable surface geological processes are weathering, mass-wasting, erosion, transportation and deposition.

The subject , physical geology, deals with the Solar system, the Earth's origin, age and internal constitution, weathering and mass-wasting, geological work of river, lake, glacier, wind, sea and groundwater. It also deals with the Volcanoes - their types & distribution, geological effects and products; earthquakes -its distribution, causes and effects. Physical Geology also projects the elementary ideas about the origin of geo synclines, concept of isostasy and mountain building(Orogeny), continental drift, seafloor spreading and plate tectonics. This subject gives the foundation for all other earth science branches.

2. Historical geology :

The planet earth has undergone several changes during each geologic period. Great mountain ranges have been folded up in one period and eroded away in the following one. Many of them have been uplifted more than once. Some of them often got washed off into the adjacent depressed zones like basins and seas. Historical geology is the discipline that uses the principles and techniques of geology to reconstruct and understand the past geological history of Earth. It is a major branch which deals with the records of events of earth history and with the historical sequence and evolution of plants and animals of past ages. Its object is to arrange the events of earth history in the regular chronological order of their occurrence and to interpret their significance. Fortunately, the historical records are preserved in the layered rocks of the crust. Historical Geology is , sometimes , called as Stratigraphical Geology. It brings together all collated details of other Branches of Geology like Paleontology, petrology and structural geology, pertaining to age-wise correlated beds.

3. Geomorphology :

Geomorphology is the scientific study of the origin and evolution of landforms and landscapes created by physical, chemical or biological processes operating at or near the Earth's surface. It is concerned with the internal geologic processes of the earth's crust, such as tectonic activity and volcanism that constructs new landforms, as well as externally driven forces of wind, water, waves, and glacial ice that modify such landforms. It is closely related to soil science, hydrology, geology and environmental science. This has the potential for applications in environmental / development planning, transport, human settlements, mining and hydrological sectors, hospitality and tourism. Geomorphology also focuses on the investigation of surface processes and the way these processes create small-scale landforms.

Geomorphology was first used as a term to describe the morphology of the Earth's surface in the 1870s and 1880s. Geomorphologists work within certain disciplines such as physical geography, geology, geodesy, engineering geology, archaeology and geotechnical engineering. This broad base of interest contributes to many research areas and interests within the field of terrain evaluation, remote sensing, defence operations, transport systems, and all urban development .

Geomorphology is further divided into various branches. To mention a few, are:
a) Evolutionary Geomorphology - which deals with the Davisian Erosion Cycles / peneplain (Footprints of Darwinian Evolution)
b) Process Geomorphology - Process geomorphology is the study of the processes responsible for landform development.
c) Quantitative Dynamic Geomorphology - Drainage basin morphology (stream order, density etc.) Newtonian mechanistic approach (stream power, fluvial erosion, diffusion/transport laws , Dynamic equilibrium approach d) Thermodynamic Geomorphology - Entropy concept
e) Predictive Geomorphology - Earthcast (extreme events – flood, landslide) - Mathematical morphology (Fractal, Spatio-temporal Geoscience Information System analysis) - Deterministic & Numerical models - Artificial Neuron Network (ANN).

The other branches include the following:

a) Planetary geomorphology
b) Mega-geomorphology
c) Tectonic geomorphology
d) Volcanic geomorphology
e) Fluvial geomorphology and river management
f) Coastal geomorphology
g) Submarine geomorphology
h) Aeolian systems and arid geomorphology
i) Tropical geomorphology

j) Cold region geomorphology.

Geomorphology is fully concerned with landforms and their origin and evolution. This subject has been studied, initially , using qualitative approaches, with the description of landforms, by describing the forces acting on Earth's surface to produce landforms and landform change. Later, more quantitative approaches came in, which were largely based on the work of Horton, Strahler, and Leopold in the 1940's and 50's. These scientists advocated for a physically-based assessment of landforms. There are many sub disciplines in geomorphology including tectonic, fluvial, storm, aeolian, floodplain, glacial, groundwater, climate, tsunami, and many others. These sub disciplines are mainly driven by distinctions in the mechanics and dynamics that are involved in the processes.

4. Fluvial Geomorphology:

The term 'Fluvial' refers to the processes associated with running waters, 'geo' refers to earth and 'morphology' refers to channel shape. Fluvial geomorphology is the scientific study of the forms and functions of streams and the interaction between streams and the landscapes that evolve around them. Fluvial geomorphology is an applied science. It is mainly devoted to understand the development of rivers, both in their natural setting as well as on how they respond to the anthropogenic changes imposed within a watershed. One of the objectives , is to predict what changes will occur to a stream channel, in response to alterations in watershed conditions; and, in turn, how these changes will affect /help human infrastructure and aquatic habitat. The geomorphology, hydrology, and ecology of river systems interact through complex processes occurring across a range of spatial and temporal scales. A river's adjustment to watershed perturbations may take thousands of years. Modifications in a stream channel may take place in less than a decade. Understanding of how these modifications, operating at different time scales, alter the width, depth, and cross-section of a channel, is critical for identifying potential problem areas, in any river system. A geomorphological approach to river management will certainly help to reduce the flood damages and improve the aquatic habitat along river courses. River Ecology is a branch which orients its approach towards the subject of fluvial geomorphology with biological inputs.

5. Coastal Geomorphology:

Coastal geomorphology, by definition, is the scientific study of the morphological development and evolution of the coasts. Coastal landforms are developed under the influence of winds, waves, currents, and sea-level changes. This branch focuses on the physical processes and their responses in the coastal zone. It is also an applied science. Sustainable management of coastal resources requires a detailed knowledge on coastal zones. Coastal zone development and management requires a thorough study of coastal geomorphology. This subject also takes the involvement of basics principles of hydrodynamics of oceanic waters. The effect of sea-level rise on coastal geomorphology is yet another area of study, in addition to global climate changes and their effects. It is a fact that rising sea-levels, result in the spatial shift of coastal geomorphology, by redistributing the coastal landforms comprising sub-tidal bed-forms, intertidal flats, salt-marshes, shingle banks, spits and bars, sand dunes, cliffs and coastal lowland. Coastal landforms act to attenuate wave and tidal energy and respond to the time-variant changes in energy conditions with reference to space and time.

6. Climatic Geomorphology:

Climatic geomorphology is the study of the role of climate in shaping landforms and the earth-surface processes. An approach used in climatic geomorphology is to study relict landforms to infer about the ancient climates. It is mainly concerned about the past climates. Climatic geomorphology identifies climatic factors such as the intensity, frequency and duration of precipitation, frost intensity, direction and power of wind, and it explains the development of landscapes under different climatic conditions. Since landscape features in one region might have evolved under certain specific climate, different from that of today, studying climatologically distinct regions of the past might help to understand the present-day landscapes. This subject helps to decipher the role of various climatic elements in shaping landforms and the earth-surface processes. The prime approach used in climatic geomorphology is to study the relict landforms to infer their ancient climates. Being often concerned about past climates, climatic geomorphology is considered to be a part of historical geology. Climatic geomorphology highlights the influence of climatic factors and explains the development of landscapes formed under different climatic conditions. The core factor is that each climate type produces its own characteristics assemblages of landforms and classifies the geomorphic processes which produces them.

7. Tropical geomorphology:

The tropics are a typical climatic region. They are characterized by particular climates, that may be dry or humid. The tropics can be divided into two primary units based on annual rainfall, the humid tropics and the arid topics. These are the belts of low latitudes and high temperature. Like climate, landforms and operating geomorphic processes are not the same across the tropics. The tropics are an assemblage of active tectonic belts, ancient cratons, alluvial valleys and subsiding deltas. Geomorphology in the tropics provides twin opportunities to discover new facts and to apply such information to manage the environment for a sustainable future. Tropical geomorphology has a tendency to look forward rather than look back exclusively at past landforms. Relative to temperate zones, the tropics contain areas of high temperatures, high rainfall intensities and high evapotranspiration, all of which are climatic features relevant for surface processes.

Tropical zones include a great variety of landforms and ecosystems. These areas are not only containing important natural resources but also face numerous natural hazards. Humid tropical areas contain numerous mineral, hydrocarbon, forest, and agricultural resources. These belts are located on tectonically active zones and hence they are often affected by earthquakes and tsunamis. Volcanic hazards are also very severe, especially the explosive ones, with the bursting of fire clouds, ash falls, and lahars. in addition to these, the highest occurrence of other hazards associated with tropical areas include tropical cyclones strong destructive winds, floods, and slides related to the cyclonic rains, as well as onshore storm surges caused by wind and atmospheric pressure changes. The analyses of tropical geomorphology are useful for planning , alleviation of environmental degradation and avoiding of natural hazards.

8. Glacial geomorphology:

Glacial geomorphology is concerned principally with the role of glacial ice in landform and landscape evolution. It is the scientific study of the processes, landscapes, and landforms produced by ice sheets, valley glaciers, and other ice masses on the surface of the Earth. These processes include understanding how ice masses move, and how glacial ice erodes, transports, and deposits sediment. This subject is much useful to the planetary geologists who are interested in understanding the evolution and history of the surface of nearby planets in our solar system. It has been reported that the planet Mars is covered with permafrost, where the soil temperatures are permanently below the freezing point of water. Bitter cold temperatures dominate the Martian equatorial regions, with an annual-mean temperature of the soil colder than -50 deg C, and colder still at middle and high latitudes. Therefore, any water present in the Martian soil must be in the form of ice. Glacial deposits form characteristic flow features that indicate thick piles of water ice in a slow viscous motion.

9. Periglacial Geomorphology:

Glacial and periglacial geomorphology are those branches of geomorphology concerned with the evolution of landscapes in high latitudes and altitudes. Periglacial geomorphology must also be viewed as one of the group of sciences that concern the cryosphere. Periglacial geomorphology has a special interest in the thawing and freezing of ground. The core of periglacial geomorphology is concerned with the study of freezing processes, associated with ground ice, and their related landforms. Such an approach places permafrost in a central position, within periglacial geomorphology. This subject primarily focuses on the geomorphological processes and landforms associated with glaciers, permafrost, periglacial and slope environments. Periglacial environments are characterised by frost action and the recurrent presence of a snow cover. The salient components of modern periglacial geomorphology include the study of i) the nature of permafrost-related processes, ground ice, and associated landforms; ii) the azonal processes that operate in cold non-glacial environments; iii) the ice-marginal (proglacial) environment and associated paraglacial transitions; iv) the alpine (montane) environment; v) Pleistocene cold-climate paleo-environmental reconstructions; vi) environmental and geotechnical studies associated with frozen ground, ground freezing and global climate change.

10. Geocryology:

Geocryology is the study of frozen rock, soils, and ground. It deals with the origin, historical development, and conditions of existence of frozen strata in the earth's crust. It helps to study the processes and phenomena that occur in freezing, frozen, and thawing rock, soils, and ground, as well as their structure, composition, and properties. The subject also deals with the geophysical, physico-geological, geomorphological, and hydrogeological phenomena that are related to the processes of the freezing, thawing, and diagenesis of frozen strata. In addition to developing the theory of such processes, geocryology also deals with the development of methods of influencing processes of freezing in the interests of construction, transportation, agriculture, and other activities. There are two main branches , as —general geocryology and engineering geocryology. The second one has much more practical significances.

The early development of geocryology occurred in Russia as early as 1924. The first edition of a standard text which came from the Soviet Union, Obshcheye Merzlotovedeniya (General Permafrostology) , was published in the year 1940. By comparison, North American geocryology is of relatively recent origin. Geocryology got emerged initially from geophysics. Today, geocryology uses various methods of investigation—as a complex of field (expeditionary) and laboratory methods of the geological, geographic, and geophysical sciences and the physical and physicochemical laboratory methods. Geocryology combines the experimental research with theoretical basis and makes extensive use of numerical approaches.

11. Tectonic geomorphology:

Tectonic geomorphology is the study of the interplay between tectonic and geomorphic processes in regions where the Earth's crust actively deforms. Tectonic geomorphology is the study of the interplay between tectonic and surface processes that shape the landscape in regions of active deformation. Recent advances in the quantification of rates and physical basis of tectonic and surface processes have rejuvenated the field of tectonic geomorphology. Modern tectonic geomorphology is an exciting and highly integrative field which utilizes techniques and data derived from studies of geomorphology, seismology, geochronology, structure, geodesy, and Quaternary climate change. While emphasizing new insights from the last decade of research, Tectonic Geomorphology reviews the fundamentals of the subject which include the nature of faulting and folding, the creation and use of geomorphic markers for tracing deformation, chronological techniques which date deformation, geodetic techniques for defining recent deformation, and paleo-seismologic approaches to calibrate past deformation. Tectonic geomorphology is an integrated subject that presents stimulating challenges to anyone trying to extract information from deforming landscapes.

12. Submarine geomorphology:

Submarine geomorphology deals with the form, origin, and development of features of the oceanic bottoms . In shallow marine environments, the landforms include ripples, dunes, sand waves, sand ridges, shorelines, and subsurface channels. In the continental slope transition zone the features studied are submarine canyons and gullies, inter-canyon areas, intra-slope basins, and slump and slide scars. The deep ocean basins contain varied landforms like trenches , trench fans, sediment wedges, abyssal plains and distributary channels.

13. Planetary geomorphology:

Planetary geomorphology is yet another branch of geomorphology. It involves the study of landforms on planets and their satellites. It is a modern branch. Most of the surface processes on other planets and their satellites depend on various factors like mean distance from the Sun, annual receipt of solar energy, rotational period, and on the nature of the planetary atmospheric conditions. Observed geomorphic processes include weathering, wind activity, fluvial activity, glacial activity, and mass wasting.

14. Geomorphometry:

Geomorphometry is yet another branch of geomorphology. It is also called as landform morphometry. It helps to study quantitatively the geometric forms of the land surfaces. The concepts of geomorphometry dates back to the work of both Alexander von Humboldt and Carl Ritter, who postulated these ideas in the early and mid-nineteenth century. Morphometric analysis**,** quantitative description and analysis of landforms are the primary focus in this subject. Morphometry is an essential means in geomorphic analysis of an area. Morphometry is defined as the measurement and mathematical analysis of the configuration of the earth's surface and of the shape and dimension of its landforms. It is done mainly to understand the structure, processes and evolution of landscape. Analysis of the flow pattern in the basin helps to relate the runoff characteristics to the morphometric parameters. The quantitative analysis of drainage basins is an important aspect of characterization of its sub-basins and watersheds. Such characterization of watersheds plays an important role in forecasting the hydrological behavior within the system and thereby it helps planning for hydrologic designs.

15. Human geomorphology:

The subject of anthropogenic geomorphology is the description of the wide and ever-widening range of surface landforms, extremely diverse in origin and in purpose, created by the operation of human society. In a broader sense, artificially created landforms have manifold influences on the environment and modify the natural processes. Human geomorphology studies the impacts humans have on the globe, on reshaping the landforms. Thus, it is difficult to imagine a location or circumstance that has not been impacted by geomorphic processes, by the existence of human beings. The subject of anthropogenic geomorphology is broadened by the fact that the artificially created landforms have manifold influences on the environment (e.g. alterations in meso- and microclimate, biota, etc.). In addition, they may also modify natural processes. Human geomorphic action may induce cascading environmental changes, whose study obviously lies within the scope of anthropogenic geomorphology.

The major fields of anthropogenic geomorphology are: Mining and processes involved and the resulting landforms, industrialization and its impact reflected in industrogenic landforms, settlement (urban) expansion exerting a major influence on the landscape over ever increasing areas, advanced farming which heavily relying on rivers, water management (river channelization, drainage). All these occupies a special position in anthropogenic geomorphology. Agriculture is a major social activity causing changes on the surface. Agrogenic impacts also include transformation due to forestry. Although warfare is not a productive activity it has long-established surface impacts. In contrast, the impacts of tourism and sports activities are rather new fields of study in anthropogenic geomorphology.

16. Applied geomorphology:

Applied geomorphology is the study of interactions of humans with landscapes and landforms. The interaction between geomorphology and public policies, with contributions on rural land-use and soil erosion, urban land-use, slope management, river management, coastal management, and policy formulation are discussed in this subject. Landslides , debris flows and soil erosion may become more severe in some places. The sediment load of some rivers may increase, some beaches and cliffs may erode faster, some of the coastal lowlands may become submerged, and frozen ground in the tundra environments may thawing processes. Applied geomorphologists are concerned with all these potentially damaging changes, their causative factors and to provide solutions to solve them also.

17. Biogeomorphology and Ecogeomorphology:

Biogeomorphology and ecogeomorphology are the study of interactions between organisms and the development of landforms. Organisms affect geomorphic processes in a variety of ways. For example, trees can reduce landslide potential where their roots penetrate to underlying rock, plants and their litter inhibit soil erosion. The biochemicals produced by plants accelerate the chemical weathering of bedrock and regolith. Similarly, the marine animals cause the bioerosion of coral. The study of the interactions between marine biota and coastal landform processes is called coastal biogeomorphology. Biogeomorphology has two-way interaction between geomorphology and ecology. Ecogeomorphology is synonymous with biogeomorphology. There are some key applications of biogeomorphological research. The roles of organisms in environmental reconstruction, trace fossil analysis, extraterrestrial geomorphology, environmental engineering and the built environment are the major aspects.

18. Phytogeomorphology:

The subject phyto-geomorphology can be defined as the study of relationships between the earth's relief features and the distribution of plant species. The subject mainly emphasizes on the importance of combining plants and landforms in studies related to the land surface of the earth and in recognition of their interdependence. It forms a powerful tool for the survey, management and planning of our environment. In addition, there are more specific discipline-oriented studies that can benefit directly or indirectly from a phyto-geomorphic approach. It is a fact that the balance between landforms and vegetation varies greatly. This subject is a part of biogeomorphology. It deals with the narrower subject of how terrain affects plant growth. It focuses on how terrain attributes affect crop growth and yield in a farm field. Precision agriculture models where crop variability is at least partially defined by terrain attributes can be considered as phytogeomorphological precision agriculture. Phytogeomorphology is an interdisciplinary subject including the concepts of plant ecology, geography and geology. Due to this, the study of phyto-geomorphology has attracted geographers, plant ecologists and also geologists each with diverse objectives.

19 Hydrogeomorphology :

The term of hydrogeomorphology was first used by Scheidegger in 1973. Hydrogeomorphology is defined as “an interdisciplinary science that focuses on the interaction and linkage of hydrologic processes with landforms or earth materials and the interaction of geomorphic processes with surface and subsurface water in temporal and spatial dimensions". Hydrogeomorphology is considered as the basic study of landforms caused by the action of water. This branch describes and evaluates the geomorphic environment, in which water occurs and circulates. Hydrogeomorphology of a drainage basin is a function of rainfall kinematics**,** surface topography, drainage basin morphology and runoff. Geological conditions may also control and influence the effect of most of these factors. The role of these factors are reflected as drainages which in-turn provide the information to understand the situation and to make the proper decisions on water resources management. It is majoritively a quantitative study , of areal, linear and relief morphometric aspects of a drainage basin, provides the theoretical base for all the hydrogeomorphic approaches.

20. Engineering geomorphology:

Engineering geomorphology is concerned with the evaluation of landform changes, especially the effects of construction on the environment, notably on the operation of surface processes and the risks from surface processes, whether current processes or the legacies of past processes. Engineering geomorphology provides practical support for engineering decision-making (project planning, investigation, design and construction) and engineering geomorphologists form an integrate part of the engineering or environmental team. Engineering geomorphology has developed in the last few decades to support a number of distinct areas of engineering, including river engineering, coastal engineering, and geotechnical engineering, where engineering geomorphology has complemented engineering geology and has proven to be valuable, especially for rapid site reconnaissance and slope stability studies. Engineering geomorphology can also be applied to agricultural engineering, primarily in the investigation and management of soil erosion problems.

21. Paleontology or Palaeontology:

Paleontology (US spelling) or palaeontology (UK spelling) is the scientific study of the developing history of life on earth. It is the study of ancient plants and animals based on their fossil record. It is a fact that the evidence of existence of all life on earth, since the origin, are mostly preserved in rocks. This includes the study of body fossils, tracks, burrows, cast off parts, fossilized faeces ("coprolites"), and chemical residues. Body fossils and trace fossils are the principal types of evidences that help to know about the ancient life. In addition, the geochemical evidences also help to decipher the evolution of primitive life existed before.

The subject of Paleontology helps to determine the organisms' evolution and interactions with each other and their environments (their paleoecology). It also heavily relies on the two subjects such as biology and geology. It differs from archaeology in that it excludes the study of anatomically modern humans. It uses techniques drawn from a wide range of allied sciences like biochemistry, mathematics, and engineering. Use of all techniques from other sciences, has enabled paleontologists to discover much of the evolutionary history of life, almost all the way back to the origin of Earth. As the knowledge level has increased, paleontology became a specialised subject with more and more sub-divisions. Some of which focus on different types of fossil organisms , while the other branched out and orients towards the ecology and environmental history of ancient climates. On several fronts, paleontology overlaps with geology (the study of rocks and rock formations) as well as with botany, biology, zoology and ecology.

Today, paleontology has become a very big subject with its own branches. These branches are unique in their applications. The major subdivisions of paleontology include paleozoology (animals), paleobotany (plants) and micropaleontology (microfossils) and palynology. Paleozoologists may specialise in invertebrate paleontology, which deals with animals without backbones or in vertebrate paleontology, dealing with fossils of animals with backbones, including fossil hominids (paleoanthropology). Micropaleontologists study microscopic fossils, including organic-walled microfossils whose study is called palynology. There are many developing specialties such as paleobiology, paleoecology, ichnology (the study of tracks and burrows) and taphonomy (the study of what happens to organisms after they expire). Major areas of study include the correlation of rock strata with their geologic ages and the study of evolution of life forms.

22. Invertebrate Paleontology:

Invertebrate paleontology (it is also spelled as Invertebrate palaeontology) is considered to be a subfield of paleontology, paleozoology, or paleobiology. It is the scientific study of prehistoric invertebrates by analyzing invertebrate fossils in the geologic record. The invertebrates include the non-vertebrate creatures of the kingdom Animalia (or Metazoa) in the biotic domain of Eukaryota. By phyletic definition, these are many-celled, sub-vertebrate animals. They lack a vertebral column, spinal column, vertebrae, backbone, or long, full-length notochord -- in contrast, of course, to the vertebrates , in the one phylum of Chordata. The invertebrates have never had a cartilaginous or boney internal skeleton. It has gill slits, ribs and jaws. Throughout the geologic time, invertebrates have remained non-craniate creatures.

23. Vertebrate Paleontology:

Vertebrates are all the animals with backbones, the fishes, amphibians, reptiles, birds, and mammals. These animals have attracted a great deal of study. Vertebrate paleontology is a subfield of paleontology. The study seeks to discover, the features of fossilized remains, the behavior, reproduction and appearance of extinct animals with vertebrae or a notochord. Vertebrate paleontology covers everything from the tiny, fish-like creatures that first evolved backbones, to the salamander-like ancestors of all land vertebrates including dinosaurs, mammals, flying and swimming reptiles, mastodons, marsupials.

Vertebrate paleontology embraces far beyond the study of large, legendary creatures. Smaller animals, like our ancestors, the early mammals, are equally important. Small animals tend to be more common in the fossil record and better preserved. Hence, they reveal enormous amounts of information on the ecosystems and climates of Earth's distant past. The fields of paleobiology, paleoecology, biomechanics, anatomy, paleoclimatology, evolutionary biology and many others are represented in vertebrate paleontology research.

24. Micropaleontology:

Micropaleontology (also spelled as micropalaeontology) is a modern branch of palaeontology. It deals with the study of microfossils, or fossils that require the use of a microscope to see the organism, its morphology and its characteristics. Since the size of the microfossils are generally ranging between 0.001mm and 1 mm, their study requires the use of light or electron microscopes. Fossils which can be studied with the naked eye or low-powered magnification, such as a hand lens, are referred to as macrofossils. the microfossils are the remains of unicellular, multicellular micro-organisms and the dissociated elements and skeletal fragments of macro-organisms. The types of families of microfossils studied and analysed are Foraminifera, Ostracods, Coccolithophora, Diatoms, Radiolaria and Dinoflagellates.

Micropaleontology is also one of the largest branches of paleontology. The microfossils are by far the most abundant of all fossils present on the earth's stratigraphic beds. The practical value of marine microfossils in various fields of historical geology is enhanced by their minute size, abundant occurrence, and wide geographic distribution in sediments of all ages and in almost all the marine environments. Due to their small sizes and large numerical abundance, relatively small sediment samples can usually yield enough data for the application of more rigorous quantitative methods of analysis. Marine microfossils occur in sediments of Precambrian to Recent ages, and in every part of the stratigraphic column, one or more groups can always be found more useful for biostratigraphic and paleoecologic correlations.

Microfossils remain an indispensable part of any sedimentary basin study, providing the biostratigraphical and palaeoecological framework and, increasingly, a measure of maturity of hydrocarbonprone rocks. Microfossils are vital indicators for oil exploration. The condition of the fossils indicates whether the petroleum source rocks have been buried and heated sufficiently to generate oil from trapped organic matter. Micropalaeontology brings three unique perspectives to the study of evolution: the dimension of time, abundance of specimens (allowing statistical analysis of trends) and long complete fossil records, particularly in marine groups.

25. Palynology:

The term palynology was introduced by Hyde and Williams in 1944. Palynology is the scientific study of contemporary and fossil palynomorphs, including pollen, spores, orbicules, dinocysts, acritarchs, chitinozoans and scolecodonts, together with particulate organic matter (POM) and kerogen found in sedimentary rocks and sediments. The particles of a size between five and 500 micrometres, found in rock deposits, and composed of organic material are analysed in this subject. A classic palynologist analyses the particulate samples collected from the air, from water, or from deposits including sediments of any age. The condition and identification of those particles, organic and inorganic, give the palynologist clues to the life, environment, and energetic conditions that produced them. (Palynology does not include diatoms, foraminifera or other organisms which have siliceous or calcareous exoskeletons). Today, palynology has become an interdisciplinary branch of earth science and biological science, particularly plant science.

Actuopalynology is the study of extant palynomorphs which are either living, still retain their cell contents, or whose cell contents have been removed by maceration.

Paleopalynology is the study of fossil palynomorphs, where "fossil" is defined as "any indication of past life" including the term "sub-fossil." The study of chitinozoans (animal remains), fungal spores, dinoflagellates, acritarchs and other organisms (except diatoms) is also included in palaeopalynology.

Copropalynology (Greek 'kopros' means dung) is the study of palynomorphs present in coprolite (= fossilized excrement) of animals. Human coprolite is preserved in dry caves. Pollen and spore analyses of human coprolite provide information about the diet of prehistoric humans.

Pollen analysis of herbivore coprolite provides data to reconstruct the composition of pastures of that time. This study also includes the pollen analysis of recent excreta. Forensic palynologists determine the last diet of a murdered person by pollen analyses of stomach, gut and feces.

Entomopalynology is the study of pollen grains that are associated with insects. This study mainly encompasses melissopalynology, research on honeybees, foraging distances of insects and pollination biology, etc. The basic purpose of studying this subject is to find the relation of pollinators and crop yield. It is observed that in apples, melons and almonds etc. the yield increases with the increase of pollinators. Some pollinators are pests on some crops. By studying the pollinators and pests, efficient management practices can be developed to increase the crop yield.

Latropalynology is the 'study of spores and pollen as applied to human health problems'—Traverse. It is known that pollen and spore have medicinal properties. As for example Arabian physicians use Lycopodium spores— commercially called 'vegetable sulphur' for the treatment of stomach disorders. The spores of Adiantum phillippinense are used to cure coughs.

Forensic Palynology is the study of palynomorphs that are used as evidence in criminal cases and resolve other legal problems. Forensic palynology also includes identifying and linking the suspect to the scene of the crime.

26. Stratigraphical palynology:

Stratigraphical palynology is a branch of micropalaeontology and paleobotany, which studies fossil palynomorphs from the Precambrian to the Holocene. The subject relies on the use of palynomorphs**,** their identification, distribution, and abundance to correlate among sedimentary sequences of any age, or to provide chronological control for these sedimentary sequences.

27. Quaternary Palynology:

Quaternary Palynology deals with the quantitative analysis of pollen, spores and related microfossils in sediments of Quaternary age (the last 2.5 million years). Quaternary Palynology relies heavily on the precise dating for correlation among stratigraphic sequences, and for reconstructing rates of environmental change. For the late-Quaternary (the last 50,000 years), time control is based primarily based on radiocarbon dating. The Quaternary spans much of the time on the development of humans. Particularly during the late Quaternary, the influence of environmental change on humans, and the influence of humans on the environment are important aspects covered under Quaternary Palynology.

28. Archaeological Palynology:

Archaeological Palynology is another branch using palynology as an archaeological tool. It is also a branch of Archaeobotany - applying botanical and paleo-botanical techniques to archaeological investigations.

29. Environmental Palynology:

Environmental Palynology focuses on the use of palynomorphs**,** their identification, distribution, and abundance in order to determine the past changes in the biota, climate, or surficial geology of an area.

30. Paleobotany:

Paleobotany, is the study of ancient plants, which are existing in fossilized forms. It is one of the branches of paleontology or paleobiology. It deals with the recovery and identification of plant remains from the geological formations, and their use for the biological reconstruction of past environments (paleogeography), and both the evolutionary history of plants, with a bearing upon the evolution of life. Paleobotany includes the study of terrestrial plant fossils, as well as the study of prehistoric marine photoautotrophs, such as photosynthetic algae, seaweeds or kelp. A closely related field to this is palynology. Paleobotany is important in the reconstruction of ancient ecological systems and climate, which is known as paleoecology and paleoclimatology respectively. Paleobotany has become important to the field of archaeology, primarily for the use of phytoliths in relative dating.

31. Paleoecology:

Paleoecology (also spelled palaeoecology) is the study of interactions between organisms and/or interactions between organisms and their environments, across geologic timescales. As a discipline, paleoecology interacts with, depends on and informs a variety of fields including paleontology, ecology, climatology and biology. Paleoecology got emerged out of the field of paleontology in the 1950’s, though paleontologists have conducted paleoecological studies since the creation of paleontology in the 1700s and 1800s. Combining the investigative approach of searching for fossils with the theoretical approach of Charles Darwin and Alexander von Humboldt, paleoecology began as paleontologists began examining both the ancient organisms they discovered and their environments. Visual depictions of past marine and terrestrial communities has been considered an early form of paleoecology.

32. Palaeogeography:

Palaeogeography (or paleogeography) is the scientific study of historical geography, generally within the physical landscapes. Palaeogeography includes the study of human or cultural environments. Paleogeography yields information that is crucial to the scientific understanding in a variety of contexts. Paleogeographers also study the sedimentary environment associated with fossils for clues to the evolutionary development of extinct species. Paleogeographic evidences have contributed to the development of continental drift theory including plate tectonic theories, shape and latitudinal location of supercontinents such as Pangaea and ancient oceans such as Panthalassa. It helps to enable the reconstruction of prehistoric continents and oceans.

33. Crystallography:

The first historical references to the use of crystals come from the Ancient Sumerians (4th millennium BC). The Ancient Greeks identified quartz with the word "crystal". The study of crystals became a separate subject called as Crystallography. Crystallography is the experimental science of determining the arrangement of atoms in the crystalline solids. Today we know that crystals are made of matter, atoms, molecules and/or ions that fit together in repeating patterns, called unit cells, which like bricks stacked in three dimensions form the crystals. Inside the unit cells atoms are also repeated by symmetry operations. These patterns cause the crystals to show many sorts of unique shapes. Crystallographers use the properties and inner structures of crystals to determine the arrangement of atoms and generate knowledge that is used by chemists, physicists, biologists, and others. Crystallographers have been associated with the geosciences, metallurgy, and ceramics engineering. The pharmaceutical and biochemical fields rely extensively on the crystallographic studies.

34. X-ray Crystallography

The subject of X-ray Crystallography is a modern development in the field of crystallography.
Since the 1920s, X-ray diffraction has been the principal method for determining the arrangement of atoms in minerals and metals. The application of X-ray crystallography to mineralogy began with the structure of garnet, which was determined in 1924 by Menzer. A systematic X-ray crystallographic study of the silicates was undertaken in the 1920s. The oldest and most precise method of X-ray crystallography is single-crystal X-ray diffraction, in which a beam of X-rays strikes a single crystal, producing scattered beams. Crystallographic methods now depend on analysis of the diffraction patterns of a sample targeted by a beam of some type**.** X-rays are most commonly used; other beams used include electrons or neutrons. This is facilitated by the wave properties of the particles. Crystallographers use X-ray, neutron, and electron diffraction techniques to identify and characterize solid materials.

Since many materials can form crystals—such as salts**,** metals**,** minerals**,** semiconductors, as well as various inorganic, organic, and biological molecules—X-ray crystallography has been fundamental in the development of many scientific fields. X-ray crystallography is still the chief method for characterizing the atomic structure of new materials and in discerning materials that appear similar by other experiments. X-ray crystallography is related to several other methods for determining atomic structures. X-ray diffraction has a wide and various applications on the chemical, biochemical, physical, material and mineralogical sciences. Laue`s said that 'has extended the power of on serving minute structure ten thousand times beyond that of the optical microscope.

35. Mineralogy :

The history of mineralogy is as old as humankind. Minerals have been an important part of our society since the time of prehistoric man. Mineralogy is the branch of geology concerned with the study of minerals. The early writings on mineralogy were devoted to gemstones, mostly seen in the records of ancient Babylonia, the ancient Greco-Roman world, ancient and medieval China, and Sanskrit texts from ancient India and the ancient Islamic World. The modern study of mineralogy was founded on the principles of crystallography. It is the scientific study of chemistry, crystal structure, and physical (including optical) properties of minerals. Specific studies within mineralogy include the processes of mineral origin and formation, classification of minerals, their geographical distribution, as well as their utilization. There are several different branches to mineralogy.

Physical mineralogy:
Physical mineralogy is concerned with the physical properties and descriptions of minerals. Minerals can be described using several physical attributes, including hardness, specific gravity, luster, color, streak, and cleavage.

Chemical Mineralogy
The chemical mineralogy deals with the investigation of the chemical composition of minerals and its variation, the processes of mineral formation, and the changes minerals undergo when acted upon chemically.

36. Descriptive mineralogy

Descriptive mineralogists use the properties discussed in physical mineralogy to name and classify the new minerals. Determinative mineralogy is the branch of mineralogy that deals with identifying unknown minerals, also using the physical properties of minerals. Other branches of mineralogy include chemical mineralogy (identifying minerals to determine the chemical composition of the earth's crust), optical mineralogy (using light to determine the crystal structure of minerals).

37. Optical Mineralogy:

Optical mineralogy is the study of minerals and rocks by measuring their optical properties. Most commonly, rock and mineral samples are prepared as thin sections or grain mounts for study in the laboratory with a petrographic microscope. Optical mineralogy is used to identify the mineralogical composition of geological materials in order to help reveal their origin and evolution. It deals with the principles of optics, behaviour of light through isotropic and anisotropic substances, petrological microscope, construction and working of nicol prism, birefringence, pleochrosim , extinction, physical, chemical and optical properties of more common rock forming minerals. The subject deals with the optical properties of crystalline matter and to the polarizing microscope for optical mineral identification. Thin section and polished section studies provide important information on the crystallographic properties and the chemical composition of the common rock-forming minerals. Optical mineralogy analyses the interaction of light with minerals, most commonly limited to visible light and usually further limited to the non-opaque minerals. Opaque minerals are more commonly studied in reflected light and that study is generally called ore microscopy - alluding to the fact many opaque minerals are also ore minerals.

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Optical mineralogy deals with the study of the interaction of light with minerals, most commonly limited to visible light and usually further limited to the non-opaque minerals. Opaque minerals are more commonly studied in reflected light and that study is generally called ore microscopy - alluding to the fact many opaque minerals are also ore minerals. The most general application of optical mineralogy is to aid in the identification of minerals, either in rock thin sections or individual mineral grains. Another application occurs because the optical properties of minerals are related to the crystal chemistry of the mineral -- for example, the mineral's chemical composition, crystal structure, order/disorder. Thus, relationships exist, and correlations are possible between them and some optical property. This often allows a simple optical measurement with the petrographic microscope (a polarizing microscope) that may yield important information about some crystal chemical aspect of the mineral under study.

38. Petrology

Petrology is the scientific study of rocks, their composition, texture, and structure, their occurrence, distribution and origin in relation to physicochemical conditions and geologic processes of formation. It is concerned with all three major types of rocks—igneous, metamorphic, and sedimentary. Petrography is a branch of petrology that focuses on detailed descriptions of rocks. Someone who studies petrography is called a petrographer. The mineral content and the textural relationships within the rock are described in detail. Petrologic, petrographic, and petrogenetic studies can be applied to igneous, metamorphic or sedimentary rocks. The classification of rocks is based on the information acquired during the petrographic analysis.

Petrographic descriptions start with the field notes at the outcrop and include all macroscopic description of hand specimens. The most important tool for a petrographer is the petrographic microscope. The detailed analysis of minerals by optical mineralogy in thin section and the micro-texture and structure are critical to understanding the origin of the rock. EPMA- Electron microprobe analysis of individual grains as well as the whole rock chemical analysis by atomic absorption, X-ray fluorescence, and laser-induced breakdown spectroscopy, are used for understanding the genesis and distribution. Analysis of microscopic fluid inclusions, within the mineral grains, with a heating stage on a petrographic microscope, provides clues to the temperature and pressure conditions existent during the mineral formation.

39. Petrogenesis :

Petrogenesis refers to the origin of a rock or mineral deposit. It is an exclusive sub-branch of petrology. It is studied under specialization of various rock systems. Petrogenetic significances are very much essential for geomodelling , geodynamics and in geotctonics.

40. Petrography

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41. Igneous Petrology:

Igneous petrology is the scientific study of igneous rocks, that are formed from magma. As a branch of geology, igneous petrology is closely related to volcanology, tectonophysics, and petrology in general. The study of igneous rocks utilizes a number of techniques, some of them developed in the fields of chemistry**,** physics, or other earth sciences. Petrography**,** crystallography, and isotopic studies are common methods used in igneous petrology. The major aspects studied are magma - its composition and nature, crystallization of magma, Differentiation and assimilation, Bowen's reaction principle, Texture and structure of igneous rocks, mode of occurrence and mineralogy of igneous rocks, in addition to the classification and varieties of igneous rocks. Petrologic, petrographic, and petrogenetic studies are applied to all kinds of igneous rocks.

42. Sedimentary Petrology:

Sedimentary petrology is one of the branches of petrology. It focuses on the origin, occurrence, distribution, composition and texture of sedimentary rocks such as sandstone, shale, or limestone. These rocks consist of pieces or particles derived from other rocks or biological or chemical deposits. These masses are usually bound together in a matrix of finer material. The major aspects studied are sedimentary process and products, classification of sedimentary rocks and primary sedimentary structures like bedding, cross bedding, graded bedding, ripple marks, sole structures, parting lineation. It also includes the study of residual deposits , their mode of formation, characteristics and important types. Sedimentary petrologists work to re-establish the ancient depositional environment. Sedimentary petrology also help to study the rocks under deep burial, which may be in elevated temperature and pressure conditions. That leads to the study on the transitional area between sedimentary rock and metamorphic rock.

43. Metamorphic Petrology:

The metamorphic petrology a branch of petrology. It is concerned with decoding the mineralogical and microstructural record of burial/heating and exhumation/cooling imprinted on pre-existing sedimentary, igneous and metamorphic rocks by processes such as subduction, accretion, trench advance or retreat, collisional orogenesis and orogenic collapse. Metamorphic petrology covers the chemical and physical work done in natural systems in response to changing physical conditions. Petrogenetic processes such as recrystallization, continuous and discontinuous reactions, mixed volatile reactions and deformation are studied in detail. The principles of metamorphic petrology are then applied to a number of orogenic events through geologic time, and modern advances in research in metamorphic petrology are explored. the basic concepts include simple recrystallization; metamorphic reactions in a closed system; isograds, metamorphic facies; continuous reactions; mixed volatile reactions; metamorphism and melting; and metamoprphic tectonites and deformation.

44. Structural Geology :

Structural geology is the scientific study of the three-dimensional distribution of rock units with respect to their deformational genesis and histories. The primary goal of structural geology is to use measurements of present-day rock geometries to uncover the information about their origin and history of deformation (strain) in the rocks. It helps to understand the stress field that resulted in the observed features of strain and geometries. This understanding can also be linked to important events in the geologic past. These can also help to find out the date of events. Once the nature of these rocks are determined, petroleum geologists can discover if petroleum, natural gas, or other natural resources that are trapped within the rocks. Deposits of gold, silver, copper, lead, zinc, and other metals, are commonly located in structurally complex areas. Structural Geology aims to characterise deformation structures (geometry), to characterize flow paths followed by particles during deformation (kinematics), and to infer the direction and magnitude of the forces involved in driving deformation (dynamics). This subject is a field-based discipline. Field Geology is a branch which requires the knowledge of Geomorphology, Petrology, Sedimentology and Stratigraphy, Structural Geology and GIS. Structural geology is an essential part of engineering geology, which is concerned with the physical and mechanical properties of natural rocks.

45. Economic Geology:

Economic Geology is the scientific study of the Earth's sources of mineral raw materials and the practical application of the acquired knowledge. Economic geology is primarily concerned with the earth's materials that are used for economic and/or industrial purposes. These materials include precious stones and base metals, nonmetallic minerals, construction-grade stones, petroleum minerals, coal, and water. These materials include precious and base metals, nonmetallic minerals, construction-grade stone, petroleum minerals, coal, and water. Economic geology is a subdiscipline of the geosciences. It is “the application of geology”. It might also called as the scientific study of the Earth’s sources of mineral raw materials and the practical application of the acquired knowledge The term commonly refers to metallic mineral deposits and all other mineral resources. The techniques employed by other branches of earth sciences (such as geochemistry, mineralogy, geophysics, petrology and structural geology) are used to understand, describe, and exploit an ore deposit. Economic geology may be of interest to other professions such as engineers, environmental scientists, and conservationists because of the far-reaching impact that extractive industries have on society, the economy, and the environment. Economic geology focuses on the properties and characteristics of ores, ore minerals and gangue minerals, gives an outline of the processes of formation and classification of ore deposits, the mode of occurrence, origin, distribution (in India) and economic uses of gold, ores of iron, manganese, chromium, copper, aluminium, lead and zinc; mica, gypsum, magnesite and kyanite; diamond; coal and petroleum.

46. Ore Geology:

Geologists are involved in the study of ore deposits, which includes the study of ore genesis and the processes within the Earth's crust that form and concentrate mainly on ore minerals into economically viable quantities. The study of metallic ore deposits involves the use of structural geology, geochemistry, the study of metamorphism and its processes, as well as understanding metasomatism and other processes related to ore genesis. In general, ore deposits are delineated by mineral exploration methods, which uses geochemical prospecting, drilling and resource estimation via geostatistics to quantify economic ore bodies. The ultimate aim of this process is mining.

47. Petroleum geology:

Petroleum geology is the study of origin, occurrence, movement, accumulation, and exploration of hydrocarbon fuels. It refers to the specific set of geological disciplines that are applied to the search for hydrocarbons (oil exploration). Petroleum geology is principally concerned with the evaluation of several key elements in sedimentary basins, like, source, reservoir, seal, trap, timing, maturation, and migration. In general, all these elements must be assessed from exploration wells. Recently, the availability of inexpensive, high quality 3D seismic data (from reflection seismology) and data from various electromagnetic geophysical techniques (such as Magnetotellurics) has greatly aided the accuracy of such interpretation in oil exploration.

48. Coal geology:

Coal Geology is a modern branch of geology. It deals with all aspects of coal and the role of geology in coal industry. It deals not only with the formation, distribution, composition and character of the coals, but also with the exploration, extraction, and utilization of coal resources. The subject focuses on the origin of coal together with the physical and chemical properties of coal and coal petrology , in addition to all areas of coal exploration, production and use. Coal geology is an important field of earth science today. The evolution of coal formation was affected by paleobotanical, paleogeographic, and paleotectonic factors. Therefore, coals occurring in different basins have different characteristics that are closely related to the different coal-forming periods of geologic history.

49. Stratigraphy :

Stratigraphy is defined as "the science of rock strata." It is "the study of rock successions and the correlation of geological events and processes in time and space". Stratigraphy is a branch of geology concerned with the study of rock layers (strata) and layering (stratification). It is primarily used in the study of sedimentary and layered volcanic rocks. Stratigraphy has two related subfields. They are lithologic stratigraphy or lithostratigraphy, and biologic stratigraphy or biostratigraphy. The fundamental laws of stratigraphy, classification of the stratified rocks into groups, systems and series and classification of geologic time into eras, periods and epochs are studied in this subject.

50. Biostratigraphy:

Biostratigraphy is the branch of stratigraphy which focuses on correlating and assigning relative ages of rock strata by using the fossil assemblages contained within them. Usually the aim is correlation, demonstrating that a particular horizon in one geological section represents the same period of time as another horizon at some other section. The fossils are useful because sediments of the same age can look completely different because of local variations in the sedimentary environment. For example, one section might have been made up of clays and marls while another has more chalky limestones, but if the fossil species recorded are similar, the two sediments are likely to have been laid down at the same time. Biostratigraphy originated in the early 19th century, where geologists recognised that the correlation of fossil assemblages between rocks of similar type but different age decreased as the difference in age increased. The method was well-established before Charles Darwin explained the mechanism behind it - evolution

In paleontology, biochronology is the correlation in time of biological events using fossils. In its strict sense, it refers to the use of assemblages of fossils that are not tied to stratigraphic sections (in contrast to biostratigraphy, where they are). Collections of land mammal ages have been defined for every continent except Antarctica, and most are correlated with each other indirectly through known evolutionary lineages. A combination of argon–argon dating and magnetic stratigraphy allows a direct temporal comparison of terrestrial events with climate change and mass extinctions.

51. Lithostratigraphy:

Lithostratigraphy is a sub-discipline of stratigraphy, the geological science associated with the study of strata or rock layers. Major focuses include geochronology, comparative geology, and petrology. In general a stratum will be primarily igneous or sedimentary relating to how the rock was formed. Sedimentary layers are laid down by deposition of sediment associated with weathering processes, decaying organic matters (biogenic) or through chemical precipitation. These layers are distinguishable as having many fossils and are important for the study of biostratigraphy. Igneous layers are either plutonic or volcanic in character depending upon the cooling rate of the rock. These layers are generally devoid of fossils and represent intrusions and volcanic activity that occurred over the geologic history of the area. There are a number of principles that are used to explain the appearance of stratum. When an igneous rock cuts across a formation of sedimentary rock, then we can say that the igneous intrusion is younger than the sedimentary rock. The principle of superposition states that a sedimentary rock layer in a tectonically undisturbed stratum is younger than the one beneath and older than the one above it. The principle of original horizontality states that the deposition of sediments occurs as essentially horizontal beds.

52. Chronostratigraphy:

Chronostratigraphy is the element of stratigraphy that deals with the relative time relations and ages of rock bodies.Chronostratigraphy is the branch of stratigraphy that studies the age of rock strata in relation to time. The ultimate aim of chronostratigraphy is to arrange the sequence of deposition and the time of deposition of all rocks within a geological region, and eventually, the entire geologic record of the Earth. The standard stratigraphic nomenclature is a chronostratigraphic system based on palaeontological intervals of time defined by recognised fossil assemblages (biostratigraphy). The aim of chronostratigraphy is to give a meaningful age date to these fossil assemblage intervals and interface. Chronostratigraphical divisions are 'time/rock' units, i.e. they refer to the sequence of rocks deposited during a particular interval of time. Chronostratigraphy is the application of disciplines such as biostratigraphy, magnetostratigraphy, chemostratigraphy, cyclostratigraphy, sequence stratigraphy, and numerical dating to stratigraphic successions in order to interpret temporal correlations.

53. Magnetostratigraphy:

Magnetostratigraphy is a geophysical correlation technique used to date sedimentary and volcanic sequences. The method works by collecting oriented samples at measured intervals throughout the section. The samples are analyzed to determine their characteristic remanent magnetization (ChRM), that is, the polarity of Earth's magnetic field at the time a stratum was deposited. This is possible because volcanic flows acquire a thermoremanent magnetization and sediments acquire a depositional remanent magnetization, both of which reflect the direction of the Earth's field at the time of formation. This technique is typically used to date sequences that generally lack fossils or interbedded igneous rock.

54. Tectonostratigraphy :

In geology, tectonostratigraphy is stratigraphy that refers either to rock sequences in which large-scale layering is caused by the stacking of thrust sheets, or nappes, in areas of thrust tectonics or to the effects of tectonics on lithostratigraphy. It deals with the stratigraphy of large-scale strata caused by tectonic activity. The large-scale layering is caused by the stacking of thrust sheets, or nappes.

55. Chemostratigraphy:

Chemostratigraphy is the study of the chemical variations within sedimentary sequences to determine stratigraphic relationships. It uses chemical fingerprints stored in sediments and sedimentary rocks for stratigraphic correlation. Stable isotope signatures fixed in sedimentary inorganic and organic matter are among the most powerful proxies used in chemostratigraphy. This subject come into common usage in the early 1980s, but the basic idea of chemostratigraphy is nearly as old as stratigraphy itself. The distinct chemical signatures of sediments can be as useful as distinct fossil assemblages or distinct lithographies in establishing stratigraphic relationships between different rock layers.

Chemostratigraphy generally provides two useful types of information to the larger geological community. First, chemostratigraphy can be used to investigate environmental change on the local, regional, and global levels by relating variations in rock chemistry to changes in the environment in which the sediment was deposited. Second, regionally or globally correlatable chemostratigraphic signals can be found in rocks whose formation time is well-constrained by radionuclide dating of the strata themselves or by strata easily correlated with them, such as a volcanic suite that interrupts nearby strata. Chemostratigraphy can be applied to sediments of any age, of any lithology and from any depositional environment. More importantly, however, it can be applied to any sample, with the majority of our work being done on cuttings samples. As such, it is probably the most versatile stratigraphic tool available to the industry at this moment.

56. Sequence Stratigraphy:

Sequence Stratigraphy is a branch of geology that attempts to subdivide and link sedimentary deposits into unconformity bound units on a variety of scales and explain these stratigraphic units in terms of variations in sediment supply and variations in the rate of change in accommodation space (often associated with changes in relative sea level). The essence of the method is mapping of strata based on identification of surfaces which are assumed to represent time lines (e.g. subaerial unconformities, maximum flooding surfaces), and therefore placing stratigraphy in chronostratigraphic framework. Sequence stratigraphy is a useful alternative to a lithostratigraphic approach, which emphasizes similarity of the lithology of rock units rather than time significance. Sequence stratigraphy deals with genetically related sedimentary strata bounded by unconformities. The 'sequence' part of the name refers to cyclic sedimentary deposits.

57. Cyclostratigraphy:

Cyclostratigraphy is the study of astronomically forced climate cycles within recorded within the sedimentary successions. Astronomical cycles are variations of the Earth's orbit around the sun due to the gravitational interaction with other masses within the solar system. Due to this cyclicity solar irradiation differs through time on different hemispheres and seasonality is affected. These insolation variations have influence on Earth's climate and so on the deposition of sedimentary rocks. Cyclostratigraphic studies of rock records can lead to accurate dating of events in the geological past, to increase understanding of cause and consequences of Earth's (climate) history, and to more control on depositional mechanisms of sediments and the acting of sedimentary systems.

58. Geochemistry:

Geochemistry is a branch that uses the tools and principles of chemistry to explain the mechanisms behind major geological systems such as the Earth's crust and its oceans. The realm of geochemistry extends beyond the Earth, encompassing the entire Solar System . This subject has made important contributions to the understanding of a number of processes including mantle convection, the formation of planets and the origins of all kinds of rocks, minerals, mineral fuels, soils and valuables. The mobility of all elements on in and out of a planet are fully studied under geochemistry. Today. geochemistry is a major branch of Earth Science that applies varieties of chemical principles to deepen the understanding of the planets. Geochemists consider the globe composed of discrete spheres — rocks, fluids, gases and biology — that exchange matter and energy over a range of time scales. An appreciation for rates of reactions and the range of physical conditions responsible for the chemical expressions of each sphere provides the significant framework to study the co-evolution of the solid Earth, its oceans, atmosphere, biosphere, and climate.

Sub-disciplines of geochemistry include biogeochemistry, organic geochemistry, trace and elemental geochemistry, and metamorphic and igneous-rock geochemistry. The wings of geochemistry are, Organic Geochemistry, Inorganic Geochemistry, Stable Isotope Geochemistry, Light Stable Isotope Geochem, Metallic Element Stable Isotope Geochem, Actinide/Radionuclide Geochemistry, Petroleum Geochemistry, Aqueous Geochemistry, Environmental Geochemistry, Biogeochemistry, and Planetary Geochemistry. It involves thermodynamics, and analytical chemistry as major tools and techniques. The analytical instruments and their use are also a part of it. The instruments include inductively-coupled plasma and stable-isotope mass spectrometers, a chromFTIR lab, fully automated electron microprobe, X-ray diffractometer, laser Raman, SEM, and several other equipment facilities.

59. Isotope geochemistry:

Isotope geochemistry is yet another important branch of geology. It is based upon the study of natural variations in the relative abundances of isotopes of various elements. Variations in isotopic abundance are measured by isotope ratio mass spectrometry. This study can reveal much information about the ages and origins of rock, air or water bodies, or processes of mixing between them. Stable isotope geochemistry is largely concerned with isotopic variations arising from mass-dependent isotope fractionation, whereas radiogenic isotope geochemistry is concerned with the products of natural radioactivity. The origins of stable isotope geochemistry are closely tied to the development of modern physics in the first half of the 20th century. The discovery of the neutron in 1932 by H. Urey and the demonstration of variable isotopic compositions of light elements by A. Nier in the 1930’s and 1940’s were the precursors to this development.

60. Isotope Geology:

Rocks and minerals contain natural radioactive elements which decay at specific constant rates. Consequently, the composition of the material changes within time. The science of geochronology depends on such mechanisms. Isotope geochemistry and geochronological investigations on rocks and minerals provide geoscientists with answers to questions on various petrogenetic, mineral deposit and paleoclimatic issues. Radiogenic and stable isotopes are used widely in the Earth sciences to determine the ages of rocks, meteorites, and archeological objects, and as tracers to understand geological and environmental processes. Isotope methods determine the age of the Earth, help reconstruct the climate of the past, and explain the formation of the chemical elements in the Universe. This textbook provides a comprehensive introduction to both radiogenic and stable isotope techniques.

Isotope geology is the off spring of geology on one hand and of the concepts and methods of nuclear physics on the other side. It was initially known as‘‘nuclear geology’’. Variations in these isotope compositions yield useful information for the geological sciences (in the broad sense). The first breakthrough in isotope geology was the age determination of rocks and minerals, which at a stroke transformed geology into a much advanced quantitative science. Next came the measurement of past temperatures and the birth of paleoclimatology. Then the horizons of earth science got broadened with the emergence of the concept of isotopic tracers to encompass not only questions of the Earth’s structures and internal dynamics, of erosion, and of the transport of material, but also problems of cosmochemistry, including those relating to the origins of the chemical elements. And so isotope geology has not only extended across the entire domain of the earth sciences but has also expanded the domain, opening up many new areas, from astrophysics to environmental studies.

61. Geochronology:

Geochronology is the science of determining the age of rocks, fossils, and sediments using signatures inherent in the rocks themselves. Absolute geochronology can be accomplished through radioactive isotopes, whereas relative geochronology is provided by tools such as palaeomagnetism and stable isotope ratios. By combining multiple geochronological (and biostratigraphic) indicators the precision of the recovered age can be improved.

Geochronology is different in application from biostratigraphy, which is the science of assigning sedimentary rocks to a known geological period via describing, cataloguing and comparing fossil floral and faunal assemblages. Biostratigraphy does not directly provide an absolute age determination of a rock, but merely places it within an interval of time at which that fossil assemblage is known to have coexisted. Both disciplines work together hand in hand however, to the point where they share the same system of naming rock layers and the time spans utilized to classify layers within a stratum.

The science of geochronology is the prime tool used in the discipline of chronostratigraphy, which attempts to derive absolute age dates for all fossil assemblages and determine the geologic history of the Earth and extraterrestrial bodies. Geochronology means dating of geological events. Although this expression was first used for geological time estimates, based on sedimentation rates, this term is now commonly applied to geological dating, based on radioactive decay and spontaneous fission.

62. Thorium Geology:

Thorium is a naturally occurring radioactive element which is found in the Earth mainly in oxides, silicates, carbonates and phosphates. Thorium exists almost entirely as 232Th which has a half-life of 14 050 million years. From its natural state, 232Th decays through a number of stages to eventually form 208Pb, which is stable.The main difference is that thorium is far less mobile than uranium in oxidising surface conditions (Mernagh and Miezitis, 2008). Most thorium resources are found in heavy mineral sands such as those in the Murray Basin, which are derived from the erosion of older rocks, where thorium is contained primarily in monazite grains. Thorium is also concentrated in igneous processes. Carbonatites, such as the Mount Weld carbonatite in Western Australia are known to have anomalously high thorium contents. Alkaline igneous complexes also contain enrichments in thorium relative to average igneous rocks. Other granitic bodies and pegmatites may also have high thorium. Another important category is thorium-bearing veins and lodes. Concentrations of thorium may also be found in iron oxide Cu-Au, skarn and phosphate deposits, and in coal and peat accumulations. Thorium geology is a modern branch.

63. Dendrochronology:

It is the science that uses tree rings dated to their exact year of formation to analyze temporal and spatial patterns of processes in the physical and cultural sciences. A tree's growth rate changes in a predictable pattern throughout the year in response to seasonal climate changes, resulting in visible growth rings. Each ring marks a complete cycle of seasons, or one year, in the tree's life. Dendrochronology (or tree-ring dating) is the scientific method of dating tree rings (also called growth rings) to the exact year they were formed in order to analyze atmospheric conditions during different periods in history.

Dendrochronology is useful for determining the timing of events and rates of change in the environment (most prominently climate) and also in works of art and architecture, such as old panel paintings on wood, buildings, etc. It is also used in radiocarbon dating to calibrate radiocarbon ages. New growth in trees occurs in a layer of cells near the bark. As per one record of the year 2013, it has been noted that the oldest tree-ring measurements in the Northern Hemisphere extend back to 13,900 years. It has several wings.

Dendroarchaeology is the science that uses tree rings to date when timber was felled, transported, processed, or used for construction or wooden artifacts. Example: dating the tree rings of a beam from a ruin in the American Southwest to determine when it was built.

Dendroclimatology is the science that uses tree rings to study present climate and reconstruct past climate. Example: analyzing ring widths of trees to determine how much rainfall fell per year long before weather records were kept.

Dendroecology is another wing which uses tree rings to study factors that affect the earth's ecosystems. Example: analyzing the effects of air pollution on tree growth by studying changes in ring widths over time.

Dendrogeomorphology is the science that uses tree rings to date earth surface processes that created, altered, or shaped the landscape. Example: analyzing changes in tree growth patterns via tree rings to date a series of landslide events.

Dendroglaciology is anotherw wing which uses tree rings to date and study past and present changes in glaciers. Example: dating the inside rings of trees on moraines to establish the approximate date of a glacial advance.

Dendrohydrology is the science that uses tree rings to study changes in river flow, surface runoff, and lake levels. Example: dating when trees were inundated to determine the sequence of lake level changes over time.

Dendropyrochronology is a modern outlook which uses tree rings to date and study past and present changes in wildfires. Example: dating the fire scars left in tree rings to determine how often fires occurred in the past.

Dendroentomology is a branch that uses tree rings to date and study the past dynamics of insect populations. Because of that precision, dendrochronology is used to calibrate **radiocarbon dating**, by giving science a measure of the atmospheric conditions which are known to cause radiocarbon dates to vary.

Radiocarbon dates which have been corrected--or rather, calibrated--by comparison to dendrochronological records are designated by abbreviations such as cal BP, or calibrated years before the present.

64. Thermochronology:

Thermochronology is the study of dating the cooling of rocks through exhumation. In its simplest form, thermochronology can be considered to date the moment when a mineral passes through a specific closure temperature (Tc). Minerals have different closure temperatures and so by using a suite of thermochronometers on a single sample, its cooling path through the crust can be reconstructed. Thermochronology is the study of the thermal evolution of a region of a planet. Thermochronologists use radiometric dating along with the closure temperatures that represent the temperature of the mineral being studied at the time given by the date recorded, to understand the thermal history of a specific rock, mineral, or geologic unit. It is a subfield within geology, and is closely associated with geochronology.

A typical thermochronological study will involve the dates of a number of rock samples from different areas in a region, often from a vertical transect along a steep canyon, cliff face, or slope. These samples are then dated. With some knowledge of the subsurface thermal structure, these dates are translated into depths and times at which that particular sample was at the mineral's closure temperature. If the rock is today at the surface, this process gives the exhumation rate of the rock. Common isotopic systems used for thermochronology include fission track dating in zircon and apatite, potassium-argon and argon-argon dating in apatite, uranium-thorium-helium dating in zircon and apatite, and 4He/3He dating**.**

(U-Th)/He thermochronology is based upon the accumulation of ^{4}He in rocks and minerals over geologic time due to the radioactive decay of U, Th, and/or Sm. Although ^{4}He is constantly being produced by decay, when the rocks are at hot He will not be retained in the crystals, and will instead diffuse out of the system (and into the atmosphere, where it makes up about 1 ppm, or 0.0001%, of what we breathe). However, once a mineral is sufficiently cool, the He will be retained. Therefore, when it is possible to calculate the (U-Th)/He age of a rock or mineral, you are in effect calculating the time that has elapsed since the system switched from open (hot) to closed (cool) behavior. The transitional temperature is called the closure temperature, and is different depending on what mineral people are interested to study in.

Fission-track thermochronology/-chronometry is based on the analysis of radiation damage trails (‘fission tracks’) in uranium-bearing, non-conductive minerals and glasses. It is routinely applied on the minerals apatite, zircon and titanite.

65. Tephrochronology:

Tephrochronology is an emerging subject of earth science. It involves the use of a geochronological technique that uses discrete layers of tephra—volcanic ash from a single eruption—to create a chronological framework in which paleoenvironmental or archaeological records can be placed. Such an established event provides a "tephra horizon". The premise of the technique is that each volcanic event produces ash with a unique chemical "fingerprint" that allows the deposit to be identified across the area affected by fallout. Thus, once the volcanic event has been independently dated, the tephra horizon will act as time marker. The main advantages of the technique are that the volcanic ash layers can be relatively easily identified in many sediments and that the tephra layers are deposited relatively instantaneously over a wide spatial area. This means they provide accurate temporal marker layers which can be used to verify or corroborate other dating techniques, linking sequences widely separated by location into a unified chronology that correlates climatic sequences and events.

Tephrochronology requires accurate geochemical fingerprinting (usually via an electron microprobe). An important recent advance is the use of LA-ICP-MS (i.e. laser ablation ICP-MS) to measure trace-element abundances in individual tephra shards. One problem in tephrochronology is that tephra chemistry can become altered over time, at least for basaltic tephras.

66. Volcanology:

Volcanology (also spelled vulcanology) is the study of volcanoes, lava, magma, and related geological, geophysical and geochemical phenomena. The term volcanology is derived from the Latin word vulcan. Vulcan was the ancient Roman god of fire. Volcanologist examining tephra horizons in south-central Iceland. In 1841, the first volcanological observatory, the Vesuvius Observatory, was founded in the Kingdom of the Two Sicilies. Seismic observations are made using seismographs deployed near volcanic areas, watching out for increased seismicity during volcanic events, in particular looking for long period harmonic tremors, which signal magma movement through volcanic conduits.

Surface deformation monitoring includes the use of geodetic techniques such as leveling, tilt, strain, angle and distance measurements through tiltmeters, total stations and EDMs. This also includes GNSS observations and InSAR. Surface deformation may also indicate magma upwelling: increased magma supply produces bulges in the volcanic center's surface. Gas emissions are also monitored with equipment including portable ultra-violet spectrometers, which analyzes the presence of volcanic gases such as sulfur dioxide; or by infra-red spectroscopy (FTIR). Increased gas emissions, and more particularly changes in gas compositions, may signal an impending volcanic eruption.

Temperature changes are monitored using thermometers and observing changes in thermal properties of volcanic lakes and vents, which may indicate upcoming activity. Satellites are widely used to monitor volcanoes, as they allow a large area to be monitored easily. They can measure the spread of an ash plume, as well as SO_2 emissions. Other geophysical techniques (electrical, gravity and magnetic observations) include monitoring fluctuations and sudden change in resistivity, gravity anomalies or magnetic anomaly patterns that may indicate volcano-induced faulting and magma upwelling. Stratigraphic analyses includes analyzing tephra and lava deposits and dating these to give volcano eruption patterns, with estimated cycles of intense activity and size of eruptions. It is a very unique subject of its own.

67. Geophysics:

Geophysics is a major subject of natural science. It is a core branch of geology. It is concerned with the physical processes and physical properties of the Earth and its surrounding space environment, and the use of quantitative methods for their analysis. The term geophysics sometimes refers only to the geological applications: Earth's shape; its gravitational and magnetic fields; its internal structure and composition; its dynamics and their surface expression in plate tectonics, the generation of magmas, volcanism and rock formation. The study includes the water cycle including snow and ice; fluid dynamics of the oceans and the atmosphere; electricity and magnetism in the ionosphere and magnetosphere and solar-terrestrial relations; and analogous problems associated with the Moon and other planets.

Although geophysics was only recognized as a separate discipline in the 19th century, its origins date back to ancient times. The first magnetic compasses were made from lodestones, while more modern magnetic compasses played an important role in the history of navigation. The first seismic instrument was built in 132 BC. Isaac Newton applied his theory of mechanics to the tides and the precession of the equinox; and instruments were developed to measure the Earth's shape, density and gravity field, as well as the components of the water cycle. In the 20th century, geophysical methods were developed for remote exploration of the solid Earth and the ocean, and geophysics played an essential role in the development of the theory of plate tectonics. Today, Geophysics is applied to societal needs, such as mineral resources, mitigation of natural hazards and environmental protection.

Geophysical survey data are used to analyze potential petroleum reservoirs and mineral deposits, locate groundwater, find archaeological relics, determine the thickness of glaciers and soils, and assess sites for environmental remediation. While there are many divisions of geophysics such as oceanography, atmospheric physics, climatology, and planetary geophysics, this brochure describes three of the most popular branches of geophysics: Petroleum Geophysics and Environmental Geophysics.

The major branches of geophysics are:

1. Biogeophysics – study of how plants, microbial activity and other organisms alter geologic materials and affect geophysical signatures.
2. Exploration geophysics – the use of surface methods to detect concentrations of ore minerals and hydrocarbons.
3. Geophysical fluid dynamics – study of naturally occurring, large-scale flows on Earth and other planets.
4. Geodesy – measurement and representation of the Earth, including its gravitational field.
5. Geodynamics – study of modes of transport deformation within the Earth: rock deformation, mantle convection, heat flow, and lithosphere dynamics.
6. Geomagnetism – study of the Earth's magnetic field, including its origin, telluric currents driven by the magnetic field, the Van Allen belts, and the interaction between the magnetosphere and the solar wind.
7. Mathematical geophysics – development and applications of mathematical methods and techniques for the solution of geophysical problems.
8. Mineral physics – science of materials that compose the interior of planets, particularly the Earth.
9. Near-surface geophysics – the use of geophysical methods to investigate small-scale features in the shallow (tens of meters) subsurface.
10. Paleomagnetism – measurement of the orientation of the Earth's magnetic field over the geologic past.
11. Seismology – study of the structure and composition of the Earth through seismic waves, and of surface deformations during earthquakes and seismic hazards.
12. Tectonophysics – study of the physical processes that cause and result from plate tectonics.

68. Exploration Geophysics:

Exploration geophysics is an applied branch of geophysics, which uses physical methods, such as seismic, gravitational, magnetic, electrical and electromagnetic at the surface of the Earth to measure the physical properties of the subsurface, along with the anomalies in those properties. It is most often used to detect or infer the presence and position of economically useful geological deposits, such as ore minerals; fossil fuels and other hydrocarbons; geothermal reservoirs; and groundwater reservoirs.
Exploration geophysics can be used to directly detect the target style of mineralization, via measuring its physical properties directly. For example, one may measure the density contrasts between the dense iron ore and the lighter silicate host rock, or one may measure the electrical conductivity contrast between conductive sulfide minerals and the resistive silicate host rock.

In archaeology, geophysical survey is ground-based physical sensing techniques used for archaeological imaging or mapping. Remote sensing and marine surveys are also used in archaeology, but are generally considered separate disciplines. Other terms, such as "geophysical prospection" and "archaeological geophysics" are generally synonymous.

69. Seismology:

Seismology is the scientific study of earthquakes and the propagation of elastic waves through the Earth or through other planet-like bodies. The field also includes studies of earthquake environmental effects such as tsunamis as well as diverse seismic sources such as volcanic, tectonic, oceanic, atmospheric, and artificial processes such as explosions. A related field that uses geology to infer information regarding past earthquakes is paleoseismology. A recording of earth motion as a function of time is called a seismogram. A seismologist is a scientist who does research in seismology.

70. Paleoseismology:

Paleoseismology is the study of ancient rocks and sediments for evidence of seismic events, such as earthquakes and tsunamis, from times before records were kept. The basic assumption that paleoseismologists use is that what happened in the past will most likely happen again in the future. Therefore, the more information that can be gathered about the past, the better idea we'll have about what is likely to happen in the future. Paleoseismology looks at geologic sediments and rocks, for signs of ancient earthquakes. It is used to supplement seismic monitoring, for the calculation of seismic hazard.

Paleoseismology is usually restricted to geologic regimes that have undergone continuous sediment creation for the last few thousand years, such as swamps, lakes, river beds and shorelines. Many notable discoveries have been made using the techniques of paleoseismology. It is now known (using paleoseismology) that nearly all the movement of the fault takes place with extremely large earthquakes. All of these seismic events (with a moment magnitude of over 8), leave some sort of trace in the sedimentation record. Paleoseismology has become an important component of seismic risk analysis, which is mandated for nuclear power plants, dams, waste repositories, and other critical structures.

71. Reflection seismology:

Seismology is the study of acoustic waves in the earth. Reflection seismology is a subset of controlled source seismology. It is the primary method the oil industry uses to find mineral resources. Processing reflection seismic data is highly computer intensive. Reflection seismology uses man-made sources to create sound waves. The size of sources can range from sledge hammers striking metal plates to large, several thousand pound chemical explosions. Sources in the water are typically airguns , large, metal canisters which fill up with compressed air that is suddenly released like the popping of a balloon. Environmentally sensitive Vibrator trucks can shake the ground very powerfully to produce sound waves. The sound waves travel through the earth and reflect off boundaries between rock layers having different acoustic properties. The reflections are digitally recorded by a nominally linear array of small instruments called geophones. The data is processed to account for loss of signal with increasing distance, noise, geometrical factors, and other things. The final product is a seismic cross section. This one shows some folds lying under horizontal rock layers. Reflection seismology (or seismic reflection) is used as a method of exploration geophysics that uses the principles of seismology to estimate the properties of the Earth's subsurface from reflected seismic waves. Reflection seismology is similar to sonar and echolocation.

72. Refraction Seismology:

Refraction Seismology is the science of studying the earth's subsurface zones using artificial sources of forces sent as wave forms of energy. One can study subsurface velocity and layer interface structure by analyzing the first arrival times of P-waves (longitudinal or compressional waves) at the surface of the earth. This technique is termed seismic refraction. Applications of subsurface imaging include locating buried archeological sites, assessing subsurface geological hazards, defining aquifer geometry, and exploring for fossil fuel and other natural resources.

Seismic refraction is a geophysical principle governed by Snell's Law. Used in the fields of engineering geology, geotechnical engineering and exploration geophysics, seismic refraction traverses (seismic lines) are performed using a seismograph(s) and/or geophone(s), in an array and an energy source. Seismic refraction data led A. Mohorovicvic in 1909 to one of the most important discoveries about earth structure. Seismic refraction surveying has largely contributed to the understanding of the architecture and composition of the earth's crust and uppermost mantle. Crustal thicknesses of the ocean and continental lithosphere have been determined largely due to the frequently encountered strong impedance contrasts at the crust–mantle boundary.

73. Forensic Seismology:

Forensic seismology is the forensic use of the techniques of seismology to detect and study distant phenomena, particularly explosions, including those of nuclear weapons. It is a modern branch of Geology. Because of the efficiency with which seismic waves propagate through the Earth and the technical difficulties of decoupling explosions to diminish their seismic radiation, forensic seismology is a critical technique in the enforcement of bans on underground nuclear testing. In addition to nuclear explosions, the signatures of many other kinds of explosions can also be detected and analyzed by forensic seismology, and even other phenomena such as ocean waves (the global microseism), the movement of icebergs across the sea floor or in collision with other icebergs, or explosions within submarines.

74. Helioseismology:

Helioseismology is the process of inferring the internal structure and kinematics of the Sun from the propagation of seismic waves, particularly acoustic waves (p waves) and surface gravity waves (f waves). It was developed by analogy to geoseismology (originally called simply seismology), and subsequently there emerged asteroseismology. In this the seismic waves are analysed to constrain the internal structures of other stars. Because the Sun is fluid, to a first approximation it cannot support shear waves (s-waves), unlike the seismic waves on Earth. An exception is the magneto-acoustic waves which appear to be important only in the atmosphere.

The helioseismic waves are generated by the turbulence in the convection zone immediately beneath the Sun's surface. Certain frequencies are amplified by constructive interference, leading to resonance. In other words, the turbulence "rings" the sun like a bell. The resonant waves are reflected near the photosphere, the visible surface of the sun, where they can be observed. The oscillations are detectable in almost any time series of solar images, but are best observed by measuring the Doppler shift of atmospheric absorption lines. Details of the propagation of the seismic waves through the Sun, inferred from the resonant frequencies, reveal the Sun's inner structure, allowing astrophysicists to develop an extremely detailed representation of the hydrostatic stratification and the internal angular velocity. Millions of modes of vibration, excited by solar convection, enable astrophysicists to see inside the Sun, just as geophysicists can probe the internal structure of the Earth thanks to earthquakes.

Over the past twenty five years, helioseismology has produced a considerable number of discoveries in solar, stellar, and fundamental physics. Helioseismology has provided by far the most precise tests for the theory of stellar structure and evolution, implying, in particular, a revision of the standard model of particle physics to solve the solar neutrino problem. Today, the most exciting aspect of helioseismology is the search for clues regarding the origin and variability of the Sun’s magnetic field, possibly the most important unsolved problem in solar physics. The general belief is that the dynamo process, whereby magnetic field lines are stretched and twisted by internal shearing motions, causes the solar magnetic cycle. Helioseismology is our only hope to confirm this paradigm by mapping internal mass motions, structural asphericities, and their temporal variations. Helioseismology has already provided some important results, revealing regions of rotational shear in the Sun’s interior, solar-cycle variations in the rotation rate, and mysterious quasi-periodic changes at the base of the convection zone.

75. Asteroseismology:

Asteroseismology is the scientific study of global oscillations on distant stars. It is entering into a very exciting period of discoveries. Many stars, covering a wide range of masses and evolutionary states, are known to exhibit oscillations. Stellar oscillations have considerable diagnostic potential and allow stellar mass and age to be determined with unprecedented precision. Such knowledge for a sufficient sample of stars will revolutionize stellar evolution and galactic evolution studies.

Asteroseismology also has the potential to constrain internal stellar rotation and locate the borders of convection and ionization zones. Such information would help to understand dynamo-generated stellar activity cycles and the solar-stellar connection. These exciting possibilities for the study of stellar structure, evolution, and activity will be fully realized once high-precision observations become available for a large sample of stars.

The asteroseismology of planet-host stars will be particularly useful to characterize the properties of detected exoplanets. Precise seismic estimates of the masses, radii, and ages of host stars will make it possible to infer the masses, radii and ages of the transiting planets. The Kepler mission is a space based instrument launched in 2009 and is providing unprecendented observations of stellar oscillations. Confirmed planetary systems will be fully characterized through the asteroseismology of their host stars and the follow-up observations. Observations of solar-like stars will also help to constrain our knowledge about the past and future life of the Sun.

76. Meteorology:

Meteorology is a branch of the Earth and atmospheric sciences. It includes the study of atmospheric chemistry and atmospheric physics, with a major focus on weather forecasting. The study of meteorology dates back to a millennia, though significant progress in meteorology did not occur until the 18th century. The 19th century saw modest progress in the field after weather observation networks were formed across broad regions. Prior attempts at prediction of weather depended on the historical data. Meteorological phenomena are observable weather events that are explained by the science of meteorology. Meteorological phenomena are described and quantified by the variables of Earth's atmosphere: temperature, air pressure, water vapor, mass flow, and the variations and interactions of those variables, and how they change over time. Different spatial scales are used to describe and predict weather on local, regional, and global levels. Since climate and weather are essential to all life and life support systems, people concentrated this subject first, in the human civilization. It is one of the oldest science of even common man. Today, meteorology has itself became a larger area of study.

The major branches of meteorology are :

- Microscale meteorology – the study of atmospheric phenomena about 1 km or less, smaller than mesoscale, including small and generally fleeting cloud "puffs" and other small cloud features
- Mesoscale meteorology – the study of weather systems about 5 kilometers to several hundred kilometers, smaller than synoptic scale systems but larger than microscale and storm-scale cumulus systems, such as sea breezes, squall lines, and mesoscale convective complexes
- Synoptic scale meteorology – is a horizontal length scale of the order of 1000 kilometres (about 620 miles) or more.

The other applied branches are aeronautical meteorology , agricultural meteorology , animal meteorology , applied meteorology , architectural meteorology , artillery meteorology , ballistic meteorology , chemical meteorology , climatology and meteorology , coastal meteorology , colloid meteorology and comparative meteorology. Meteorology, climatology, atmospheric physics, and atmospheric chemistry are sub-disciplines of the atmospheric sciences. Meteorology and hydrology compose the interdisciplinary field of hydrometeorology. The interactions between Earth's atmosphere and its oceans are part of a coupled ocean-atmosphere system. Meteorology has application in many diverse fields such as the military, energy production, transport, agriculture, and construction.

77. Aviation meteorology:

Weather and related environmental phenomena can have a large impact on the aviation industry, and to ensure the safety and regularity of international aviation, weather services for the industry are provided within a framework of standards and recommended practices established by the International Civil Aviation Organization (ICAO). Fundamentals of Aviation Meteorology aims to provide an understanding of the physical properties of the atmosphere and how they affect the weather, with an emphasis on the factors affecting aviation. Aviation meteorology (MET) is an essential element of the complex system that constitutes Air Traffic Management (ATM) in its broadest sense. Weather conditions all aspects of ATM operations, e.g. by variations in head and tail-wind components, through changes in pressure and temperature values at airports, and in imposing low visibility operating conditions. Adverse meteorological conditions have the greatest impact on the ATM system creating disruption and the consequent problems of disturbed flow rates, lost capacity and induced additional costs. It is a very essential subject of international travel and tourism. It is contributing much to world systems of travel, by air. For all pilots and air-craft engineers, aviation meteorology is a compulsory subject to be taught by earth scientists.

78. Hydrometeorology :

Hydrometeorology is a branch of meteorology and hydrology that studies the transfer of water and energy between the land surface and the lower atmosphere. UNESCO has introduced several programmes and activities that deal with the study of natural hazards of hydrometeorological origin and the mitigation of their effects. Among these hazards are the results of natural processes or phenomena of atmospheric, hydrological or oceanographic nature such as floods, tropical cyclones, drought and desertification. Many countries have established an operational hydrometeorological capability to assist with forecasting, warning and informing the public of these developing hazards. Hydrometeorology is a also branch of meteorology that deals with the hydrologic cycle, the water budget, and the rainfall statistics of storms.

A hydrometeorologist prepares and issues forecasts of accumulating (quantitative) precipitation, heavy rain, heavy snow, and highlights areas with the potential for flash flooding. Typically the range of knowledge that is required overlaps with climatology, mesoscale and synoptic meteorology, and other geosciences. The multidisciplinary nature of the branch can result in technical challenges, since tools and solutions from each of the individual disciplines involved may behave slightly differently, be optimized for different hard- and software platforms and use different data formats.

79. Agricultural Meteorology:

Agricultural meteorology the branch of meteorology that deals with the relationship of weather and climate to crop and livestock production and soil management. Agricultural Meteorology involves the integration of climatological and meteorological data and techniques into agricultural problems, such as crop production, soil moisture, moisture stress, and migration of pests. A good background in basic math and sciences is required. Meteorologists, soil scientists, agricultural hydrologists, and agronomists are persons concerned with studying the effects of weather and climate on plant distribution, crop yield, water-use efficiency, phenology of plant and animal development, and the energy balance of managed and natural ecosystems.

80. Nuclear Meteorology:

Nuclear meteorology investigates the distribution of radioactive aerosols and gases in the atmosphere. Nuclear meteorology investigates the distribution of radioactive aerosols and gases in the atmosphere and has a long history: "With the widespread use of atomic energy, large quantities of radioactive gases and aerosols of artificial origin have been deposited in the atmosphere during the last fifteen years; contamination of the atmosphere has occurred, presenting a biological hazard ". Nuclear reactors as well as other major nuclear units require extensive meteorological monitoring during the entire life-cycle (i.e., design, engineering, construction, cold and hot functional testing, operation, and decommissioning). The meteorological information is used for routine radiological and chemical release consequence analysis, real-time consequence assessments of accidental releases of radiological and chemical species, and potential environmental impacts resulting from design basis accidents of new nuclear facilities or those related to the modifications of the existing facilities. In addition, the meteorological monitoring program supports environmental compliance, development of impact analyses, Safety Analysis Reporting , accident assessments, and the protection of the workforce during operations from natural phenomena hazards. The broad scope of the meteorological monitoring program includes all parameters necessary to characterize the atmospheric environment within a 20 km radius of these nuclear facilities and beyond.

81. Maritime Meteorology:

Maritime meteorology deals with air and wave forecasts for ships operating at sea. Organizations such as the Ocean Prediction Center, Honolulu National Weather Service forecast office, United Kingdom Met Office, and JMA prepare high seas forecasts for the world's oceans.

82. Military Meteorology:

Military meteorology is the research and application of meteorology for military purposes. In the United States, the United States Navy's Commander, Naval Meteorology and Oceanography Command oversees meteorological efforts for the Navy and Marine Corps while the United States Air Force's Air Force Weather Agency is responsible for the Air Force and Army.

83. Environmental Meteorology:

Environmental meteorology mainly analyzes industrial pollution dispersion physically and chemically based on meteorological parameters such as temperature, humidity, wind, and various weather conditions.

84. Satellite Meteorology :

Satellites serve a wide variety of purposes from transmission of television signals via communication satellites to guidance and tracking systems of defense satellites. For meteorologists, satellites provide a comprehensive view of the world's weather by observing weather and the environment on a scale not possible by other means. Fifty years ago, satellite meteorology did not exist . Today, not only do satellites observe clouds, but measure other non- visible radiation from the earth and atmosphere. Satellite Meteorology refers to the study of the earth's atmosphere and oceans using data obtained from remote sensing devices flown onboard satellites orbiting the earth. Satellite Meteorological services involve receiving satellite data from Indian and International satellites, its processing for generation of images in all channels, derivation of operational products their archival and their real time utilization for weather forecasting. The various products include cloud top temperature, vertical profiles of temperature, humidity, fog, sea surface temperature, atmospheric motion vectors, outgoing long-wave radiation, total precipitable water etc.

85. Forensic meteorology :

Forensic meteorology is a branch of meteorology concerning with the scientific study of weather, applied to the process of reconstructing weather events for a certain time and location for unraveling the truth. This is done by acquiring and analyzing local weather reports such as surface observations, radar and satellite images, other data, and eyewitness accounts. Forensic meteorology is most often used in court cases, including insurance disputes, personal injury cases, and murder investigations. With increasing losses from severe weather in recent years, the demand for forensic meteorological services has also grown.

86. Polar meteorology:

Polar meteorology is the study of the atmosphere of Earth's polar regions. Surface temperature inversion is typical of polar environments and leads to the katabatic windphenomenon. The vertical temperature structure of polar environments tends to be more complex than in mid-latitude or tropical climates. The collection of polar meteorology data started in 1893 with Fridtjof Nansen during his

North Pole expedition. One of the goals of the expedition was to make detailed meteorological and early oceanographic measurements.

87. Climatology:

Climatology is one of the branches of Earth and Atmospheric Sciences. Climatology is the science of studying the average atmospheric conditions of a region in long-term perspective. It includes a systematic study of atmospheric conditions pertaining to weather and climate. Climatology aims to study the nature of climate, the causes and interpretations of its spatial variation and its association with biosphere. It is closely related to meteorology and geography due to the fact that all global atmospheric processes are spatially distributed.

Climatologists evaluate

1) long-term weather conditions of a vast region over a long period of time.
2) Climate and its distribution on the earth's surface, horizontally and vertically
3) The effects of human activities on different components of the atmospheric conditions including weather and climate, and
4) The role of climate and weather on the biosphere and hydrosphere.

The primary goal of Climatology is to study the unique characteristics of atmosphere in controlling the global climate, origin, types of climates, causes and processes influencing the climatic variations, elements of weather and the impact of climate on humans or vice-versa. There are three specific branches involved in climatology as Physical Climatology, Regional Climatology and Applied Climatology.

The Physical Climatology is mainly concerned with atmospheric phenomena and climates.
Regional Climatology deals with regional variations of climatic conditions which include Micro climate, Local climate, Meso Climate and Macro Climate. The subject of Climatology involves a lot of scientific concepts, principles, measurements and interpretations in addition to the basic understanding of the atmospheric processes.

Weather Forecasting is a major field of predicting the weather conditions comprising the temperature of atmospheric air, movement of wind, humidity, sunshine hours, cloudiness, precipitation and atmospheric disturbances over a place or region, well in advance. Different sources of weather and climatological data are collected on daily, weekly, monthly and annual bases from global network of observatories and used to forecast. Global life is fully dependent on the knowledge of weather for carrying out various domestic and industrial activities.

88. Applied Climatology:

Applied Climatology deals with climatic controls of human activities and the application of climatic knowledge in solving unique problems faced by human population. The root for climatology lies in meteorology. It was Greeks who tried to understand the atmosphere and its influence on life. The first written records about the atmosphere were given by Hippocrates in 400 B.C. Aristotle brought out the first compendium on Meteorology as weather science.

89. Paleoclimatology:

Paleoclimatology (in British spelling, palaeoclimatology) is the study of changes in climate taken on the scale of the entire history of Earth. It uses a variety of proxy methods from the Earth and life sciences to obtain data previously preserved within things such as rocks, sediments, ice sheets, tree rings, corals, shells and microfossils. It then uses the records to determine the past states of the Earth's various climate regions and its atmospheric system. Studies of past changes in the environment and biodiversity often reflect on the current situation, specifically the impact of climate on mass extinctions and biotic recovery.

90. Dendroclimatology:

Dendroclimatology is the science of determining past climates from trees (primarily properties of the annual tree rings). Tree rings are wider when conditions favor growth, narrower when times are difficult. Other properties of the annual rings, such as maximum latewood density (MXD) have been shown to be better proxies than simple ring width. Using tree rings, scientists have estimated many local climates for hundreds to thousands of years previous. By combining multiple tree-ring studies (sometimes with other climate proxy records), scientists have estimated past regional and global climates. Tree rings are especially useful as climate proxies in that they can be well-dated via dendrochronology, i.e. matching of the rings from sample to sample. This allows extension backwards in time using deceased tree samples, even using samples from buildings or from archeological digs. Another advantage of tree rings is that they are clearly demarked in annual increments, as opposed to other proxy methods such as boreholes. Furthermore, tree rings respond to multiple climatic effects (temperature, moisture, cloudiness), so that various aspects of climate (not just temperature) can be studied.

91. Hydrology:

Hydrology is the science that encompasses the occurrence, distribution, movement and properties of the waters of the earth. All of the physical, chemical and biological processes involving water as it travels its various paths in the earth's spheres are discussed in this subject. Hydrologists apply their scientific knowledge and mathematical principles to solve water-related problems in society in terms of its problems of quantity, quality and availability. Students who plan to become hydrologists need a strong emphasis in mathematics, statistics, geology, physics, computer science, chemistry and biology. Over a period of time, a lot of branches in the subject of Hydrology, have grown.
Hydrology is the study of the movement, distribution, and quality of water on earth and other planets, including the hydrological cycle, water resources and environmental watershed sustainability**.**
Hydrology is the study of the movement, distribution, and quality of water on earth and other planets, including the hydrologic cycle, water resources and environmental watershed sustainability. A practitioner of hydrology is a hydrologist, working within the fields of earth or environmental science, physical geography, geology or civil and environmental engineering. Hydrology is subdivided into surface hydrology and groundwater hydrology. Domains of hydrology include hydrometeorology, surface hydrology, hydrogeology, drainage basin management and water quality, where water plays the central role. Oceanography and meteorology are not included because water is only one of many important aspects within those fields.

92. Hydrogeology /Geohydrology:

Hydrogeology is the study of the distribution and movement of water in aquifers and shallow porous media—that is, the porous layers of rock, sand, silt, and gravel below the Earth's surface. Hydrogeology examines the rate of diffusion of water through these media as the water moves down its energy gradient. The flow of water in the shallow subsurface is also pertinent to the fields of soil science, agriculture**,** and civil engineering. The flow of water and other fluids **(**hydrocarbons and geothermal fluids) in deeper formations is relevant to the fields of geology, geophysics, and petroleum geology. Geohydrology is the area of geology that deals with the distribution and movement of groundwater in the soil and rocks of the Earth's crust. The term geohydrology is often used interchangeably.

93. Surface-water hydrology:

Surface-water hydrology is a major branch which encompasses scientific studies of all surface waters of the globe (overland flows, rivers, lakes, wetlands, estuaries, oceans, etc.). Surface-water hydrology analyses and relates the dynamics of flow in surface-water systems (rivers, canals, streams, lakes, ponds, wetlands, marshes, arroyos, oceans, etc.). This also includes the field measurement of flow (discharge); the statistical variability at each setting; floods; drought susceptibility and the fluid mechanics of surface waters. In-depth analysis of surface-water components of the hydrologic cycle, hydrometeorology, evaporation/transpiration, rainfall-runoff relationships, open-channel flow, flood hydrology, fluid mechanics, and statistical and probabilistic methods in hydrology, are all coming under this subject. Surface-water hydrology includes the relation between rainfall and surface runoff as it is an important aspect of water resources planning, movement of storm and sewerage (wastewater or sewage), irrigation facilities for agriculture, environmental protection, and for flood control. The relationships between groundwater and surface water includes baseflow analysis, stream-aquifer interactions, flood frequency analysis, urban drainages, waterlogging and reservoir sedimentation studies.

94. Isotope Hydrology:

Isotope hydrology is a field of hydrology that uses isotopic dating to estimate the age and origins of water and of movement within the hydrologic cycle. The techniques are used for water-use policy, mapping aquifers, conserving water supplies, and controlling pollution. It replaces or supplements past methods of measuring rain, river levels and other bodies of water over many decades. Isotope hydrology is the study of the isotopic signatures of water. This subfield of hydrology utilizes isotopic dating to determine the origin and age of water throughout its movement within the hydrologic cycle. Isotopic dating involves measuring the levels of deviation in the isotopes of oxygen and hydrogen in water. Researchers are able to determine groundwater dated as far back as the Ice Age by using these techniques. Isotope hydrology deals with water usage policy, mapping aquifers, conservation of water resources, and maintaining pollution levels.

95. Forest hydrology:

Forest hydrology is an interdisciplinary applied science that intersects the disciplines of hydrology and forestry**.** It is primarily involved with the research and analysis of the effects of **forest** cover and changes of land use on water yield**,** quality and timing.

96. Urban Hydrology:

Urban hydrology is a science, part of land hydrology investigating the hydrological cycle, water regime and quality in urbanized territory. Urban hydrology is an applied science that will have an increasing role to play in the sustainability of human societies. Facing present growth of urban population, it is increasingly difficult to find and utilize new sources of water necessary to satisfy growing water demand.

97. Wetland Hydrology

Wetland hydrology is the study of the movement of water in and out of the wetland ecosystem. In wetlands the presence of water is the overwhelming characteristic of the ecosystem. Wetlands are a unique hydrologic feature of the landscape. One particularly important attribute is their position as the transition zone between aquatic and terrestrial ecosystems. Wetlands share aspects of both aquatic and terrestrial environments because of this position.

98. Ecohydrology:

Ecohydrology is the study of ecological processes in the hydrologic cycle**.** As these processes occur in the soil and plant foliage, ecohydrologists study how the hydrologic system affects plant physiology, soil moisture, and plant diversity and spatial orientation in various regions over a period of time. Ecohydrology has four main components: infiltration of precipitation into the soil, evapotranspiration, leakage of water into deeper portions of the soil not accessible to the plant, and runoff from the ground surface.

99. Statistical hydrology / Stochastic Hydrology:

By analyzing the statistical properties of hydrologic records, such as rainfall or river flow, hydrologists can estimate future hydrologic phenomena. When making assessments of how often relatively rare events will occur, analyses are made in terms of the return period of such events. Other quantities of interest include the average flow in a river, in a year or by season.
These estimates are important for engineers and economists so that proper risk analysis can be performed to influence investment decisions in future infrastructure and to determine the yield reliability characteristics of water supply systems. Statistical information is utilized to formulate operating rules for large dams forming part of systems which include agricultural, industrial and residential demands.

100. Hydroinformatics:

Hydroinformatics is a branch of informatics which concentrates on the application of information and communications technologies (ICTs) in addressing the increasingly serious problems of the equitable and efficient use of water for many different purposes. Growing out of the earlier discipline of computational hydraulics, the numerical simulation of water flows and related processes remains a mainstay of hydroinformatics, which encourages a focus not only on the technology but on its application in a social context. On the technical side, in addition to computational hydraulics, hydroinformatics has a strong interest in the use of techniques originating in the so-called artificial intelligence community, such as artificial neural networks or recently support vector machines and genetic programming. These might be used with large collections of observed data for the purpose of data mining for knowledge discovery, or with data generated from an existing, physically based model in order to generate a computationally efficient emulator of that model for some purpose.

Hydroinformatics recognises the inherently social nature of the problems of water management and of decision making processes, and strives to understand the social processes by which technologies are brought into use. Since the problems of water management are most severe in the majority world, while the resources to obtain and develop technological solutions are concentrated in the hands of the minority, the need to examine these social processes are particularly acute.

101. Oceanography:

Oceanography is a science concerned with the physico-chemical characteristics of oceanic water, its depth, temperature, salinity, movements like tides, waves and currents, flora and fauna found at various zones of seas and oceans. As it deals with the distribution and processes of these water bodies, it comes under earth sciences in general. The subject deals with the physical, chemical and biological conditions of oceans. It is an inter-disciplinary subject and an emerging area for marine engineering. It is the science of seas and oceans. Ever since people started sailing the oceans, attempts have been made to map them. Ptolemy's oldest map is an example.

Ocean exploration began around 5000 B.C. with the first ocean diving and the first sailing vessels. Many advances that were made in the subject of oceanography, were all through the great ocean expeditions and explorations.

Oceanography is an interdisciplinary science. It uses the principles and insights from biology, chemistry, geology, meteorology, and physics to analyze ocean currents, marine ecosystems, ocean storms, waves, ocean plate tectonics, and features of the ocean floor, including exotic biomes such as cold seeps and hydrothermal vents.

Oceanography is a part of the subjects like Physical Geography, Marine biology, Marine geology, Fishery biology, Marine Engineering and Marine Geophysics. Subjects like historical geology, palaeontology and palaeo-climatology are all inter-related subjects to oceanography. It is an inter-disciplinary subject.

Branches of oceanography

Oceanography is a very vast subject. It has several branches. The major branches of oceanography are, Physical Oceanography, Chemical Oceanography, Biological Oceanography, Geological Oceanography, Marine Biology, Applied Oceanography, Marine Meteorology, and Palaeo-oceanography. Although oceanography is the scientific study of the ocean, the sub-discipline of physical oceanography is principally concerned with the study of the structure and movement of water in the oceans.

The study of oceanography is divided into these four branches:

Geological oceanography, or marine geology, is the study of the geology of the ocean floor including plate tectonics and paleoceanography.

Biological oceanography, or marine biology, investigates the ecology of marine organisms in the context of the physical, chemical, and geological characteristics of their ocean environment and the biology of individual marine organisms.

Chemical oceanography and ocean chemistry, are the study of the chemistry of the ocean. Whereas chemical oceanography is primarily occupied with the study and understanding of seawater properties and its changes, focuses ocean chemistry primarily on the geochemical cycles. Chemical oceanography is the study of ocean chemistry: the behavior of the chemical elements within the Earth's oceans. The ocean is unique in that it contains - in greater or lesser quantities - nearly every element in the periodic table.

Much of chemical oceanography describes the cycling of these elements both within the ocean and with the other spheres of the Earth system (see biogeochemical cycle). These cycles are usually characterised as quantitative fluxes between constituent reservoirs defined within the ocean system and as residence times within the ocean. Of particular global and climatic significance are the cycles of the biologically active elements such as carbon, nitrogen, and phosphorus as well as those of some important trace elements such as iron.

Another important area of study in chemical oceanography is the behaviour of isotopes (see isotope geochemistry) and how they can be used as tracers of past and present oceanographic and climatic processes. For example, the incidence of 18O (the heavy isotope of oxygen) can be used as an indicator of polar ice sheet extent, and boron isotopes are key indicators of the pH and CO2 content of oceans in the geologic past.

102. Physical Oceanography:

Physical Oceanography deals with the physics of the Ocean. It describes the physical processes influencing the oceans and coastal regions, the interaction of the ocean with the atmosphere, the distribution of oceanic winds, currents, heat fluxes and water masses, Oceanographic Exploration, evolution of scientific concepts, physical setting of seas and oceans- dimensions, sea-floor, bathymetry, databases. Sound in oceans is an important phenomena for oceanographic explorations.

Physical oceanography studies the ocean's physical attributes including temperature-salinity-density structure(stratification), mixing, surface waves, internal waves, surface tides, internal tides, and currents. Physical oceanography is the study of physical conditions and physical processes within the ocean, especially the motions and physical properties of ocean waters. It is further divided into the following branches:

Descriptive physical oceanography seeks to research the ocean through observations and complex numerical models, which describe the fluid motions as precise as possible.

Dynamical physical oceanography focuses primarily upon the processes that govern the motion of fluids with emphasis upon theoretical research and numerical models. These are part of the large field of Geophysical Fluid Dynamics (GFD) that is shared together with meteorology.

103. Geological Oceanography :

Geological Oceanography is a division of oceanography. It is mainly dealing with the basic concepts of lithosphere & hydrosphere. It includes the study of the oceanic crust, continental margins, ocean bottom relief, ocean basins, oceanic ridges, rift-valleys, Island arcs, seamounts, marine sedimentation, geology of corals, beach forms and processes, water masses , factors affecting ocean circulation, waves and currents, tides and energy coastal erosion and drifting of sediments, sea level changes, depositional environments and marine deposits. Geological oceanography is also concerned with the occurrence of oil-traps and energy sources, tectonic movements- underwater eruptions, mud volcanoes and impacts of tsunamis.

104. Biological Oceanography:

The basic ecological concepts are central to many studies of biological oceanography. The study of marine life, habitat, interactions, abiotic environment, phytoplankton and primary production, zooplankton, migrations and changes, energy flow & mineral cycling, marine food chains, food webs, nektons, marine reptiles, mammals, seabirds, mariculture, Benthic plants and animals, inter-tidal environments, beaches, coral reefs, estuaries and mangroves are all studied under biological oceanography. Deep sea ecology and marine pollution are also the other two major important areas of study under biological oceanography.

105. Chemical Oceanography:

Chemical Oceanography is the study of everything about the chemistry of the ocean , distribution and dynamics of the elements, isotopes, atoms and molecules. The chemistry of the ocean is closely tied to ocean circulation, climate, the plants and animals that live in the ocean, and the exchange of material with the atmosphere, cryosphere, continents, and mantle. This ranges from fundamental physical, thermodynamic and kinetic chemistry to two-way interactions of ocean chemistry with biological/ geological and physical processes.

Chemical oceanography includes processes that occur on a wide range of spatial scales; from global to regional to local to microscopic dimensions, and temporal scales; from geological epochs to glacial-interglacial to millennial, decadal, interannual, seasonal, diurnal and all the way to microsecond time scales. Much of chemical oceanography describes the cycling of the chemical elements both within the ocean and with the other spheres of the Earth system. It encompasses both inorganic and organic chemistry, and includes studies of atmospheric and terrestrial processes as well.

106. Palaeooceanography :

Palaeo-oceanography is the study of the history of the oceans in the geologic past with regard to circulation, chemistry, biology, geology and patterns of sedimentation and biological productivity. Palaeo-oceanographic studies using environment models and different proxies enable the scientific community to assess the role of the oceanic processes in the global climate by the re-construction of past climate at various intervals. Palaeo-oceanographic research is also intimately tied to palaeo-oclimatology. Radiometric dating of ocean rocks is an important aspect in this subject. Marine carbonates record the strontium isotopic (87Sr/86Sr) composition of the seawater in which they are formed. They give good indications for many oceanographic analysis.

107. Paleopedology:

Paleopedology (palaeopedology in the United Kingdom) is the discipline that studies soils of past geological eras, from quite recent (Quaternary) to the earliest periods of the Earth's history. Paleopedology can be seen either as a branch of soil science (pedology) or of paleontology, since the methods it uses are in many ways a well-defined combination of the two disciplines. Paleopedology's earliest developments arose from observations in Scotland circa 1795 whereby it was found that some soils in cliffs appeared to be remains of a former exposed land surface.

108. Paleophycology:

Paleophycology (also once known as paleo algology) is the subdiscipline of paleobotany. This subject deals with the study and identification of fossil algae and their evolutionary relationships and ecology. The field is very important in the science of paleolimnology as the algae leave many indicators of fossil ecosystems. Primary and most familiar are both fossil shells from diatoms and biogeochemical traces of algal pigments in lake sediments. These fossils are clues to changes in nutrient availability and ecology of lakes.

109. Sedimentology:

Sedimentology is the scientific study of sedimentary rocks and the processes by which they were formed. It is concerned with the composition and genesis of sediments and sedimentary rocks, and the creation of predictive models that resemble and predict sedimentation. It's used to describe sedimentation processes by interpreting the facies in order to know the characteristics, methodology and principles of sedimentation. Sedimentology encompasses the study of modern sediments such as sand, silt, and clay, and the processes that result in their formation (erosion and weathering), transport, deposition and diagenesis.

Sedimentologists apply their understanding of modern processes to interpret geologic history through observations of sedimentary rocks and sedimentary structures. Sedimentary rocks cover up to 75% of the Earth's surface, record much of the Earth's history, and possess all the fossil record. Using these studies, sedimentologists apply their understanding of modern processes to ancient rock, to try to understand how it formed. Sedimentology is closely linked to stratigraphy, the study of the physical and temporal relationships between rock layers or strata. Sedimentary processes lead to the development of sediments include physical processes (weathering and erosion), chemical processes (precipitation of chemical compounds in water solutions) and biological processes. The subject also focuses on the sedimentation principles, methodology and characteristics of sediments. The principles of sedimentary rocks are, 1) Principle of superposition, 2) Principle of original horizontality, 3) Principle of lateral continuity, and 4) Principle of cross-cutting relationships.

110. Marine Geology:

Marine geology or geological oceanography is the study of the history and structure of the ocean floor. It involves geophysical, geochemical, sedimentological and paleontological investigations of the ocean floor and coastal zone. Marine geology has strong ties to physical oceanography.

Marine geology or geological oceanography is the study of the history and structure of the ocean floor. It involves geophysical, geochemical, sedimentological and paleontological investigations of the ocean floor and coastal zone. Marine geology has strong ties to geophysics and to physical oceanography. Marine geological studies were of extreme importance in providing the critical evidence for sea floor spreading and plate tectonics in the years following World War II. The deep ocean floor is the last essentially unexplored frontier and detailed mapping in support of both military (submarine) objectives and economic (petroleum and metal mining) objectives drives the research.

111. Mining Geology:

Mining is the extraction of valuable minerals or other geological materials from the earth usually from an ore body, lode, vein, seam, reef or placer deposits. These deposits form a mineralized package that is of economic interest to the miner. Ores recovered by mining include metals, coal, oil shale, gemstones, limestone, chalk, dimension stone, rock salt, potash, gravel, and clay. Mining is required to obtain any material that cannot be grown through agricultural processes, or created artificially in a laboratory or factory. Mining in a wider sense includes extraction of any non-renewable resource such as petroleum, natural gas, or even water. Mining of stones and metal has been a human activity since pre-historic times. Modern mining processes involve prospecting for ore bodies, analysis of the profit potential of a proposed mine, extraction of the desired materials, and final reclamation of the land after the mine is closed.

Mining operations usually create a negative environmental impact, both during the mining activity and after the mine has closed. Hence, most of the world's nations have passed regulations to decrease the impact. Work safety has long been a concern as well, and modern practices have significantly improved safety in mines. Levels of metals recycling are generally low. Unless future end-of-life recycling rates are stepped up, some rare metals may become unavailable for use in a variety of consumer products. Due to the low recycling rates, some landfills now contain higher concentrations of metal than mines themselves.

112. Engineering Geology:

Engineering geology is the application of the geology to engineering study for the purpose of assuring that the geological factors regarding the location, design, construction, operation and maintenance of engineering works are recognized and accounted for. Engineering geologists provide geological and geotechnical recommendations, analysis, and design associated with human development and various types of structures. The realm of the engineering geologist is essentially in the area of earth-structure interactions, or investigation of how the earth or earth processes impact human made structures and human activities.

Engineering geolog**y** is the application of the geology to engineering study for the purpose of assuring that the geological factors regarding the location, design, construction, operation and maintenance of engineering works are recognized and accounted for. Engineering geology studies may be performed during the planning, environmental impact analysis, civil or structural engineering design, value engineering and construction phases of public and private works projects, and during post-construction and forensic phases of projects. Works completed by engineering geologists include; geological hazard assessments, geotechnical, material properties, landslide and slope stability, erosion, flooding, dewatering, and seismic investigations, etc.

Engineering geology studies are performed by a geologist or engineering geologist that is educated, trained and has obtained experience related to the recognition and interpretation of natural processes, the understanding of how these processes impact human made structures (and vice versa), and knowledge of methods by which to mitigate against hazards resulting from adverse natural or human made conditions. The principal objective of the engineering geologist is the protection of life and property against damage caused by various geological conditions. The practice of engineering geology is also very closely related to the practice of geological engineering and geotechnical engineering. If there is a difference in the content of the disciplines, it mainly lies in the training or experience of the practitioner.

113. Planetary geology :

Planetary geology, alternatively known as astrogeology or exogeology, is a planetary science discipline concerned with the geology of the celestial bodies such as the planets and their moons, asteroids, comets, and meteorites. Although the geo- prefix typically indicates topics of or relating to the Earth, planetary geology is named as such for historical and convenience reasons; applying geological science to other planetary bodies. Due to the types of investigations involved, it is also closely linked with Earth-based geology. Planetary geology includes topics such as determining the internal structure of the terrestrial planets, and also looks at planetary volcanism and surface processes such as impact craters, fluvial and aeolian processes. The structures of the giant planets and their moons are also examined, as is the make-up of the minor bodies of the Solar System, such as asteroids, the Kuiper Belt, and comets.

114. Geotectonics :

Geotectonics has a special place among the geological disciplines. Geotectonics is a subject of earth science which deals with the phenomena of solid earth on a global scale and the timescale of the earth's history. It is the subject relating to the shape, structure, and arrangement of the rock masses resulting from structural deformation of the earth's crust. It encompasses the aspects like radioactive dating, isotope analysis, and deformation mechanisms of fault rocks. The research methods are mainly concerned with the observations and measurements during field work, indoor analyses and experiments using rock samples, employing modeling and theories to support them. In trying to discover the deep-lying causes of tectonic processes, geotectonics has to unite the results of all the Earth sciences. This field also emphasis on the plate geometries, geodynamical processes, and sedimentary products. Origin and history of major tectonic elements of the earth, especially their interaction through time are discussed in detail. Geotectonics deals with solid earth phenomena on a global scale and the timescale of the earth's history.

115. Neotectonics:

Neotectonics, a subdiscipline of tectonics, is the study of the motions and deformations of Earth's crust (geological and geomorphological processes) that are current or recent in geologic time. The term may also refer to the motions/deformations in question themselves.

116. Quaternary Geology:

The Quaternary period is characterized by a series of large-scale environmental changes that have profoundly affected and shaped both landscapes and life on Earth. One of the most distinctive features of the Quaternary has been the periodic build-up of major continental ice sheets and mountain ice caps in many parts of the world . The Quaternary period is subdivided into the Pleistocene ("Ice Age") and the Holocene (present warm interval) epochs. Quaternary geology is the branch of geology that study developments from 2.6 millions years ago onwards. In particular, the subject Quaternary geology focuses on the process and deposits that developed during the quaternary, a period characterized by glacial-interglacial cycles. Quaternary Geology is a unique discipline that deals with the youngest period in Earth's history -- circa the past 2.6 million years. This period is characterized by major climate fluctuations and transitions between glacial and inter-glacial periods. Many of the landforms, soil and loose rock (glacial debris) that are present in Norway got originated during these glaciations.

117. Geoarchaeology:

Geoarchaeology is a multi-disciplinary approach which uses the techniques and subject matter of geography, geology and other Earth sciences to examine topics which inform archaeological knowledge and thought. Geoarchaeologists study the natural physical processes that affect archaeological sites such as geomorphology, the formation of sites through geological processes and the effects on buried sites and artifacts post-deposition. Geoarchaeologists' work frequently involves studying soil and sediments as well as other geographical concepts to contribute an archaeological study. Geoarchaeologists may also use computer cartography, geographic information systems (GIS) and digital elevation models (DEM) in combination with disciplines from human and social sciences and earth sciences. Geoarchaeology is important to the society because it informs archaeologists about the geomorphology of the soil, sediments and the rocks on the buried sites and artifacts they're researching on. By doing this we are able locate ancient cities and artifacts and estimate by the quality of soil how "prehistoric" they really are.

118. Himalayan geology:

The Himalayas is a vast, formidable and home to the Earth's highest peaks. The mountain range stretches inexorably through Indian, Bhutan, Nepal, China (Tibet) and Pakistan separating the Tibetan Plateau to the north from India's alluvial plains to the south. Himalayan Geology is an interesting branch of Indian Geology. It delas with the tectonic framework and structure of mountains, or 'evolution' for the geologic history and formation of mountains. To understand how the Himalaya formed we need to consider its structure - the types and ages of the rocks and the nature of faults that have fashioned these mountains. Geological mapping in various parts of the Himalaya over the past century has led the geologists to divide these mountains into six major longitudinal zones or northwest-northeast trending belts. Although local differences exist to some degree, the overall consistency of these zones along the entire length of the Himalaya is significant, and points to a single tectonic explanation for the mountain formation. The six zones of the Himalayans are studied in detail in this branch.

119. Cosmogony:

Cosmogony (or cosmogeny) is any model concerning the origin of either the cosmos or universe. Physical cosmology is the study of the largest-scale structures and dynamics of the Universe and is concerned with fundamental questions about its origin, structure, evolution, and ultimate fate. Cosmology is the scientific study of the large scale properties of the universe as a whole. It endeavors to use the scientific method to understand the origin, evolution and ultimate fate of the entire Universe. Like any field of science, cosmology involves the formation of theories or hypotheses about the universe which make specific predictions for phenomena that can be tested with observations. Depending on the outcome of the observations, the theories will need to be abandoned, revised or extended to accommodate the data. The prevailing theory about the origin and evolution of our Universe is the so-called Big Bang theory. Cosmogony can be distinguished from cosmology, which studies the universe at large and throughout its existence, and which technically does not inquire directly into the source of its origins.

120. Nuclear Geophysics:

Nuclear geophysics is the study and practice of nuclear physics as applied to geology. Examples of different materials dealt with by nuclear geophysics include raw materials such as petroleum, water, metalliferous minerals and coal as well as processed materials such as glass, purified minerals and ceramics. The methodology of nuclear geophysics started with the discovery, by Henry Becquerel in 1896, of the radioactivity in uranium sulphate. Since then it has evolved up to contemporary measurement technology which includes electronically actuated radiation sources and high resolution detectors interfaced with miniaturized, user friendly computers. The past fifty years have witnessed an enormous development in nuclear geophysics enabled by the progress in other physical disciplines, mathematics, geology itself and information science. Nuclear geophysics depends on the interaction of nuclear radiation with geological materials. The effects detected or measured are also radiations. What provides the practical basis for nuclear geophysics is the fact that the geological properties of the materials are factors determining the characteristics of these detected radiations

Nuclear geophysics must also deal with the way in which we measure the effects of nuclear radiation interacting with geological materials in the various stages of the of their purification processes, in order to provide data assisting the control of these processes. Its application may assist humanity both in discovering more natural resources and in extracting these resources more effectively and efficiently. In all these aspects, the practice of nuclear geophysics may assist humanity by increasing or maintaining the distribution of resources and, on the other hand, by minimizing their waste, either during their extraction from the ground or during the stage of mineral processing.

121. Photogeology:

Photogeology is a modern branch of geology concerned with the identification and study of geological features through the study of aerial photographs. It involves the techniques of interpreting the geology from aerial photographs or compiling the geological maps there from. Photogeology is the interpretation of the geological and geomorphological features as well as various litho-units on the aerial photographs. The use of aerial photographs to obtain both qualitative and quantitative geologic information is referred to as photogeology. Aerial photographs are widely used today for identifying and mapping landforms, drainage patterns, structural features such as faults and folds, and rock or lithologic Units.

Aerial photographs are a source of geological information that may be unobtainable elsewhere. The advantages of the study of the aerial photographs are, a) it saves time b). it provides to observe a larger area, c). it has more detailed ground surface than maps, d). the photographs can be studied anytime and at anywhere, e). the studies carried out on the photographs are cheaper than studies in the field, f). studies carried out on the aerial photographs are easier than studies in the field. The only disadvantage of the aerial photographs is the absence of the topographic contours and the geographic names.

122. Remote Sensing:

Remote sensing is the science of obtaining information about objects or areas from a distance, typically from aircraft or satellites. Remote sensors collect data by detecting the energy that is reflected from Earth. These sensors can be on satellites or mounted on aircraft. Remote sensors can be either passive or active. Passive sensors respond to external stimuli. They record natural energy that is reflected or emitted from the Earth's surface. The most common source of radiation detected by passive sensors is reflected sunlight. In contrast, active sensors use internal stimuli to collect data about Earth. For example, a laser-beam remote sensing system projects a laser onto the surface of Earth and measures the time that it takes for the laser to reflect back to its sensor.

Remote sensing has a wide range of applications in many different fields. The image analysis helps to monitor shoreline changes, track sediment transport, and map coastal features. Data can be used for coastal mapping and erosion prevention, monitor ocean circulation and current systems, measure ocean temperature and wave heights, and track sea ice. Remote sensing helps in hazard assessment to track hurricanes, earthquakes, erosion, and flooding. Data can be used to assess the impacts of a natural disaster and create preparedness strategies to be used before and after a hazardous event. Satellite data helps to monitor land use, map wetlands, and chart wildlife habitats. The application potential is very huge.

123. Environmental Geology:

Environmental geology, like hydrogeology, is an applied science concerned with the practical application of the principles of geology in the solving of environmental problems. It is a multidisciplinary field that is closely related to engineering geology and, to a lesser extent, to environmental geography. Environmental geology, like hydrogeology, is an applied science concerned with the practical application of the principles of geology in the solving of environmental problems. It is a multidisciplinary field that is closely related to engineering geology and, to a lesser extent, to environmental geography. Each of these fields involves the study of the interaction of humans with the geologic environment, including the biosphere, the lithosphere, the hydrosphere, and to some extent the atmosphere. In other words, environmental geology is the application of geological information to solve conflicts, minimizing possible adverse environmental degradation or maximizing possible advantageous condition resulting from the use of natural and modified environment.

124. Ceramography:

Ceramography is the art and science of preparation, examination and evaluation of ceramic microstructures. Ceramography is part of the broader field of materialography, which includes all the microscopic techniques of material analysis, such as metallography, petrography and plastography. Ceramography is usually reserved for high-performance ceramics for industrial applications. It focuses on how to saw, mount, grind, polish, etch, examine, interpret and measure ceramic microstructures. The microstructure is the structure level of approximately 0.1 to 100 µm, between the minimum wavelength of visible light and the resolution limit of the naked eye. The microstructure includes most grains, secondary phases, grain boundaries, pores, micro-cracks and hardness microindentions. Most bulk mechanical, optical, thermal, electrical and magnetic properties are significantly affected by these microstructures. The fabrication method and process conditions are generally indicated by the microstructure. The root cause of many ceramic failures is evident in the microstructure, which helps to avoid such problems.

125. Limnology :

Limnology is the study of lakes and inland water bodies. It is also regarded as a division of ecology or environmental science. It covers the biological, chemical, physical, geological, and other attributes of all inland waters (running and standing waters, both fresh and saline, natural or man-made). This includes the study of lakes and ponds, rivers, springs, streams and wetlands. A more recent sub-discipline of limnology, termed landscape limnology, studies, manages, and conserves these aquatic ecosystems using a landscape perspective. Limnology is closely related to aquatic ecology and hydrobiology, which study the aquatic organisms in particular, in regard to their hydrological environment. Although limnology is sometimes equated with freshwater science, this is erroneous since limnology also comprises the study of inland salt lakes.

126. Paleolimnology:

Paleolimnology is the study of the physical, chemical, and biological information preserved in freshwater deposits, primarily from lakes. Such important proxy indicators of past environmental change can be used to reconstruct the history of a particular lake and/or can provide valuable information on broader ecological and environmental scales (e.g. climate, landscape changes). Paleolimnology is a scientific sub-discipline closely related to both limnology and paleoecology. Palaeolimnological studies are concerned with reconstructing the paleoenvironments of inland waters (lakes and streams; freshwater, brackish, or saline) – and especially changes associated with such events as climatic change, human impacts (e.g., eutrophication, or acidification), and internal ontogenic processes.

Paleolimnological studies are commonly based on meticulous analyses of sediment cores, including the physical, chemical and mineralogical properties of sediments, and diverse biological records (e.g., fossil diatoms, cladocera, ostracodes, molluscs, pollen, pigments, or chironomids). Many of today's environmental problems, such as lake acidification, lake eutrophication, heavy metal accumulation in aquatic and terrestrial ecosystems, as well as climate change are not spontaneous events, rather they are the consequence of long-term perturbations. The most commonly used biological indicators in paleolimnology are the glass cell walls of diatoms, a major group of algae consisting of over 10,000 species. Other biological indicators commonly used in paleolimnology include the scales and cysts of chrysophyte algae, shells and body parts of animals, and the chitinous exoskeletons of a large number of invertebrates.

127. Hydrobiology:

Hydrobiology is the science of life and life processes in water. Much of modern hydrobiology can be viewed as a sub-discipline of ecology but the sphere of hydrobiology includes taxonomy, economic biology, industrial biology, morphology, physiology etc. The major distinguishing aspect is that all relate to aquatic organisms. Much work is closely related to limnology and can be divided into lotic system ecology (flowing waters) and lentic system ecology (still waters). One of the significant areas of current research is eutrophication. Another subject of research is the acidification of mountain lakes. Long-term studies are carried out on changes in the ionic composition of the water of rivers, lakes and reservoirs in connection with acid rain and fertilisation. Much of the early work of hydrobiologists were concentrated on the biological processes utilised in sewage treatment and water purification especially slow sand filters.

128. Sedimentology:

Sedimentology encompasses the study of modern sediments such as sand, silt, and clay and the processes that result in their formation (erosion and weathering), transport, deposition and diagenesis. The aim of sedimentology is studying the characteristics sediments and derive information on the depositional conditions which acted to deposit the rock unit, and the relation of the individual rock units in a basin into a coherent understanding of the evolution of the sedimentary sequences and basins, and thus, the Earth's geological history as a whole. Sedimentologists apply their understanding of modern processes to interpret geologic history through observations of sedimentary rocks and sedimentary structures. The principle of superposition is critical to the interpretation of sedimentary sequences . The methods employed by sedimentologists to gather data and evidence on the nature and depositional conditions of sedimentary rocks include; measuring and describing the outcrop and distribution of the rock unit; descriptions of rock core, describing the progression of rock units within a basin, describing the lithology of the rock, and analysing the geochemistry of the rock.

129. Geoinformatics:

Geoinformatics is the science and the technology of using geospatial data for modeling and simulation purposes. It uses the infrastructure of information science to address the problems of geology, geography, cartography and related branches of science and engineering. It is the art, science and technology of acquisition, storage, processing, production, presentation and dissemination of geospatial information. Geoinformatics has, at its core, the technologies supporting the processes of acquiring, analyzing and visualizing spatial data. . In real word, there are many geographical features which include topographic features, land use, land cover, soils, forests, rocks, water bodies, agriculture, city, streets, communication lines, district, etc. These are spatial data often represented by a map. Information about these features is attribute data which may form part of an information system. Geoinformatics is the integration of different disciplines dealing with spatial information. The advent of Satellite Remote Sensing and subsequent development of Global Positioning System (GPS) and Geographical Information System (GIS) have made significant changes in surveying and map making.

130. Geomatics:

Geomatics is a subfield of geoinformatics. It deals with surveying and geospatial engineering and geospatial technology. It orients on gathering, storing, processing, and delivering geographic information or spatially referenced information. Geomatics includes the tools and techniques used in land surveying, remote sensing, cartography, geographic information systems(GIS), global-navigation satellite systems (GPS, GLONASS, Galileo, Compass), photogrammetry, geophysics, geography, and related forms of earth mapping. The related field of hydrogeomatics covers the area associated with surveying work carried out on, above or below the surface of the sea or other areas of water.

Geospatial science is an academic discipline of incorporating various fields like surveying, geographic information systems, hydrography and cartography.

131. Gemology or gemmology:

Gemmology or gemmology is the science dealing with natural and artificial gemstone materials. It is considered a geoscience and a branch of mineralogy. Some jewelers are academically trained gemologists and are qualified to identify and evaluate gems. The first gemological laboratory serving the jewelry trade was established in London in 1925. Gemstones are basically categorized based on their crystal structure**,** specific gravity**,** refractive index**,** and other optical properties, such as pleochroism. The physical property of "hardness" is defined by the non-linear Moh's scale of mineral hardness. Gemmologists study these factors while valuing or appraising cut and polished gemstones. Gemmological microscopic study of the internal structure is used to determine whether a gem is synthetic or natural by revealing natural fluid inclusions or partially melted exogenous crystals that are evidence of heat treatment to enhance color. The spectroscopic analysis of cut gemstones also allows a gemmologist to understand the atomic structure and identify its origin, which is a major factor in valuing a gemstone.

Gemmologists a) examines gemstones, such as jade, sapphires, and rubies, to evaluate their genuineness, quality, and value, utilizing knowledge of gems and market valuations, b) examines gem surfaces and internal structure, using polariscope, refractometer, microscope, and other optical instruments, to differentiate between stones, identify rare specimens, or to detect flaws, defects, or peculiarities affecting gem values, c) immerses stones in prescribed chemical solutions to determine specific gravities and key properties of gemstones or substitutes, which indicate physical characteristics of stone for gem identification, quality determination, and for appraisal, d) grades stones for color, perfection, and quality of cut, e) estimates wholesale and retail value of gems, following pricing guides, market fluctuations, and various economic changes that affect distribution of precious stones. Gemmologists may advise customers and others in use of gems to create attractive jewellery items.

132. Pedology :

Pedology, in the American usage of the word, can be viewed as the study of soil properties and processes in situ on the landscape. Pedology is the study of soils in their natural environment. It is one of two main branches of soil science, the other being edaphology. It is the study of soils in their natural environment. It is one of two main branches of soil science, the other being edaphology. Pedology deals with pedogenesis, soil morphology, and soil classification, while edaphology studies the way soils influence plants, fungi, and other living things. soils are products of weathering from a parent material, which is mainly the rock regolith. Parent material is the underlying geological material (generally bedrock or a superficial or drift deposit) in which soil horizons form. Soils typically inherit a great deal of structure and minerals from their parent material, and, as such, are often classified based upon their contents of consolidated or unconsolidated mineral material that has undergone some degree of physical or chemical weathering and the mode by which the materials were most recently transported. Due to these reasons, pedology is considered as a branch of geology. Except plants and animals, all other four major factors of soil genesis are coming under the subject of geology. Pedology includes the analysis of a soil's evolution and how it functions.

133. Ore Dressing and Metallurgy:

Metallurgy is the branch of science and technology concerned with the properties of metals and their production and purification. Metallurgy is a domain of materials science and engineering that studies the physical and chemical behaviour of metallic elements, their inter-metallic compounds, and their mixtures, which are called alloys. Metallurgy is also the technology of metals: the way in which science is applied to the production of metals, and the engineering of metal components for usage in products for consumers and manufacturers. The production of metals involves the processing of ores to extract the metal they contain, and the mixture of metals, sometimes with other elements, to produce alloys. Metallurgy is distinguished from the craft of metalworking, although metalworking relies on metallurgy, as medicine relies on medical science, for technical advancement. Metallurgy is subdivided into ferrous metallurgy (sometimes also known as black metallurgy) and non-ferrous metallurgy or colored metallurgy. Ferrous metallurgy involves processes and alloys based on iron while non-ferrous metallurgy involves processes and alloys based on other metals. The production of ferrous metals accounts for 95 percent of world metal production.

In the field of extractive metallurgy, mineral processing, also known as ore dressing, is the process of separating commercially valuable minerals from their ores. Ore dressing is the first stage in the extraction of a metal from an ore in which as much gangue as possible is removed and the ore is prepared for smelting, refining, etc. It is also called as mineral dressing or mineral processing. The object of ore dressing is, broadly, to prepare the crude ore for more economical transportation and for further processing to recover the metallic contents.

134. Materials Science:

It is the scientific study of the properties and applications of materials of construction or manufacture (such as ceramics, metals, polymers, and composites), derived from the earth's natural resources. Materials science still incorporates elements of physics, chemistry, and engineering. Materials scientists emphasize understanding how the history of a material (its processing) influences its structure, and thus the material's properties and performance. The understanding of processing-structure-properties relationships is called the § materials paradigm. This paradigm is used to advance understanding in a variety of research areas, including nanotechnology, biomaterials, and metallurgy. Crystallography is a useful tool for materials scientists. In single crystals, the effects of the crystalline arrangement of atoms is often easy to see macroscopically, because the natural shapes of crystals reflect the atomic structure. Further, physical properties are often controlled by crystalline defects. The understanding of crystal structures is an important prerequisite for understanding crystallographic defects. Mostly, materials do not occur as a single crystal, but in polycrystalline form, i.e., as an aggregate of small crystals with different orientations. Because of this, the powder diffraction method, which uses diffraction patterns of polycrystalline samples with a large number of crystals, plays an important role in structural determination.

Another application of material science is the structures of ceramics and glass typically associated with the most brittle materials. Bonding in ceramics and glasses uses covalent and ionic-covalent types with SiO_2 (silica or sand) as a fundamental building block. Ceramics are as soft as clay or as hard as stone and concrete. Usually, they are crystalline in form. Most glasses contain a metal oxide fused with silica. The study of metal alloys is a significant part of materials science. Of all the metallic alloys in use today, the alloys of iron **(**steel**,** stainless steel**,** cast iron**,** tool steel**,** alloy steels**)** make up the largest proportion both by quantity and commercial value. The field is inherently interdisciplinary**,** and the materials scientists/engineers must be aware and make use of the methods of the physicist, chemist and engineering, in addition to the subjects like crystallography and mineralogy.

135. Nanogeoscience:

Nanogeoscience is the study of nanoscale phenomena related to geological systems. Predominantly, this is interrogated by studying environmental nanoparticles between 1-100 nanometers in size. Other applicable fields of study include studying materials with at least one dimension restricted to the nanoscale (e.g. thin films, confined fluids) and the transfer of energy, electrons, protons, and matter across environmental interfaces. The physical and chemical properties of the Earth and other terrestrial planets depend on the atomic to nanoscale structure of their constituent rocks, minerals and fluids.

Nanoscience is concerned with investigating material properties that change as physical dimensions approach the atomic scale and quantum effects become important. Earth materials with at least one nanoscale dimension are ubiquitous and include fault rocks, magnetic particles in sediments, biominerals and nanofossils, exsolutions in igneous and metamorphic crystals, intercrystalline fluid films and weathering layers at mineral surfaces, as well as nanoparticles in the atmosphere, oceans and polar ice sheets. Crucially, almost all elementary interactions between the lithosphere, atmosphere, biosphere and hydrosphere generally occur at the nanoscale across mineral surfaces. Nanogeosciences involves the integration of microscopy, spectroscopy, and theoretical modeling combined with experimental and fieldwork studies on the bulk behaviour associated with nanoscale mechanisms. Electron microscopy and related spectroscopy methods have been key techniques in this field for decades.

Nanogeoscience addresses a number of issues crucial to the geological sciences. The transport of metals and organics in the near-surface environment, global geochemical and climate cycles (including the carbon cycle), ore genesis and exploitation, soil science; microbial geochemical action; origin of life; space weathering and planetary surfaces; atmospheric particle transport and ice nucleation; and even deep Earth processes are to mention a few.

Nanogeoscience also emphasises on various aspects including environmental safety, national security, and human health; mining, minerals, oil, and gas; environmentally friendly manufacturing and new geomimetic materials; and agriculture and food. The challenges that are to be tackled include finding the ways i) to ensure safe drinking water, ii) to store waste responsibly, iii) to convert CO2 back to rock form where it will be stable for thousands of years, iv) to understand how organisms make biominerals, such as bones, teeth and shells and v) to squeeze a bit more oil from reservoirs that are reaching the end of their lifetime. All these aspects are focussed under nanogeoscience.

136. Medical Geology:

Medical geology is an emerging interdisciplinary scientific field studying the relationship between natural geological factors and their effects on human and animal health. All living organisms are composed of major, minor, and trace elements, given by nature and supplied by geology. Medical geology is a rapidly growing discipline dealing with the influence of natural geological and environmental risk factors on the distribution of health problems in humans and animals. As a multi-disciplinary scientific field, medical geology has the potential of helping medical and public health communities all over the world.

Medical Geology integrates professionals from medicine, geography and geology to handle problems accruing from the geology of an area. Three aspects of geology are relevant for a comprehensive study of health problems arising from the geology of a particular environment, namely: mineralogy, geochemistry and hydrogeology. Hazardous effects are caused by the excessiveness or deficiency of essential and non- essential trace elements such as: As, F-, I- , Se, Rn, Mn, Cd and Pb. Good understanding of health issues arising from geologic materials comes from sound knowledge of the classification of elements from the biological point of view because not all elements have been proven to cause health problems. Therefore, medical geology is mainly geared towards identifying and understanding the harmful elements. It is widely known that the state of our environment affects us in many ways. Minerals and rocks are going to have some impact on human and animal populations because that is what the earth is composed of.

Medical geology brings professionals from both the medicine field and the geology field to help us understand this relationship. There are many ways in which humans come into contact with the earth's elements and below are only a few ways in which we become exposed to them. In its broadest sense, medical geology studies exposure to or deficiency of trace elements and minerals; inhalation of ambient and anthropogenic mineral dusts and volcanic emissions; transportation, modification and concentration of organic compounds; and exposure to radionuclides, microbes and pathogens. The name of the discipline may be new, but the impacts of geologic materials on human health have been recognized for thousands of years.

137. Geochemical Prospecting.

Geochemical prospecting is the use of chemical properties of naturally occurring substances (including rocks, glacial debris, soils, stream sediments, waters, vegetation, and air) as aids in a search for economic deposits of metallic minerals or hydrocarbons. The subject deals with the prospecting for minerals with portable chemical kits designed for rapid testing of metallic elements in surface waters. Geochemical prospecting for minerals includes any method of mineral exploration based on systematic measurement of the chemical properties of a naturally occurring material. The purpose of the measurements is the location of geochemical anomalies or of areas where the chemical pattern indicates the presence of ore in the vicinity. Anomalies may be formed either at depth by igneous and metamorphic processes or at the earth's surface by agents of weathering, erosion, and surficial transportation.

Several factors contributed to the rapid development of geochemical prospecting during the twentieth century. It was found that most metallic mineral deposits are surrounded by halos of abnormal trace-element concentrations in the adjacent and enclosing rocks. Also, abnormal trace-element concentrations in materials such as glacial sediment, soil, spring or stream water, and stream sediment were recognized as being derived from the weathering of mineral deposits. Understanding of the significance of landscape in geochemical exploration has progressed considerably, permitting the most effective set of field techniques and interpretive procedures to be selected for any given set of field conditions.

Geochemical prospecting surveys fall into two broad categories, strategic or tactical, which may be further subdivided according to the material samples. Strategic surveys imply coverage of a large area (generally several thousands of square kilometers) where the primary objective is to identify districts of enhanced mineral potential; tactical surveys comprise the more detailed follow-up to strategic reconnaissance.

138. Exploration Geochemistry:

Geochemistry can be defined as the measurement of the relative and absolute abundance of the elements and isotopes in various parts of the Earth with the object of discovering the principles governing their distribution and migration throughout the geological cycle. Exploration geochemistry concentrates particularly on the abundance, distribution, and migration of ore elements, or elements closely associated with ore, with the object of detecting ore deposits. This distinction is only one of emphasis since ores are natural, but not abundant, products of the overall rock-forming cycle.

139. Field Geology:

Geology is a field science. Without sustained fieldwork, no theoretical aspect of geology can be taught and no geological and mineral exploration or research can be carried out. In short, without field studies there would be no science of geology. Field work, supplemented by laboratory studies, is a cornerstone for the geological sciences. Field geology is necessarily founded upon observation and inference. Only features that are superficial can be observed; all else must be inferred. The ability to infer and to infer correctly is the goal of training in field geology, for one's proficiency as a geologist is measured by one's skill in drawing safe and reasonable conclusions from observed phenomena. Practical field training of students is therefore an essential requirement of undergraduate and postgraduate courses in geology. Students have to learn to make independent geological observations and measurements on the ground. Field Geology is the capstone course for the Geology program and requires knowledge gained in Geomorphology, Petrology, Sedimentology and Stratigraphy, Structural Geology and GIS.

140. Gondwana Geology:

Gondwana refers an ancient supercontinent that broke up about 180 million years ago. The continent eventually split into landmasses we recognize today: Africa, South America, Australia, Antarctica, the Indian subcontinent and the Arabian Peninsula.

141. Precambrian Geology:

Precambrian Geology focusses on the origin of the earth's crust and the mineral deposits which it holds. The Precambrian covers almost 90% of the entire history of the Earth. It has been divided into three eras: the Hadean, the Archean and the Proterozoic. The Precambrian Era comprises all of geologic time prior to 600 million years ago. Precambrian Geology provides a suitable framework for assessing various Earth dynamic and biospheric hypotheses, including the modern plate tectonic paradigm and the Gaian hypothesis. It uses geographic and tectonic location, lithostratigraphy, geochronology, and petrogenesis as a basis for considering Precambrian coastal evolution--including the role of plate tectonics. Detailed consideration is given to the endogenic and exogenic processes which formed the continental crust and also to its subsequent secular evolution across Precambrian time.

142. Military Geology:

The application of the earth sciences to such military concerns as terrain analysis, water supply, foundations, and construction of roads and air-fields. The Military Geology Unit was a unit in the United States military during World War II. It was established on June 24, 1942, six months after Pearl Harbor. "During World War II geology won its spurs as an important tool in both planning and operations in the US Army. This growth of geology was due to the increased appreciation on the part of our military leaders of the importance of scientific techniques and information, and to the increased appreciation on the part of our scientists of the usefulness of their abilities in the solution of a large variety of very practical problems. n warfare, military geologists pursue five main categories of work: tactical and strategic terrain analysis, fortifications and tunnelling, resource acquisition, defence installations, and field construction and logistics. In peace, they train for wartime operations and may be involved in peace-keeping and nation-building exercises. the branch of geology that studies the geological structure of terrain and the hydrogeological conditions from the point of view of the requirements of engineering support for troop combat actions; substantiates the location of various fortified works, airfields, military roads and bridges, military hydro-engineering and other structures, and the organization of troop water supply; evaluates the passability of the terrain for different combat arms; and searches for and explores underground waters and inorganic construction materials.

143. Astrogeology:

The same principles of geology that we use to investigate the Earth can also be applied to other planets. Astrogeology is the study of geology of celestial bodies. It is necessary to study the origin and evolution of the planets and satellites in the Solar System, specifically the geologic processes operating on these bodies. Hence, this subject aims to scientifically study and map extraterrestrial bodies, to plan and conduct planetary exploration missions, and to explore and develop new technologies in data processing and analysis, archiving, and distribution.

144. Geodynamics:

Geodynamics is a subfield of geophysics. It deals with the dynamics of the Earth. It applies physics, chemistry and mathematics to the understanding of how mantle convection leads to plate tectonics and geologic phenomena such as seafloor spreading, mountain building, volcanoes, earthquakes, faulting and so on. The subject primarily focuses on the forces that drive the mantle convection, plate motion and deformation of Earth's material. Geodynamics is concerned with deep mantle processes such as mantle convection, cold drips, hot plumes and their links to plate motion, including dynamic plate subsidence and uplift, and plate tectonic processes. Geodynamics involves things that are working at the scales > 100 km. Numerical modeling is at the core aspect of modern geodynamics.

145. Modern Isotope Geochemistry:

Modern isotope geochemistry is a rapidly expanding field that has a part to play in a broad range of earth and planetary sciences - from extra-solar system processes to environmental geoscience. this new edition of a popular textbook is completely updated and places more emphasis on the uses of radiogenic isotopes in environmental earth science.

146. Geostatistics:

The application of statistics to solve the problems in geology is called as geostatistics. Geostatistics is a branch of geology utilizing the methods of statistics for analyzing the spatial or spatiotemporal phenomena of earth's systems, resources and processes. It incorporates the spatial (and in some cases temporal) coordinates of the data within the analyses. This subject was developed originally to predict probability distributions of ore grades for mining operations. Geostatistics originated from the mining and petroleum industries . But currently it is applied in diverse disciplines including petroleum geology, hydrogeology, hydrology, meteorology, oceanography, geochemistry, geometallurgy, geography, forestry, environmental control, landscape ecology, soil science, and agriculture. Serious applications of geostatistics require the use of digital computers.

147. Mathematical Geology:

Mathematical Geology is the application of mathematics to the geosciences. It was born in 1960’s in order to evaluate the geological data and construct geological models by applying mathematical and statistical methods with computers. It was applied in many branches of geology to solve various geological problems. It has not only supplied new tool for geology, but also integrated the geology from empirical science to theoretical science. The mathematical geology has developed many new mathematical models and analytical methods for solving different geological problems. The models developed by mathematical geology can be used not only in geological sciences but also in other natural and social sciences. Within geology, the application of numerical methods has been given various names, such as numerical geology, geo mathematics, geostatistics and geosimulation.

148. Environmental Geochemistry:

Environmental geochemistry is the application of chemical principles to predicting the fate of organic and inorganic pollutants at the earth's crustal surface, hydrosphere and in the atmosphere. Metal pollutants are treated using equilibrium with solids and aqueous solutions. Environmental Geochemistry investigates the impact of natural geochemical processes, and human-induced anthropogenic environmental disturbances on natural ecosystems like rivers, lakes, soils, forests as well as on human health. Environmental geochemistry is concerned with the sources, distribution and interactions of chemical elements in the rock-soil-water-air-plant- animal-human systems. The primary source of elements are igneous rocks of which silicates and alumino-silicates are the dominant compounds.

Certain chemical principles are essential for understanding environmental problems and then to use these principles can be applied to solve the real-world problems.The major aspects studied are mineral solubility, complexation, acids and bases, carbonate chemistry, rock weathering and clay formation, adsorption and ion exchange, redox reactions, microbial energetics and redox zonation, the geochemistry of iron, sulfur, trace elements, and radionuclides, and geochemical kinetics. The areas covered are geochemistry in surface and groundwater, applications of geochemical principles in lithosphere-hydrosphere interactions, geochemistry of soils, environmental biogeochemistry , and application of geochemical principles in environmental quality assessment and remediation.

149. Glaciology:

Glaciology is the study of ice in the environment. Important components are seasonal snow, sea ice, glaciers, ice sheets and frozen ground. Ice in all its forms plays a prominent role in climate and environmental change. Glaciology is the scientific study of glaciers, or more generally ice and natural phenomena that involve ice. It is an interdisciplinary Earth science that integrates geophysics, geology, physical geography, geomorphology, climatology, meteorology, hydrology, biology, and ecology. The impact of glaciers on people includes the fields of human geography and anthropology. The discoveries of water ice on the Moon, Mars, Europa and Pluto add an extraterrestrial component to the field, as in "astroglaciology". Glaciologist are concerned with a wide range of topics regarding the past, present and future behavior of glaciers.

150. Lunar Geology:

The Earth's Moon is the largest natural satellite in the inner Solar System. The Moon is also a witness to more than 4.5 Ga of Solar System history. The geology of the Moon (sometimes called selenology, although the latter term can refer more generally to "lunar science") is quite different from that of Earth. It is the study of the moon's crust, rocks, strata, etc. Lunar Geology tends to cover two broad areas of study; Maria (and/or Basins) and Highlands. The two major lunar geologic disciplines are Geochemistry and Geophysics. Lunar Prospectors use its Neutron Spectrometer and Gamma Ray Spectrometer to determine the bulk elemental composition of the Moon as well as to identify potential lunar resources, including water ice (in the permanently shadowed poles). Geological studies of the Moon are mainly based on a combination of Earth-based telescope observations, measurements from orbiting spacecraft, lunar samples, and geophysical data. The lunar landscape is characterized by impact craters, their ejecta, a few volcanoes, hills, lava flows and depressions filled by magma.

Selenology & Selenography:

Selenography is the study of the surface and physical features of the Moon. Historically, the principal concern of selenographists was the mapping and naming of the lunar maria, craters, mountain ranges, and other various features. This task was largely finished when high resolution images of the near and far sides of the Moon were obtained by orbiting spacecraft during the early space era. Nevertheless, some regions of the Moon remain poorly imaged (especially near the poles) and the exact locations of many features (like crater depths) are uncertain by several kilometers. Today, selenography is considered to be a subdiscipline of selenology, which itself is most often referred to as simply "lunar science."

Conclusion:

The subject of earth science encompasses both pure and applied science branches. The geology illuminates the past, sustains the present and promotes the future, are the statements which are coined to depict the geological windows of the world. It grows and drives with heritage, culture and society. Geology is always in the service of humankind.

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