Semester 6

Unit-1.

Origin and Evolution of Life

Origin of life: It is generally agreed that all life today evolved by common descent from a single primitive lifeform. We do not know how this early form came about, but scientists think it was a natural process which took place perhaps 3,900 million years ago.

Origin of earth and its atmosphere: Earth is believed to have formed about 5 billion years ago. In the first 500 million years a dense atmosphere emerged from the vapor and gases that were expelled during degassing of the planet's interior. These gases may have consisted of hydrogen (H_2), water vapor, methane (CH_4) , and carbon oxides. Prior to 3.5 billion years ago the atmosphere probably consisted of carbon dioxide (CO_2), carbon monoxide (CO), water (H_2O), nitrogen (N_2), and hydrogen.The hydrosphere was formed 4 billion years ago from the condensation of water vapor, resulting in oceans of water in which sedimentation occurred.

Evolution is a branch of science deals with the unfolding of new and complex species from simple species.

There are different plants and the animals which evolve in different ways in different habit, habitat or adaption. In general evolution is a dynamic process in which gradual change of body morphology takes place, after long period of time convert into more and more complex animal.

Scientific hypothesis- Chemical

evolution of life:

Chemical evolution describes chemical changes on the primitive Earth that gave rise to the first forms of life. The first living things on Earth were prokaryotes with a type of cell similar to present-day bacteria. Prokaryote fossils have been found in 3.4-million-year-old rock in the southern part of Africa, and in even older rocksin Australia, including some that appear to be photosynthetic. All forms of life are theorized to have evolved from the original prokaryotes, probably 3.5-4.0 billion years ago.

a) Formation of Simple Compounds: The first stage of chemical evolution, molecules in the primitive environment formed simple organic substances, such as amino acids, methane, ammonia, water etc.

b) Formation of Organic Compounds: In the second stage of chemical evolution, the simple organic molecules (such as amino acids) that formed and accumulated joined together into larger structures (such as proteins). The units linked to each other by the process of dehydration synthesis to form polymers.

c) Formation of complex organic compound: simple organic molecules combined to form complex organic compounds like polysaccharides, fats, protein, nucleotides, nucleosides, nuclic acid etc.

Biological evolution:

a) Formation of Protobionts (Coacervates): The next step in chemical evolution suggests that polymers interacted with each other and organized into aggregates, known as protobionts. Protobionts are not capable of reproducing, but had other properties of living things.

b) Formation of primitive life: In this stage protobionts developed the ability to reproduce and pass genetic information from one generation to the next.

Evolution is defined as slow and gradual process in which simple animal slowly changes into complex animal in relation to environment.Evolution can also define as descent with modification. Based upon the origin, evolution categories into two types;

a) Inorganic evolution: Evolution of inorganic structure such as earth itself, valleys, plateaus, hills, Himalayas, etc.

b) Organic evolution: Evolution of the animals from the simplest organic compounds such as amino acid, glucose, fructose, fatty acid, nucleotides, etc.

On the basis of the morphological characters, organic evolution further sub-divide into following;

a) Progressive evolution: Gradual change in the animal character from the simple to more and more complex. For e.g. origin of man from monkey like creature.

b) Retrogressive evolution: Development of the adults in primitive forms. For e.g.; Herdmania or Ascidian

c) Parallel evolution: Evolution of two similar different animals goes side by side in their general characters during evolution. For e.g. old worldmonkey and new world monkey.

e) Convergent evolution: Animals having similar functional characters but belongs to different category of animals. For eg; wings of bat, bird, butterfly, etc.

f) Divergent evolution: Evolution from the common ancestor but looks different in the morphological character. For eg: Hominoidea group like gorilla, Orangutan, Chimpanzee and Man.

Theories of Evolution:

For the explanation of origin of life, there are different theories. Some of them are follows;

a) Theory of spontaneous generation.

b) Theory of special creation.

c) Theory of cosmozoan.

d) Theory of biogenesis.

e) Theory of steady state.

f) Theory of catastrophism.

g) Theory of organic evolution, etc.

Theory of spontaneous generation: This theory said that origin of life takes place suddenly and instantly from non- living things. For example;

1. Crocodile evolved from the muddy water of river Nile.

2. Desert scorpion evolved from camel dung or excreta.

3. Flies, insect evolved from the decomposite materials.

4. Moist clothes with grains after 20-21 days found young of rats.

In that period, Pasture experimentally proved that origin of life takes place from pre- existing life. After the view of Pasteur, this theory was totally discarded.

Theory of special creation: This theory said that all the living beings existing these days were also present in the beginning simply remain in unknown.

This view could not explain the development of new animals or plants as well as growth of population. Therefore, later the religious people published theory of special creation which said that all the living beings were created by god and goddess.

Theory of cosmozoan: This theory said that first primitive life on the earth surface was come from outer surface or space and was called Panspermia.

Due to lack of evidences this theory was also discarded.

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Theory of biogenesis: This theory related with the origin of life from free existing life. The theory was forwarded

by Francesco Reddi. Later theory was supported by the scientist Spallanzeni and Pasteur.

1. Reddi's experiment: He collected dead snakes, meat and put into the several jar with or without coverings. In the covered jar, he didn't find any extra life but found in the jars having no coverings. Thus he concluded that orifgin of life takes place from pre- existing life not from non-living things.

2. Spallanzeni's experiment: He collected both from the continous boil meat and was kept in several jars with or without coverings. He also found extra life development only in the jars without coverings. Thus concludes in similar manner.

3. Pasteur's experiment: Pasteur experimented simple experiment as shown in the figure. He took swan necked bottle in which kept hay particles and added tap water. The solution was boiled for hours and hours. Then, let free for few days. After few days, he found certain extra life in the neck of the bottle having condensed liquid. But no sign of extra life in the main solution. After that he broke the neck of the bottle and again let free for few days. Later found extra life in the main solution which no doubt came from atmospheric air. Hence origin of life only takes place from pre-existing life but never from non-living things.

Theory of Organic evolution:

This is the latest and most scientific theory which said that in the beginning origin of life took place from simplest organic compounds but later from pre- existing life.

It is believed that our planet earth existed since 4.5 billion years back. In the beginning, the surface of the earth was too hot. Temperature believed between 3000-4000ºC and was surrounded by primitive atmosphere. As the time passed gradually temperature decreases on the surface. Various reactions took place in the primitive atmospheric gases in the presence of high voltage energy. As a result first primitive living solution was developed at the sea bed. It was called coacervate solution having replicating characters. After the solution has also called Darwin's little pond or earth primodeal soup or both.

The coacervate solution shows the composition of organic compound like amino acid, pentose sugar, fatty acid, nucleotides etc. With the change of climatic condition from the coacervate solution evolved first primitive life called cynobacteria or blue green algae. Since 3.2 billion years back. Later evolved prokaryotic organisms like bacteria and evolved eukaryotic organism like protozoans. In these manner slowly evolved more and more complex organisms such as poriferans, coelenterates, platyhelmenths and so on.

Oparin- Holdane theory:

Alexander Oparin in 1923 and JBS Haldane in 1928, both the scientist supported theory of organism and published theory called Oparin Holdane theory.

According to this theory said that in the beginning life was originated from the simplest organic compounds. In the early origin of the earth was blanketed by primitive atmosphere or reducing atmosphere which constituted various gases like CO_2 , CO, SO_2, SO_3, N_2, NO_2, N_2O_5, H_2S, CH_4, H_2O, etc. Among these gases, most of the gases reacted with each other in presence of high energy which may be energy from lightening, energy from solar energy or sun, energy from radioactive element, energy from volcanic eruptions.

The reactions of gases resulted out of the permission of primitive living replicating solution coacervate. This solution evolved first life cyanobacteria or blue green algae.

Conclusion: Origin of life took place from simplest organic compound in the beginning but not these days.

Miller Urey experiment:

Miller and Urey in 1953 experimentally supported the theory given by Oparin Haldane regarding origin of life from simplest organic compounds.
They set up the experiment as shown in the figure, in the gas bulb four gases were taken such as water vapour, H_2,CH_4 and ammonia and were reacted at very high voltage. After the reaction, reacted gases, passed through cooling jacket for condensation. The condensed liquid was collected in the resultant bottle and analysed in the lab.

Resultant solution was found the mixture of amino acid and pentose sugar which was also the basic component of coacervate solution.

There is no doubt that in the beginning life originated from the simplest organic compound but these days. Only, originate from the pre-existing.

Evidences for the support of organic evolution:

1. Evidence from comparative anatomical character or morphological characters.

a)Homologus organs

b) Analogous organs

c)Vestigeal organs

d)Connective link

2.Evidence from embryological character.

3.Evidence from paleontological or fossil research character.

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4.Evidence from physiology or bio-chemistry 6.Evidence

from Genetics.

a). Homologus organs: They are those organs having similar origin and anatomy but differ in morphology and functions.With the help of homologous organs of the animals can trace out the common ancestor. For eg; forelimb bones of the animals are humerous, Radio-ulna, carpels, metacarpels and phallenges.

In the above animals origin of the bones are similar anatomically arrangement are similar but only differs in their morphology and functions because of different adaption. Hence having similar characters in the origin showed that all the vertebrates might have the common origin in the beginning.

b). Analogous organs: They are those organs which look different in origin, anatomy and morphology but have similar functions. For eg;Wings of bird – forelimb modification Wings of butterfly – thoracic appendage.

c). Vestigeal organs: They are those organs which were functional in the past but these days became totally non-functional.With the help of vestigial organs also can find out the possible ancestor. It is believed that in human body, there are more than 200 vestigeal organs organs which showed the origin of man from different characters. Some of the vestigial organs are as follows;

Name of the organ	Location of the organ	function	Possible origin
1.Pinnae muscles	Around the pinnae	Help in the movement of pinnae for the collection of sound.	Movable pinnae ancestor
2.Vermiform appendex or short cylindrical	In between calcium and colon i.e. in the large intestine	Secrete enzyme cellulose for the digestion of cellulose or pectin or chloroplast	herbivorous
3.Mictitating membrane or 3rd eye lid or plica-semilunaris	Outside the eye ball	Protection for cornea	Functional mictitating ancestor
4.Post-anal tail	Very close to anus upper	For body balancing	Tailed ancestor

d). Connective link (connecting link): Connecting link or missing link is a character shown by the animals belonging to two or more than two different groups. For e.g. extinct Jurrasic reptile or bird Archeopteryx is the best example of it. It shows the character of two different groups.

1. Avian character:- Body covers by feathers.- Four limbs modified into wings.- Presence of tail feathers- Bones pneumatic- Flying habit

2. Reptilian character:- Hind limbs scaled- Beak with teeth- Tail short- On the land shows crawling locomotion.

Therefore birds are also called glorified reptiles.

3. Evidence from embryological character: Embryology deals with the development of embryos, every vertebrate embryo shows following common character.

a. Presence of single median eye spot for sensation.

b. Presence of simple two chamber heart.

c. Presence of pharyngeal gill slits for respiration.

d.Presence of post and tail.

Presence of similar above character in all the vertebrate embryos means they might have the common ancestor. This character was present in prehistoric embryos so can be called as Phylogeny characters and also found in present embryos, can be called as ontogeny characters. Therefore, it can be said that ontogeny follows phylogeny.

According to the scientist Huxley, ontogeny follows phylogeny said to be recapitulation characters produced theory of recapitulation.

3. Evidence from paleontological or fossil research character:

Paleontogy deals with the study of fossils belonging to extinct animals. The study of fossil provides most convening and direct evidence of evolution. They help to trace the facts correlated with their origin and evolution, relationship, increasing complexity etc. The fossil evidences reveal a gradual development of organisms with time. Animals are better preserved as fossils as compared to plants.

Types of fossil:

Unaltered: In, these types, whole bodies of extinct organisms have been formed frozen in ice at the poles. This type of fossil found about 25000 years ago.

Petrified: This is rare type of the fossil. In this type the organic parts of body gets partly or completely replaced by mineral deposits, the replacement of organic parts by minerals deposits is called petrifaction.

Impression: These are formed by the organisms or the parts of the organism come in contact with soft clay.

Compression: These fossils are formed as a result of burial of organisms. It is useful in the study of the external morphology.

Cast or moulds: These are formed when an organism get submerged in water containing lime. Moulds exhibit the same external configurations of the organisms.

Importance of Paleontology:

1. It helps to reconstruct or build the chain of evolution.

2. It helps to understand the way of evolution.

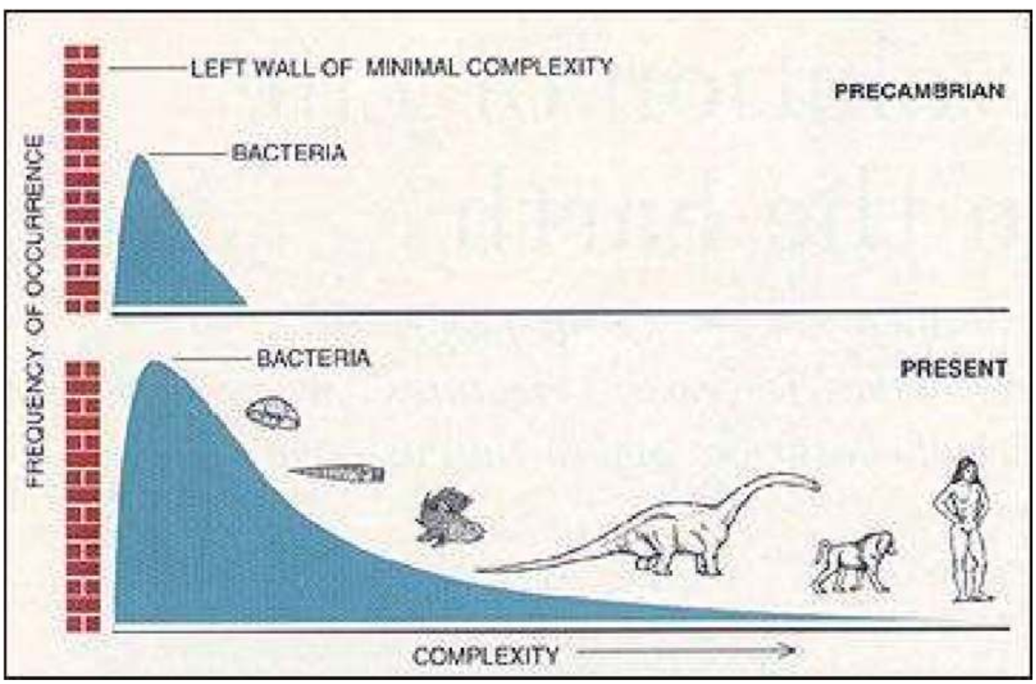
3. It helps to study about the habitat and behavior of the extinct organism.

4. It helps to understand the structure of extinct animal.

Origin and Evolution of life through ages:

Like all other revolutions in the history of science the revolution brought about by Darwin's theory of evolution is most prominent in its impact on the concept of origin of life on the earth. Among all the planets, nature has chosen to bestow gift of life on the Earth only.

In 1831 Darwin sets sail on the HMS Beagle and in 1844 he wrote the theory on the origin of species. Evolution is a process which is imposed upon any living creature usually at incomparably low speeds by which various traits are filtered according to the most significant and most insignificant depending upon various external as well as internal factors. According to evolutionary theory, all life originated from a common unicellular ancestor through natural selection.



Law of faunal succession proposed by William Smith (law of faunal succession) suggests that a regular but interrelated evolutionary change is observed in fauna and flora vertically in a geological column traceable over a wider area. There are various sources of information that lead us to study process of evolution among which the most important and relevant one is data obtained from fossils. Palaeontology is the science which studies past life available in the form of preserved skeletons, imprints, moulds and casts properly known by the name "Fossil".

The concept put forward by Darwin was not so popular and obvious until the unearthing of fossils the discovery of which opened doors for new advancements for theory of evolution. The origin of the universe some 12 billion years ago with big bang explosion while the Earths origin took about 4.6 billion years back. The oldest fossil records available those in the form of blue green algae “stromatolite” fossils dates back to 3.49 billion years obtained from the N.E. Australia. Since then organisms had been evolving in to more and more complex life forms which can be presented by the evolutionary tree as shown below.

From the fossil record it is clear that first life forms were single celled bacteria originated from water giving rise to complex organisms like invertebrates animals without back bones which in turn were followed by more complex ones like fishes as reported in fossil record. Trilobites named on their three lobed body plan are extinct group of vertebrate which developed during the Cambrian era are rich in their fossil record and act as index fossils. Index Fossils are fossils with reasonably wide geographical distribution but short geological range, this property adds to their excellency for correlation purposes.

- Birth of Earth - approximately 4600 million years ago - The Hadean Period (4600 m.y. - 3800 m.y.): Universe originated 12 billion years ago as calculated by the Galilean Telescope by measuring the distance of the farthest particle travelled from the centre since the Big Bang took place.
- The earliest cells and stromatolites - The Archaean Period (3800 m.y. - 2500m.y.): The oldest fossil records available those in the form of blue green algae “stromatolite” fossils dates back to 3.49 billion years obtained from the N.E. Australia.
- The first algae - 1200 million years ago - The Proterozoic Era (2500 m.y. - 544 m.y.): The final Era of the Precambrian, the Proterozoic Era, spans the time between 2500 million and 544 million years ago. Fossils of both primitive single celled and more advanced multicellular organisms begin to appear in abundance in rocks from this era. The name, proterozoic, means "early life."
- The Vendian animals - 570 million years ago - The Vendian Period (650 m.y. - 544 m.y):Also known as the Ediacaran period, the Ediacaran fauna is puzzling to many palaeontologists because of the absence of their relation with other animals
- The Cambrian Explosion - The Cambrian Period (544m.y.- 505 m.y.). Named after the Cambria, “Roman name for whales” is the earliest period of the Palaeozoic era. The term Explosion means rapid evolution and diversification of organisms during this period.
- The Rise of the fish - The Ordovician Period (505 m.y.-440 m.y.): It is named after a Celtic tribe called the Ordovices and it was during this period the first plants appeared. The Ordovician is best known for the presence

of its diverse marine invertebrates, including graptolites, trilobites, brachiopods, and the conodonts (early vertebrates).

- Venturing on land - the Silurian Period (440 m.y. - 410 m.y.): This was the time when some plants and animals left the water and colonized the land for the first time.
- Invasion of the land - the Devonian Period (410m.y. - 360m.y.): named after Devonshire, England. During this period early arthropods and vertebrates invaded land by reducing water loss and maximising oxygen uptake.
- Reptiles and Conifers - the Carboniferous Period (360m.y. - 286m.y.): Carboniferous named after the rich deposits of carbon (coal) in England, during this period collusion of continents led to the development of Appalachian mountains of N. America, the Hercynian Mountains in UK and Ural Mountains of Europe.
- Pangea - the Permian Period (286m.y.- 248m.y.): further assembling of continents brought northern supercontinent Laurasia and Gondwana together to form Pangea surrounded by a single water body Panthalasa.
- Mammals and dinosaurs - the Triassic Period (248m.y.-213m.y.): Lower most period of the Mesozoic Era. Animals of this period were either those who survived the Extinction in the late Permian, or new groups which flourished during the rest of the Mesozoic which include Dinosaurs.
- Dinosaurs and birds - the Jurassic Period (213 m.y. - 145 m.y.): Jurassic is known as the age of Dinosaurs named after the Jura Mountains between France and Switzerland. Studies have revealed that it was during this period that continental drift, driven by upwelling heat from deep within the earth, caused the super continent Pangea to breakup.
- The final season of the dinosaurs - The Cretaceous Period (145m.y.-65m.y.): Named after the Chalk (creta) deposits of this age forming white cliffs along the English Channel between Great Britton and France. It was a time when many of the typically Mesozoic life forms - ammonites, belemnites, gymnosperms, ichtyosaurs, plesiosaurs, pterosaurs and dinosaurs - were in decline. But all of these groups radiated and diversified during some or all of their time and towards the end of the late Cretaceous they showed a variety of patterns of extinction. Towards the end of this period world witnessed a Major Extinction event wiping out more than 96% of the life forms including the gigantic Dinosaurs.
- Archaic mammals and early primates - the Palaeocene Epoch (65m.y.- 55.5m.y.): Named after the Greek words "palaois" (old) and "ceno" (new), indicating the presence of new fauna and flora associated with the old ones from the Cretaceous.
- Whales and horses - The Eocene Epoch (55.5 m.y. - 33.7m.y.):`Its name derives from the Greek words "eos" (dawn) and "ceno" (new), i.e., the dawning of new fossil forms.

- Grasses and primates - the Oligocene Epoch (33.7m.y. - 23.8m.y.): Greek words "oligos" (little, few) and "ceno" (new) indicating that there were only a few new fossil types. The Oligocene is thus a relatively short span of time, though a number of changes occurred during this time. These include the appearance of the first elephants with trunks and the appearance of many grasses -- plants that would produce vast tracts of grasslands in the following epoch, the Miocene.

- Kelp forests and horses - the Miocene Epoch (23.8 m.y. - 5.3m.y.): "meion" (less) and "ceno" (new)
- The first hominids - the Pliocene Epoch (5.3 m.y. - 1.8 m.y.): "pleion" (more) and "ceno" (new). Upper most epoch of the Tertiary period in which first man (hominid) or human like primates evolve in eastern Africa about

  5.3 million years ago.
- Glaciation, the Moa and Homo sapiens - the Pleistocene Epoch (1.8 m.y. - 10,000 y.): Pleistocene is famous for worldwide cooling with alternate Glacial periods (inwhich most of the earth was covered under snow cover owing to cooling of the earth) and Inter Glacial periods (comparatively hotter periods which led to melting of the snow)

- The Age of Humans - the Holocene Epoch (8,000 years - present): However each and every organism influences their environments but humans have influenced the global environments in a manner quite unlike that of any other organism.

Geological time scale International Stratigraphic Chart:

- Surprisingly Geology is sometimes misinterpreted with History but as a matter of fact Geology has no constraints of time like History. Stratigraphy, Palaeontology and Geochronology are few of the basic branches of geology concerned with the study of time frame of Geology. With the Big Bang and origin of universe some 12 billion years ago various episodes led to the origin of the solar system and ultimately the earth 4.6 billion years ago. Scientists are busy in finding out the way Origin of life took place and various theories were put forward of which theories of Biogenesis and abiogenesis are worth appreciation. As already mentioned total History of the Earth and various events, episodes, changes and processes responsible for carrying out those changes are recorded in the rock record (igneous, sedimentary and Metamorphic) and more appropriately in fossil record. Therefore Geological time Scale better called the History of the Earth and Fossils are the pages of the book of records.

- Geological time scale International Stratigraphic Chart given by International Union of Geological Sciences is divisible in four major divisions EONOTHEM/Eons measuring in age in billions of yearsPRECAMBRIAN: 4600 – 540Ma further subdivisions called ERATHEM/Eras five in number viz; Archean 3600-2500Ma, Proterozoic 2500- 540Ma, PHANEROZOIC: Palaeozoic 545-251.4Ma, Mesozoic 250-65.5Ma,

  Cenozoic 65-present. Further smaller subdivisions for example Archean Era is subdivided in to EoArchean, PaleoArchean, MesoArchean, and NeoArchean, while the Proterozoic Era is divided in to four Systems/Periods

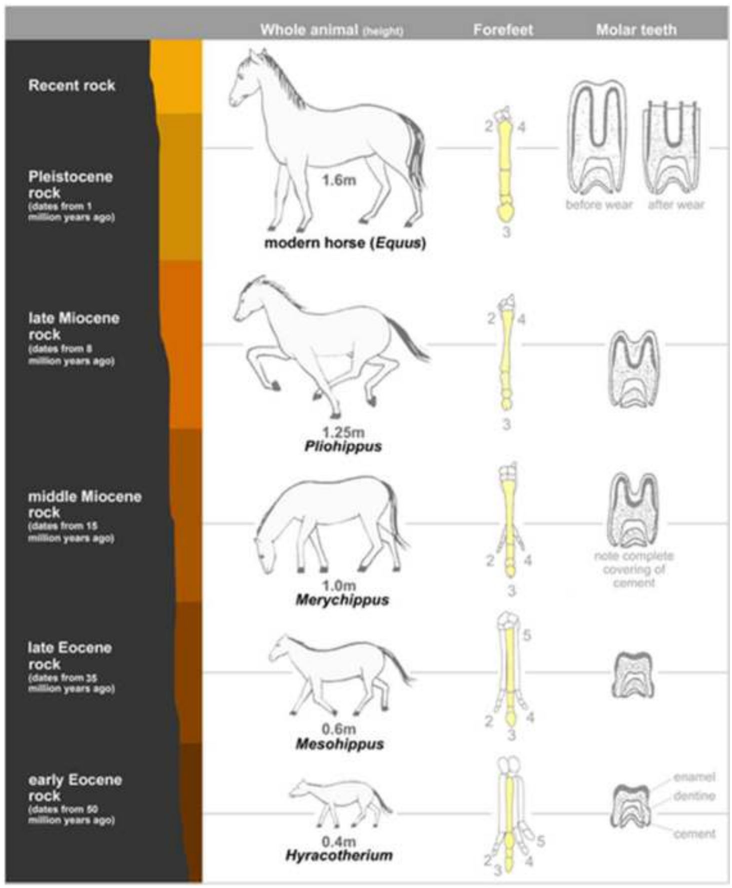
PalaeoProterozoic 2500Ma-1600Ma, Mesoproterozoic 1600Ma-1000Ma, and NeoProterozoic1000Ma-540. In the same way Palaeozoic Era is divided in to six Systems/Periods Cambrian 545Ma-495Ma ancient name for Wales and applied as a system name by Adam Sedgwick in 1835, Ordovician 495Ma-440Ma Name adapted by Charles Lapworth in 1879 from that of an ancient tribe, the Ordovices, Silurian 440Ma-417Ma named for the Silures, an ancient tribe that had inhabited the type area in the Welsh borderland region, Devonian 417Ma-354Ma Named by William Lonsdale in 1837 after the county Devon, England for the marine facies of the Old Red Sandstone, Carboniferous 354Ma-292Ma and Permian 292Ma-251.4Ma named after type section near Perm, Russia correspondingly Mesozoic Era is divided in three periods Triassic 250Ma-205.1Ma, Jurassic 205.1Ma142.0Ma named after the type section Jura Mountains of Switzerland., and Cretaceous 142Ma-65.5Ma finally Cenozoic Era has three Systems/Periods viz; Palaeogene 65.5Ma-23.8Ma, Neogene 23.8Ma-1.81Ma, and at the top Quaternary period 1.81Ma-0.00Ma.

Preliminary idea about faunal succession:

The concept of faunal succession was propounded by W. M. Smith in his “Principle of faunal succession” which states that fossils within sedimentary rocks witness a progressive evolutionary change vertically and retain this characteristic property over comparatively wider areas horizontally while at some stages got extinct as well. In other words concept of faunal succession can be understood by the fact that animals and plants thriving in a particular age die and are buried under sedimentary cover under particular circumstances with the passage of time complex organisms develop as a result of evolution and consequently new sedimentary rocks are formed containing these new types of organisms. According to the “Principle of Superposition” in an undisturbed rock stratum older rocks will be at the bottom with simpler organisms while the youngest rocks will be on top of the sequence entombing younger but more developed organisms. The concept of faunal succession has been used for decades now for correlation purposes and biostratigraphy (Reconstruction of Stratigraphy with the help of existing fossil assemblages in a rock stratum) in post depositional denuded areas.

Faunal succession can be better understood from the geological time scale where large scale evolutionary changes become evident from bottom bacteria like creatures (blue green algae, stromatolite etc.) to top highly specialized animals and plants including man, elephant, horse amphibians and mammals. Living fossils are fossils that have not witnessed a considerable change over a large geological time while as a rule most of the animals have witnessed either extinction, modification or a complete revision with change in environment. As a case study trilobites were a dominant community in the Cambrian period but were entirely wiped away and got extinct at Cambrian-Ordovician boundary. Brachiopods one of the famous invertebrate phyla of Cambrian onwards has continued with most of its traits since their inception however most of its species got extinct and few species of this community are found in most of the brackish water environments today.

Similarly modern horses are a product of a continuous evolutionary transformation from a dog sized animal (Hyracotherium) to the present tall and fast and furious modern horse (Equus).



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Evolutionary changes are somewhat selective as can be inferred from the table.

PALEOBIOLOGY

INTRODUCTION

Life on Earth began early the oldest undoubted fossils are about 3500 million years old, (Archean). Life must have evolved much earlier than 3.5 Ga but the record of which is not discovered yet or life was lacking hard parts what is a basic criteria for them to get preserved efficiently.

The basic distinction among organisms is between unicellular organisms and multicellular organisms. Unicellular organisms: prokaryotes and eukaryotes. All organisms can be classified as either heterotrophic (or abiotic “obtains food from other organic matter”) or autotrophic (synthesizes its own organic materials).

Prokaryotes are primitive, unicellular organisms in which the protoplasm and the genetic material are encased within a cell wall but the genetic material is not located within a nucleus, reproduce asexually.

Eukaryotes are relatively advanced unicellular organisms, the genetic material is enclosed in a special nucleus within the cell, reproduce sexually.

Biologists now agree that there are three fundamental domains of life: eubacteria (Bacteria); archaebacteria (Archaea); and eukaryotes (Eucarya). The big mystery is, of course: what was the common original ancestor, It's extremely unlikely that we will ever find any direct fossil evidence of it in the early geologic record.

Fossils:

A fossil can be defined, broadly, as any evidence of past plant or animal life contained in a sediment or a sedimentary rock. The word comes from the Latin fossilis, an adjective meaning "dug up". In the early days of geology, the term was applied to any interesting natural object (minerals; pieces of ore; pieces of rock; traces of life) that were, literally, dug out of the ground. The term gradually came to be restricted to materials that give evidence of past life.

Fossils are remnants of animals and plants usually millions of years old as preserved in soft rocks during the course of their burial with the sediments in anoxic environments. Fossils can be full body fossils, bones only, tracks, trials, fossils fecals, trees, bacteria etc.

Two types

- Mega fossils: fossils observed by naked eye (Brachiopods, Lamellibranches, Elephant, Man, Horse, Dinosaurs etc.)
- Microfossils: fossils which require the use of microscope (Foraminifera, Ostracods, Conodonts, Cocolithophores etc.).

A suitable environment is required to get any dead creature to be transferred to a fossil or fossilised fall in the processes of fossilisation. The one responsible for the formation is especially known as coalification and the one by which wood is transformed in to fossil wood is known as petrification and in special terms as per-mineralization.

Two kinds of fossils:

Body fossils are the actual organism or some part of it, or the imprint of the organism or some part of it.

Trace fossils, which are physical evidence of the life activities of now vanished organisms. Tracks, trails, burrows, feeding marks, and resting marks are all trace fossils. In relatively young sediments and rocks, the actual body parts of organisms are often preserved. In older rocks, however, the body parts are usually dissolved away, or recrystallized, or replaced by another kind of mineral. Paleontologists usually collect large numbers of rock pieces and then split them in the laboratory with special mechanical splitting devices to try to find at least a few fossils.

Conditions for fossilisation:

Following are the necessary conditions for the formation of fossils:

1. Presence of hard parts- bones, teeth and hard woody material is preserved owing to its resistance to decay till anoxic conditions are created.

2. Quick burial- this is also very important because even harder parts can get destroyed if not buried quickly by the action of atmospheric gases, water and bacteria.

3. Medium of deposition and nature of sediment- Ocean basins are regarded as all-time finest places for the preservation of dead animals and plants and subsequent formation of fossils because of lots of animal carapaces and sediment load available. Shale is the best medium; fossils are also preserved in sandstones however coarse grained rocks like grits, conglomerates are not regarded as preferable because of their void spaces.

4. Climate: Climate can play a crucial role in the preservation ability of a fossil. Polar Regions are famous deposition sites for mammoth fossils. Animals trapped inside freezing water are preserved as full fossils. Interestingly fossils of blood, delicate hair (fur) and food inside mouth and stomach have been found very helpful to observe the feeding habits of animals.

5. Presence of Mineralised solutions- after burial under sediment hard parts of an animal or plant is replaced with a proper mineral (calcium, magnesium, Silica, or quarts) percolating through the underground.

Application of fossils:

Whatever with certainty we know about past is by means of fossils. Fossils are regarded as the pages of the book of History of earth. Fossils have enormous application in geological sciences and palaeontology (Science in which we study fossils i, e, studying ancient life). Few of the countless applications can be listed below.

1. Taxonomy: is the study of the conception, naming, and classification of organism groups used as a main tool in their classification.

2. Biostratigraphy: “Principle of faunal Succession” states that fossils succeed each other vertically in a specific, reliable order that can be identified over wide horizontal distances. In other words fossil assemblage accompanied by a sedimentary formation changes with the change in age, lithology, of the strata in a vertical column owing to their facies change. A facies may be defined as a body of rock that acquires unique features “lithology, fossil content, structures, and represent a distinct environment of deposition to those of the other facies.

3. Paleoecology: Using the notion “present is the key to the past” for determination of past environments of the formations occupying the fossils by comparing them with their living counterparts. Various attributes which can be calculated are “paleo-salinity, paleo-temperature, and paleo-bathymetry.
4. Paleogeography: Reconstructing past geography of the continents, oceans, and other geomorphological features of the earth by using the fossil data as a tool for comparative study. Paleogeography has enabled us to explore

and demonstrate the concept of plate motion (Plate Tectonics) by studying the formations on both sides of the oceans which seemed to fit in to a Jig Saw fit.

5. Petroleum Industry: application of fossils in the Petroleum Industry is innumerable particularly those of microfossil group “foraminifera”. Petroleum is formed from the accumulation of tinny microorganisms and other few important water animals along with fine muddy sediments on the ocean bottom over a prolonged time period. Microfossils are therefore utilised as a guide fossil for the investigation of potential petroleum basins by reconstructing biostratigraphy.

Morphology, Geological, Geographical and Stratigraphic distribution of the following:

BRACHIOPODS

(Phylum Brachiopoda)

Time span: Early Cambrian to now

Organism

The soft body is enclosed in a shell consisting of two valves. The shell is usually fixed to the sea floor by a stalk (the pedicle) that protrudes through an opening (the pedicle foramen) in one of the valves, called the pedicle valve. The other, smaller, valve is called the brachial valve.

Brachiopods are filter feeders: most of the shell cavity is filled with a long, looped band called the lophophore on which are sticky filaments with cilia that wave to create a current through the shell cavity. Small food particles are caught by the filaments and passed to a simple gut.

Skeleton

The valves are hinged or articulated for a short or long distance along one edge. Unlike mollusks, the valves have a symmetry plane that bisects both valves perpendicular to the hinge line; the two valves are fundamentally different in shape, not just mirror images.

The valves are usually robust, and they have always been of calcite, so they preserve relatively well. Some brachiopods have chitinophosphatic instead of calcareous shells. Size varies from less than a centimeter to several centimeters. Valve shape varies widely. Ribs and growth ridges are of varying prominence.

Classification

Brachiopods are subdivided into two classes, Inarticulata and Articulata. The inarticulates are those with chitinophosphatic shells. They're not very abun-dant in the fossil record and they're not very useful stratigraphically, but they're interesting because they're so well adapted and evolutionarily conservative: one genus, Lingula, has been around since the Early Cambrian!

The articulates are subdivided into six orders, whose names we won't burden you with. Figure 9B-2 (Clarkson, E.N.K., 1979, Invertebrate Palaeontology and Evolution: George Allen & Unwin, 323 p. Figure 7.13) shows a variety of different forms. These orders have various time spans, and varying degrees of importance during their time spans. Only three have not become extinct.

Importance

Brachiopods were a major component of invertebrate faunas in the past, especially in the Paleozoic; their heyday was from the beginning of the Ordovician to the end of the Permian. They are of only minor importance now. The shells are usually well preserved, and they are stratigraphically important, especially in the mid-Paleozoic.

Habitat

Brachiopods are attached bottom dwellers, on various sediment types; they are exclusively marine, usually shallow.

Distribution

Brachiopods live only in the sea. Most species avoid locations with strong currents or waves, and typical sites include rocky overhangs, crevices and caves, steep slopes of continental shelves, and in deep ocean floors. However, some articulate species attach to kelp or in exceptionally sheltered sites in intertidal zones. The smallest living brachiopod, Gwynia, is only about 1 millimetre (0.039 in) long, and lives in between gravel. Rhynchonelliforms (Articulata excluding Craniida), whose larvae consume only their yolks and settle and develop quickly, specialize in specific areas and form dense populations that can reach thousands per meter. Young adults often attach to the shells of more mature ones. On the other hand, inarticulate brachiopods, whose larva swim for up to a month before settling, have wide ranges. Members of the discinoid genus Pelagodiscus have a cosmopolitan distribution.

Comments

Brachiopods are the most common fossil you'll find in many Lower and Middle Paleozoic rocks. Warning: you can see the same brachiopod in various views, because there's an inner and an outer surface to each of the two valves, and you see each of the four surfaces in either positive or negative. Sometimes just the cemented filling (called a steinkern) of the still-articulated shell is preserved; this looks like a shell itself, but it's the negative of both the inner surfaces.

CEPHALOPODS

(Phylum Mollusca)

Time span: Late Cambrian to now

Organism

Cephalopods are mollusks that live in a single chambered shell. As with all the mollusks, the soft body has a mouth, an anus, and gills (Figure 9B-5; Shrock, R.R., and Twenhofel, W.H., 1953, Principles of Invertebrate Paleontology: McGraw-Hill, 816 p. Figure 10_55 and Clarkson, E.N.K., 1979, Invertebrate Palaeontology and Evolution: George Allen & Unwin, 323 p. Figure 8.20).

Cephalopods are the most advanced of mollusks: their brains are more highly developed and their sense organs are more specialized than in pelecypods or gastropods. They are predatory carnivores with a highly developed ability to swim.

Cephalopods have an effective means of maintaining buoyancy: the cham-bers, each containing both gas and water, are connected by a long tube, the si-phuncle, though which water can be added or removed from the chambers to adjust the bulk density of the animal. The danger of implosion restricts cephalopods to the uppermost several hundred meters of the ocean.

Skeleton

Some cephalopods are coiled (usually tightly, and almost always planispi-rally; Figures 9B-5, 9B-6; Clarkson, E.N.K., 1979, Invertebrate Palaeontology and Evolution: George Allen & Unwin, 323 p. Figure 8.18) and others are straight (Figure 9B-7; Shrock, R.R., and Twenhofel, W.H., 1953, Principles of Invertebrate Paleontology: McGrawHill, 816 p. Figure 10_58) to somewhat curved, but the common element of all the shells is that they are made up of many chambers. New chambers are added at the outer end as the animal grows, and the animal lives in the outermost chamber.

The outer surface of the shell shows closely spaced growth lines, and the inner surface of the shell (which is often seen in fossils that are internal molds) is marked by sutures where the septa between adjacent chambers meets the shell wall.

Classification

A large number of different kinds of cephalopods, divided into three sub-classes, developed during the Paleozoic. Most of these had straight or curved shells, although some were coiled. These are usually called nautiloids (one kind was the forerunner of the modern Nautilus), but it would be better to call them non-ammonoid cephalopods. All of these except the coiled forms that led to Nautilus became extinct by the end of the Paleozoic.

Cephalopods of another subclass, called ammonoids (often also called ammonites), became abundant in the Mesozoic. Ammonoids have beautiful planispirally coiled shells.

The only other geologically important group, the belemnites, with straight shells, belong to still another subclass; they evolved in the Late Paleozoic and be-came extinct in the Early Cenozoic.

Habitat

Cephalopods swim freely in the shallow waters of the open ocean, and the shell settles to the bottom after the organism dies. Since they do not live on the bottom, they can be geographically wide-ranging, and can be found in a variety of sediments, although fine sediment is the rule.

Geological Distribution:

The first gastropods were exclusively marine, with the earliest representatives of the group appearing in the Late Cambrian (Chippewaella, Strepsodiscus),

Commonly, fossil gastropods from the rocks of the early Palaeozoic era are too poorly preserved for accurate identification. Still, the Silurian genus Poleumita contains fifteen identified species. Fossil gastropods were less common during the Palaeozoic era than bivalves.

Most of the gastropods of the Palaeozoic era belong to primitive groups, a few of which still survive. By the Carboniferous period many of the shapes seen in living gastropods can be matched in the fossil record, but despite these similarities in appearance the majority of these older forms are not directly related to living forms. It was during the Mesozoic era that the ancestors of many of the living gastropods evolved.

One of the earliest known terrestrial (land-dwelling) gastropods is Maturipupa, which is found in the Coal Measures of the Carboniferous period in Europe, but relatives of the modern land snails are rare before the Cretaceous period, when the familiar Helix first appeared.

Cepaea nemoralis: another European pulmonate land snail, which has been introduced to many other countries

In rocks of the Mesozoic era, gastropods are slightly more common as fossils; their shells are often well preserved. Their fossils occur in ancient beds deposited in both freshwater and marine environments. The "Purbeck Marble" of the Jurassic period and the "Sussex Marble" of the early Cretaceous period, which both occur in southern England, are limestones containing the tightly packed remains of the pond snail Viviparus.

Rocks of the Cenozoic era yield very large numbers of gastropod fossils, many of these fossils being closely related to modern living forms. The diversity of the gastropods increased markedly at the beginning of this era, along with that of the bivalves.

Certain trail-like markings preserved in ancient sedimentary rocks are thought to have been made by gastropods crawling over the soft mud and sand. Although these trace fossils are of debatable origin, some of them do resemble the trails made by living gastropods today.

Gastropod fossils may sometimes be confused with ammonites or other shelled cephalopods. An example of this is Bellerophon from the limestones of the Carboniferous period in Europe, the shell of which is planispirally coiled and can be mistaken for the shell of a cephalopod.

Gastropods are one of the groups that record the changes in fauna caused by the advance and retreat of the Ice Sheets during the Pleistocene epoch

Importance

Cephalopods, especially nautiloids in the Paleozoic and ammonoids in the Mesozoic, are of enormous stratigraphic importance. They are among the very best index fossils, because the species tend to be short-ranging in time and longranging in space (See especially Figure 9B-7A).

Comments

Cephalopods are common enough in certain rock types to be useful, but they are not common as fossils. You're not nearly as likely to see a cephalopod as a brachiopod, a crinoid, or a pelecypod.

GASTROPODS

(Phylum Mollusca)

Time span: Early Cambrian to now

Organism

The body of a gastropod is in three parts: a head, a foot, and viscera (Figure 9B-12; Clarkson, E.N.K., 1979, Invertebrate Palaeontology and Evolution: George Allen & Unwin, 323 p. Figure 8.15). The head has a mouth, a pair of stalked eyes, and tentacles that act as sensory organs. The mouth opens into a cavity, the pharynx, containing a chitinous band, the radula, with transverse teeth. The radula acts as a rasp or file for boring and for cutting up vegetation (gastropods are herbivorous). The foot is a flat creeping organ behind the head underneath the body. Gastropods have a heart, a liver, kidneys, and a well developed nervous system. Aquatic forms have gills, and terrestrial forms have lungs. There are male and female gastropods.

Skeleton

Most gastropod shells have the form of a helicoid spiral in which the cone is coiled loosely or tightly around an imaginary axis (Figure 9B-13; Clarkson, E.N.K., 1979, Invertebrate Palaeontology and Evolution: George Allen & Unwin, 323 p. Figure 8.16). The tightness of the coiling varies considerably, as does overall shape and also external ornamentation. The shells of modern gastropods are calcitic, but judging by the poorness of preservation, those of Paleozoic gastropods were probably aragonitic.

Many gastropods have a horny or calcareous plate, the operculum, carried on the back part of the foot, to close the shell opening after the animal retreats entirely within its shell. You don't often find fossil opercula.

Classification

Gastropods are subdivided into three subclasses: Prosobranchiata, which includes most of the fossil gastropods as well as modern marine shelled gas-tropods; Opisthobranchiata, which includes marine gastropods that have lost their shells; and Pulmonata, which have developed lungs and become adapted to life on land.

Habitat

Gastropods have an amazingly wide range of adaptation, from abyssal ocean depths to high mountains. The marine shelled gastropods of interest to paleon-tologists must have mostly crawled upon mud and sand bottoms. Some modern gastropods also cling tenaciously to rocks.

The first gastropods were exclusively marine, with the earliest representatives of the group appearing in the Late Cambrian (Chippewaella, Strepsodiscus), though their only gastropod character is a coiled shell, so they could lie in the stem lineage, if they are gastropods at all Early Cambrian organisms like Helcionella and Scenella are no longer considered gastropods,[citation needed] and the tiny coiled Aldanella of earliest Cambrian time is probably not even a mollusk

As such, it's not until the Ordovician that the first crown-group members arise.[24] By the Ordovician period the gastropods were a varied group present in a range of aquatic habitats. Commonly, fossil gastropods from the rocks of the early Palaeozoic era are too poorly preserved for accurate identification. Still, the Silurian genus Poleumita contains fifteen identified species. Fossil gastropods were less common during the Palaeozoic era than bivalves.

Most of the gastropods of the Palaeozoic era belong to primitive groups, a few of which still survive. By the Carboniferous period many of the shapes seen in living gastropods can be matched in the fossil record, but despite these similarities in appearance the majority of these older forms are not directly related to living forms. It was during the Mesozoic era that the ancestors of many of the living gastropods evolved.

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In rocks of the Mesozoic era, gastropods are slightly more common as fossils; their shells are often well preserved. Their fossils occur in ancient beds deposited in both freshwater and marine environments. The "Purbeck Marble" of the Jurassic period and the "Sussex Marble" of the early Cretaceous period, which both occur in southern England, are limestones containing the tightly packed remains of the pond snail Viviparus.

Rocks of the Cenozoic era yield very large numbers of gastropod fossils, many of these fossils being closely related to modern living forms. The diversity of the gastropods increased markedly at the beginning of this era, along with that of the bivalves.

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Gastropod fossils may sometimes be confused with ammonites or other shelled cephalopods. An example of this is Bellerophon from the limestones of the Carboniferous period in Europe, the shell of which is planispirally coiled and can be mistaken for the shell of a cephalopod.

Gastropods are one of the groups that record the changes in fauna caused by the advance and retreat of the Ice Sheets during the Pleistocene epoch.

Importance

Gastropods generally evolved slowly and are long-ranging in time, so they are not of major importance for correlation. Their abundance has generally in-creased through time.

Comments

Gastropods are not abundant in many rocks, but if you hunt around you're likely to find one. Preservation of Paleozoic gastropods is usually as external impressions.

GRAPTOLITES

(Phylum Hemichordata)

Time span: Middle Cambrian to Early Mississippian

Organism and Skeleton

Graptolites were free-floating colonial marine animals. The skeleton con-sists of a series of hollow interlinked tubes constructed of a thin sheetlike material called periderm (Figure 9B-14; Clarkson, E.N.K., 1979, Invertebrate Palaeontology and Evolution: George Allen & Unwin, 323 p. Figure 10.1). The first-formed part of the graptolite is a conical tube called the sicula. Upward from the sicula grew a number of cuplike thecae. The thecae show prominent growth lines. All the thecae are connected by a common canal, so presumably food caught by the individual animals was ingested and shared by the whole colony. The colonies had various numbers of branches, or stipes. The entire colony is known as a rhabdosome. Nothing is known about the the soft-bodied animals that occupied the thecae.

Classification

Graptolites (officially, class Graptolithina) are divided into several orders, only two really important: Dendroidea (dendroids), Cambrian to Mississippian, and Graptoloidea (graptoloids), Early Ordovician to Early Devonian. The dendroids were many-branched colonies; the graptoloids had rhabdosomes with only a few stipes (eight, four, two, or just one).

Habitat

Dendroids appear to have been sessile benthonic organisms (Figure 9B-15; Clarkson, E.N.K., 1979, Invertebrate Palaeontology and Evolution: George Allen & Unwin, 323 p. Figure 10.3 and Shrock, R.R., and Twenhofel, W.H., 1953, Principles of Invertebrate Paleontology: McGraw-Hill, 816 p. Figure 15_25). They probably grew upright, with a holdfast below the sicula and with the stipes extending upward like a shrub. Graptoloids, on the other hand, seem to have been planktonic.

Graptolite, any member of an extinct group of small, aquatic colonial animals that first became apparent during the Cambrian Period (542 million to 488 million years ago) and that persisted into the Early Carboniferous Period (359 million to 318 million years ago). Graptolites were floating animals that have been most frequently preserved as carbonaceous impressions on black shales, but their fossils have been found in a relatively uncompressed state in limestones. They possessed a chitinous (fingernail-like) outer covering and lacked mineralized hard parts. When found as impressions, the specimens are flattened, and much detail is lost.

The graptolite animal was bilaterally symmetrical and tentacled. It has been suggested that graptolites are related to the hemichordates, a primitive group of invertebrates. Graptolites have proved to be very useful for the stratigraphic correlation of widely separated rock units and for the finer division of Lower Paleozoic rock units (Cambrian to Devonian); examples include the genera Climacograptus, Clonograptus, Didymograptus, Diplograptus, Monograptus, Phyllograptus, and Tetragraptus. Graptolites show a gradual development through time, and evolutionary relationships between different graptolite groups have been discovered and analyzed.

Importance

Graptolites are very important for dating Ordovician and Silurian rocks. But there are problems: graptolite species are fairly long-ranging in time, and preservation is not really good, and graptolites are found mainly in deep-water shales, not coarser shallow-marine rocks.

Comments

Graptolites are almost always preserved as carbonaceous films on bedding planes, because of compression and diagenesis after the colony came to rest on a mud bottom and was buried. So unless the shale tends to split along bedding planes, which is a lot less common than along the cleavage, you don't have much chance of finding graptolites.

TRILOBITES

(Phylum Arthropoda)

Time span: Early Cambrian to Permian

Organism

Paleontologists are hampered in their understanding of the soft-body anatomy and physiology of trilobites because trilobites are extinct. Trilobites had chitinous exoskeletons. (Chitin is a kind of nitrogenous polysaccharide that's extremely resistant to solution once it's secreted by the organism). Not much is known about the soft body, but it it's known that trilobites molted.

Skeleton

The chitinous skeleton is always in three parts (Figure 9B-19; Clarkson, E.N.K., 1979, Invertebrate Palaeontology and Evolution: George Allen & Unwin, 323 p. Figure 11.3. and Figure 9B-20; Clarkson, E.N.K., 1979, Invertebrate Palaeontology and Evolution: George Allen & Unwin, 323 p. Figure 11.13): a head or cephalon, in one piece; a thorax, which is segmented; and a tail or pygid-ium, in one piece. The cephalon usually shows a raised bulbous central area, the glabella, on which are two compound eyes, each facet a single crystal of calcite.

On the underside (the ventral side) of the thorax is a pair of appendages, usually not preserved, on each segment. The segmentation of the thorax allowed some trilobites to roll themselves up, probably for protection.

Classification

Trilobites are classified into about eight orders and sixteen suborders based on morphology of hard parts (Figure 9B-21; Shrock, R.R., and Twenhofel, W.H., 1953, Principles of Invertebrate Paleontology: McGraw-Hill, 816 p. Figure 13_36). Many characteristics need to be taken into account in classification, and it's hard to know which are the most significant.

Of the six suborders apparently already in existence when trilobites devel-oped hard parts at the beginning of the Cambrian, four became extinct at the end of the Cambrian, but ten appeared near the end of the Cambrian. (Evolutionary lineages are hard to figure out, though.) Of those, only one survived beyond the end of the Devonian.

Habitat

Trilobites must have walked, crawled, plowed, or scooted upon the sediment surface in search of food. The "doubletire-tread" track represented by the trace fossil Cruziana was certainly made by plowing trilobites, and various other scratch-mark trace fossils were probably made by walking or skimming trilobites. Trilobites are Importance

Several thousand species have been described. Trilobites are of great strati-graphic value in the Cambrian (zoned almost entirely on trilobites) and of some-what lesser value in the Ordovician. In the Ordovician, trilobites and brachiopods in shallow-water facies are played off against graptolites in deeper-water facies. In Silurian and younger rocks they are much less important than other fossil groups for correlation.

Comments

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Comments

Trilobite fossils are common enough that with some patience you can often find them in the appropriate rock types in the Lower and Middle Paleozoic. You usually find pieces of the cephalon or pygidium. It's almost always the upper (dorsal) surface, not the lower (ventral).

The taxonomic status of trilobites is unclear. It's clear that they should be called arthropods, but it's generally agreed that arthropods are actually poly-phyletic. The official view is that trilobites are a questionable subphylum of the artificial phylum Arthropoda, but maybe they should be a separate phylum. types in the Lower and Middle Paleozoic.

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Unit-2

Micropaleontology:

Micropaleontology, the study of microfossils, is a division of paleontology. Microfossils are fossils usually lesser than 1 mm and broadly speaking they are two types viz., organic walled and mineral walled. The organic walled forms are spore, pollen, acritarchs, chitinozoans whereas mineral walled are further divided into calcareous foraminifera, Ostracoda, bryozoa, nanoplankton, calcareous algae, dinoflagellates; siliceous diatoms, radiolaria, silicoflagellates; and phosphatic conodonts. The study of which must be carried out using the light or electron microscope. To achieve this course, the microfossils must be studied in terms of morphology, structure, chemical and mineralogical composition and taxonomy to discover their origin and systematic affinities. Some remains of ancient life-forms are preserved as fossils in diverse sediments and provide evidence on the changing richness and variety of species, but also on the environmental conditions during past eras. A species that only survived within short periods of the geological history, but were widely spread, act as index fossils with which, e.g., the age of sedimentary deposits can be determined (biostratigraphy). The analysis of fossils is also essential for the reconstruction of past environments, paleoenvironment; the distribution of terrestrial and water paleogeography, the exploration of the paleoceanography and the development of climate or paleoclimate. In addition, the planktonic and nektonic habits of some microfossils gives them the added additional benefit of appearing across a wide range of facies or paleoenvironments, as well as consuming nearglobal distribution, creating biostratigraphic correlation even more powerful and effective. Thus, their communication with the present-day physical, chemical and biological characteristics of the ocean water will be addressed.

FORAMINIFERA

Foraminifera (or forams, for short) belong to the Protozoa (unicellular animals). There are still Foraminifera alive today. Foraminifera (forams for short) are single-celled organisms (protists) with shells or tests (a technical term for internal shells). They are abundant as fossils for the last 540 million years. The shells are commonly divided into chambers that are added during growth, though the simplest forms are open tubes or hollow spheres. Depending on the species, the shell may be made of organic compounds, sand grains or other particles cemented together, or crystalline $CaCO_3$ (calcite or aragonite).

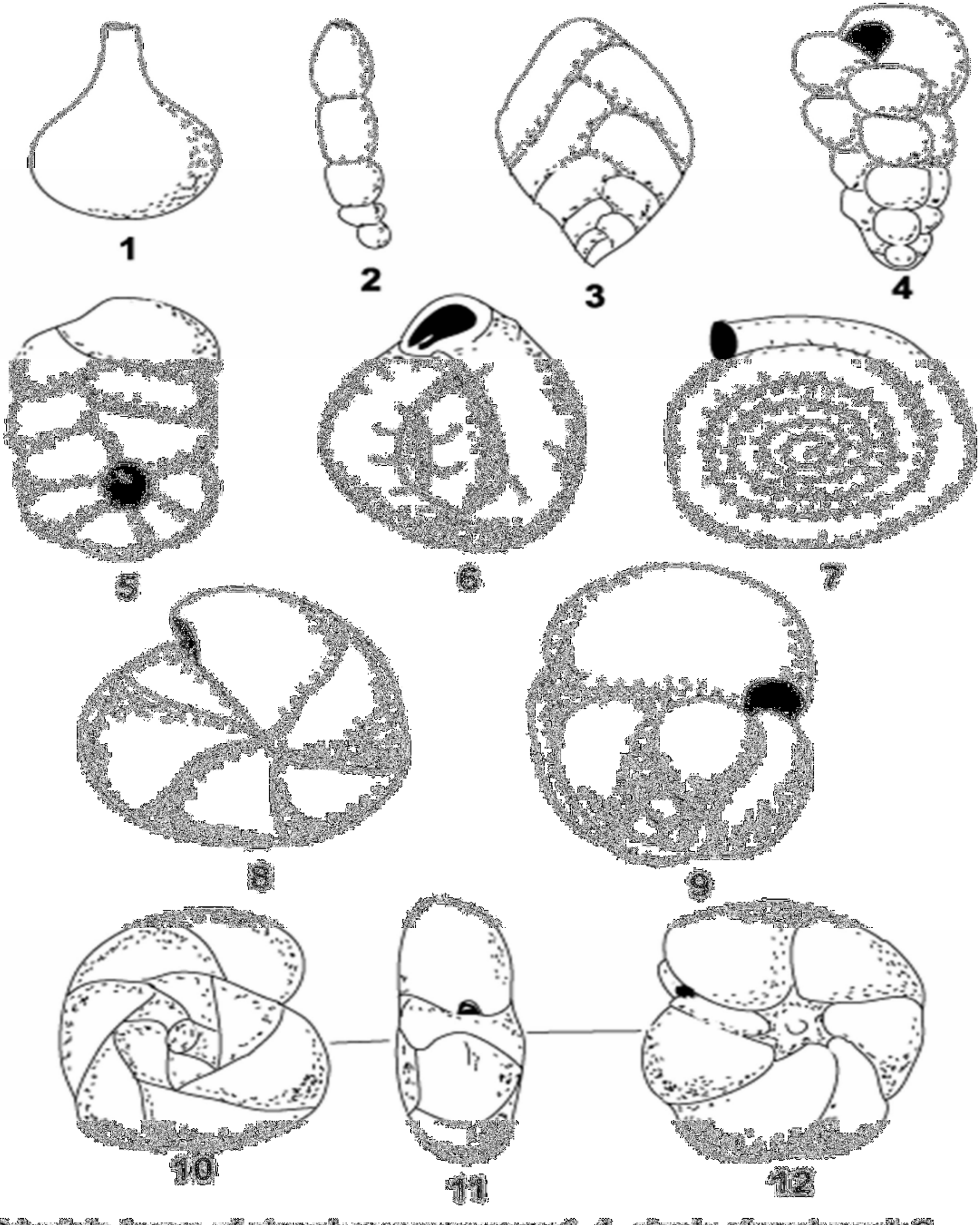
Fully grown individuals range in size from about 100 micrometers to almost 20 centimeters long. Some have a symbiotic relationship with algae, which they "farm" inside their shells. Other species eat foods ranging from dissolved organic molecules, bacteria, diatoms and other single-celled algae, to small animals such as copepods. They catch their food with a network of thin pseudopodia (called reticulopodia) that extend from one or more apertures in the shell. Benthic (bottom-dwelling) foraminifera also use their pseudopodia for locomotion. The study of fossil foraminifera has many applications beyond expanding our knowledge of the diversity of life. Fossil foraminifera are useful in biostratigraphy, paleoecology, paleobiogeography, and oil exploration.

Foraminifera provide evidence about past environments:

Because different species of foraminifera are found in different environments, paleontologists can use the fossils to determine environments in the past. Foraminifera have been used to map past distributions of the tropics, locate ancient shorelines, and track global ocean temperature changes during the ice ages. If a sample of fossil foraminifera contains many extant species, the present-day distribution of those species can be used to infer the environment at that site when the fossils were alive. If samples contain all or mostly extinct species, there are still numerous clues that can be used to infer past environments. These include species diversity, the relative numbers of planktonic and benthic species, the ratios of different shell types, and shell chemistry. Some species are geologically short-lived and some forms are only found in specific environments. Therefore, a paleontologist can examine the specimens in a small rock sample like those recovered during the drilling of oil wells and determine the geologic age and environment when the rock formed.

Geology: Foraminifera have a geological range from the earliest Cambrian to the present day. The earliest forms which appear in the fossil record (the allogromiine) have organic test walls or are simple agglutinated tubes. The term "agglutinated" refers to the tests formed from foreign particles "glued" together with a variety of cements. Foraminifera with hard tests are scarce until the Devonian, during which period the fusulinids began to flourish culminating in the complex fusulinid tests of the late Carboniferous and Permian times; the fusulinids died out at the end of the Palaeozoic. The miliolids first appeared in the early Carboniferous, followed in the Mesozoic by the appearance and radiation of the rotalinids and in the Jurassic the textularinids. The earliest forms are all benthic, planktic forms do not appear in the fossil record until the Mid Jurassic in the strata of the northern margin of Tethys and epicontinental basins of Europe. They were probably meroplanktic (planktic only during late stages of their life cycle). The high sea levels and "greenhouse" conditions of the Cretaceous saw a diversification of the planktic foraminifera, and the major extinctions at the end of the Cretaceous included many planktic foraminifera forms. A rapid evolutionary burst occurred during the Palaeocene with the appearance of the planktic globigerinids and globorotalids and also in the Eocene with the large benthic foraminifera of the nummulites, soritids and orbitoids. The orbitoids died out in the Miocene, since which time the large foraminifera have dwindled. Diversity of planktic forms has also generally declined since the end of the Cretaceous with brief increases during the warm climatic periods of the Eocene and Miocene.

Foraminifera are classified primarily on the composition and morphology of the test. Three basic wall compositions are recognised, organic (protinaceous mucopolysaccharide i.e. the allogromina), agglutinated and secreted calcium carbonate (or more rarely silica). Agglutinated forms, i.e the Textulariina, may be composed of randomly accumulated grains or grains selected on the basis of specific gravity, shape or size; some forms arrange particular grains in specific parts of the test. Secreted test foraminifera are again subdivided into three major groups, microgranular (i.e. Fusulinina), porcelaneous (i.e. Miliolina) and hyaline (i.e. Globigerinina). Microgranular walled forms (commonly found in the late Palaeozoic) are composed of equidimensional subspherical grains of crystalline calcite. Porcelaneous forms have a wall composed of thin inner and outer veneers enclosing a thick middle layer of crystal laths, they are imperforate and made from high magnesium calcite. The hyaline foraminifera add a new lamella to the entire test each time a new chamber is formed; various types of lamellar wall structure have been recognised, the wall is penetrated by fine pores and hence termed perforate. A few "oddities" are also worth mentioning, the Suborder Spirillinina has a test constructed of an optically single crystal of calcite, the Suborder Silicoloculinina as the name suggests has a test composed of silica. Another group (the Suborder Involutina) have a two chambered test composed of aragonite. The Robertinina also have a test composed of aragonite and the Suborder Carterina is believed to secrete spicules of calcite which are then weakly cemented together to form the test.



Principle types of chamber arrangement. 1, single chambered; 2, uniserial; 3.biserial; 4, triserial; 5, planispiral to biserial; 6, milioline; 7, planispiral evolute; 8, planispiral involute; 9, streptospiral; 10-11-12,

OSTRACODS

Introduction: Are by far the most complex organisms studied within the field of micropalaeontology. They are Metazoa and belong to the Phylum Arthropoda (as trilobites), Class Crustacea (as lobsters and crabs). An important distinguishing feature Ostracods share with other arthropods is the bilateral symmetry of their body form. The paired body parts are enclosed in a dorsally hinged carapace composed of low magnesium calcite, which is what is commonly preserved in the fossil record. They are found today in almost all aquatic environments including hot springs, caves, within the water table, semi-terrestrial environments, in both fresh and marine waters, within the water column as well as on (and in) the substrate. In fact almost anywhere that's wet, even if only for a brief period

Ostracod-like organisms (bivalved arthropods) are recorded from the Cambrian, but it is uncertain whether these can be classified as true ostracods. Myodocopid and podocopid forms are recorded from the Ordovician. All these early forms are marine, the first freshwater forms (Darwinulacea and Carbonita) occur in the Carboniferous and by the Jurassic ostracods are common in freshwater environments. Between the Silurian/Devonian and the present there are big gaps in the fossil record of planktonic marine forms, which is thought to reflect weak calcification of the carapace

Classification: The Class Ostracoda is separated from other Crustacea by their laterally compressed body, undifferentiated head, seven or less thoracic limbs and the bivalved, perforate carapace lacking growth lines. The living ostracods are further classified in many cases by variations in their appendages and other soft parts. Although exceptionally well preserved fossil ostracods with the soft parts intact have been found these are very rare and therefore the morphological features (see below) of the carapace have become vital in fossil ostracod classification. The Ostracoda have been divided into five Orders, the extant Podocopida and Myodocopida and the extinct Phosphatocopida, Leperditicopida and Palaeocopida (however, the latter groups may well not be ostracods in the strict biological sense). Graptolite, any member of an extinct group of small, aquatic colonial animals that first became apparent during the Cambrian Period (542 million to 488 million years ago) and that persisted into the Early Carboniferous Period (359 million to 318 million years ago). Graptolites were floating animals that have been most frequently preserved as carbonaceous impressions on black shales, but their fossils have been found in a relatively uncompressed state in limestones. They possessed a chitinous (fingernail-like) outer covering and lacked mineralized hard parts. When found as impressions, the specimens are flattened, and much detail is lost.

The graptolite animal was bilaterally symmetrical and tentacled. It has been suggested that graptolites are related to the hemichordates, a primitive group of invertebrates. Graptolites have proved to be very useful for the stratigraphic correlation of widely separated rock units and for the finer division of Lower Paleozoic rock units (Cambrian to Devonian); examples include the genera Climacograptus, Clonograptus, Didymograptus, Diplograptus, Monograptus, Phyllograptus, and Tetragraptus. Graptolites show a gradual development through time, and evolutionary relationships between different graptolite groups have been discovered and analyzed.

Evolution of modern horse

On the basis of fossils records, it is conferred that the true ancestor of modern horse was Eiohippus which where lived 52 million years back. It was the size of the fox and possessed 4 limbs digits. From eiohippus modified into miohippus and mericyppus since 27 million year back. The body size slightly increases with 3 digits in the limbs. Phiohippus came into existence with almost the size of the donkey with two functional digits in the limbs with slightly extended Muzzele since 13 million year.

The modern horse equals gained full body shape since 2 million year back which is still continuing. Due to continuous running habit limbs of the modern horse.Hence in compare to the other evidence paleontological evidence is the best due to recovery of fossils of the extinct animals.

Evidence from physiology or bio-chemistry:

The bio-chemical natures of the cells of the animal are very similar to each other. E.g. enzyme tripase which digest protein in the amino acid is also present in the earthworm, cockroach, and frog and even in man. Similarly amylase and lipase are also present, help in the digestion of carbohydrate and fat. Presence of enzyme in lower invertebrates and higher invertebrates. Lower and higher invertebrate's means probably belongs to common ancestor. The analysis of single animal cells shows similar characters in the cells of the all animals.

Blood sera or serum constitute plasma and corpuscles. RBC of the all mammals looks more or less similar showing similar origin.

About 5ml of blood of man and monkey, horse and donkey, cow and buffalo etc mixed together in the test tube shows less agglutination. If the blood of man and monkey mixed together with the blood of horse and donkey immediately agglutination takes place that is man and monkey must have close ancestor.

The haematic crystal of man and monkey looks very similar but differs with the horse and donkey or cow which also shows the similar common ancestor.

Darwinism or Darwin's theory of origin of species by Natural Selection:

Charles Darwin (1809-1882) was a nature lover and was good English writer. After completing his graduation about five years travelled in his own ship named HM Beagle around the Britain. Again from 1835-1855 travelled nearly for 20 years crossing over European seas and Indian ocean. From that voyage he has collected many animal species. In the same period another young scientist Sir Alfred Wallace was also study about the different nature of beaks of birds in Malayan peninsula. In 1858, Darwin and Wallace combinedly published book origin of species which became highest book sell in the world. In 1859, Darwin separately published the theory called theory of origin of species by natural selection. Similarly in 1871, published the book called Descent of Man which also became second highest book sell in the world.

Monumental regarding the theory:

1.Animals are highly fertile yet their totalnumber almost remains constant.

2.Struggle for existence.

3.Variation and heredity.

4.Natural selection

5. Origin of species.

1. Animals are highly fertile, yet their total number remains constant:

All the animals have high reproductive rate in their life cycle. For eg; one pair of housefly lay eggs about 6-7 batches of eggs, each batch of egg content 130-150 number of eggs , such egg hatches in 10^{th} day and after 14^{th} day again start reproduction.Therefore till first parent lived number of housefly approximately would be 191 X 10^{i8} numbers.

If all the generation of the housefly continue their life cycle then in the near future world will be ruled by only housefly which is not happened yet. Although the reproductive rate is very high but in the nature population almost remain to be constant due to various factors.

2. Struggle for existence:
Increase in the numbers of the animals population automatically increases competition in between inters specific and intra specific animals. Due to such competitions develop food chain in which eating and being eaten process continue. As a result after long time only those animals continue their life cycles that can fight for struggle for existence mainly for food and space.

3. Variation and Heredity:

Animals who could fight for struggle for existence only continue their life cycles. Among those animals having best variation will only continue life cycle as heredity, rest of all automatically dies.

4. Natural Selection or Survival of the fittest (Spencer):

Animals that can fight for struggle for existence possess best variation and heredity characters are said to be best of the best animal commonly called survival of the fittest. Such animals Darwin termed as naturally selected animals. After the selection by the nature ready for evolution of next animal.

5. Origin of new species:

From the naturally selected animals after long period of time changes in their morphological and anatomical characters due to various adaptations. As a result from those animals originate new species which is called origin of species.

Significances:

1. Darwin is the second pioneer to give the theory about origin of species by natural selection.

2. Every monumental are directly or indirectly related with the effect of environment.

3. First theory to explain about origin of new species in most simple manner which anyone can understood.

Criticisms:

1. Darwin did not mention about vestigial organs which are found in the animals.

2. No mentioning about mutation because without mutation origin of new species never takes place i.e. by natural selection new species never evolved.

3. Variation whether somatic or genetic because only genetic variation are heredity. 4. If applies to human beings becomes totally failure because of;

a) Human population never becomes constant.

b) Not only struggle for existence other also continue life cycle like beggars.

c)Instead of survival of the fittest in man only arrival becomes most fitted.

Neo-Darwinism:

After the dead of Darwin, his followers represented Neo- Darwinism which based upon the genetic character. This theory was developed when gene was discovered in 1901 by American Scientist Margon, Shutton, etc. The origin of species by natural selection become failure because for the evolution of new species should change in the character of the genes.

Mutation is the key character in the origin of species which takes place by;

a) Change in the characters of chromosomes.

b) Change in the number of chromosome.

c) Change in the characters of genes present in the chromosomes.

Neo-Darwinism forwarded many important ideal to explain his theory.

1. Germplasm Theory: in 1886, August Weismann explains about this theory. He explains that the body of an organism is composed of two types of protoplasm, i.e. Somatoplasm and germplasm.

2. Mutation theory: The concept of mutation is given by scientist Hugo De Vries. While he was studying in evening prime rose. The changes in the character of leaves, flowers, coloration of flower etc. are depending upon the character of chromosomes.

Hence for the evolution of any animals, mutation is most or mutation is a raw material for the origin of new species.

3. Isolation: Separation of organisms of a species into several groups or populations under geographical factors is supposed to be one of the most significant factors responsible for evolution.

4. Natural Selection: Animals that can fight for struggle for existence possess best variation and heredity characters are said to be best of the best animal commonly called natural selection. Further, natural selection creates new adaptive relations between population and environment, by favoring some gene combinations, rejecting others.

5. Genetic Drift: The variation in the gene frequency within population, simply because of chance rather than by natural selection is called genetic drift.

6. Gene pool: A gene pool may be defined as the total variety of genes and alleles present in sexually reproducing population. The gene pool may be changed by, mutation, hybridization and natural selection.

7. Genetic Recombinant: The rearrangement of genes that occurs at the time of gametes formation is known as recombination. The recombination is the major source of genetic variations in the population which play a significant role in evolution.

Semester 6

Human Evolution:

Phylum: Chordata

Sub phylum: Vertebrata

Group: Gnathostomata

Super class: Tetrapoda

Class: Mammalia

Sub class: Eutheria

Order: Primate

Sub Order: Anthropridea

Infra Order: Catarrhini

Super Family: Hominidae

Human beings have achieved tremendous development in electronic fields, communication fields and space fields. But unfortunately still now nobody knows the real ancestor.

Scientists TH Huxley was the first who wrote book about the evolution of man in 1863. Similarly Charles Darwin in 1871 published the book called Descent of Man. Similarly their came many scientist who discovered human fossils and wrote books in different ways. It is believed that ape like animals were evolved during Miocene period and man like creature developed in the Pliocene period of Cenozoic era.

On the basis of the taxonomic characters there is no doubt that man evolved from monkey like creature, the common group is Anthropoidea. It is conformed that man and chimpanzes, gorilla, orangutan were evolved from the common super family Hominoidea. Similary on the basis of genetic characters the banding patterns in the gene of man and gorilla looks similar.

To study human evolution in brief can be present as follows;

1. prior to the ape man.
2. Prior to the ape man including pre-historic man.
3. Prior to the prehistoric man including modern man or man of today.

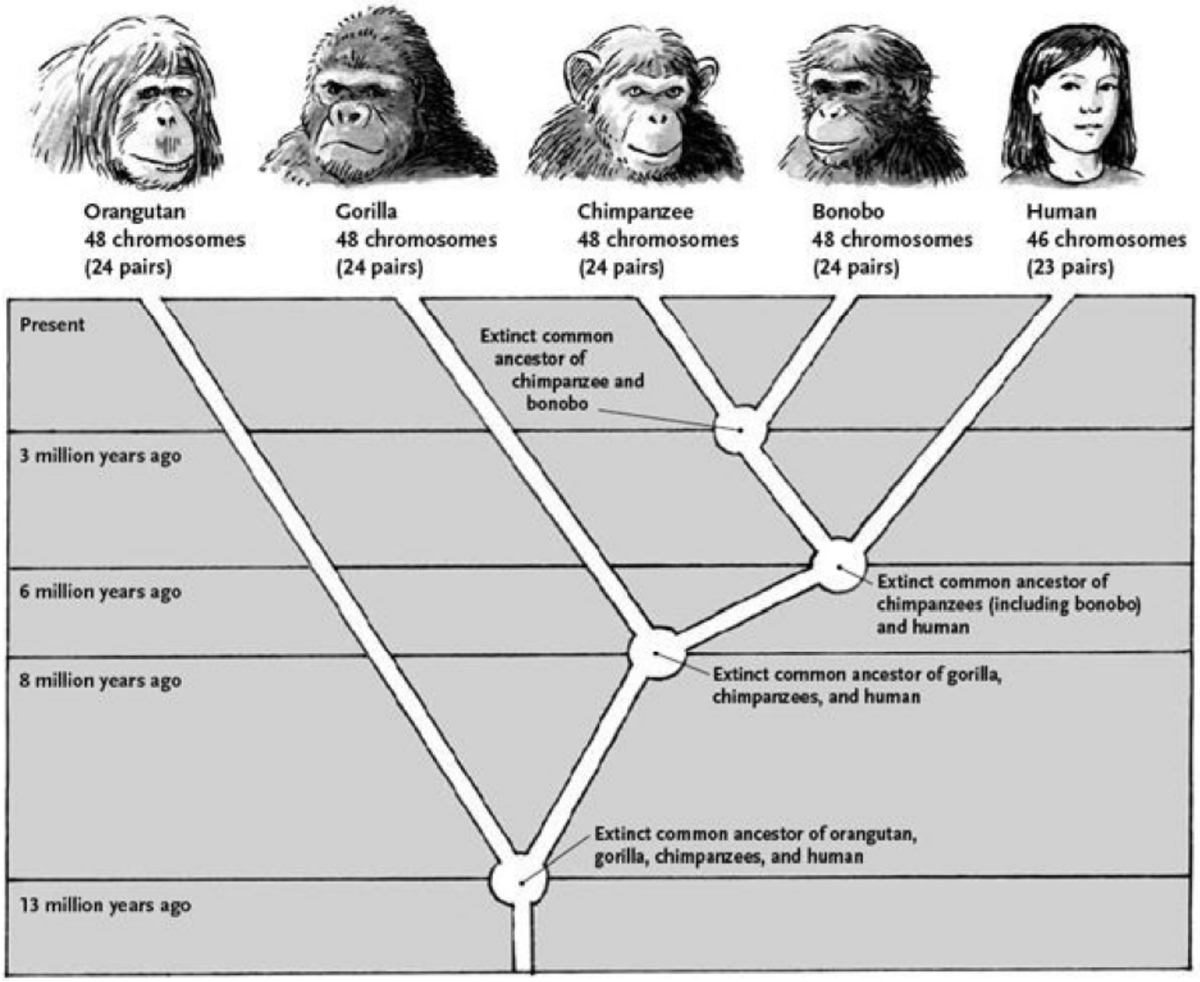


Fig: Human evolution chain

1. Prior to the ape man:

Ape man was developed from the Miocene period with having more or less similar characters of the modern man.

Anthropologists Lewis 1930, leaky 1955 have discovered fossil of ape man from the different regions of the world. On the basis of the fossil character some of the ape man is as follows:

- Dryopethicus
- Oreopethicus
- Aegyptopethicus
- Ramapethicus
- Shivapethicus, etc.

The fossil analyzed following characters;

Almost walked by bipedal locomotion, nose almost flat, forehead flat, arrangement of teeth in the jaws are similar, possess arched palate, cranial capacity varies between 400- 600cc etc.

2. Prior to the ape man including pre-historic man:

After the ape men evolved man like pre historic man nearly from Pliocene period. There are many fossils of the pre historic men. Some the fossils are as follows;

1. Zinjan thropus: leaky in 1959 discovered fossils from Tanzania which analyzed about 5 fit tall, walked almost erect, more intelligent than the ape man, developed communicating ways as well as hunting tools.

2. Anotralpethius African: Antrophologist Prosf Dart in 1924 discovered fossils of child from Australia and later from Africa. The fossils analyzed about 4 fit tall, slight raised of nose bone, development of forehead, etc. Similarly from the different parts recorded the fossils of the following pre-historic men; a) Pithecanthropus – Java man

Java man, extinct hominin known from fossilremains found on the island of Java, Indonesia. It is discovered by the Dutch anatomist in the early 1890s were the first known fossils of the species Homo erectus.

Java man was characterized by a cranial capacity averaging 900 cubic cm (smaller than those of later specimens of H. erectus), a skull flat in profile with little forehead, a crest along the top of the head for attachment of powerful jaw muscles, very thick skull bones, heavy browridges, and a massive jaw with no chin. The teeth are essentially human though with some apelike features, such as large, partly overlapping canines. Thighbones show that Java man walked fully erect, like modern man, and attained a height of about 170 cm (5 feet 8 inches). b) Sinanthropus – Peking man

Peking man, extinct hominin of the species Homo erectus, known from fossils found at Zhoukoudian near Beijing. Peking man was identified as a member of the human lineage by Davidson Black in 1927 on the basis of a single tooth.
Peking man is characterized by a cranial capacity averaging about 1,000 cubic cm, though some individual skull capacities approached 1,300 cubic cm—nearly the size of modern man's. Peking man had a skull that was flat in profile, with a small forehead, a keel along the top of the head for attachment of powerful jaw muscles, very thick skull bones, heavy browridges, an occipital torus, a large palate, and a large, chinless jaw. The teeth are essentially modern, though the canines and molars are quite large, and the enamel of the molars is often wrinkled. The limb bones are indistinguishable from those of modern humans.

c) Atlanthropus – Atlantic man

d) Homohobilis – Toolmaker man

e) Eounthropus dowsoni- dowsoni man

f) Homo neanderthalenis –Neandenthal man

Neanderthals are our closest extinct human relative. Some defining features of their skulls include the large middle part of the face, angled cheek bones, and a huge nose for humidifying and warming cold, dry air. Their bodies were shorter and stockier than ours, another adaptation to living in cold environments. But their brains were just as large as ours and often larger - proportional to their brawnier bodies.

Neanderthals made and used a diverse set of sophisticated tools, controlled fire, lived in shelters, made and wore clothing, were skilled hunters of large animals and also ate plant foods, and occasionally made symbolic or ornamental objects. There is evidence that Neanderthals deliberately buried their dead and occasionally even marked their graves with offerings, such as flowers. No other primates, and no earlier human species, had ever practiced this sophisticated and symbolic behavior.

g) Homo soloensis- solaman

h) Homo rhodesiensis – Rhodesian man.

The common character of the latest Pre historic man is as follows;

1. They walked in almost erect posture.
2. Development of nasal bone, forehead increases the cranial capacity of bone, bipedal locomotion, more intelligent, discovered different metal hunting tools, discovery of fires, know how to cook, lived in families, development of communicating ways, used animal skin as cloth , etc.
3. Prior to the prehistoric man including modern man or man of today:

The latest prehistoric man is consider as Cro-Magnon man which were lived since 1.5 lakhs years back of become extinct since 15,000 years back. The fossils of this man were recovered by Anthropologist Mac. Gregot in 1868 in sedimentary rocks called Cro–Magnon rocks, first in Germany, Then in France, Czeehkaslovakia. The fossils analyzed the following characters:

1. Height ranges between 5 to 6 fit tall.
2. More intelligent than the prehistoric men.
3. Nose further raise, cheek distinct, fore head distinct.
4. Cranal capacity between 1590-1600 cc.
5. Complete bipedal locomotion, body almost erect.
6. Used animal skin as cloth, lived in colonies or in families.
7. Development of highly sophisticated metal hunting tools.
8. Know how to cook i.e. use of fire.
9. Development of communication or language etc. Before the extinction of Cro-Magnon man, they migrated in three different regions.After the extinction of Cro-Magnon man came into existence man of today or modern man Homosapienswith more developed character such as; site of intelligence increased although cranial capacity slightly reduced to 1500-1550cc, developed various communicating ways or languages, enter into the age of aluminum age, discovered many technologies in the various fields, completely erect body, etc.

In these manner modern man is also on the ways of changing thus probably in the future will changed into Homosapiensfutureless with further developed characters.

Semester 6

Difference between man and Apes

There are a number of distinctive features of human species which make it different from his close relatives, the anthropoid apes (for example, gibbons, orangutan, gorilla and chimpanzee).

1. The human species walks erect on two feet (bipedal). He is terrestrial, gregarious (lives in community) and omnivorous. On the other hand, the apes are semi-erect, for-handed, tree-dwellers and less gregarious. Legs in man are 30% longer than the arms.

2. Hands of man are not specially modified as we find in bats and whales. Thumbs are better developed. Arms of ape reach below the knees. Apes walk with a bent posture and balance themselves on the knuckles of their hands. The hind limbs of the apes enable them to grasp an object. But the feet of man act as a platform and are suitable for palntigrade (walking on the soles of feet) type of locomotion.

3. The thumb of ape is short. In man the thumb is longer and it is more mobile to close in on other fingers. As a result, the hand can be used for a variety of purposes.

4. Bipedal locomotion in man leaves the arms and hand free for carrying or doing things, the movable joints of arms, wrists, hands and fingers afford a great deal of versatility and the forelimbs can be used with great dexterity for handling tools.

5. Teeth of an (incisor, canine, premolar and molar) are smaller and more ordered. The jaws and nose are smaller than those of gorilla. The capacity of the human brain box is 100cc; in gorilla it is 510cc.

6. The space between the two eyes is close enough for distance perception and stereoscopic vision.

7. The retina in the eye of man is provided with cone cells which perceive different colors.

8. In man the brow ridge is not as prominent as in gorilla.

Elephant Evolution

The genus name, Loxodonta, for the African elephant means lozenge-shaped teeth for the chewing surfaces.

Mammalia (Class)

About 180 million years ago, mammals arose from a reptile-like lineage about the same time as true dinosaurs. About 80 Million years ago, the genetic linage of elephants split from primates. The tree shrew is considered our nearest common ancestor.

It is believed that 50-60 million years ago, Moeritheriums, approximately the size of current day pigs, were the roots from which the proboscideans evolved. Based on both morphological and biochemical evidence, it is generally agreed that the manatees, dugongs, and hyraxes are the closest living relatives of today's elephants. This is incredible given the vast difference in sizes, external appearance and the fact that these animals occupy completely different habitats.

Proboscidae (Order)

The order under which Elephants are classified is the Proboscidea. This means animals with trunks/proboscis.

Over the course of evolutionary history, it has been estimated that there have been about 352 species of Probscideans. The creatures of this order have inhabited every continent except Australia and Antarctica. All but two (the African and Asian elephants) have died out.

It has been hypothesised that Proboscideans were able to exist in so many environments because they were capable of specialising to particular habitats. This enabled them to disperse across the continents. However, this very advantage became a disadvantage in the face of radical changes in their habitats. Because of their specialisation, they were unable to adapt to change in order to survive. Their large size proved to be a hinderance to their adaptive abilities.

The trend in the evolution of Proboscidea has generally been longer limb bones and larger skulls and teeth. As Proboscideans have grown taller, their trunks have grown longer.

Because their heads are far from the ground, nature has compensated for this height by developing the trunk as a necessary tool. For such large animals, the trunk has provided a fast and convenient way of reaching food and water on the ground. This has meant that they do not have to bend down to drink or feed, which would put them in a vulnerable position. A long trunk has enabled Proboscideans to investigate the ground for food and water while still watching and listening for approaching danger. As a result, nature has selected in favour of longer trunks. This is one of the elephant's most interesting and unique physical features.

Elephantidae (Family)

The family Elephantidae developed from the order Proboscidea. The Asian elephant, both species of African elephant and the Mammoth sit within this family. Previous to these species however were other closely related ancestors:

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Trilophodon

This species lived about 26 million years ago, characterised by having four tusks. Two tusks curved upward out of the upper jaw and two tusks curved downward out of the lower jaw.

Deinotherium

This creature had two downward curving tusks that were probably used in a shovel-like manner to scoop vegetation out of the watery swamps where it lived. It existed approximately 25 million years ago. They had no tusks in their upper jaw, making them somewhat unusual.

Platybelodon

This creature also had two lower flattened tusks, again probably used for digging and scooping vegetation.

Mastadons

More correctly classified as part of the family Mammutidae, the remains of the first Mammutidae (descended from the paleomastodon) were found in the 25 million-year-old Oligocene strata in Africa and Eurasia. These animals were about the size of today's elephants, but more solidly built with a hairy body.

Elephas Maximus / Asian Elephant (Genus)

At about the same time that the mammoth was coming into existence, so was the Asian elephant, Elephas. It also originated in Africa and it is believed to have a stronger evolutionary tie to mammoths than it has with African elephants.

Asian elephants spread throughout Eurasia and they now exist in India, Sri Lanka, China, Bangladesh and Southeast Asia. Elephas maximus indicus is the Indian subspecies. Elephas maximus sumatranus is the subspecies of Sumatra. On the island of Sri Lanka, there is also a subspecies called Elephas maximus maximus. The isolation that the island has provided has allowed a divergent evolution to occur. Most of the bulls there are tuskless, though they are not a separate species. This may be the result of a selection process in which, over a period of centuries, bulls with particularly large tusks were shot by ivory hunters and had fewer offspring as a result. This is a sad, but interesting example of the role that humans can play in the evolution of other species.

Loxodonta / African Elephant

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The African elephant, Loxodonta, appeared about 1.5 million years ago. It is the “newest” elephant species in evolutionary terms and differs from the Asian elephant in its larger size and the fact that both males and females have tusks.

The largest of all elephants is the the savanna or bush elephant, Loxodonta africana. There is also a much smaller forest elephant called Loxodonta cyclotis, which inhabits the equatorial rain forests of West and Central Africa. They tend to have small, rounded ears and darker skin. Interbreeding occurs between the savanna and forest elephants in areas where the two habitats meet.

At one time, African elephants inhabited the whole of the African continent. Now they are found only south of the Sahara, due to shrinking habitat and the effects of man’s presence (namely the ivory trade). Another interesting evolutionary feature of elephants, particularly relevant to African elephants, is their infrasonic hearing and moaning. This ability to hear sound waves below our own hearing level is a crucial means of communication for elephants out on the wide-open plains. It allows them to “talk” to each other without alerting predators to their position (the predators can’t hear their communication).

PALEOBOTONY

The Indian Gondwana Flora:

The most important fossil flora of India is what is known as the Gondwana Flora which covers the period Upper Carboniferous to Jurassic. Indian plant fossils are known before (a few) and after (quite a large number) this period but no flora is as interesting as the Gondwana Flora. Towards the end of the Palaeozoic were the great Hercynian mountain building waves.

This was followed in the Upper Carboniferous and the Permian by severe glaciation and the Permian in India is the greatest coal- forming age. The geography of the Earth at that time was quite different from what it is today

There were three continents—the Eur-American Continent (modern Europe and North America) to the North-West, Angaraland (Siberia and North China) to the North-East and a vast Gondwana land on the South which combined the land masses of India, Africa, Australia, South America and Antarctica. In between the continents was the great Sea of Tethys.

The Gondwana land has been named after the Gond tribe of Madhya Pradesh ruled by the famous Rani Durgabati during the reign of Akbar. The name was coined by H. B. Medlicott in 1872 but actually published by O. Feistmantel in 1876. The Gondwana land began to split in the Jurassic as shown by the intensive lava injections at that age.

There was drifting apart of the continents in the Cretaceous, gradually bringing them to their present positions. Another series of great mountain building waves built the present dominant Mountains (Himalayas, Alps, etc.) on the location of the Sea if Tethys.

The whole Gondwana land (now distributed over five continents) shows a uniformity of the Flora (and also the Fauna).

In Indian Geology the Gondwana rocks are considered to form a Group which is almost equivalent to an Era like Palaeozoic. Feistmantel (1882) divided the Gondwana into Lowor Gondwana (Permo-Carboni- ferous with Glossopteris Flora), Middle Gondwana (Triassic with Glossopteris-Thiimfeldia (Dicroidium Flora) and Upper Gondwana (Jurassic with Ptilophyllum Flora). This three-fold division has been followed by many authorities like Wadia and Lele. But many other authorities prefer a two-fold division into Lower Gondwana (Upper Carboniferous to Lower Triassic) and Upper Gondwana (Lower Triassic to Jurassic, probably reaching Cretaceous).

The two-fold division is supported by the two (Glossopteris Flora and Thinnfeldia (Dicroidium)—Ptilophyllum Flora) distinct floras (and faunas) in the two divisions.
There is a sudden break between the two floras as during the Upper Permian and Triassic intensive glaciation and drought killed most of the previous early Gymnosperms and arborescent Pteridophytes giving place to the more modern Gymnosperms and herbaceous Pteridophytes (mainly ferns).

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The two-fold division is supported by the two (Glossopteris Flora and Thinnfeldia (Dicroidium)—Ptilophyllum Flora) distinct floras (and faunas) in the two divisions.

There is a sudden break between the two floras as during the Upper Permian and Triassic intensive glaciation and drought killed most of the previous early Gymnosperms and arborescent Pteridophytes giving place to the more modern Gymnosperms and herbaceous Pteridophytes (mainly ferns).

Indian Gondwana beds are named as shown in Table II. The two-fold system (i.e., only Upper and Lower Gondwana) has been followed in this book but the Middle Gondwana beds and fossils have also been pointed out.

As seen from the Table, places in Indian showing Gondwana rocks occur mainly in the Damodar, Sone, Narbada, Godavari and Mahanadi Valleys. There are also some exposure along the Himalayan foothills of Nepal, Bhutan and Arunachal and also in the Punjab, Himachal, Kashmir and Baluchistan.

Upper Gondwana rocks are more detached occurring in patches along Rajmahal-Cuttack to Kanya Kumari, in Madhya Pradesh, Rewa, Saurashtra, Kutch and in Ceylon. The Map in Figure 514 shows the principal outcrops of Gondwana rocks. It should be noted against that the Triassic beds (Maleri, Mahadeva, Pachmarhi, Parsora, Panchet) spreading from Sone to Godavari Valleys are placed by some in Middle Gondwana.

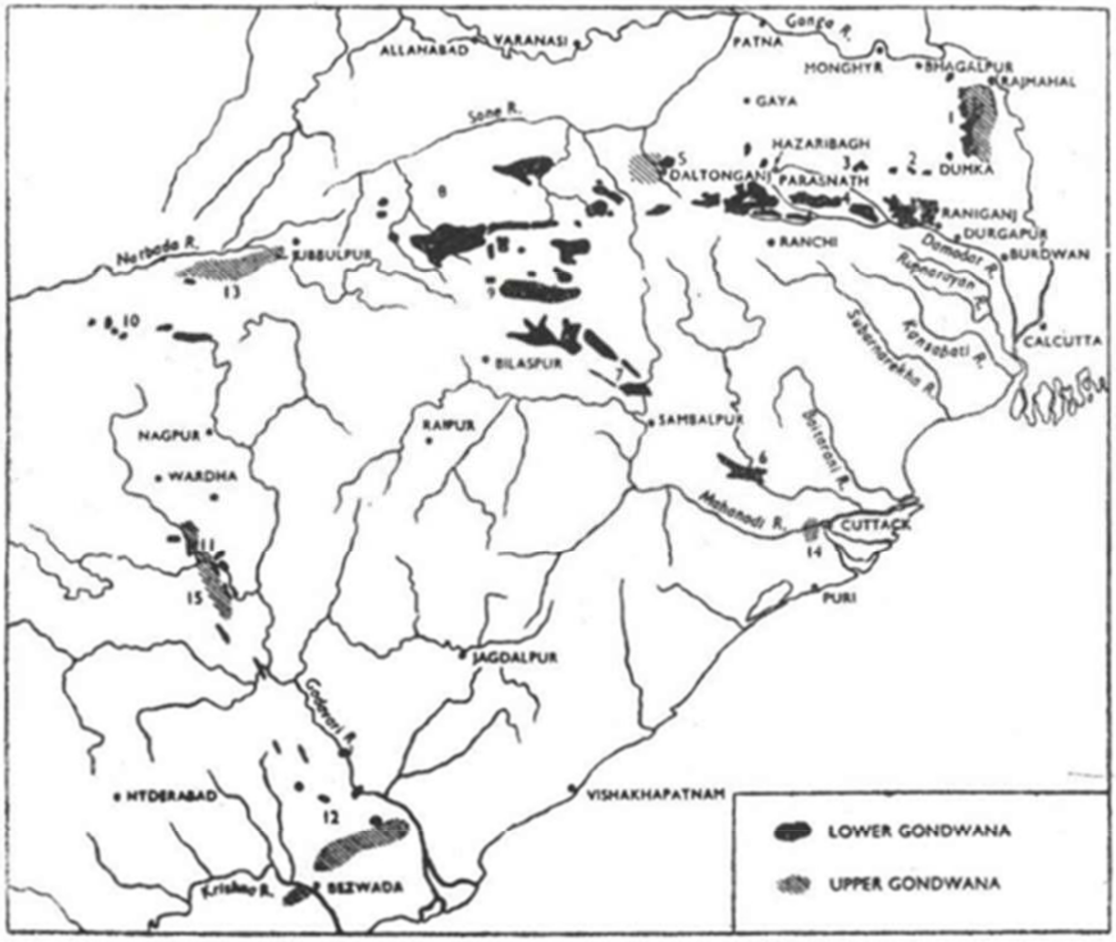


Fig. 514. Map showing the major Gondwana beds in India. Coal is also located in these places. 1. Rajmahal, 2. Deoghar, 3. Giridih, 4. Hazaribagh-Raniganj (Damodar Valley), 5. Palamau, 6. Talchir, 7. Mahanadi Valley, 8. Sone Valley, 9 Chhatisgarh (Madhya Pradesh), 10. Satpura, 11. Wardha Valley, 12. Godavari Valley, 13. Pachmarhi-Mahadeva-Jubbulpur, 14. Atgarh (Orissa), 15. Maleri-Chikiala.

Unit-3rd

REMOTE SENSING:

Introduction

Remote sensing is the science of acquiring, processing, and interpreting images obtained from satellites and aircraft. These images record the interaction between electromagnetic energy and matter. Geophysical methods, such as seismic, electrical, magnetic, and gravity surveys, are not considered remote sensing because these methods measure force fields rather than electromagnetic radiation.

Aerial photography is the original form of remote sensing and remains the most widely used method. Aerial photography analyses have played major roles in the discovery of many oil and mineral deposits around the world. These successes, using the visible region of the electromagnetic spectrum, suggested that it might be possible to obtain comparable results by using other regions of the spectrum. In the 1960s, technologic developments made it possible to acquire images using a variety of wavelengths, including reflected infrared (IR), thermal IR, and microwave. Also in the 1960s, the development and deployment of manned and unmanned satellites began and provided an orbital vantage point for acquiring images of Earth.

Electromagnetic Spectrum

The electromagnetic spectrum is the ordering of EM radiation according to wavelength, or in other words, frequency or energy. The EM spectrum is most commonly presented between eosmic rays and radiowaves, the intervening parts being gamma rays, X-rays, ultra-violet, visible, near-infrared, thermal-infrared, farinfrared and microwave (Fig. 2.3). The EM speetrum from 0.02-llm to -m wavelength can be divided into two main parts, the optical range and the mierowave range. The optieal range refers to that part of the EM speetrum in whieh optical phenomena of reflection and refraetion can be used to focus the radiation. lt extends from X-rays (0.02-llm wavelength) through visible and includes far-infrared (1 mm wavelength). The mierowave range is from I-mm to I-rn wavelength.

For remote sensing purposes, as treated later, the most important speetral regions are 0.4-14 f.lm (lying in the optical range) and 2 mm-0.8 m (lying in the microwave range). There is a lack of unanimity amount scientists with regard to the nomenclature of some of the parts of the EM speetrum. For example, the wavelength at 1.5 f.lm is considered as near-IR (Fraser and Curran 1976; Hunt 1980), middle-IR (Silva 1978), and short-wave-IR (Goetz et al. 1983). The nomenclature followed throughout the present work is shown in Fig below

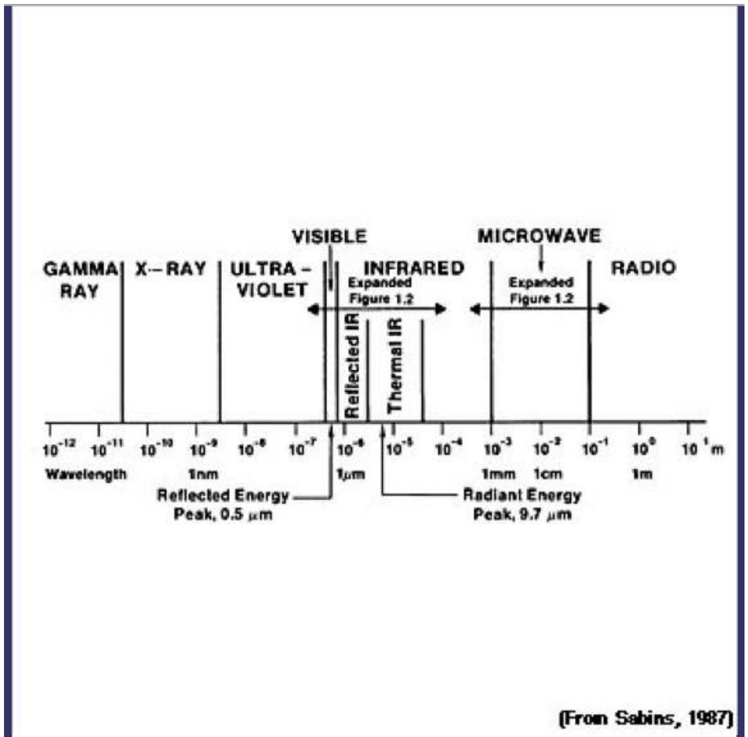


Figure 1

The expanded regions shown in Figure 1. depict the spectral regions used in remote sensing.). All matter radiates a range of electromagnetic energy, with the peak intensity shifting toward progressively shorter wavelengths as the temperature of the matter increases.

We divide the electromagnetic spectrum on the basis of wavelength into regions Table 1.The electromagnetic spectrum ranges from the very short wavelengths of the gamma ray region (measured in fractions of nanometers) to the long wavelengths of the radio region (measured in meters). Notice that the visible region, from 0.4 to 0.7 mm, occupies only a small portion of the spectrum. (The horizontal scale in Figure 1 is logarithmic in order to portray the shorter wavelengths). We can record energy reflected from the earth during daytime as a function of wavelength. The maximum amount of energy is reflected at 0.5 mm wavelength, which corresponds to the green band of the visible region, and is called the reflected energy peak. The earth also radiates energy both day and night, with the maximum energy radiating at a wavelength of 9.7 □m. This radiant energy peak occurs in the thermal band of the IR region.

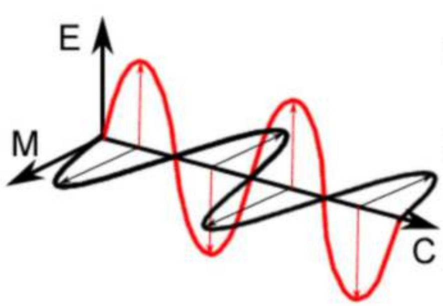
Region	Wavelength	Remarks

Gamma ray	< 0.03 nm	Incoming radiation is completely absorbed by the upper atmosphere and is not available for remote sensing.
X-ray	0.03 to 3.0 μm	Completely absorbed by atmosphere. Not employed in remote sensing.
Ultraviolet	0.03 to 0.4 μm	Incoming wavelengths less than 0.3 mm are completely absorbed by ozone in the upper atmosphere.
Photographic UV band	0.3 to 0.4 μm	Transmitted through atmosphere. Detectable with film and photodetectors, but atmospheric scattering is severe.
Visible	0.4 to 0.7 μm	Imaged with film and photodetectors. Includes reflected energy peak of Earth at 0.5 μm.
Infrared	0.7 to 100 μm	Interaction with matter varies with wavelength. Atmospheric transmission windows are separated by absorption bands.
Reflected IR band	0.7 to 3.0 μm	Primarily reflected solar radiation, but very hot targets emit some energy at these wave-lengths. The band from 0.7 to 0.9 μm is detectable with film and is called the photographic IR band.
Thermal IR band	3 to 5 μm	Principal atmospheric windows in the thermal region. Images at these wavelengths are 8 to 14 μm acquired by opticalmechanical scanners and special vidcon systems.
Microwave	0.1 to 30 μm	Longer wavelengths can penetrate clouds, fog, and rain. Images may be acquired in the active or passive mode

Radar	0.1 to 30 µm	Active form of microwave remote sensing. Radar images are acquired at various wavelength bands.
Radio	> 30 µm	Longest wavelength portion of electromagnetic spectrum. Some classified radars with very long wavelength operate in this region.

Electromagnetic energy refers to all energy that moves with the velocity of light in a harmonic wave pattern. The word harmonic implies that the component waves are equally and repetitively spaced in time. The wave concept explains the propagation of Electromagnetic energy, but this energy is detectable only in terms of its interaction with matter. In this interaction, Electromagnetic energy behaves as though it consists of many individual bodies called photons that have such particle-like properties as energy and momentum. Electromagnetic waves can be described in terms of their: • Velocity: The speed of light, c=3*108 m*sec-1). • Wavelength: l, the distance from any position in a cycle to the same position in the next cycle, measured in the standard metric system. Two units are usually used: the micrometer (mm, 106m) and the nanometer (nm, 10-9m).

• Frequency: n, the number of wave crests passing a given point in specific unit of time, with one hertz being the unit for a frequency of one cycle per second. Wavelength and frequency are related by the following formula: c = l* n ElectroMagnetic radiation consists of an electrical field (E) which varies in magnitude in a direction perpendicular to the direction in which the radiation is traveling, and a magnetic field (M) oriented at right angles to the electrical field. Both these fields travel at the speed of light (c).



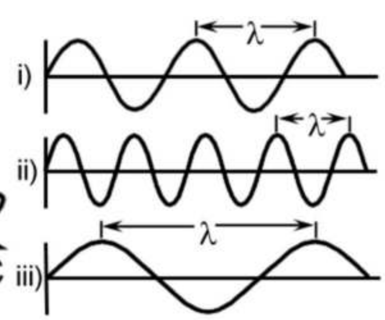


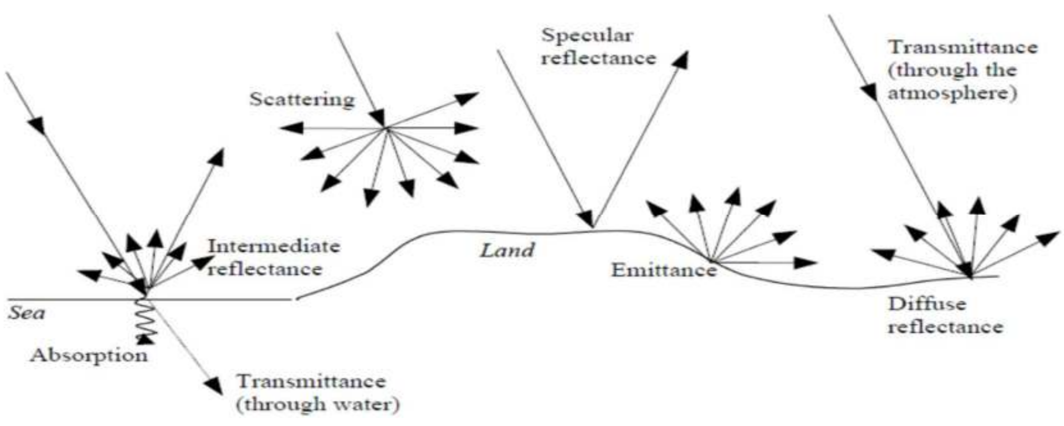
Figure: Electro-Magnetic radiation

Figure: wavelength and frequency

Semester 6

Interaction mechanisms A number of interactions are possible when Electromagnetic energy encounters matter, whether solid, liquid or gas. The interactions that take place at the surface of a substance are called surface phenomena. Penetration of Electromagnetic radiation beneath the surface of a substance results in interactions called volume phenomena. The surface and volume interactions with matter can produce a number of changes in the incident Electromagnetic radiation; primarily changes of magnitude, direction, wavelength, polarization and phase. The science of Remote Sensing detects and records these changes. The resulting images and data are interpreted to identify remotely the characteristics of the matter that produced the changes in the recorded Electromagnetic radiation. The following interactions may occur:

• Radiation may be transmitted, that is, passed through the substance. The velocity of Electromagnetic radiation changes as it is transmitted from air, or a vacuum, into other substances. • Radiation may be absorbed by a substance and give up its energy largely to heating the substance. • Radiation may be emitted by a substance as a function of its structure and temperature. All matter at temperatures above absolute zero, 0°K, emits energy. • Radiation may be scattered, that is, deflected in all directions and lost ultimately to absorption or further scattering (as light is scattered in the atmosphere). • Radiation may be reflected. If it is returned unchanged from the surface of a substance with the angle equal and opposite to the angle of incidence, it is termed specular reflectance (as in a mirror). If radiation is reflected equally in all directions, it is termed diffuse. Real materials lie somewhere in between.



The interactions with any particular form of matter are selective with regard to the Electromagnetic radiation and are specific for that form of matter, depending primarily upon its surface properties and its atomic and molecular structure.

Laws regarding the amount of energy radiated from an object

Planck Radiation Law

The primary law governing blackbody radiation is the Planck Radiation Law, which governs the intensity of radiation emitted by unit surface area into a fixed direction

(solid angle) from the blackbody as a function of wavelength for a fixed temperature.

The Planck Law can be expressed through the following equation

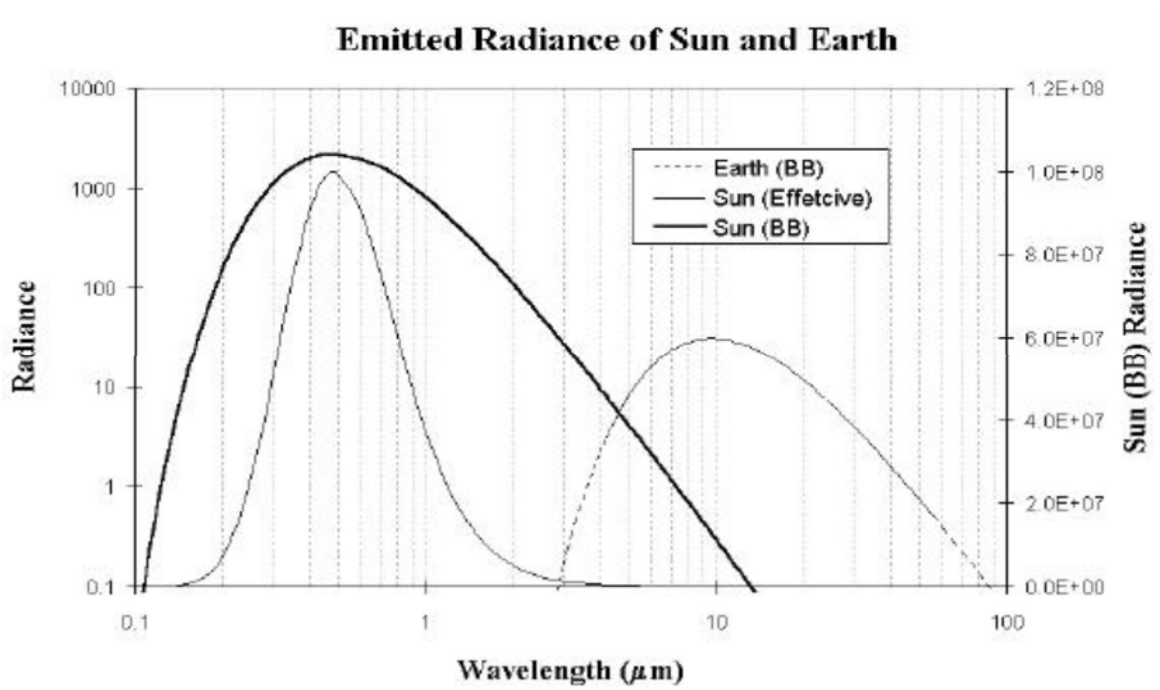
$$E(\lambda, T) = \frac{2hc^2}{\lambda^5} \frac{1}{e^{hc/\lambda kT} - 1}$$

$$h = 6.625 \times 10^{-27} \text{ erg-sec (Planck Constant)}$$

$$k = 1.38 \times 10^{-16} \text{ erg/K (Boltzmann Constant)}$$

$$c = 3 \times 10^{10} \text{ cm/sec (Speed of Light)}$$

Every object with a temperature above the absolute zero radiates energy. The relationship between wavelength and the amount of energy radiated at different wavelengths, is shown in the following figure, and formulated above.



The figure shows the emitted radiance of the Earth and the Sun as Black Bodies (each given on a different Y scale), according to Plank Law, and also the effective radiance of the sun reaching the Earth. It can be seen, that from about 23 mm the radiance emitted from the Earth is greater than reaching us from the Sun (both of them presented on the same scale).

Wien's displacement law

For an object at a constant temperature the radiant power peak refers to the wavelength at which the maximum amount of energy is radiated, which is expressed as lmax. The sun, with a surface temperature of almost 6000°K, has its peak at 0.48mm

(wavelength of yellow). The average surface temperature of the earth is 290°K (17°C), which is also called the ambient temperature; the peak concentration of energy emitted from the earth is at 9.7mm.

This shift to longer wavelengths with decreasing temperature is described by Wien's displacement law, which states: lmax = 2,897mm°K / Trad°K .

Black body concept, Emissivity and Radiant Temperature

Temperature is a measure of the concentration of heat. The concentration of kinetic heat of a body of material may be called the kinetic temperature, Tkin and is measured by a thermometer placed in direct contact with the material. By definition a black body is a material that absorbs all the radiant energy that strikes it. A black body also radiates the maximum amount of energy, which is dependent on the kinetic temperature. According to the Stefan-Boltzman law the radiant flux of a black body, Fb, at a kinetic temperature, Tkin, is Fb = s* Tkin 4 where s is the Stefan- Boltzman constant, 5.67*10-12 W*cm-2*°K-4.

A black body is a physical abstraction, for no material has an absolute absorptivity, and no material radiates the full amount of energy as defined in the equation above. For real materials a property called emissivity, e, has been defined, as e=Fr/Fb, where Fr is radiant flux from a real material. For a black body e=1, but for all real materials e<1. Emissivity is wavelength dependent, which means that the emissivity of a material is different when is measured at different wavelengths of radiant energy (each material has both a reflectance spectrum and an emissivity spectrum – see later). In the next table are given the average emissivities of various materials in the 8 to 12mm wavelength region (thermal), which is used in Remote Sensing.

Material	Emissivity, e
Polished metal surface	0.006
Granite	0.815
Quartz sand, large grains	0.914

Dolomite, polished 0.929

Basalt, rough 0.934

Asphalt paving 0.959

Concrete walkway 0.966

A coat of flat black paint 0.970

Water, with a thin film of petroleum 0.972
Water, pure 0.993

Thus, the radiant flux of a real material may be expressed as Fr = e*s* Tkin 4 . Emissivity is a measure of the ability of a material to both radiate and absorb energy. Materials with a high emissivity absorb and radiate large proportions of incident and kinetic energy, respectively (and vice-versa). The result, is that two surfaces, with the same kinetic temperature but with a different emissivity will have a different radiant temperature. As Remote Sensing devices measure the radiant temperature, in order to derive the kinetic temperature of the object, we need to know its emissivity, that is, we need to be able to identify the material (see later, in the chapter about atmospheric corrections). Then we can apply the following equation: Trad=e1/4Tkin .

The Landsat program is the longest-running enterprise for acquisition of satellite imagery of Earth. On July 23, 1972 the Earth Resources Technology Satellite was launched. This was eventually renamed to Landsat.[1] The most recent, Landsat 8, was launched on February 11, 2013. The instruments on the Landsat satellites have acquired millions of images. The images, archived in the United States and at Landsat receiving stations around the world, are a unique resource for global change research and applications in agriculture, cartography, geology, forestry, regional planning, surveillance and education, and can be viewed through the U.S. Geological Survey (USGS) 'EarthExplorer' website. Landsat 7 data has eight spectral bands with spatial resolutions ranging from 15 to 60 meters; the temporal resolution is 16 days.[2] Landsat images are usually divided into scenes for easy downloading. Each Landsat scene is about 115 miles long and 115 miles wide (or 100 nautical miles long and 100 nautical miles wide, or 185 kilometers long and 185 kilometers wide).

India's remote sensing programme under the Indian Space Research Organization (ISRO) started off in 1988 with the IRS-1A, the first of the series of indigenous state-of-art operating remote sensing satellites,which was successfully launched into a polar sun-synchronous orbit on March 17, 1988 from the Soviet Cosmodrome at Baikonur.

It was a proud moment for the country and showed the maturity of the satellites in the various requirements for managing natural resources of the nation. It has sensors like LISS-I which had a spatial resolution of 72.5 meters with a swath of 148 km on ground. LISS-II had two separate imaging sensors, LISS-II A and LISS-II B, with spatial resolution of 36.25 meters each and mounted on the spacecraft in such a way to provide a composite swath of 146.98 km on ground.These tools quickly enabled India to map, monitor and manage its natural resources at various spatial resolutions. The operational availability of data products to the user organisations further strengthened the relevance of remote sensing applications and management in the country.

SPOT Satellite for observation of Earth") is a commercial high-resolution optical imaging Earth observation satellite system operating from space. It is run by Spot Image, based in Toulouse, France. It was initiated by the CNES (Centre national d'études spatiales – the French space agency) in the 1970s and was developed in association with the SSTC (Belgian scientific, technical and cultural services) and the Swedish National Space Board (SNSB). It has been designed to improve the knowledge and management of the Earth by exploring the Earth's resources, detecting and forecasting phenomena involving climatology and oceanography, and monitoring human activities and natural phenomena. The SPOT system includes a series of satellites and ground control resources for satellite control and programming, image production, and distribution. Earlier satellites were launched using the European Space Agency's Ariane 2, 3, and 4 rockets, while SPOT 6 and SPOT 7 were launched by the Indian PSLV.

MODIS:

The Moderate Resolution Imaging Spectroradiometer (MODIS) is a payload scientific instrument built by Santa Barbara Remote Sensing[1] that was launched into Earth orbit by NASA in 1999 on board the Terra (EOS AM) Satellite, and in 2002 on board the Aqua (EOS PM) satellite. The instruments capture data in 36 spectral bands ranging in wavelength from 0.4 µm to 14.4 µm and at varying spatial resolutions (2 bands at 250 m, 5 bands at 500 m and 29 bands at 1 km). Together the instruments image the entire Earth every 1 to 2 days. They are designed to provide measurements in large-scale global dynamics including changes in Earth's cloud cover, radiation budget and processes occurring in the oceans, on land, and in the lower atmosphere. MODIS utilizes four on-board calibrators in addition to the space view in order to provide in-flight calibration: solar diffuser (SD), solar diffuser stability monitor (SDSM), spectral radiometric calibration assembly (SRCA), and a v-groove black body.[2] MODIS has used the marine optical buoy for vicarious calibration. MODIS is succeeded by the VIIRS instrument on board the Suomi NPP satellite launched in 2011 and future Joint Polar Satellite System (JPSS) satellites

Interaction of EMR with Earth's Surface

Electromagnetic radiation that passes through the earth's atmosphere without being absorbed or scattered reaches the earth's surface to interact in different ways with different materials constituting the surface.

There are three ways in which the total incident energy will interact with earth's surface materials. These are AbsorptionTransmission, and Reflection.

Absorption (A) occurs when radiation (energy) is absorbed into the target while transmission (T) occurs when radiation passes through a target. Reflection (R) occurs when radiation "bounces" off the target and is redirected.

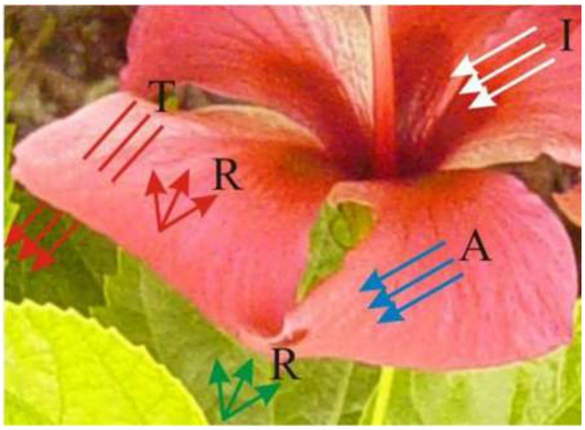
How much of the energy is absorbed, transmitted or reflected by a material will depend upon:

- Wavelength of the energy

- Material constituting the surface, and

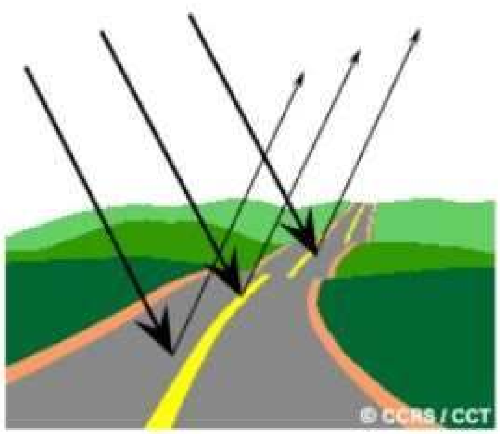
- Condition of the feature.

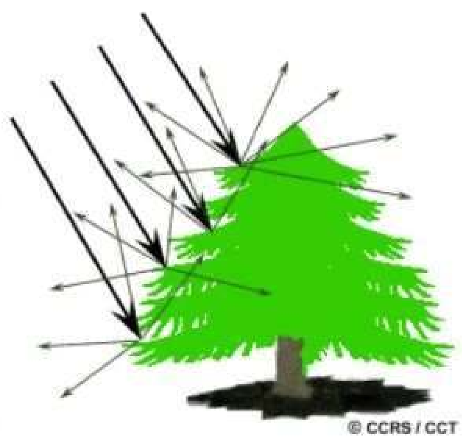
- In remote sensing, we are most interested in measuring the radiation reflected from targets.



Reflection from surfaces occurs in two ways:

1. When the surface is smooth, we get a mirror-like or smooth reflection where all (or almost all) of the incident energy is reflected in one direction. This is called Specular Reflection and gives rise to images.
2. When the surface is rough, the energy is reflected uniformly in almost all directions. This is called Diffuse Reflection and does not give rise to images.





Specular Reflection

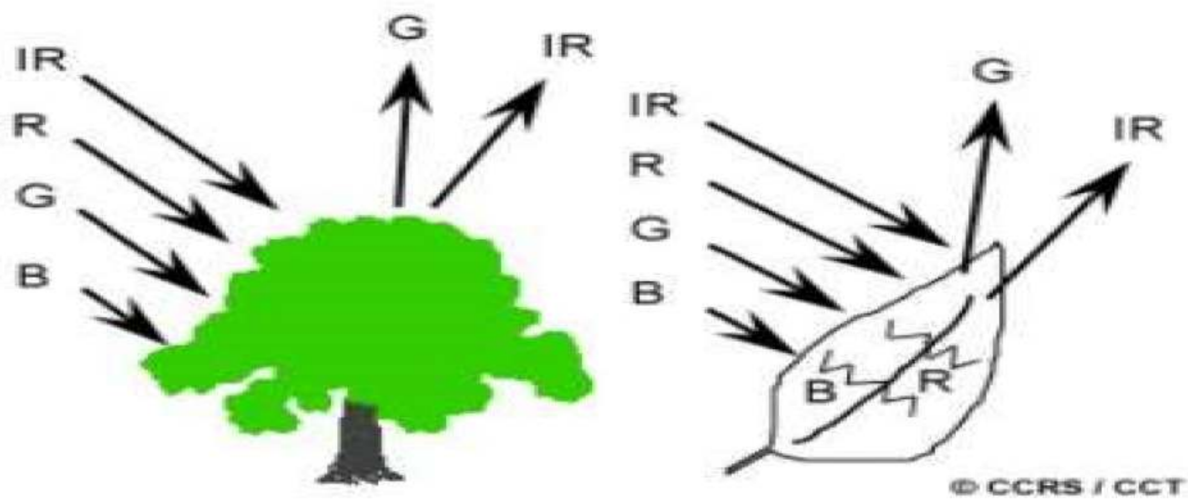
Diffuse Reflection

Most surface features of the earth lie somewhere between perfectly specular or perfectly diffuse reflectors. Whether a particular target reflects specularly or diffusely, or somewhere in between, depends on the surface roughness of the feature in comparison to the wavelength of the incoming radiation.

If the wavelengths are much smaller than the surface variations or the particle sizes that make up the surface, diffuse reflection will dominate. For example, fine-grained sand would appear fairly smooth to long wavelength microwaves but would appear quite rough to the visible wavelengths.

Let's take a look at a couple of examples of targets at the Earth's surface and how energy at the visible and infrared wavelengths interacts with them.
Vegetation: A chemical compound in leaves called chlorophyll strongly absorbs radiation in the red and blue wavelengths but reflects green wavelengths.

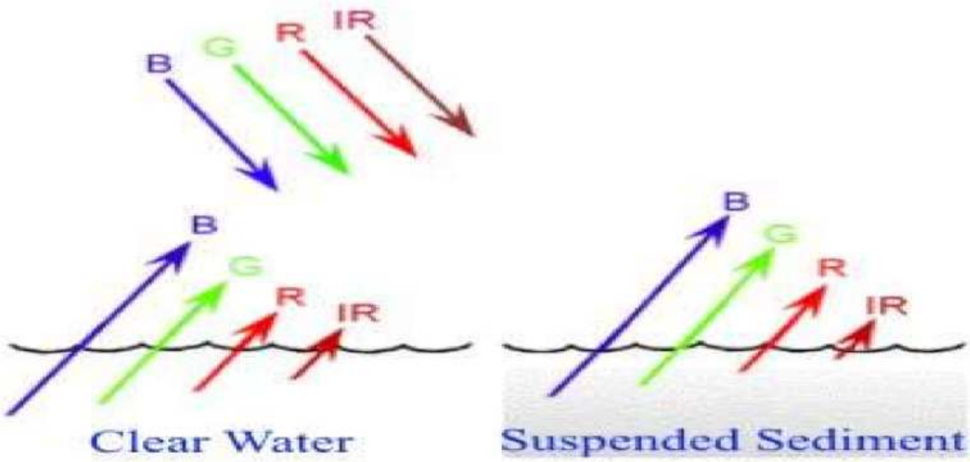
- Leaves appear "greenest" to us in the summer, when chlorophyll content is at its maximum. In autumn, there is less chlorophyll in the leaves, so there is less absorption and proportionately more reflection of the red wavelengths, making the leaves appear red or yellow (yellow is a combination of red and green wavelengths).



- The internal structure of healthy leaves act as excellent diffuse reflectors of near-infrared wavelengths. If our eyes were sensitive to near-infrared, trees would appear extremely bright to us at these wavelengths. In fact, measuring and monitoring the near-IR reflectance is one way that scientists can determine how healthy (or unhealthy) vegetation may be.

Water:

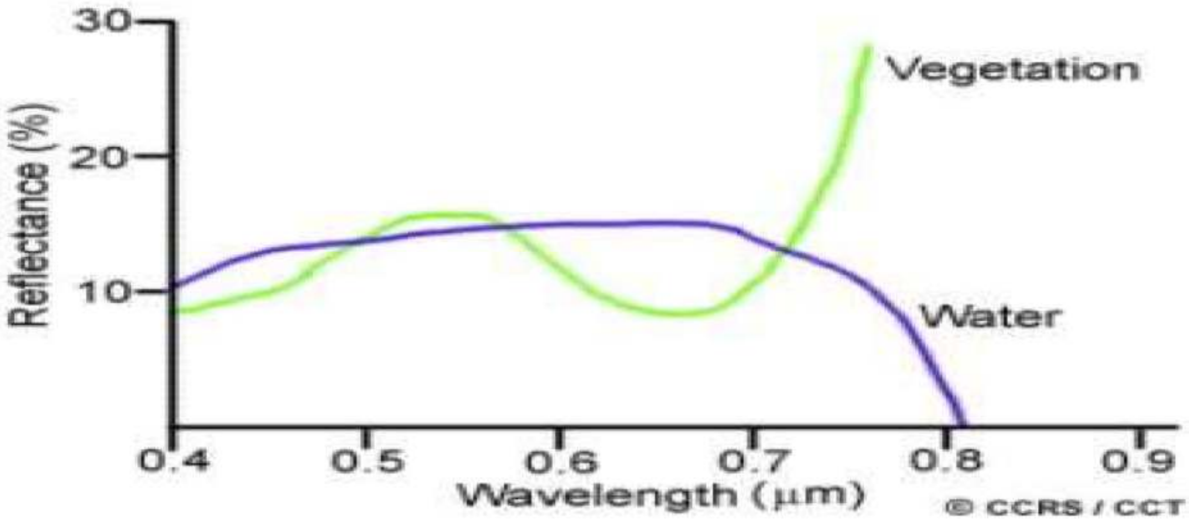
Longer wavelength visible and near infrared radiation is absorbed more by water than shorter visible wavelengths. Thus water typically looks blue or blue-green due to stronger reflectance at these shorter wavelengths, and darker if viewed at red or near infrared wavelengths.



- If there is suspended sediment present in the upper layers of the water body, then this will allow better reflectivity and a brighter appearance of the water.
- The apparent colour of the water will show a slight shift towards longer wavelengths.
- Suspended sediment (S) can be easily confused with shallow (but clear) water, since these two phenomena appear very similar.
- Chlorophyll in algae absorbs more of the blue wavelengths and reflects the green, making the water appear more green in colour when algae is present.
- The topography of the water surface (rough, smooth, floating materials, etc.) can also lead to complications for water-related interpretation due to potential problems of specular reflection and other influences on colour and brightness.
- We can see from these examples that, depending on the complex make-up of the target that is being looked at, and the wavelengths of radiation involved, we can observe very different responses to the mechanisms of absorption, transmission, and reflection.

Spectral Response of Materials:

By measuring the energy that is reflected (or emitted) by targets on the Earth's surface over a variety of different wavelengths, we can build up a spectral response for that object. The spectral response of a material to different wavelengths of EMR can be represented graphically as a Spectral



Reflectance Curve.

It may not be possible to distinguish between different materials if we were to compare their response at one wavelength. But by comparing the response patterns of these materials over a range of wavelengths (in other words, comparing their spectral reflectance curves), we may be able to distinguish between them. For example, water and vegetation may reflect somewhat similarly in the visible wavelengths but are almost always separable in the infrared.

Spectral response can be quite variable, even for the same target type, and can also vary with time (e.g. "green-ness" of leaves) and location.

- Knowing where to "look" spectrally and understanding the factors which influence the spectral response of the features of interest are critical to correctly interpreting the interaction of electromagnetic radiation with the surface

Photogeology and its applications…

Photogeology is the interpretation of the geological and geomorphological features as well as various lithofacies on the aerial photographs. Some other terms such as "aerogeology" and "airgeology" are also used. Aerial photographs are a source of geological information that may be unobtainable elsewhere. An aerial photograph is the picture of the ground surface taken from the air with a camera pointing downward.

The study of the aerial photographs can't substitute the field investigations but rather it helps and contributes to them. The advantages of the study of the aerial photographs can be listed as follows:

a. it saves time b. it provides to observe a larger area c. it has more detailed ground surface than maps

d. photographs can be studied anytime and at anywhere e. 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.

Applications:

A. Geographic and geologic locations. Recognizing the general geographic and geologic location of a project area, limits the types of feature which could be present. Once the area is defined, the structure and rock types can usually be determined. For example, in an area in SW New Mexico, sedimentary and crystalline rock units would be expected. Thrust faulting would not be expected in stable basin and shelf areas.

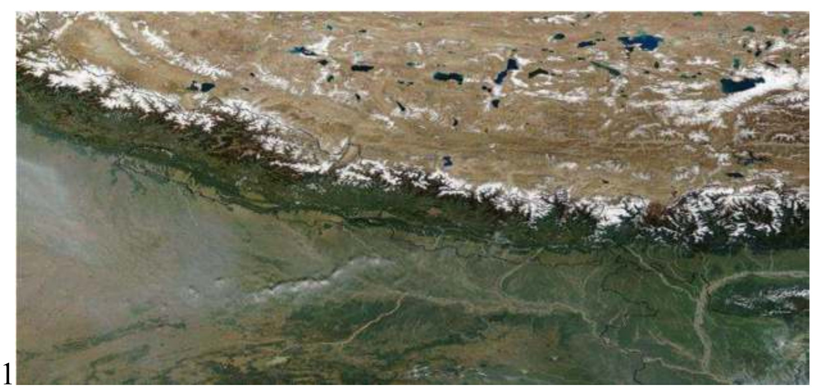
B. Literature survey. Research into literature, before a photogeologic study is undertaken, will determine the general sequence of rock units and their types if published data are available. Some of the major tectonic elements can also be learned. Published geomorphic information should be studied. C. Climate of the past and present. Weathering will affect the rocks in different climates. For example, carbonate rocks are easily dissolved in the humid climates, in the arid climates they stand out as ridges. In addition to these general considerations, specific topographical form, photographic characteristics, vegetation, location and relation to other objects are used in the identification and interpretation of features seen on aerial photographs. When analyzed within the above framework, 1) shape, or form, 2) tonal and textural relations, and 3) drainage will permit recognition, delineation and analysis of the geologic features within most photogeologic project areas. Photointerpretation involves observing certain tones, shapes, and other characteristics of photographic images and determining their geologic significance by a combined deductive or inductive reasoning

Applications of remote sensing(geomorphological mapping)
1: Remote sensing is the observation of surfaces or objects while not being in direct contact with them. By this definition, cameras are remote sensors, observing the environment around us but not requiring us to touch the objects photographed; our eyes also fall into this category. The more commonly accepted example of remote sensing is the use of satellites in orbit around the earth to observe the surface for monitoring purposes. Since the development of Google Earth, access to such data has become available to everyone for free. However, remote sensing for environmental monitoring is more involved than simply looking at one's neighbourhood from above: it has the capability to provide wide-scale observations of all geomorphological features on Earth's surface. We are able to monitor the changing shape of Earth's surface, assess the processes occurring, and identify landforms in remote regions that might otherwise be inaccessible.

In its most simple application, we can take a remotely sensed image of Earth's surface and interpret what we see to produce a geomorphological map. This allows us to map regions rapidly that might otherwise take many weeks of manual exploration and cartography. Such mapping processes can even be automated, to a certain extent. One constraint that we have, however, relates to the spatial resolution of particular sensors, such as the smallest area on Earth's surface that a sensor can distinguish. For continental-scale features such as mountain ranges, sensors with a coarser resolution may be sufficient (for example, the NASA sensor, MODIS, which at best has a pixel size of 250 m) (see Figure 1). For smaller scale features, such as mountain glaciers, or even sand dunes (see Figure 2), the use of higher spatial resolution sensors will be necessary. For example, Worldview II is a new satellite launched in 2009 with a sub-metre spatial resolution.

What is also useful with regard to today's remote sensors is the availability of hyperspectral imagery; that is, imagery viewing the surface not just in the visible bands to produce what might look like a photograph, but imagery viewing the surface in different bands of the electromagnetic spectrum. This allows the detection of certain materials which often reflect differences in the geomorphology. For example, we can distinguish different rock and sediment types and can inspect for different minerals within rock; we can assess vegetation cover and we can, to a certain extent, determine the moisture content of the surface.Aside from actual images of the surface, remote sensing also has the geomorphological application of being able to provide three-dimensional representations of the surface in the production of digital elevation models (see Figure 3). On a number of orbiting satellites (and also on some airplanes), radar systems actively beam electromagnetic radiation to Earth and detect these as they bounce off the surface and return to the corresponding sensor; the longer this process takes, the further the reflecting surface must be from the sensor, thereby indicating the shape of the land below. Not only is this useful for an instantaneous representation of the topography but it is immensely useful for monitoring how this may change over time, perhaps due to subsidence or uplift of the surface, or themovementofa glacier (see Figure 4).The utility of remote sensing for geomorphological studies is immense. It allows for the rapid assessment of large areas and for the monitoring of changes to these areas – things that would be impossible to do using field studies alone. This is not to say that remote sensing might one day completely replace the requirement for on-the-ground field work but it will continue to provide an additional source of information for geomorphological studies at all spatial scales.

Fig1



Semester 6

Fig 2

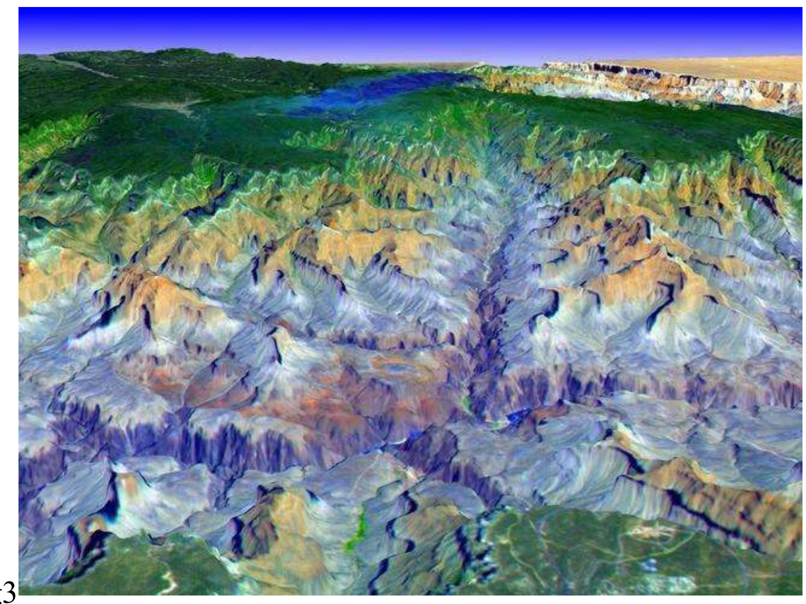


Fig3

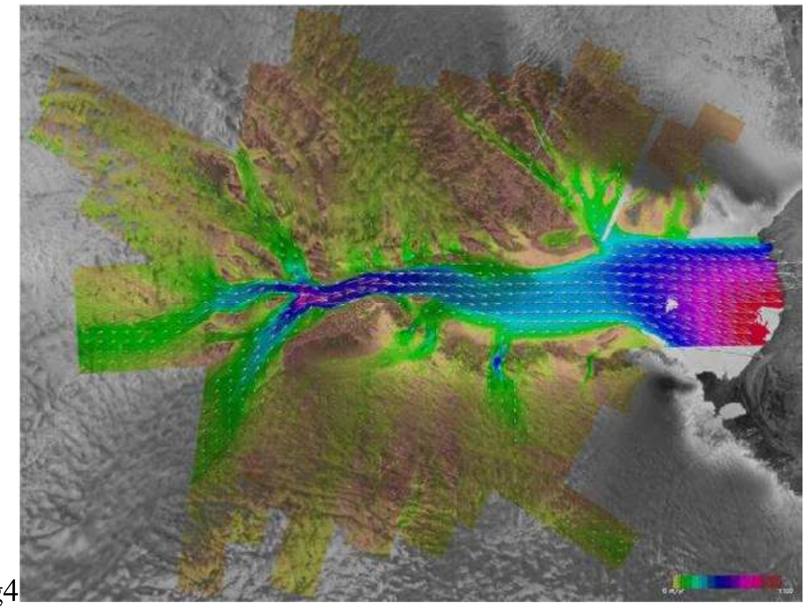


Fig4

Application of remote sensing in geological hazard assesment

For purposes of assessing natural hazards in the context of integrated development planning studies, it is not necessary to have real-time or near real-time remote sensing imagery. What is required is the ability to define areas of potential exposure to natural hazards by identifying their occurrence or conditions under which they are likely to occur and to identify mechanisms to prevent or mitigate the effects of those hazards. This section considers the practical detectability by remote sensing technology of the potential for floods, hurricanes, earthquakes, volcanic eruptions and related hazards, and landslides. It will become evident that some of these hazards are interrelated, e.g., floods and hurricanes; earthquakes, volcanoes and landslides.

The ability to identify these natural hazards or their potential for occurring depends on the resolution of the image, the acquisition scale of the sensor data, the working scale, scenes free of clouds and heavy haze, and adequate textural and tonal or color contrast. The availability of stereomodels of the scene being studied can greatly enhance the interpretation. Figure 1-4 displays satellite remote sensing attributes to be taken into consideration for the assessment of various hazards.

After a hazard is identified, formulating appropriate mitigation measures and developing response plans may require different remote sensing data sets. This additional remote sensing data needed are most likely to include greater detail of the infrastructure, e.g., roads and facilities. This may have to be derived from aerial photography.

1. Floods

Floods are the most common of natural hazards that can affect people, infrastructure, and the natural environment. They can occur in many ways and in many environments. Riverine floods, the most prevalent, are due to heavy, prolonged rainfall, rapid snowmelt in upstream watersheds, or the regular spring thaw. Other floods are caused by extremely heavy rainfall occurring over a short period in relatively flat terrain, the backup of estuaries due to high tides coinciding with storm surges, dam failures, dam overtopping due to landslides into a reservoir, and seiche and wind tide effects in large lakes. Occasionally an eruption on a glacier or snow-covered volcanic peak can cause a flood or a mudflow in which the terrain is radically changed and any agrarian development is totally destroyed, frequently with much loss of life.

It is impossible to define the entire flood potential in a given area. However, given the best remote sensing data for the situation and a competent interpreter, the evidence for potential flood situations can be found or inferred. The most obvious evidence of a major flood potential, outside of historical evidence, is identification of floodplain or flood-prone areas which are generally recognizable on remote sensing imagery. The most valuable application of remote sensing to flood hazard assessments, then, is in the mapping of areas susceptible to flooding.

Synoptic satellite sensor coverage of a planning study area is the practical alternative to aerial photography because of cost and time factors. The application of Landsat MSS imagery to floodplain or flood-prone area delineation has already been demonstrated by comparing pre-flood scenes with scenes obtained at the height of the flood, using Landsat MSS band 7 (near IR) images in a color additive viewer . This temporal comparison can now be done pixel by pixel in a computer. Landsat TM, with its greater spatial resolution than MSS data (30m versus 80m) and its additional spectral coverage (7 bands versus 4 bands), can be used for more detailed mapping of floodplains and flood-prone areas on larger scale maps of 1:50,000 or greater. TM data have been used for discriminating land Cover classification.

Figure 4-7 - SATELLITE IMAGERY APPLIED TO NATURAL HAZARD ASSESSMENTS

	EARTHQUAKES	VOLCANIC ERUPTION	LANDSLIDES	TSUNAMI	DESERTIFICATION	FLOODS	HURRICANES
INFORMATION TO BE OBTAINED	Land-use maps, geological maps	Maps of areas vulnerable to lava flows, ash fall, debris fall and fires	Slope maps, slopes stability, elevation, geology, soil type, areas of standing water, land-use maps	Bathymetric/ topographic maps	Land-use maps, soil moisture content, crop condition and natural vegetation	Floodplain delineation maps, land-use classification, historical data, soil cover and soil moisture	Land-use maps
SPECTRAL BAND	Visible and near IR	Visible, near IR and thermal IR	Visible	Visible, including blue and -near IR	Visible, near IR, and micro wave	Near IR, thermal IR and microwave	Visible and near IR
SPATIAL RESOLUTION	20-80m	30-80m	10-30m	30m	80m-1 km	20m (for cultural features); 30-80m (for land use); 1 km (for snow cover and soil moisture)	20m (for cultural features); 30-80m (for land use)
AREAL COVERAGE	Large area	Large area	Large area	Large coastal area	Large regional area	Large regional area	Large area
ALL WEATHER CAPABILITY	No	No	No	No	No	No	No
SYNOPTIC VIEW	Yes	Yes	Yes	Yes	Yes	Yes	Yes
STEREO CAPABILITY	Yes	Yes	Yes	Yes	No	Yes	No
FREQUENCY OF OBSERVATIONS FOR PLANNING STUDY USE	1 to 5 years	1 to 5 years	1 to 5 years	1 to 5 years	Monthly	Seasonal (except weekly for snow cover and soil moisture)	Yearly

Source: Adapted from Richards, PUB. The Utility of Landsat-D and other Satellite Imaging Systems in Disaster Management (Washington, DC: Naval Research Laboratory, 1986).

This approach to floodplain delineation does have its limitations. The area of potential flooding delineated in this manner may represent a flood level that exceeds an acceptable degree of loss. Also, no floods may have occurred during the period of the sensor operation. In this case, indirect indicators of flood susceptibility are used.. Landsat and presumably similar satellite data floodplain indicators are listed in Figure 4-7.

There are large parts of tropical humid ecosystems where adequate Landsat or other similar imagery is not available due to cloud coverage or heavy haze. In some instances the heavy tropical vegetation masks many geomorphic features so obvious in drier climates. In this case the use of available radar imagery from space or previously acquired from an aircraft survey is desirable. The radar imagery, which has a resolution comparable to Landsat TM and SPOT from both space and sub-orbital altitudes, can satisfactorily penetrate the clouded sky and define many floodplain features.

Moisture on the ground noticeably affects the radar return and, together with the textural variations emphasized by the sensor, makes radar a potentially desirable tool for flood and floodplain mapping.

2. Hurricanes

To mitigate the impact of hurricanes, the planner needs to know the frequency of storms of given intensity in the study area, to what extent these storms could affect people and structures, and what sub-areas would be most affected such as low-lying coastal, estuarine, and reverie areas threatened by flooding and storm surge. The determination of past hurricane paths for the region can be derived from remote sensing data from the U.S. National Oceanographic and Atmospheric Administration (NOAA) satellite sensors designed and operated for meteorological purposes. These data are already plotted by meteorological organizations in the U.S.A. and other countries where hurricanes are a threat. For plotting new data, the best sensor is the AVHRR which, with its 2,700km swath, makes coverage twice a day, and has appropriate resolution. The red band is useful for defining daytime clouds and vegetation, while the thermal IR band (10.50 mm to 11.50 mm) is useful for both daytime and nighttime cloud observations.

Figure 4-7: LANDSAT FLOODPLAIN INDICATORS

- Upland physiography
- Watershed characteristics, such as shape, drainage, and density
- Degree of abandonment of natural levees
- Occurrence of stabilized sand dunes on river terraces
- Channel configuration and fluvial geomorphic characteristics
- Backswamp areas
- Soil-moisture availability (also a short term indicator of flood susceptibility)
- Variations in soil characteristics
- Variations in vegetation characteristics
- Land use boundaries
- Flood alleviation measures for agricultural development on the floodplain

Source: Adapted from Rango, A. and Anderson, A.T. "Flood Hazard Studies in the Mississippi River Basin Using Remote Sensing" in Water Resources Bulletin, vol. 10, 1974.

The AVHRR is not useful in other aspects of hurricane contingency planning due to its limited spatial resolution. These planning needs require higher resolution available from other satellite sensors. If imagery of areas inundated by floods, hurricane storms, or other storms is obtained with any sensor immediately after the event, it should be used, of course, regardless of its resolution. Any such information that is obtained in a timely fashion should be used to delineate the problem areas since their definition is more exact than can be interpreted from higher resolution data obtained during a non-flood period.

Predicting areas of potential inundation along coasts and inland can be achieved using topographic maps with scales as large as 1:12,500. When such maps are not available, remote sensing techniques can be used. In areas with a distinct wet and dry season, it is desirable to obtain information for the wet season from Landsat or comparable imagery in the near IR bands, or use a color IR composite made from Landsat MSS or TM imagery or from SPOT HRV imagery. These image products can be used to identify the moisture-saturated areas susceptible to flooding as well as the higher and drier ground for potential evacuation areas. Likewise, consideration of development plans in view of this potential natural hazard can proceed in a way similar to that for areas prone to flood hazards. For flood hazard assessments, radar imagery from space or aircraft could be used (if available) in lieu of the Landsat MSS imagery. Since there is a general lack of relief in low-lying coastal areas and estuarine areas, stereoscopy would not normally play an important role in this situation. However, stereoscopic viewing even without significant relief enhancement can still reinforce the details of the scene, although at considerably greater cost.

The development planner also needs to consider the additional feature of a hurricane-its high winds. In identifying measures to mitigate wind effects, the planner may consider the type of crops grown, if an agricultural development is being planned, and the design and construction materials used in buildings.

3. Earthquakes

The planning of development in earthquake-prone areas is laden with problems. There are large human settlements already located in earthquake/prone areas.

As with other geologic hazards, the frequency of occurrence can fall in cycles of decades or centuries. Earthquakes are particularly difficult to predict at this time. Thus, mitigation emphasis is on land use planning (non-intensive uses in most hazardous areas), on building strength and integrity, on response planning, and on incorporating mitigation measures into reconstruction efforts. The main problem is the identification of the earthquake damage-prone zones . While in most areas of great earthquake activity some seismic information is available, it may not be sufficient for planning purposes. Remote sensing techniques and resulting data interpretation can play a role in providing additional information.

Tectonic activity is the main cause of destructive earthquakes, followed by earthquakes associated with volcanic activity. Where the history of earthquakes due to seismic activity is present in an area, the faults associated with the activity can frequently be identified on satellite imagery. Where volcanic-related earthquakes occur, the source is generally not as obvious: it may be due to movement on a fault near the surface or deep within the earth, to caldera collapse, or to magma movement within the volcanic conduit.

In order to identify earthquake hazards it is necessary to have the expertise to recognize them and then determine the correct remote sensing tools to best delimit them. Landsat imagery has been effectively and widely used for this purpose since it is less expensive and more readily available than other remote sensing data. Airborne radar mosaics have been successfully used for the delineation of fault zones. Generally, two mosaics can be made of an area: one with the far range portion of the SLAR and the other with the near range portion. The former is best used in areas of low relief where the relief needs to be enhanced, and the latter in areas of high relief where the shadow effect is not needed or may be detrimental to the image.
Radar is applicable to delineate unconsolidated deposits sitting on fault zones-upon which most of the destruction occursto identify areas where an earthquake can trigger landslides. This is best accomplished on stereomodels using

adjoining and overlapping radar flight lines. Conventional aerial photography, in black and white or color, would also work well for this purpose.

An alternative, which is adequate but not as good as using radar and aerial photography, is to use multispectral imagery obtained from the Landsat TM and/or MSS or SPOT HRV sensors. Color IR composites or straight near-IR imagery from these sensors at scales up to about 1:100,000 can be used to define active surface fault zones, but not as efficiently as with the radar images. The distinction between bedrock versus unconsolidated materials and the areas of potential landslide hazards can be defined but, again, only if stereocoverage is available. SPOT sensors can provide this capability.

While radar imagery is an ideal data source, available coverage is extremely limited, and contracting airborne radar is usually prohibitively expensive. Landsat TM and MSS are the most practical data source, simply because of its availability, and both provide sufficient resolution for regional planning studies.

4. Volcanic Eruptions and Related Hazards

Many hazards are associated with the conditions brought about by volcanic activity. Active volcanoes pose hazards which include the immediate release of expelled ash, lava, pyroclastic flows, and/or poisonous hot gases; volcanic earthquakes; and the danger of mudflows and floods resulting from the rapid melting of snow and ice surrounding the vent during eruption. Some secondary hazards may threaten during volcanic activity or during periods of dormancy. These include landslides due to unstable accumulations of tephra, which may be triggered by heavy rains or by earthquakes.

Each volcano has its own particular behavior within a framework of given magmatic and tectonic settings. Prediction of a volcano's behavior is extremely difficult, and the best evidence for the frequency of activity and its severity is the recorded history of eruptions. Imminent eruptions are now best recognized by on-site seismic monitoring. Some classifications distinguish between active, inactive, dormant, and extinct volcanoes. But since some of the most catastrophic eruptions have come from "extinct" volcanoes, many volcanologists have abandoned such a classification, settling for a simple distinction between short-term and long-term periodicity.

Gawarecki et al. (1965) first detected volcanic heat from satellite remote sensing using thermal IR imagery from the high resolution IR radiometer (HRIR). Remote sensing data interpretation can lead to the recognition of past catastrophic events associated with recently active volcanoes (recently in the geologic sense), as in the Andes and the Lesser Antilles. This information together with the available historical data can be used as the basis of assessing the risks of an area with potential volcano-related hazards.

The varied nature and sizes of volcanic hazards require the use of various types of sensors from both satellites and aircraft. The relatively small area involved with volcanoes should encourage the use of aerial photography in their analysis. Panchromatic black and white stereo aerial coverage at scales between 1:25,000 to 1:60,000 is usually adequate to recognize and map geomorphic evidence of recent activity and associated hazards. Color and color IR photography may be useful in determining the possible effects of volcanic activity on nearby vegetation, but the slower film speed, lower resolution, and high cost diminish much of any advantage they provide.

The airborne thermal IR scanner is probably the most valuable tool in surveying the geothermal state of a volcano. The heat within a volcano and underlying it and its movement are amenable to detection. Because of the rapid decrease in resolution with increasing altitude (about 2m per 1,000m) the surveys need to be made at low altitudes under 2,000m.

An IR pattern of geothermal heat in the vicinity of a volcano is an indication of thermal activity which many inactive volcanoes display. Many volcanoes thought to be extinct may have to be reclassified if aerial IR surveys discover any abnormally high IR emissions from either the summit craters or the flanks. Changes in thermal patterns can be obtained for a volcano only through periodic aerial IR surveys taken under similar conditions of data acquisition. The temperature and gas emission changes, however, can be monitored on the ground at ideal locations identified on the thermal imagery, making periodic overflights unnecessary. Continuous electronic monitoring of these stations is possible by transmission through a geostationary data relay satellite, another phase of remote sensing.

The thermal IR bands of the satellite sensors now available have inadequate spatial and thermal resolution to be of any significant value to detect the dynamic change in volcanic geothermal activity. In addition to sensing geothermal heat, however, other remote sensing techniques are useful in preparing volcanic hazard zonation maps and in mitigating volcanic hazards. Mitigation techniques requiring photo interpretation and topographic maps include predicting the path of potential mudflows or lava flows and restricting development in those areas.

5. Landslides

Landslides, or mass movements of rock and unconsolidated materials such as soil, mud, and volcanic debris, are much more common than is generally perceived by the public. Many are aware of the catastrophic landslides, but few are aware that small slides are of continuous concern to those involved in the design and construction business. These professionals can often exacerbate the problem of landsliding through poor planning, design, or construction practices. Frequently, the engineer and builder are also forced into difficult construction or development situations as a result of ignoring the potential landslide hazard. This can be avoided if there is early recognition of the hazard and there is effective consultation between planners and the construction team prior to detailed development planning. The mass movement of bed rock and unconsolidated materials results in different types of slides, magnitudes, and rates of movement. An area with a potential landslide hazard usually has some evidence of previous occurrences, if not some historical record. Unfortunately, some types of landslides, particularly those of small size, cannot be delineated on remote sensing imagery or through aerial photography. Usually the scars of the larger slides are evident and, although the smaller slide features may not be individually discerned, the overall rough appearance of a particular slope can suggest that mass movement occurred. If a fairly accurate geologic map is available at a reasonable scale (1:50,000 or larger) rock types and/or formations susceptible to landslides may be examined for evidence of movement. An example of this would be finding a shale in a steeper than usual slope environment, implying the strong possibility of a landslide history. An examination of stream traces frequently shows deflections of the bed course due to landslides. If one can separate out the tectonically controlled stream segments, those deflections due to slides or slumps often become evident.

Typical features that signify the occurrence of landslides include chaotic blocks of bedrock whose only source appears to be upslope; crescentic scarps or scars whose horns point downward on a normal-looking slope; abnormal bulges with disturbed vegetation at the base of the slope; large intact beds of competent sedimentary or other layered rock displaced down dip with no obvious tectonic relationship; and mudflow tongues stretching outward from the base of an obviously eroded scar of relatively unconsolidated material. A good understanding of the structural geology of the study area frequently places these superficial anomalies into perspective., the susceptibility to landslides is relative to the area. Landslides can occur on gentle slopes as well as on steep slopes, depending on landscape characteristics.

Most landslide discussions do not address the problem of sinkholes, which are a form of circular collapse landslides. The karstic areas in which they occur are easy to identify even on some satellite imagery (MSS, TM, SPOT, etc.) due to their pitted appearance and evidence of the essentially internal drainage. Despite the obvious occurrence of many sinkholes, many individual small sinkholes are subtle and not easily recognized. These are frequently the sites of collapse and subsequent damage to any overlying structure when ground water is removed to satisfy development needs, which results in lowering the water table and undermining the stability of the land.

The spatial resolution required for the recognition of most large landslide features is about 10m (Richards, 1982). However, the recognition depends to a great extent on the ability and experience of the interpreter and is enhanced by the availability of stereoscopic coverage, which can be expensive to acquire. Stereoscopic coverage and the resolution requirements preclude use of most satellite-borne sensor imagery, although large block landslides can be detected on Landsat MSS and TM imagery.

Given the spatial resolution requirement, SPOT HRV-P (panchromatic mode) imagery can be useful with its 10m resolution. Its broad band coverage, however, is not conducive to providing adequate contrast in scenes involving heavily vegetated tropics, where most of the potential hazards occur. Ameliorating this factor slightly is the availability of stereocoverage. It is important to understand that this is specifically programmed for the SPOT satellite and that stereocoverage is not normally acquired during sensor operation.

Detection of landslide features is more easily achieved using airborne sensors. Aerial photography with its normal stereoscopic coverage is the best sensor system with which to define landslides, both large and small. Aerial photographic scales as small as 1:60,000 can be used. Black and white panchromatic or IR films are adequate in most cases, but color IR may prove better in some instances. The IR-sensitive emulsions, as stated earlier, eliminate much of the haze found in the humid tropics. The open water or other moisture in back of recent slump features stands out as an anomaly in the aerial IR stereomodel, either in black and white or color. The color IR photography might, in some rare cases, show the stress on the vegetation caused by recent movement. If the scales are large enough, tree deformation caused by progressive tilting of the slope of the soil might also be detected.

A more sensitive detector of moisture associated with landslides is the thermal IR scanner. This sensor is particularly useful in locating seepage areas that lubricate slides. It is particularly effective during the night, when there is a maximum temperature difference between the terrain and the effluent ground water. Despite its utility many factors rule out the widespread use of the thermal IR scanner. These factors include the low altitude required for reasonable spatial resolution, the large number of flight lines required for the large area involved, and the geometrical distortions Inherent in the system. If the terrain to be interpreted has some relief and is nondescript, these distortions become an even greater problem when the data are interpreted by making the location of features very difficult.

SLAR, especially the X-band synthetic aperture radar with its nominal 10m resolution, can be marginally useful in a stereo mode because of its ability to define some larger textures related to landslides. In some cloud-prone environments radar may be the only sensor that can provide interpretable information.

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Active faults and earthquakes

Optical as well as radar satellite imagery are excellent tools to map active faults. They occur in regionally different patterns, and the knowledge of these patterns, the reconstruction of the kind of movements along the faults, and their connection with active volcanoes will greatly help in the assessment of geological hazards. If compared with information on the location of seismic hypo- and epi-centres areas prone to earthquakes can be more precisely delineated. Observations from LANDSAT-TM images in the Himalayan mountains of Nepal and China revealed a clear connection between of active faults, associated with earthquakes, and the occurrence of large landslides. Effects of earthquakes of the kind, which devastated Mexico City in 1986 can be predicted by mapping large basins and analyse the underground sediments with conventional geological methods.

The delineation of active faults becomes an urgent necessity. Many damsites in the world have been constructed on active faults and the knowledge of the distribution of such faults, especially when they are associated with earthquake hypo-and epi-centres might help to mitigate larger losses due to dam collapses and landslides, as well as by direct earthquake damage.

Application of remote sensing (land use land cover mapping)

Land Cover & Land Use

Although the terms land cover and land use are often used interchangeably, their actual meanings are quite distinct. Land cover refers to the surface cover on the ground, while Land use refers to the purpose the land serves. The properties measured with remote sensing techniques relate to land cover, from which land use can be inferred, particularly with ancillary data or a priori knowledge.

Land use applications of remote sensing include the following:

- natural resource management
- wildlife habitat protection
- baseline mapping for GIS input
- urban expansion / encroachment
- routing and logistics planning for seismic / exploration / resource extraction activities
- damage delineation (tornadoes, flooding, volcanic, seismic, fire)
- legal boundaries for tax and property evaluation

target detection - identification of landing strips, roads, clearings, bridges, land/water interface

Mapping

Mapping constitutes an integral component of the process of managing land resources, and mapped information is the common product of analysis of remotely sensed data.

Mapping applications of remote sensing include the following:

Planimetry:

Land surveying techniques accompanied by the use of a GPS can be used to meet high accuracy requirements, but limitations include cost effectiveness, and difficulties in attempting to map large, or remote areas. Remote sensing provides a

means of identifying and presenting planimetric data in convenient media and efficient manner. Imagery is available in varying scales to meet the requirements of many different users. Defence applications typify the scope of planimetry applications - extracting transportation route information, building and facilities locations, urban infrastructure, and general land cover. digital elevation models (DEM's):

Generating DEMs from remotely sensed data can be cost effective and efficient. A variety of sensors and methodologies to generate such models are available and proven for mapping applications. Two primary methods if generating elevation data are 1. Stereogrammetry techniques using airphotos (photogrammetry), VIR imagery, or radar data (radargrammetry), and 2. Radar interferometry. Baseline thematic mapping / topographic mapping:

As a base map, imagery provides ancillary information to the extracted planimetric or thematic detail. Sensitivity to surface expression makes radar a useful tool for creating base maps and providing reconnaissance abilities for hydrocarbon and mineralogical companies involved in exploration activities. This is particularly true in remote northern regions, where vegetation cover does not mask the microtopography and generally, information may be sparse. Multispectral imagery is excellent for providing ancillary land cover information, such as forest cover. Supplementing the optical data with the topographic relief and textural nuance inherent in radar imagery can create an extremely useful image composite product for interpretation.

Applications of Remote Sensing in Hydrology

Remote Sensing and GIS technologies are well-established tools and are routinely used in applied hydrology, forestry, land use dynamics analyses, etc. Abilities of remote sensing technology in hydrology are to measure spatial, spectral, and temporal information and provide data on the state of the earth's surface. It provides observation of changes in hydrological states, which vary over both time and space that can be used to monitor hydrological conditions and changes. Sensors used for hydrological applications cover a broad range of electromagnetic spectrum. Both active sensors that send a pulse and measure the return pulse (like radar, microwave etc.) and passive sensors that measure emissions or reflectance from natural sources (like Sun, thermal energy of the body) are used. Sensors can provide data on reflective, thermal and dielectric properties of earth's surface.

Remote sensing techniques indirectly measure hydrological variables, so the electromagnetic variables measured by remote sensing have to be related to hydrological variables empirically or with transfer functions.

Remote sensing applications in hydrology that are being used today are mainly in:

- Precipitation estimation
- Runoff computations
- Snow hydrology applications
- Evapotranspiration over land surface
- Evaluation of soil moisture content
- Water quality modelling
- Groundwater identification and estimation
- Hydrological modelling

GIS can play fundamental role in the application of spatially distributed data to hydrological models. In conventional applications, results either from remote sensing or from GIS analyses serve as input into hydrological models. Land use and snow cover are the most commonly used input variables for hydrological models. The integration of GIS, database management systems and hydrological models speed up the use of remote sensed data in hydrological applications Enivornmental impact of exploration on air,soil,surface and subsurface waters.

Impacts of exploration on air quality

Airborne emissions occur during each stage of the mine cycle, but especially during exploration, development, construction, and operational activities. Mining operations mobilize large amounts of material, and waste piles containing small size particles are easily dispersed by the wind.

The largest sources of air pollution in mining operations are:

•Particulate matter transported by the wind as a result of excavations, blasting, transportation of materials, wind erosion (more frequent in open-pit mining), fugitive dust from tailings facilities, stockpiles, waste dumps, and haul roads.
Exhaust emissions from mobile sources (cars, trucks, heavy equipment) raise these particulate levels
•Gas emissions from the combustion of fuels in stationary and mobile sources, explosions, and mineral processing.

Once pollutants enter the atmosphere, they undergo physical and chemical changes before reaching a receptor .These pollutants can cause serious effects to people's health and to the environment.

Large-scale mining has the potential to contribute significantly to air pollution, especially in the operation phase. All activities during ore extraction, processing, handling, and transport depend on equipment, generators, processes, and materials that generate hazardous air pollutants such as particulate matter, heavy metals, carbon monoxide, sulfur dioxide, and nitrogen oxides.

Impacts of exploration on soil quality

Mining can contaminate soils over a large area. Agricultural activities near a mining project may be particularly affected. According to a study commissioned by the European Union:

"Mining operations routinely modify the surrounding landscape by exposing previously undisturbed earthen materials. Erosion of exposed soils, extracted mineral ores, tailings, and fine material in waste rock piles can result in substantial sediment loading to surface waters and drainage ways. In addition, spills and leaks of hazardous materials and the deposition of contaminated windblown dust can lead to soil contamination.

"SOIL CONTAMINATION: Human health and environmental risks from soils generally fall into two categories: (1) contaminated soil resulting from windblown dust, and (2) soils contaminated from chemical spills and residues. Fugitive dust can pose significant environmental problems at some mines. The inherent toxicity of the dust depends upon the proximity of environmental receptors and type of ore being mined. High levels of arsenic, lead, and radionucleides in windblown dust usually pose the greatest risk. Soils contaminated from chemical spills and residues at mine sites may pose a direct contact risk when these materials are misused as fill materials, ornamental landscaping, or soil supplements.
Impacts on water resources

Perhaps the most significant impact of a mining project is its effects on water quality and availability of water resources within the project area. Key questions are whether surface and groundwater supplies will remain fit for human consumption, and whether the quality of surface waters in the project area will remain adequate to support native aquatic life and terrestrial wildlife.

Acid mine drainage and contaminant leaching

The potential for acid mine drainage is a key question. The answer will determine whether a proposed mining project is environmentally acceptable. When mined materials (such as the walls of open pits and underground mines, tailings, waste rock, and heap and dump leach materials) are excavated and exposed to oxygen and water, acid can form if iron sulfide minerals (especially pyrite, or 'fools gold') are abundant and there is an insufficient amount of neutralizing material to counteract the acid formation. The acid will, in turn, leach or dissolve metals and other contaminants from mined materials and form a solution that is acidic, high in sulfate, and metal-rich (including elevated concentrations of cadmium, copper, lead, zinc, arsenic, etc.)

Leaching of toxic constituents, such as arsenic, selenium, and metals, can occur even if acidic conditions are not present. Elevated levels of cyanide and nitrogen compounds (ammonia, nitrate, nitrite) can also be found in waters at mine sites, from heap leaching and blasting.

Acid drainage and contaminant leaching is the most important source of water quality impacts related to metallic ore mining.

As Earthworks explains:

"Acid mine drainage is considered one of mining's most serious threats to water resources. A mine with acid mine drainage has the potential for long-term devastating impacts on rivers, streams and aquatic life.

"HOW DOES IT FORM? Acid mine drainage is a concern at many metal mines, because metals such as gold, copper, silver and molybdenum, are often found in rock with sulfide minerals. When the sulfides in the rock are excavated and exposed to water and air during mining, they form sulfuric acid. This acidic water can dissolve other harmful metals in the surrounding rock. If uncontrolled, the acid mine drainage may runoff into streams or rivers or leach into groundwater. Acid mine drainage may be released from any part of the mine where sulfides are exposed to air and water, including waste rock piles, tailings, open pits, underground tunnels, and leach pads.

"HARM TO FISH & OTHER AQUATIC LIFE: If mine waste is acid-generating, the impacts to fish, animals and plants can be severe. Many streams impacted by acid mine drainage have a pH value of 4 or lower – similar to battery acid. Plants, animals, and fish are unlikely to survive in streams.

"TOXIC METALS: Acid mine drainage also dissolves toxic metals, such as copper, aluminum, cadmium, arsenic, lead and mercury, from the surrounding rock. These metals, particularly the iron, may coat the stream bottom with an orangered colored slime called yellowboy. Even in very small amounts, metals can be toxic to humans and wildlife. Carried in water, the metals can travel far, contaminating streams and groundwater for great distances. The impacts to aquatic life may range from immediate fish kills to sublethal, impacts affecting growth, behavior or the ability to reproduce.

"Metals are particularly problematic because they do not break down in the environment. They settle to the bottom and persist in the stream for long periods of time, providing a long-term source of contamination to the aquatic insects that live there, and the fish that feed on them.

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"PERPETUAL POLLUTION: Acid mine drainage is particularly harmful because it can continue indefinitely causing damage long after mining has ended. Due to the severity of water quality impacts from acid mine drainage, many hardrock mines across the west require water treatment in perpetuity. Even with existing technology, acid mine drainage is virtually impossible to stop once the reactions begin. To permit an acid generating mine means that future generations will take responsibility for a mine that must be managed for possibly hundreds of years.

Erosion of soils and mine wastes into surface waters For most mining projects, the potential of soil and sediment eroding into and degrading surface water quality is a serious problem.

According to a study commissioned by the European Union:
"Because of the large area of land disturbed by mining operations and the large quantities of earthen materials exposed at sites, erosion can be a major concern at hardrock mining sites. Consequently, erosion control must be considered from the beginning of operations through completion of reclamation. Erosion may cause significant loading of sediments (and any entrained chemical pollutants) to nearby waterbodies, especially during severe storm events and high snow melt periods.

"Sediment-laden surface runoff typically originates as sheet flow and collects in rills, natural channels or gullies, or artificial conveyances. The ultimate deposition of the sediment may occur in surface waters or it may be deposited within the floodplains of a stream valley. Historically, erosion and sedimentation processes have caused the build-up of thick layers of mineral fines and sediment within regional flood plains and the alteration of aquatic habitat and the loss of storage capacity within surface waters. The main factors influencing erosion includes the volume and velocity of runoff from precipitation events, the rate of precipitation infiltration downward through the soil, the amount of vegetative cover, the slope length or the distance from the point of origin of overland flow to the point where deposition begins, and operational erosion control structures.

"Major sources of erosion/sediment loading at mining sites can include open pit areas, heap and dump leaches, waste rock and overburden piles, tailings piles and dams, haul roads and access roads, ore stockpiles, vehicle and equipment maintenance areas, exploration areas, and reclamation areas. A further concern is that exposed materials from mining operations (mine workings, wastes, contaminated soils, etc.) may contribute sediments with chemical pollutants, principally heavy metals. The variability in natural site conditions (e.g., geology, vegetation, topography, climate, and proximity to and characteristics of surface waters), combined with significant differences in the quantities and characteristics of exposed materials at mines, preclude any generalisation of the quantities and characteristics of sediment loading.

"The types of impacts associated with erosion and sedimentation are numerous, typically producing both short-term and longterm impacts. In surface waters, elevated concentrations of particulate matter in the water column can produce both chronic and acute toxic effects in fish.

"Sediments deposited in layers in flood plains or terrestrial ecosystems can produce many impacts associated with surface waters, ground water, and terrestrial ecosystems. Minerals associated with deposited sediments may depress the pH of surface runoff thereby mobilising heavy metals that can infiltrate into the surrounding subsoil or can be carried away to nearby surface waters. The associated impacts could include substantial pH depression or metals loading to surface waters and/or persistent contamination of ground water sources. Contaminated sediments may also lower the pH of soils to the extent that vegetation and suitable habitat are lost.

"Beyond the potential for pollutant impacts on human and aquatic life, there are potential physical impacts associated with the increased runoff velocities and volumes from new land disturbance activities. Increased velocities and volumes can lead to downstream flooding, scouring of stream channels, and structural damage to bridge footings and culvert entries. In areas where air emissions have deposited acidic particles and the native vegetation has been destroyed, runoff has the potential to increase the rate of erosion and lead to removal of soil from the affected area. This is particularly true where the landscape is characterised by steep and rocky slopes. Once the soils have been removed, it is difficult for the slope to be revegetated either naturally or with human assistance,

Watersupply :human ,agriculture and industrial
A human can survive without food for 3 weeks or more, but cannot survive without water for more than a few days. In addition, water is essential for producing food. In fact, 70 percent of the world's freshwater use is for agriculture. The remaining 30 percent is split between industrial and household uses, the proportion of which varies from country to country. On average, experts estimate that about 20 percent of the world's freshwater use is for industry and about 10 percent is for household uses.

Agriculture As we have just noted, the largest use of water worldwide is for agriculture. During the last 50 years, as agricultural output has kept up with human population growth, the amount of water used for irrigation throughout the world has more than doubled. Indeed, producing a metric ton of grain (1,000 kg, or 2,200 pounds) requires more than 1 million liters of water (264,000 gallons). Together, India, China, the United States, and Pakistan account for more than half the irrigated land in the world. In the United States, approximately one-third of all freshwater use is for irrigation

IRRIGATION Since agriculture is the greatest consumer of fresh water throughout the world, agriculture presents the greatest potential for conserving water by changing irrigation practices. There are four major techniques for irrigating crops: furrow irrigation, flood irrigation, spray irrigation, and drip irrigation fig below

(a) Furrow irrigation

(b) Flood irrigation

(c) Spray irrigation

(d) Drip irrigation

Irrigation techniques. Several techniques are used for irrigating agricultural crops, each with its own setof costs and benefits.

The oldest technique is furrow irrigation (FIGURE a), which is easy and inexpensive. The farmer digs trenches, or furrows, along the crop rows and fills them with water, which seeps into the ground and provides moisture to plant roots. Furrow irrigation is about 65 percent efficient, meaning that 65 percent of the water is accessible to the plants; the other 35 percent either runs off the field or evaporates. A second technique is flood irrigation (FIGURE b), which involves flooding an entire field with water and letting the water soak in evenly. This technique is generally more disruptive to plant growth than furrow irrigation, but is also slightly more efficient, ranging from 70 to 80 percent efficiency. A third technique is spray irrigation (FIGURE c), which is more expensive than furrow or flood irrigation and also uses a fair amount of energy. Water is pumped from a well into an apparatus that contains a series of spray nozzles that spray water across the field, like giant lawn sprinklers. The advantage of spray irrigation is that it is 75 to 95 percent efficient. The fourth technique is drip irrigation (FIGURE d), which uses a slowly dripping hose that is either laid on the ground or buried beneath the soil. Drip irrigation using buried hoses is over 95 percent efficient. It has the added benefit of reducing weed growth because the surface soil remains dry, which discourages weed germination. Drip irrigation systems are particularly useful in fields containing perennial crops such as orchard trees, where the hoses do not have to be moved for annual plowing of the field. Efficient irrigation technology benefits the environment by reducing water consumption and by reducing the amount of energy needed to deliver the water. However, as with all human activities, the trade-offs involved in each irrigation technique (water costs, energy costs, and equipment costs) need to be weighed to determine the best solution for each situation.

Industry

Water is required for many industrial processes, such as generating electricity, cooling machinery, and refining metals and paper. In the United States, approximately one-half of all water used goes toward generating electricity. It is important to distinguish between water that is withdrawn from and returned to its source and water that is withdrawn and consumed. For example, water that passes through a turbine at a hydroelectric dam is withdrawn from a reservoir to generate electricity, but that water is not consumed. It passes from the reservoir through the turbine and back to the river flowing away from the dam. That is not to say that this process has no effect on the environment. We discussed the ecological impacts of damming rivers earlier in this chapter. In addition, passing millions of gallons of water through a spinning turbine kills millions of fish each year. Some processes that generate electricity do consume water. This means that some of the water used is not returned to the source from which it was removed, but instead enters the atmosphere as water vapor. Thermoelectric power plants, including the many plants that generate heat using coal or nuclear reactors, are large consumers of water. These plants use heat to convert water into steam, which is then used to turn turbines. The steam needs to be cooled and condensed before it can be returned to the water’s source. In many plants, this cooling is accomplished using massive cooling towers. If you have ever seen a nuclear power plant, even from a distance, you may have seen the large plumes of water vapor rising up for thousands of meters from the cooling towers. The towers allow much of the steam from the plant to condense and cool into liquid water, but a large fraction of it is lost to the atmosphere. This water vapor represents the water that is consumed by nuclear reactors.The refining of metals and paper also requires large amounts of water. Copper, used extensively for electrical wiring, re-quires 440 L (116 gallons) of water per kilogram to refine. Aluminum, used in products as diverse as automobiles and aluminum foil for cooking, requires 410 L (108 gallons) per kilogram. Steel, used to manufacture home appliances, cars, buildings, and other products, requires 260 L (68 gallons) per kilogram. When we use paper, we indirectly use water. A kilogram of paper requires 125 L (33 gallons) of water to manufacture. All of this means that a great deal of water is used in industry.

Societal implication of major hydroelectric ,industrial and nuclear projects.

Impacts of hydroelectric projects

Land Use

The size of the reservoir created by a hydroelectric project can vary widely, depending largely on the size of the hydroelectric generators and the topography of the land. Hydroelectric plants in flat areas tend to require much more land than those in hilly areas or canyons where deeper reservoirs can hold more volume of water in a smaller space.

At one extreme, the large Balbina hydroelectric plant, which was built in a flat area of Brazil, flooded 2,360 square kilometers—an area the size of Delaware—and it only provides 250 MW of power generating capacity (equal to more than 2,000 acres per MW) [1]. In contrast, a small 10 MW run-of-the-rive plant in a hilly location can use as little 2.5 acres (equal to a quarter of an acre per MW)

Flooding land for a hydroelectric reservoir has an extreme environmental impact: it destroys forest, wildlife habitat, agricultural land, and scenic lands. In many instances, such as the Three Gorges Dam in China, entire communities have also had to be relocated to make way for reservoirs.

Wildlife Impacts

Dammed reservoirs are used for multiple purposes, such as agricultural irrigation, flood control, and recreation, so not all wildlife impacts associated with dams can be directly attributed to hydroelectric power. However, hydroelectric facilities can still have a major impact on aquatic ecosystems. For example, though there are a variety of methods to minimize the impact (including fish ladders and in-take screens), fish and other organisms can be injured and killed by turbine blades.

Apart from direct contact, there can also be wildlife impacts both within the dammed reservoirs and downstream from the facility. Reservoir water is usually more stagnant than normal river water. As a result, the reservoir will have higher than normal amounts of sediments and nutrients, which can cultivate an excess of algae and other aquatic weeds. These weeds can crowd out other river animal and plant-life, and they must be controlled through manual harvesting or by introducing fish that eat these plants . In addition, water is lost through evaporation in dammed reservoirs at a much higher rate than in flowing rivers.

In addition, if too much water is stored behind the reservoir, segments of the river downstream from the reservoir can dry out. Thus, most hydroelectric operators are required to release a minimum amount of water at certain times of year. If not released appropriately, water levels downstream will drop and animal and plant life can be harmed. In addition, reservoir water is typically low in dissolved oxygen and colder than normal river water. When this water is released, it could have negative impacts on downstream plants and animals. To mitigate these impacts, aerating turbines can be installed to increase dissolved oxygen and multi-level water intakes can help ensure that water released from the reservoir comes from all levels of the reservoir, rather than just the bottom (which is the coldest and has the lowest dissolved oxygen).

Life-cycle Global Warming Emissions

Global warming emissions are produced during the installation and dismantling of hydroelectric power plants, but recent research suggests that emissions during a facility's operation can also be significant. Such emissions vary greatly depending on the size of the reservoir and the nature of the land that was flooded by the reservoir.

Small run-of-the-river plants emit between 0.01 and 0.03 pounds of carbon dioxide quivalent per kilowatt-hour. Lifecycle emissions from large-scale hydroelectric plants built in semi-arid regions are also modest: approximately 0.06 pounds of carbon dioxide equivalent per kilowatt-hour. However, estimates for life-cycle global warming emissions from hydroelectric plants built in tropical areas or temperate peatlands are much higher. After the area is flooded, the vegetation and soil in these areas decomposes and releases both carbon dioxide and methane. The exact amount of emissions depends greatly on site-specific characteristics. However, current estimates suggest that life-cycle emissions can be over 0.5 pounds of carbon dioxide equivalent per kilowatt-hour

To put this into context, estimates of life-cycle global warming emissions for natural gas generated electricity are between 0.6 and 2 pounds of carbon dioxide equivalent per kilowatt-hour and estimates for coal-generated electricity are 1.4 and 3.6 pounds of carbon dioxide equivalent per kilowatt-hour.

Impacts of nuclear projects

The use of nuclear power as a source of domestic energy has increased significantly over the past decade and is expected to continue to do so in the years to come. However, the use of this form of energy does not come without a unique set of consequences. These can range from environmental impact, altering to a great extent the balance in the flora and fauna of a region, to causing social problems to do with social consensus and risk perceptions of people living in the vicinity of such a plant. This paper discusses some of the down-sides nuclear power generation is credited for.

Heat Rejection

As is with the case of thermal power plants (based on fossil fuels), nuclear power plants require some means by which they can expel heat as part of their condenser system. The amount of heat varies from the different components used in the plant but on an average about 60 to 70% of thermal energy from the nuclear fuel is rejected out of the plant. Some plants use cooling towers while some use a large body of water, such as an artificial lake or a natural body of water such as a lake or a river. It also adversely affects the aquatic life of the ecosystem into which heat is rejected. In some cases, the heat rejected into water bodies can cause fluctuations in flow rates of rivers and anomalies in sea level. One particular research done showed an average rise in sea level of about 3mm/yr of the Northeast coast of US.

Gaseous Emissions

The gaseous emissions from a nuclear power plant can be of different forms and intensities. Nuclear power plants use diesel generators as a means for back-up electric power in case of emergencies. Most are also required to run and test these systems once every month to ensure their working. As such, they release greenhouses gases into the atmosphere. These gases primarily consist of carbon dioxide, carbon monoxide, nitrous oxides and sulfur dioxides. Apart from greenhouse gases, exhaust gases from buildings containing radioactive processes is radioactive in nature. In addition, in plants with boiling water reactors, the air ejector exhaust is radioactive as well. Such exhausts are passed through delay pipes, storage tanks and hydrogen recombines before release into the environment to ensure that radiation levels are in accordance to regulations. Radioactive exhaust from nuclear power plants is also known to cause skin problems of several kinds.

Environmental Impact

Perhaps the impact which is easiest to notice is the effect on the environment, particularly in terms of flora and fauna. To start with, the setting up of a nuclear plant requires a large area, preferably situated near a natural water body. This is usually accompanied with clearing of forests which disturbs the natural habitat of several creatures and gradually upsets the ecological balance of the region. Apart from this, studies have shown that due to the heat rejected into the water bodies, there have been significant drops in the populations of several species of fish in certain regions of US. Another significant effect is the increased amount of sulfur dioxide in the air which causes acid rain to form which then leads to contamination of surface water bodies of the region, reduction of productivity of the soil, and has several other negative effects on the region's vegetation and human health.

Social Impact

Setting up a nuclear power plant in any region does not come without concerns and criticism from a wide variety of people. People in such regions fear the threat of being exposed to unusual levels of radiation. The natural water sources in such places are also doubted to contain plant emissions especially if the plant uses the body of water as a heat sink. In addition, during the post 9-11 era, there has also been an increased concern over reactor safety and integrity. As such, a lot of effort has to go into convincing the people living around the plant that it is securely designed with several safety measures. Among other impacts that it can have on the region, plant commissioning in a region causes impairment of aesthetic, recreational and natural conservation values and also significantly lowers the value of the surrounding property.

EARTHQUAKE:

Scale of intensity:

Seismic intensity scales categorize the intensity or severity of ground shaking (quaking) at a given location, such as resulting from an earthquake. They are distinguished from seismic magnitude scales, which measure the magnitude or overall strength of an earthquake.
Intensity scales are based on the observed effects of the shaking, such as the degree to which people or animals were alarmed, and the extent and severity of damage to different kinds of structures or natural features. The maximal intensity observed, and the extent of the area where shaking was felt (see isosiesmal map, below), can be used to estimate the location and magnitude of the source earthquake; this is especially useful for historical earthquakes where there is no instrumental record. Ground shaking can be caused in various ways (volcanic tremors, avalanches, large explosions, etc.), but shaking intense enough to casuse damagae is usually due to rupturing of the earth's crust known as earthquakes. The intensity of shaking depends on several factors:

- The "size" or strength of the source event, such as measured by various seismic magnitude scales.
- The type of seismic wave generated, and its orientation.
- The depth of the event.
- The distance from the source event.
- Site response due to local geology

Site response is especially important as certain conditions, such as unconsolidated sediments in a basin, can amplify ground motions as much as ten times.

Where an earthquake is not recorded on seismographs an isoseismic map showing the intensities felt at different areas can be used to estimate the location and magnitude of the quake. Such maps are also useful for estimating the shaking intensity, and thereby the likely level of damage, to be expected from a future earthquake of similar magnitude. In Japan this kind of information is used when an earthquake occurs to anticipate the severity of damage to be expected in different areas.

The intensity of local ground-shaking depends on several factors besides the magnitude of the earthquake, one of the most important being soil conditions. For instance, thick layers of soft soil (such as fill) can amplify seismic waves, often at a considerable distance from the source, while sedimentary basins will often resonate, increasing the duration of shaking. This is why, in the 1989 Loma Prieta earthquake, the Marina district of San Francisco was one of the most damaged areas, though it was nearly 100 km from the epicenter. Geological structures were also significant, such as where seismic waves passing under the south end of San Francisco Bay reflected off the base of the Earth's crust towards San Francisco and Oakland. A similar effect channeled seismic waves between the other major faults in the area.

Preventive Measures against earthquakes

Personal measures

- Seek shelter under stable tables or under door frames.
- If outside, stay away from buildings, bridges and electricity pylons and move to open areas.
- Avoid areas at risk from secondary processes, such as landslides, rockfall and soil liquefaction.
- After an earthquake, check gas, water and electricity pipes and lines for damage.

- Listen to the radio and follow the instructions issued by the authorities.

Technical/biological measures

- No measures can be taken to prevent earthquakes themselves, however limited measures exist that can counteract their secondary effects like landslides, rockfall and soil liquefaction.
- Earthquake-proof planning and design of buildings
- The microzoning of the local geological substratum provides indicators of areas in which tremors will have a particularly strong or attenuated effect.

Organisational measures

- At present, earthquake prediction is insufficiently precise to provide the public with sufficient advance warning. For this reason, adequate preparedness and assistance in catastrophes is extremely important in areas affected by earthquakes. Measures of this nature enable numbers of human lives to be saved.

LANDSLIDES:

A landslide, also known as a landslipor mudslide, is a form of mass wasting that includes a wide range of ground movements, such as rockfalls, deep failure of slopes, and shallow debris flows. Landslides can occur underwater, called a submarine landslide, coastal and onshore environments. Although the action of gravity is the primary driving force for a landslide to occur, there are other contributing factors affecting the original slope stability. Typically, pre-conditional factors build up specific sub-surface conditions that make the slope area prone to failure, whereas the actual landslide often requires a trigger before being released. Landslides should not be confused with mudflows, a form of mass wasting involving very to extremely rapid flow of debris that has become partially or fully liquefied by the addition of significant amounts of water to the source material.

Landslides occur when the slope changes from a stable to an unstable condition. A change in the stability of a slope can be caused by a number of factors, acting together or alone. Natural causes of landslides include:

- groundwater (pore water) pressure acting to destabilize the slope
- loss or absence of vertical vegetative structure, soil nutrients, and soil structure (e.g. after a wildfire – a fire in forests lasting for 3–4 days)
- erosion of the toe of a slope by rivers or ocean waves
- weakening of a slope through saturation by snow melting, glaciers melting, or heavy rain
- earthquakes adding loads to barely stable slope earthquake-caused liquefaction destabilizing slopes volcanic eruptions.

Landslides are aggravated by human activities, such as

- deforestation, cultivation and construction, which destabilize the already fragile slopes.
- vibrations from machinery or traffic

- blasting
- earthwork which alters the shape of a slope, or which imposes new loads on an existing slope
- in shallow soils, the removal of deep-rooted vegetation that binds colluvium to bedrock
- construction, agricultural or forestry activities (logging) which change the amount of water infiltrating the soil.

Prevention and correction of landslides;

Slope vegetation

One the quickest and easiest ways to prevent a landslide on a slope is to vegetate it.this landslide prevention method works best on slopes that are not too steep or if the movement hasn't already begun, this method can be easily done by planting a groundcover or hire a landscaper to vegetate the slope.

Retaining walls

A solid well designed reading should be made of sturdy materials such h as masonry brick stone or steel, drainage material behind the walls help increase the stability of the wall
Diverting debris pathways

Building pathways to divert debris is another option to prevent landslides o your property ,these pathways can be made with the help of retaining walls .

Temporary prevention

For temporary prevention sandbags can be used to divert water from uncontrolled spilling Just as retaining walls or diverted pathways do another method is to protect unstable areas with plastic sheeting, tarps or even burlap especially in the areas with no vegetation because of recent fires.

Floods:

Magnitude and frequency of floods

Urbanization and flooding

Streams are fed by runoff from rainfall and snowmelt moving as overland or subsurface flow. Floods occur when large volumes of runoff flow quickly into streams and rivers. The peak discharge of a flood is influenced by many factors, including the intensity and duration of storms and snowmelt, the topography and geology of stream basins, vegetation, and the hydrologic conditions preceding storm and snowmelt events.

Land use and other human activities also influence the peak discharge of floods by modifying how rainfall and snowmelt are stored on and run off the land surface into streams. In undeveloped areas such as forests and grasslands, rainfall and snowmelt collect and are stored on vegetation, in the soil column, or in surface depressions. When this storage capacity is filled, runoff flows slowly through soil as subsurface flow. In contrast, urban areas, where much of the land surface is covered by roads and buildings, have less capacity to store rainfall and snowmelt. Construction of roads and buildings often involves removing vegetation, soil, and depressions from the land surface. The permeable soil is replaced by impermeable surfaces such as roads, roofs, parking lots, and sidewalks that store little water, reduce infiltration of water into the ground, and accelerate runoff to ditches and streams. Even in suburban areas, where lawns and other permeable landscaping may be common, rainfall and snowmelt can saturate thin soils and produce overland flow, which runs off quickly. Dense networks of ditches and culverts in cities reduce the distance that runoff must travel overland or through subsurface flow paths to reach streams and rivers. Once water enters a drainage network, it flows faster than either overland or subsurface flow. With less storage capacity for water in urban basins and more rapid runoff, urban streams rise more quickly during storms and have higher peak discharge rates than do rural streams. In addition, the total volume of water discharged during a flood tends to be larger for urban streams than for rural streams. For example, streamflow in Mercer Creek, an urban stream in western Washington, increases earlier and more rapidly, has a higher peak discharge and volume during the storm on February 1, 2000, and decreases more rapidly than in Newaukum Creek, a nearby rural stream. As with any comparison between streams, the differences in streamflow cannot be attributed solely to land use, but may also reflect differences in geology, topography, basin size and shape, and storm patterns.

The hydrologic effects of urban development often are greatest in small stream basins where, prior to development, much of the precipitation falling on the basin would have become subsurface flow, recharging aquifers or discharging to the stream network further downstream. Moreover, urban development can completely transform the landscape in a small stream basin, unlike in larger river basins where areas with natural vegetation and soil are likely to be retained.

Nature and extent of flood hazard

A flood occurs when water overflows or inundates land that's normally dry. This can happen in a multitude of ways. Most common is when rivers or streams overflow their banks. Excessive rain, a ruptured dam or levee, rapid ice melting in the mountains, or even an unfortunately placed beaver dam can overwhelm a river and send it spreading over the adjacent land, called a floodplain. Coastal flooding occurs when a large storm or tsunami causes the sea to surge inland.

Most floods take hours or even days to develop, giving residents ample time to prepare or evacuate. Others generate quickly and with little warning. These flash floods can be extremely dangerous, instantly turning a babbling brook into a thundering wall of water and sweeping everything in its path downstream.

Disaster experts classify floods according to their likelihood of occurring in a given time period. A hundred-year flood, for example, is an extremely large, destructive event that would theoretically be expected to happen only once every century. But this is a theoretical number. In reality, this classification means there is a one-percent chance that such a flood could happen in any given year. Over recent decades, possibly due to global climate change, hundred-year floods have been occurring worldwide with frightening regularity.

Hazards associated with flooding can be divided into primary hazards that occur due to contact with water, secondary effects that occur because of the flooding, such as disruption of services, health impacts such as famine and disease, and tertiary effects such as changes in the position of river channels. Throughout the last century flooding has been one of the most costly disasters in terms of both property damage and human casualties. Major floods in China, for example, killed about 2 million people in 1887, nearly 4 million in 1931, and about 1 million in 1938 The 1993 flood on the upper Mississippi River and Midwest killed only 47 people, but the U.S. Army Corps of Engineers estimates the total economic loss at between 15 and 20 billion dollars.

Primary Effects

Again, the primary effects of floods are those due to direct contact with the flood waters. As seen in the video last lecture, water velocities tend to be high in floods. As discharge increases velocity increases.

- With higher velocities, streams are able to transport larger particles as suspended load. Such large particles include not only rocks and sediment, but, during a flood, could include such large objects as automobiles, houses and bridges.
- Massive amounts of erosion can be accomplished by flood waters. Such erosion can undermine bridge structures, levees, and buildings causing their collapse.
- Water entering human built structures cause water damage. Even with minor flooding of homes, furniture is ruined, floors and walls are damaged, and anything that comes in contact with the water is likely to be damaged or lost. Flooding of automobiles usually results in damage that cannot easily be repaired.
- The high velocity of flood waters allows the water to carry more sediment as suspended load. When the flood waters retreat, velocity is generally much lower and sediment is deposited. After retreat of the floodwaters everything is usually covered with a thick layer of stream deposited mud, including the interior of buildings.
- Flooding of farmland usually results in crop loss. Livestock, pets, and other animals are often carried away and drown.
- Humans that get caught in the high velocity flood waters are often drowned by the water.
- Floodwaters can concentrate garbage, debris, and toxic pollutants that can cause the secondary effects of health hazards.

Secondary and Tertiary Effects

Remember that secondary effects are those that occur because of the primary effects and tertiary effects are the long term changes that take place. Among the secondary effects of a flood are:

- Disruption of services - o Drinking water supplies may become polluted, especially if sewerage treatment plants are flooded. This may result in disease and other health effects, especially in under developed countries.

- Gas and electrical service may be disrupted.
- Transportation systems may be disrupted, resulting in shortages of food and clean-up supplies. In under developed countries food shortages often lead to starvation.

• Long - term effects (tertiary effects)-
  - Location of river channels may change as the result of flooding, new channels develop, leaving the old channels dry.
  - Sediment deposited by flooding may destroy farm land (although silt deposited by floodwaters could also help to increase agricultural productivity).
  - Jobs may be lost due to the disruption of services, destruction of business, etc. (although jobs may be gained in the construction industry to help rebuild or repair flood damage).
  - Insurance rates may increase.
  - Corruption may result from misuse of relief funds.
  - Destruction of wildlife habitat

Coastal hazards:

Tropical cyclones:

A flood occurs when water overflows or inundates land that's normally dry. This can happen in a multitude of ways. Most common is when rivers or streams overflow their banks. Excessive rain, a ruptured dam or levee, rapid ice melting in the mountains, or even an unfortunately placed beaver dam can overwhelm a river and send it spreading over the adjacent land, called a floodplain. Coastal flooding occurs when a large storm or tsunami causes the sea to surge inland.

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How do tropical cyclones form?

In the tropics there is a broad zone of low pressure which stretches either side of the equator. The winds on the north side of this zone blow from the north-east (the north-east trades) and on the southern side blow from the south-east (south-east trades).

Within this area of low pressure the air is heated over the warm tropical ocean. This air rises in discrete parcels, causing thundery showers to form. These showers usually come and go, but from time to time, they group together into large clusters of thunderstorms. This creates a flow of very warm, moist, rapidly rising air, leading to the development of a centre of low pressure, or depression, at the surface.

There are various trigger mechanisms required to transform these cloud clusters into a tropical cyclone. These trigger mechanisms depend on several conditions being 'right' at the same time. The most influential factors are:

1. a source of warm, moist air derived from tropical oceans with sea surface temperatures normally in the region of, or in excess, of 27 °C;
2. winds near the ocean surface blowing from different directions converging and causing air to rise and storm clouds to form;
3. winds which do not vary greatly with height - known as low wind shear. This allows the storm clouds to rise vertically to high levels;
4. sufficient distance from the equator to provide spin or twist.

The Coriolis force caused by the rotation of the Earth helps the spin of this column of rising air. The development of the surface depression causes an increase in the strength of the trade winds. The spiralling winds accelerate inwards and upwards, releasing heat and moisture as they do so.

As the depression strengthens it becomes a tropical storm and then a hurricane or typhoon. A mature hurricane or typhoon takes the form of a cylinder of deep thundercloud around a centre that is relatively free from clouds. There is a relatively small area of intense horizontal winds at the surface, often well over 100 m.p.h., while air rises strongly above, maintaining the deep cumulonimbus clouds.

Further aloft at about six miles, the cloud tops are carried outwards to give thick layer clouds due to the outwardspiralling winds leaving the tropical cyclone core. At the centre of the tropical cyclone, air is subsiding, which makes it dry and often cloud free, and there is little or no wind at the surface. This is called the eye of the storm.

Tsunamis:

Tsunamis are giant waves caused by earthquakes or volcanic eruptions under the sea. Out in the depths of the ocean, tsunami waves do not dramatically increase in height. But as the waves travel inland, they build up to higher and higher heights as the depth of the ocean decreases. The speed of tsunami waves depends on ocean depth rather than the distance from the source of the wave. Tsunami waves may travel as fast as jet planes over deep waters, only slowing down when reaching shallow waters. While tsunamis are often referred to as tidal waves, this name is discouraged by oceanographers because tides have little to do with these giant waves.

Tsunami waves do not resemble normal undersea currents or sea waves because their wavelength is far longer.[5] Rather than appearing as a breaking wave, a tsunami may instead initially resemble a rapidly rising tide. For this reason, it is often referred to as a "tidal wave", although this usage is not favoured by the scientific community as it might give the false impression of a causal relationship between tides and tsunamis. Tsunamis generally consist of a series of waves, with periods ranging from minutes to hours, arriving in a so-called "internal wave train".[6] Wave heights of tens of metres can be generated by large events. Although the impact of tsunamis is limited to coastal areas, their destructive power can be enormous, and they can affect entire ocean basins. The 2004 Indian Ocean tsunami was among the deadliest natural disasters in human history, with at least 230,000 people killed or missing in 14 countries bordering the Indian Ocean

Tidal wave

Tsunami aftermath in Aceh, Indonesia, December 2004.

Tsunamis are sometimes referred to as tidal waves.[10] This once-popular term derives from the most common appearance of a tsunami, which is that of an extraordinarily high tidal bore. Tsunamis and tides both produce waves of water that move inland, but in the case of a tsunami, the inland movement of water may be much greater, giving the impression of an incredibly high and forceful tide. In recent years, the term "tidal wave" has fallen out of favour, especially in the scientific community, because the causes of tsunamis have nothing to do with those of tides, which are produced by the gravitational pull of the moon and sun rather than the displacement of water. Although the meanings of "tidal" include "resembling"[11] or "having the form or character of"[12] the tides, use of the term tidal wave is discouraged by geologists and oceanographers.

Seismic sea wave

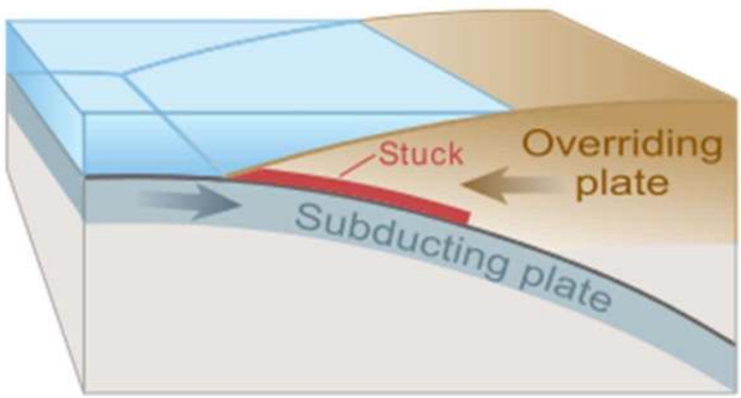
The term seismic sea wave also is used to refer to the phenomenon, because the waves most often are generated by seismic activity such as earthquakes.[13] Prior to the rise of the use of the term tsunami in English, scientists generally encouraged the use of the term seismic sea wave rather than tidal wave. However, like tsunami, seismic sea wave is not a completely accurate term, as forces other than earthquakes – including underwater landslides, volcanic eruptions, underwater explosions, land or ice slumping into the ocean, meteorite impacts, and the weather when the atmospheric pressure changes very rapidly – can generate such waves by displacing water.

Causes

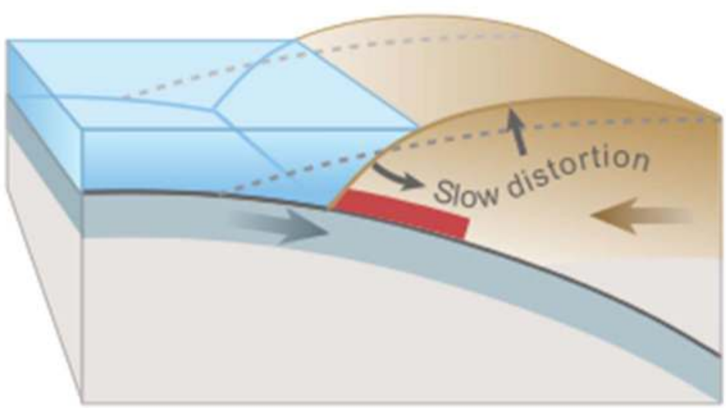
The principal generation mechanism (or cause) of a tsunami is the displacement of a substantial volume of water or perturbation of the sea.[21] This displacement of water is usually attributed to either earthquakes, landslides, volcanic eruptions, glacier calvings or more rarely by meteorites and nuclear tests.[22][23] The waves formed in this way are then sustained by gravity.[how?]

Seismicity

Tsunami can be generated when the sea floor abruptly deforms and vertically displaces the overlying water. Tectonic earthquakes are a particular kind of earthquake that are associated with the Earth's crustal deformation; when these earthquakes occur beneath the sea, the water above the deformed area is displaced from its equilibrium position.[24] More specifically, a tsunami can be generated when thrust faults associated with convergent or destructive plate boundaries move abruptly, resulting in water displacement, owing to the vertical component of movement involved. Movement on normal (extensional) faults can also cause displacement of the seabed, but only the largest of such events (typically related to flexure in the outer trench swell) cause enough displacement to give rise to a significant tsunami, such as the 1977 Sumba and 1933 Sanriku events.[25][26]

- 

Drawing of tectonic plate boundary before earthquake

- 

Overriding plate bulges under strain, causing tectonic uplift.

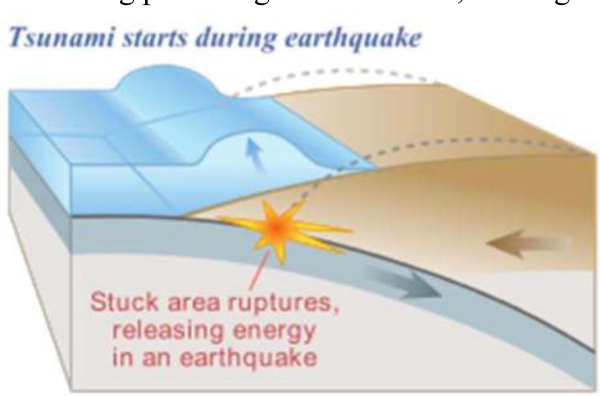
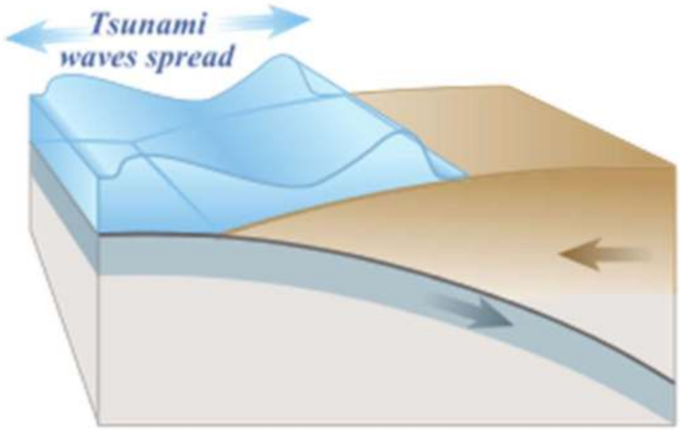
- 

Plate slips, causing subsidence and releasing energy into water.



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The energy released produces tsunami waves.

Tsunamis have a small amplitude (wave height) offshore, and a very long wavelength (often hundreds of kilometres long, whereas normal ocean waves have a wavelength of only 30 or 40 metres),[27] which is why they generally pass unnoticed at sea, forming only a slight swell usually about 300 millimetres (12 in) above the normal sea surface. They grow in height when they reach shallower water, in a wave shoaling process described below. A tsunami can occur in any tidal state and even at low tide can still inundate coastal areas.

On April 1, 1946, the 8.6 M_w Aleutian Islands earthquake occurred with a maximum Mercalli intensity of VI (Strong). It generated a tsunami which inundated Hilo on the island of Hawaii with a 14-metre high (46 ft) surge. Between 165 and 173 were killed. The area where the earthquake occurred is where the Pacific Ocean floor is subducting (or being pushed downwards) under Alaska.

Examples of tsunami originating at locations away from convergent boundaries include Storegga about 8,000 years ago, Grand Banks 1929, Papua New Guinea 1998 (Tappin, 2001). The Grand Banks and Papua New Guinea tsunamis came from earthquakes which destabilised sediments, causing them to flow into the ocean and generate a tsunami. They dissipated before travelling transoceanic distances.

The cause of the Storegga sediment failure is unknown. Possibilities include an overloading of the sediments, an earthquake or a release of gas hydrates (methane etc.).
The 1960 Valdivia earthquake (M_w 9.5), 1964 Alaska earthquake (M_w 9.2), 2004 Indian Ocean earthquake (M_w 9.2), and 2011 Tōhoku earthquake (M_w9.0) are recent examples of powerful megathrust earthquakes that generated tsunamis (known as teletsunamis) that can cross entire oceans. Smaller (M_w 4.2) earthquakes in Japan can trigger tsunamis (called local and regional tsunamis) that can devastate stretches of coastline, but can do so in only a few minutes at a time.

Landslides

In the 1950s, it was discovered that larger tsunamis than had previously been believed possible could be caused by giant submarine landslides. These rapidly displace large water volumes, as energy transfers to the water at a rate faster than the water can absorb. Their existence was confirmed in 1958, when a giant landslide in Lituya Bay, Alaska, caused the highest wave ever recorded, which had a height of 524 metres (over 1700 feet).[28] The wave did not travel far, as it struck land almost immediately. Two people fishing in the bay were killed, but another boat managed to ride the wave.

Another landslide-tsunami event occurred in 1963 when a massive landslide from Monte Toc entered the Vajont Dam in Italy. The resulting wave surged over the 262 m (860 ft) high dam by 250 metres (820 ft) and destroyed several towns. Around 2,000 people died.[29][30] Scientists named these waves megatsunamis.

Some geologists claim that large landslides from volcanic islands, e.g. Cumbre Vieja on La Palma in the Canary Islands, may be able to generate megatsunamis that can cross oceans, but this is disputed by many others.

In general, landslides generate displacements mainly in the shallower parts of the coastline, and there is conjecture about the nature of large landslides that enter the water. This has been shown to subsequently affect water in enclosed bays and lakes, but a landslide large enough to cause a transoceanic tsunami has not occurred within recorded history. Susceptible locations are believed to be the Big Island of Hawaii, Fogo in the Cape Verde Islands, La Reunion in the Indian Ocean, and Cumbre Vieja on the island of La Palma in the Canary Islands; along with other volcanic ocean islands. This is because large masses of relatively unconsolidated volcanic material occurs on the flanks and in some cases detachment planes are believed to be developing. However, there is growing controversy about how dangerous these slopes actually are.

Meteotsunamis

Some meteorological conditions, especially rapid changes in barometric pressure, as seen with the passing of a front, can displace bodies of water enough to cause trains of waves with wavelengths comparable to seismic tsunamis, but usually with lower energies. These are essentially dynamically equivalent to seismic tsunamis, the only differences being that meteotsunamis lack the transoceanic reach of significant seismic tsunamis and that the force that displaces the water is sustained over some length of time such that meteotsunamis can't be modelled as having been caused instantaneously. In spite of their lower energies, on shorelines where they can be amplified by resonance, they are sometimes powerful enough to cause localised damage and potential for loss of life. They have been documented in many places, including the Great Lakes, the Aegean Sea, the English Channel, and the Balearic Islands, where they are common enough to have a local name, rissaga. In Sicily they are called marubbio and in Nagasaki Bay, they are called abiki. Some examples of destructive meteotsunamis include 31 March 1979 at Nagasaki and 15 June 2006 at Menorca, the latter causing damage in the tens of millions of euros.[32]

Meteotsunamis should not be confused with storm surges, which are local increases in sea level associated with the low barometric pressure of passing tropical cyclones, nor should they be confused with setup, the temporary local raising of sea level caused by strong on-shore winds. Storm surges and setup are also dangerous causes of coastal flooding in severe weather but their dynamics are completely unrelated to tsunami waves.[32] They are unable to propagate beyond their sources, as waves do.

Coastal erosion:

Coastal erosion is the wearing away of material from a coastal profile including the removal of beach, sand dunes, or sediment by wave action, tidal currents, wave currents, drainage or high winds (see also beach evolution). Waves, generated by storms, wind, or fast moving motor craft, can cause coastal erosion, which may take the form of long-term losses of sediment and rocks, or merely the temporary redistribution of coastal sediments; erosion in one location may result in accretion nearby. The study of erosion and sediment redistribution is called coastal morphodynamics. It may be caused by hydraulic action, abrasion, impact and corrosion by wind, water, and other forces, natural or unnatural.

On non-rocky coasts, coastal erosion results in rock formations in areas where the coastline contains rock layers or fracture zones with varying resistance to erosion. Softer areas become eroded much faster than harder ones, which typically result in landforms such as tunnels, bridges, columns, and pillars. Over time the coast generally evens out. The softer areas fill up with sediment eroded from hard areas, and rock formations are eroded away.[1] Also abrasion commonly happens in areas where there are strong winds, loose sand, and soft rocks. The blowing of millions of sharp sand grains creates a sandblasting effect. This effect helps to erode, smooth and polish rocks. The definition of abrasion is grinding and wearing away of rock surfaces through the mechanical action of other rock or sand particles. Factors that influence erosion rates

Primary factors

The ability of waves to cause erosion of the cliff face depends on many factors.

The hardness (or inversely, the erodibility) of sea-facing rocks is controlled by the rock strength and the presence of fissures, fractures, and beds of non-cohesive materials such as silt and fine sand.

The rate at which cliff fall debris is removed from the foreshore depends on the power of the waves crossing the beach. This energy must reach a critical level to remove material from the debris lobe. Debris lobes can be very persistent and can take many years to completely disappear.

Beaches dissipate wave energy on the foreshore and provide a measure of protection to the adjoining land.

The stability of the foreshore, or its resistance to lowering. Once stable, the foreshore should widen and become more effective at dissipating the wave energy, so that fewer and less powerful waves reach beyond it. The provision of updrift material coming onto the foreshore beneath the cliff helps to ensure a stable beach.

The adjacent bathymetry, or configuration of the seafloor, controls the wave energy arriving at the coast, and can have an important influence on the rate of cliff erosion. Shoals and bars offer protection from wave erosion by causing storm waves to break and dissipate their energy before reaching the shore. Given the dynamic nature of the seafloor, changes in the location of shoals and bars may cause the locus of beach or cliff erosion to change position along the shore.

Coastal erosion has been greatly affected by the rising sea levels globally. There has been great measures of increased coastal erosion on the Eastern seaboard of the United States. Locations such as Florida have noticed increased coastal erosion. In reaction to these increases Florida and its individual counties have increased budgets to replenish the eroded sands that attract visitors to Florida and help support its multibillion-dollar tourism industries.

Introduction to GIS and its applications:

Semester 6

GIS (Geographic Information System) is a kind of software that enables: • The collection of spatial data from different sources (Remote Sensing being one of them). • Relating spatial and tabular data. • Performing tabular and spatial analysis. • Symbolize and design the layout of a map. A GIS software can handle both vector and raster data (some handle only one of them). Remote Sensing data belongs to the raster type, and usually requires special data manipulation procedures that regular GIS does not offer. However, after a Remote Sensing analysis has been done, its results are usually combined within a GIS or into database of an area, for further analysis (overlaying with other layers, etc). In the last years, more and more vector capabilities are being added to Remote Sensing softwares, and some Remote Sensing functions are inserted into GIS modules.

1.Agriculture

GIS application in agribusiness, for example, rural mapping plays a crucial part in the administration of soil and water system of any farmland. The GIS horticulture and farming mapping have primary devices for management of the rural area. They work by creating and executing the precise data into a mapping domain. GIS application in farming additionally helps in administration and control of horticultural assets.

2.DisasterManagement

One of the main areas of GIs application relates to disasters. Disaster GIS application has its uses in the Earthquake prediction, Richter scale mapping, measuring landslide vulnerability, knowing the hurricane response and creating evacuation plans.Specialists can predict the natural disasters and can make the impact of a calamity less.

3.CrimeAnalysisandStatistics

GIS is vital to law enforcement and planning regarding crime analysis. Most cop-forces in the USA are using this GIS application for a long time. Programmed and digital mapping of stated crime has made the method much easy, especially considering the increasing number of crime rates. The strength of this GIS application to share maps and study for correlations between various types of crimes gives police a better opinion of an overall situation. The Crime GIS application helps in responding to crimes in a data-driven way and tracing out the location of criminals. It is also used in making an incident map, auto-theft, and recovery, emergency calls, and dispatch. Furthermore, GIS is helpful in missing body search, forensic, stalking, illegal smuggling location finding and many more uses.

4.Transportation

The GIS application has significant application in transportation, too. It helps in the creation of efficient and safest routes for travel or products delivery and outlining traffic rules. More usages include parking problems, logistics management, street repair, airline and railway planning, urban traffic air pollution, etc

5:telecommunications

Radio-wave propagation, locating cell towers, network management, antenna height optimization are some of the uses of GIS application. The task of ensuring the proper network functions including billing, outages, and testing by GIS shared services.

6.Archaeology

This GIS application also holds utmost importance. GIS is presently basic to numerous components of archaeology as it goes up against more elements and attributes of environmental science.Revealing lost cities with the help of LiDAR, doing the archaeological survey, geographic text analysis, site investigation, 3D archaeology are the areas to work, to name a few.

7.Public Health

The global disease monitoring in real-time for creating health map, tracking the outbreak and spread of various dreadful diseases like Ebola, Asthma, etc. is one of the main jobs. Finding distance to health care and public health informatics are also equally important tasks of GIS application.

8.GIS Mapping

Mapping serves as the one of the extensive functionality of GIS application. It is used for mapping the spatial location of genuine-world specialties and imagine the spatial connections among them. It studies the relations between different places, mapping population density. Also, scanning the land areas and finding out what is happening in an area. These are few examples of various fields where GIS mapping is used.So, here are some of the majorly known areas of GIS application and so are the opportunities in various fields; be it Government or Private Job sector.Don't forget to explore more areas as there are thousands of them.

INTRODUCTION

Stratigraphy, scientific discipline concerned with the description of rock successions and their interpretation in terms of a general time scale. It provides a basis for historical geology, and its principles and methods have found application in such fields as petroleum geology and archaeology.

Stratigraphic studies deal primarily with sedimentary rocks but may also encompass layered igneous rocks (e.g., those resulting from successive lava flows) or metamorphic rocks formed either from such extrusive igneous material or from sedimentary rocks.

A common goal of stratigraphic studies is the subdivision of a sequence of rock strata into mappable units, determining the time relationships that are involved, and correlating units of the sequence—or the entire sequence—with rock strata elsewhere. Following the failed attempts during the last half of the 19th century of the International Geological Congress (IGC; founded 1878) to standardize a stratigraphic scale, the International Union of Geological Sciences (IUGS; founded 1961) established a Commission on Stratigraphy to work toward that end. Traditional stratigraphic schemes rely on two scales: (1) a time scale (using eons, eras, periods, epochs, ages, and chrons), for which each unit is defined by its beginning and ending points, and (2) a correlated scale of rock sequences (using systems, series, stages, and chronozones). These schemes, when used in conjunction with other dating methods—such as radiometric dating (the measurement of radioactive decay), paleoclimatic dating, and paleomagnetic determinations—that, in general, were developed within the last half of the 20th century, have led to somewhat less confusion of nomenclature and to ever more reliable information on which to base conclusions about Earth history.

Because oil and natural gas almost always occur in stratified sedimentary rocks, the process of locating petroleum reservoir traps has been facilitated significantly by the use of stratigraphic concepts and data.An important principle in the application of stratigraphy to archaeology is the law of superposition—the principle that in any undisturbed deposit the oldest layers are normally located at the lowest level. Accordingly, it is presumed that the remains of each succeeding generation are left on the debris of the last.

STRATIGRAPHIC LAWS

Stratigraphic Laws are basic principles that all geologists use in deciphering the spatial and temporal relationships of rock layers. These laws were developed in the 17th to 19th centuries based upon the work of Niels Steno, James Hutton and William Smith, among others. Stratigraphic laws include the following:

1. Original Horizontality- all sedimentary rocks are originally deposited horizontally. Sedimentary rocks that are no longer horizontal have been tilted from their original position.

"Strata either perpendicular to the horizon or inclined to the horizon were at one time parallel to the horizon."

2. Lateral Continuity- sedimentary rocks are laterally continuous over large areas. A useful way for Wisconsinites to consider this law is to think of snowfalls. As snow falls, it is not limited to the intersection of Main and Division streets, nor UWSP campus, but falls over a larger area such as Central Wisconsin. Sediments also "rain" down in a simialr fashion such that sedimentary layers are laterally continuous over an area similar to, or greater than, Central Wisconsin. "Material forming any stratum were continuous over the surface of the Earth unless some other solid bodies stood in the way."

3. Superposition

"...at the time when any given stratum was being formed, all the matter resting upon it was fluid, and, therefore, at the time when the lower stratum was being formed, none of the upper strata existed." Steno, 1669.

4. Cross-Cutting Relations

"If a body or discontinuity cuts across a stratum, it must have formed after that stratum." Steno, 1669.

5. Law of Inclusions- this law states that rock fragments (in another rock) must be older than the rock containing the fragments

6.Law of Faunal Succession- This law was developed by William "Strata" Smith who recognized that fossil groups were succeeded by other fossil groups through time. This allowed geologists to develop a fossil stratigraphy and provided a means to correlate rocks throughout the world. Stratigraphic Correlation

Correlation is, as mentioned earlier, the technique of piecing together the informational content of separated outcrops. When information derived from two outcrops is integrated, the time interval they represent is probably greater than that of each alone. Presumably if all the world's outcrops were integrated, sediments representing all of geologic time would be available for examination. This optimistic hope, however, must be tempered by the realization that much of the Precambrian record—older than 541 million years—is missing. Correlating two separated outcrops means establishing that they share certain characteristics indicative of contemporary formation. The most useful indication of time equivalence is similar fossil content, provided of course that such remains are present. The basis for assuming that like fossils indicate contemporary formation is faunal succession. However, as previously noted, times of volcanism and metamorphism, which are both critical parts of global processes, cannot be correlated by fossil content. Furthermore, useful fossils are either rare or totally absent in rocks from Precambrian time, which constitutes more than 87 percent of Earth history. Precambrian rocks must therefore be correlated by means of precise isotopic dating.

Unlike the principles of superposition and crosscutting, faunal succession is a secondary principle. That is to say, it depends on other sequence-determining principles for establishing its validity. Suppose there exist a number of fossilbearing outcrops each composed of sedimentary layers that can be arranged in relative order, primarily based on superposition. Suppose, too, that all the layers contain a good representation of the animal life existing at the time of deposition. From an examination of such outcrops with special focus on the sequence of animal forms comes the empirical generalization that the faunas of the past have followed a specific order of succession, and so the relative age of a fossiliferous rock is indicated by the types of fossils it contains.

The geologic time scale is based principally on the relative ages of sequences of sedimentary strata. Establishing the ages of strata within a region, as well as the ages of strata in other regions and on different continents, involves stratigraphic correlation from place to place. Although correlation of strata over modest distances often can be accomplished by tracing particular beds from place to place, correlation over long distances and over the oceans almost invariably involves comparison of fossils. With rare exceptions, fossils occur only in sedimentary strata. Paleontology, which is the science of ancient life and deals with fossils, is mutually interdependent with stratigraphy and with historical geology. Paleontology also may be considered to be a branch of biology.

Organic evolution is the essential principle involved in the use of fossils for stratigraphic correlation. It incorporates progressive irreversible changes in the succession of organisms through time. A small proportion of types of organisms has undergone little or no apparent change over long intervals of geologic time, but most organisms have progressively changed, and earlier forms have become extinct and, in turn, have been succeeded by more modern forms. Organisms preserved as fossils that lived over a relatively short span of geologic time and that were geographically widespread are particularly useful for stratigraphic correlation. These fossils are indexes of relative geologic age and may

Stratigraphic nomenclature

The naming of stratigraphic and geologic-time units according to established practices and principles. Formal naming of a stratigraphic unit occurs when the unit is first proposed and described from a type section (see STRATOTYPE), which acts thereafter as the standard reference for that unit. Ideally, the name given is binomial, and in the case of chronostratigraphic and lithostratigraphic units consists of a preceding geographic name taken from the type locality (plus lithological description where appropriate), followed by the name of the unit, e.g. Ludlow Series and Elk Point Group. The names of biostratigraphic units consist of the name of the characteristic fossil plus the relevant unit term, e.g. Monograptus uniformis Range zone. The name chosen for a stratigraphic unit should be unique to that unit. When used as a proper name, as above, the initial letters are capitalized. Except in very special circumstances the first formal name given has priority and is adhered to. In practice many well-known units, e.g. Coal Measures, Millstone Grit, were named long before the present conventions were established, and to avoid confusion these names are preserved in their original form. Geologic-time units generally take their preceding name from that of the corresponding chronostratigraphic unit, plus the name of the unit (period, epoch, age, etc.), e.g. the Jurassic Period, from the Jurassic System (named after the type area in the Jura Mountains). The names of eons and eras (e.g. Phanerozoic Eon, Mesozoic Era) were proposed independently, so that the names for the corresponding eonothems and erathems are derived from the time units

Precambrian

The Precambrian (or Pre-Cambrian, sometimes abbreviated pЄ, or Cryptozoic) is the earliest part of Earth's history, set before the current Phanerozoic Eon. The Precambrian is so named because it preceded the Cambrian, the first period of the Phanerozoic eon, which is named after Cambria, the Latinised name for Wales, where rocks from this age were first studied. The Precambrian accounts for 88% of the Earth's geologic time.The Precambrian (colored green in the timeline figure) is a supereon that is subdivided into three eons (Hadean, Archean, Proterozoic) of the geologic time scale. It spans from the formation of Earth about 4.6 billion years ago (Ga) to the beginning of the Cambrian Period, about 541 million years ago (Ma), when hard-shelled creatures first appeared in abundance.

Dharwar Craton

The Dharwar or Karnataka Craton in South India is a piece of the earth's crust that dates back to the late Archean. As part of the Indian Shield, it has been a relatively stable geologic terrain for several billion years. The bedrock in this region formed between 3.6 and 2.5 billion years ago. The Dharwar Craton lies roughly between Chennai, Goa, Hyderabad, and Mangalore in Karnataka and Andhra Pradesh states.it is also called dharwad now days Geological History and Significance

The Dharwar Craton presents a natural cross-section of late-Archaean continental nuclei lying between longitude 72°45′–80° and latitudes 11°–19°. It is an elliptical region comprising a number of subparallel supracrustal belts. The term Dharwar craton was introduced by the Geological Survey of India to avoid confusion with early lithologies. There are three main structural zones: a root zone of highly heterogeneous petrology (from monzonite to granite) and texture (phenocryst accumulation), a "channel zone" where evidences of large scale magma ascent can be observed, and a zone of superficial intrusions, consisting in independent homogeneous intrusive bodies. In the root zone, mantle-derived magma underwent fractional crystallisation which was followed by mingling between the residual liquids and melts generated by anatexis of the surrounding gneissic basement. It is divided into eastern Dharwar Craton and western Dharwar Craton owing to their differences in lithologies and ages.The term Dharwar Supergroup is now used as synonymous with metamorphosed Precambrian sediments and including all the schistose series below the Eparchaean Unconformity. The Dharwarian rocks are mostly unfossiliferous except for the stromatolitic limestones.

Lithology of the Dharwars

The rocks of this age show extremely complex nature with clastic and chemically precipitated sediments, volcanic and plutonic rocks — all of which show varying degrees of metamorphism. The majority of the rocks are often phyllites, schists and slates. There are hornblende-, chlorite-, haematite-, and magnetite- schists, felspathic schists: quartzites and highly altered volcanic rocks, like rhyolites and andesites turned into hornblende-schists; abundant and widespread granitic intrusions; crystalline limestones and marbles; serpentinous marbles; steatite masses; beds of jaspers and massive beds of iron and manganese oxides.

Classification and distribution of aravalli

It consists of two main sequences formed in Proterozoic eon, metasedimentary rock (sedimentary rocks metamorphised under pressure and heat without melting) and metavolcanic rock (metamorphised volcanic rocks) sequences of the Aravalli Supergroup and Delhi Supergroup. These two supergroups rest over the Archean Bhilwara Gneissic Complex basement, which is a gneissic (high-grade metamorphism of sedimentary or igneous rocks) basement formed during the archean eon 4 Ga ago. It started as an inverted basin, that rifted and pulled apart into granitoid basement, initially during Aravalli passive rifting around 2.5 to 2.0 Ga years ago and then during Delhi active rifting around 1.9 to 1.6 Ga years ago. It started with rifting of a rigid Archaean continent banded gneissic complex around 2.2 Ga with the coexisting formation of the Bhilwara aulacogen in its eastern part and eventual rupturing and separation of the continent along a line parallel to the Rakhabdev (Rishabhdev) lineament to the west, simultaneous development of a passive continental margin with the undersea shelf rise sediments of the Aravalli-Jharol belts depositing on the attenuated crust on the eastern flank of the separated continent, subsequent destruction of the continental margin by accretion of the Delhi island arc (a type of archipelago composed of an arc-shaped chain of volcanoes closely situated parallel to a convergent boundary between two converging tectonic plates) from the west around 1.5 Ga. This tectonic plates collision event involved early thrusting with partial obduction (overthrusting of oceanic lithosphere onto continental lithosphere at a convergent plate boundary) of the oceanic crust along the Rakhabdev lineament, flattening and eventual wrenching (also called strike-slip plate fault, side ways horizontal movement of colliding plates with no vertical motion) parallel to the collision zone. Associated mafic igneous rocks show both continental and oceanic tholeiitic geochemistry (magnesium and iron rich igneous rocks) from phanerozoic eon (541–0 million) with rift-related magmatic rock formations.

The Aravalli-Delhi Orogen is an orogen event that led to a large structural deformation of the Earth's lithosphere (crust and uppermost mantle, such as Aravalli and Himalayas fold mountains) due to the interaction between tectonic plates when a continental plate is crumpled and is pushed upwards to form mountain ranges, and involve a great range of geological processes collectively called orogenesis

The Aravalli Range can be divided into the following parts (north to south direction):

- Archean basement, is a Banded Gneissic Complex (BGC) with schists (medium grade metamorphic rock), gneisses (high grade regional metamorphic rock), composite gneiss and quartzites. It forms the basement rock for both Delhi Supergroup and Aravalli Supergroup.
- Delhi Supergroup
  - Alwar Group, with arenaceous and mafic volcanic rocks
    - Delhi Ridge, in north

- Haryana Aravalli ranges, in the west
- Tosham Hill range, basement rocks are quartzite with chiastolite, the upper layers of quartz porphyry ring dyke, felsite, welded tuff and muscovite biotite granite rocks have commercially nonviable tin, tungsten and copper. Rajasthan Alwar range, in the east o Ajabgarh Group-Kumbhalgarh Group, with Carbonate, mafic volcanic and argillaceous rocks o Raialo Group, with Mafic volcanic and calcareous rocks
- Aravalli Supergroup o Debari Group, with Carbonates, quartzite, and pelitic rocks o Jharol Group, with Turbidite facies and argillaceous rocks

The Delhi Ridge is the northernmost end of the Aravalli range, which begins in Central Delhi at Raisina hill. The ridge diagonally traverses to the South Delhi (hills of Asola Bhatti Wildlife Sanctuary), where at the hills of Bandhwari, it meets the Haryana Aravalli range consisting of various isolated hills and rocky ridges passing along the southern border of Haryana.[16]

The Aravalli supergroup passes through Rajasthan state, dividing it into two halves, with three-fifths of Rajasthan on the western side towards Thar Desert and two third on the eastern side consisting of the catchment area of Banas and Chambal rivers bordering the state of Madhya Pradesh. Guru Shikhar, the highest peak in the Aravalli Range at 5650 feet (1722 meters) in Mount Abu of Rajasthan, lies near the south-western extremity of the Central Aravalli range, close to the border with Gujarat state. The southern Aravalli Supergroup enters the northeast of Gujarat near Modasa where it lends its name to the Aravalli district, and ends at the center of the state at Palanpur near Ahmedabad

Vindhyan supergroup,its classification,lithology and distribution

The Vindhyan basin is a sickle-shaped basin on the Bundelkhand-Aravalli Province which stabilized prior to 2.5 Ga The Vindhyan Supergroup overlies a variety of Precambrian basement rocks including Bundelkhand Granite, Mahakoshal Group, Bijawar Group, Gwalior Group, Banded Gneissic Complex (BGC) and Chhotanagpur Gneissic Complex (CGC). The Bundelkhand Granite Complex separates the Vindhyan exposures of the Son Valley area from Chambal Valley area. The Bundelkhand Granite Complex is dominated by K-rich granite emplacement within TonaliteTrondjhemiteGranodiorite complex The Mahakoshal Group (2.11.6 Ga) occurs on the southern and eastern margin of the Son Valley (Das et al., 1990; Roy and Bandyopadhyay, 1990). The Bijawar Group (2.1 Ga) remains confined on the northern and northeastern margin of Son Valley (Das et al., 1990; Roy and Bandyopadhyay, 1990). Banded Gneissic Complex (BGC) and Gwalior Group form the basement of Vindhyan Supergroup in the Rajasthan sector (Heron, 1953). The Chhotanagpur Gneissic Complex (CGC) consisting of gneisses,granites and granodiorites with enclaves of tonalitic gneisses and ultramafic rocks forms the basement of the Vindhyan basin in most parts of eastern Son Valley area.

Lithostratigraphy of Vindhyan Basin

In the 19th & early 20th century, the stratigraphy of the Vindhyan Supergroup was studied by several workers. Subsequently inter basinal correlation of spatially distributed stratigraphic units has only been established on the basis of lithological similarity These workers refined the Vindhyan stratigraphy. Auden (1933) proposed the stratigraphic framework of the Vindhyan Basin in the Son Valley and divided the Vindhyan succession into four stratigraphic units. Later workers added and improved upon

Deoland Formation

Sedimentary units in the Vindhyan Basin are primarily represented by shallow marine facies along with distal shelf to deep-water sediments. The maximum thickness of the entire Vindhyan Supergroup is estimated to be around 5 km, comprising mainly sandstone, shale and limestone and is divisible in the following stratigraphic order:

- Bhander Group
- Upper Vindhyan Rewa Group
- Kaimur Group
- Lower Vindhyan Semri Group

The Semri Group is the oldest group of the Vindhyan Supergroup. In the Maihar area, the Semri (Lower Vindhyan), Kaimur, Rewa and Bhander (Upper Vindhyan) are part of the Son Valley. The Semri Group is well exposed in the area and used for the present study. The Lower Vindhyan and Upper Vindhyan units are separated by multiple unconformities of undetermined duration . There is also evidence of an unconformity at, or near, the top of the Kaimur Group. The Semri Group in the Son Valley overlies the Bijawar Series of sediments and lavas, which contains volcanic rocks that Mathur (1981) correlates to the 1815 Ma Gwalior Volcanics. Prasad and Rao (2006) suggest that the Gwalior and Bijawar Series form an extensive part of the basement, as well as offering geophysical data suggest that the Hindoli Group extends beneath the Rajasthan section of the Vindhyan Basin. According to Bose et al. (2001), the Semri Group consists of five formations and is constituted of typically alternating shale, carbonate, sandstone and volcaniclastic units . However in the present thesis, the classification proposed by Bhattacharyya (1996) has been followed. The detailed lithostratigraphy of the Semri Group is provided below:

MIRJAPUR SUBGROUP

Deoland Formation

The Deoland Formation is dominated by conglomerate and sandstone. It is the lowermost unit of the Semri Group. Thickness varies from 200 m to 500 m. Auden (1933) named it as the Basal Conglomerate but Sastry and Moitra (1984) has named it as Deoland Formation. It shows angular unconformity with the underlying Bijawar Phyllites. It is represented by sandstone, conglomerate, breccia and lenticular bands of calcareous grit, dolostone with occasional stromatolites. The pebbles are well rounded to subangular and reach up to the size of 20 cm. It has red jasper, quartzite vein, quartz, chalcedony, black shale and slate etc. Conglomerates grade horizontally into sandstone. Sandy horizons show cross bedding and parallel bedding.

Arangi Formation

The Arangi Shale consists mainly of grey shale with thin sandstone interbeds, but its exposures are very limited and confined in the Son Valley. It overlies Deoland Formation comprising mainly shales, considered at par with Basal Shale described by Rao and Neelkantam (1978).

Kajrahat Limestone

The Kajrahat Limestone consists of limestone, dolomite and shales with widespread development of stromatolites at the upper portion of this horizon.Formation shwar area (Maihar, M.P.). It has been divided into three members as the lower flat bedded limestone, the middle biohermal limestone and the upper flat bedded limestone. Mishra et al., (1990) have given the thickness of the Kajrahat Limestone in this area as ~300 m.

In Kuteshwar Mine, hard, compact and thick bed of dark grey colour limestone is seen, which changes into light grey to pinkish colour. Thick vein (~2m) of well crystallized calcite within the limestones is recorded. The Kajrahat Limestone in this place is noticed with pyrite. The precipitated are recorded in limestone beds which are very well exposed and radiating in upwards direction. These fan- fabrics are varied in length (1cm-10 cm).

Good exposures of the middle part of the Kajrahat Limestone are exposed on the right bank of the Chhoti Mahanadi, beneath the newly constructed bridge. There are repeated cycles of Conophyton in the middle part of the Kajarahat Limestone. Many forms of Conophyton along with Colonnela, Calypso and Thyassagates have been reported from this place.There are multimember and mono member of colonies stromatolites. Their conical laminae are laterally linked with each other. In the longitudinal view, they are linked to each other with prominent concavity and a axial zone. In the transverse section the columns are oval to elliptical in shape with outer laminae encircling other colums. At the base, the columns are about 50 cm in height and 10-25 cm in diameter.

The precipitated - also very well exposed in banded and compact limestone, which has thickness up to 3 m in this place. The size of these structures varied from 1 cm-8 cm in length.

Deonar Formation

The sedimentary succession consisting of silicified shales, pyroclastics and volcanic tuffs, named as Porcellanite formation overlies the Kajrahat Formation. The term Porcellanite was first used by Mallet (1869). These rocks have been described as a stage It attains a thickness of ~ 300 m. It has been accorded the rank of a formation and is included in the Mirzapur Subgroup by Sastry and Moitra (1984). The porcellanites are banded, hard, fine grained, varying in colour from black to pale green and show concoidal fracture. Presence of abundant pumice, euhedral quartz grains, euhedral zoned zircon crystals and volcanic bombs indicate volcanic origin of these deposites .

KHEINJUA SUBGROUP

The Kheinjua Stage of Auden (1933) was later termed as the Khenjua Subgroup. It has three formations stratigraphically, the Koldaha Shale (Olive Shale), the Salkhan Limestone (Kheinjua Limestone) and the Rampur Formation (Glauconitic Sandstone).

Koldaha Shale (Olive Shale)

The Porcellanites are overlain by a thick unit of the Olive coloured Shale and Siltstone with minor sandstone. The thickness varies from 70 to 120 m. This horizon has been given the name as the Koldaha Shale. These shales are showing very thin lamination with textural and colour banding. Parallel bedding with low angle is discordances in lenticular beddings and graded bedding are noted. The Koldaha Shale is recorded near the Bansagar Lake. The thickness of this shale unit is ~10 m, with alteration of shale and siltstone This shale is friable and shows pencil cleaved fractures. The thick bed of sandstone is recorded at the top of this shale unit.

Salkhan Limestone

It has also been referred to as the Bargwan Limestone .Fawn limestone is redesignated as the Salkhan Limestone .Its maximum thickness is ~90 m. It is made up of fawn weathering, siliceous and cherty limestone and dolostone with minor shale. The Salkhan Limestone, overlying the Koldaha Shale (earlier reported as Nauhatta Limestone Formation is well developed, it is extremely fine grained and cherty in nature. On the way to Bansagar Lake via Amarpatan, 5 km before Lake (N-24 - 81), chertified Salkhan Limestone is recorded. This chert is dense, black in colour and waxy lusture on freshely broken concoidal faces. Edgewise conglomerate bed is horizontally exposed between limestone beds on this place . Megaripples and mud cracks are also exposed on bedding suface of the Salkhan Limestone.

Rampur Formation

The 85-m thick Rampur Shale belongs to the lower part of the Rohtas Formation . This formation is glauconite bearing sandstone horizon which is redesignated as the Rampur Formation . Thickness of this formation varies between 100-800 m .

The shales show ripple marks, small scale cross bedding and mud cracks. The Rampur Formation is exposed near Kudri Village, located at N-24° - 80° Shales are mostly hetrollithic, well sorted siltstones/fine grain sandstones filled with gutters marks and wrinkle marks with local spill over. Different kind of sole features are noted. The gutter fills are planer, cheveron, wavy and hummocky laminated.

ROHTAS SUBGROUP

Rohtasgarh Limestone

It is the basal unit of the Rohtas Subgroup comprising greyish to greyish black limestone and shales. Its thickness varies ~200 in east to 500 m in the west in Rewa District. At places, it shows development of nodules within the shales. Mostly it shows parallel lamination. In present study, the general geology of Rohtasgarh Limestone is observed at different localities such as, Badanpur Mine (N-24° -80° Bistara Mine (N-23° - 80° and Amehta Mine (N-24° - 80° . In these areas, limestone is present in the subsurface. The upper horizon of the Rohtasgarh Limestone is represented by the grey shales, calcareous shales and silicified shales .

Amehta and Bistara Mines have yielded very well preserved megascopic carbonaceous forms. This area is tectonically little disturbed. The folded beds are dipping at high angle in Amehta and Bistara mines. Calcite veins, microbial mat structures and slicken-side like calcite sheets are very common in these areas. Dark black shales alteration within limestones is recorded. The black shale units are ~1 cm to 15 cm thick bed between limestone beds.
Nodules are recorded from the Rohtasgarh Limestone in a dug-bore-well. These nodules are pyrite bearing, which are exposed horizontally along the interbeded limestone and grey shales near Badwar Village. This intercalation of black shale and limestone gradually passes into the Bhagwar Shale which is exposed at higher reaches of the section and on the road section to Kymore. The Bhagwar Shale is capped by Kaimur Sandstone.

Bhagwar Shale

It is the uppermost lithounit of the Rohtas Formation and also the youngest lithounit of the Semri Group in the Son Valley area. Its thickness varies from 20-125 m. It is represented by silicified shale, sandstone and carbonaceous shale. The contact of Rohtasgarh Limestone and Bhagwar Shale is seen near Bistara Mine, exposed between Rohtasgarh Limestone and Kaimur Group. A small patches the Bhagwar Shale and Porcellanite is exposed at N-24° , E- 81° Maihar .There is ~ 2 m thick section with small lateral extent exposed.

KAIMUR GROUP

The Kaimur Group derives its name from Kymore range in Central India. The name was first suggested by Oldham (1856) for the lowest Series of Vindhyan System. The Kaimur Group is an assemblage of sandstone, shale, flagstone and porcellanites and rest upon the Semri Group. The lower limit is generally marked by a conglomerate of ferruginous lateritic bed throughout a large part of its margin. The Kaimur Group is exposed almost all over the Vindhyan basin and overlaps the Semri Group. The maximum thickness is 400 m. In the Son Valley area this group has been devided into 7 lithounits.

Lower Kaimur Stage

Bijaigarh Shale Upper Quartzite Susnai Conglomeratic Breccia Silicified Shale Lower Quartzite Bijaigarh Shale Ghaghar Sandstone Susnai Breccia

REWA GROUP

The Rewa Group was mapped first time in Banda and Lalitpur district of U.P. Krishnan (1968) and Vredenburg (1906) considered the Rewa Group of rocks as separate from the underlying Kaimur by a diamondiferous conglomerate. The rocks of the Rewa Group are best developed in Panna and Satna Districts (M.P.) . The thickness of this group varies in Son Valley from 182-296 m .

Rewa Group

Upper Rewa Sandstone Jhiri Shale Lower Rewa Sandstone Panna Shale Govindgarh Sandstone Jhiri Shale Asan Sandstone Panna Shale

BHANDER GROUP

The Bhander Group constitutes the youngest group of the Vindhyan Basin. The original classification proposed by Krishnan (1968) . The Bhander Group contains the only major carbonate unit in the upper Vindhyans, a unit containing stromatolites, ooids, and micritic layers known as the Bhander or Lakheri Limestone .

The overlying Lower Bhander Sandstone marks a transition into shallow marine, sometimes fluvial, sandstone typical of the Bhander Group . The Sirbu Shale overlies the Lower Bhander Sandstone, and is in turn overlain by the Upper Bhander Sandstone observed that the upper Bhander Sandstone is primarily a unit of coarse, red sandstones, and may represent former barrier islands, sand bars, beaches and fluvial systems.

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Bhander Group

Maihar Sandstone Sirbu Shale

Bhander Limestone Ganurgarh Shale Shikoda Sandstone Sirbu Shale Bundi Hill Sandstone Lakheri Limestone Ganurgarh Shale Palaeogeography of the Vindhyan basin There have been several attempts to describe the depositional setting and palaeogeography of the Vindhyan basin. Most of the workers considered the Vindhyan succession as nearshore marine deposits with intermittent subaerial exposure. In other cases, tidal, barrier bar, beach and lagoonal facies

Paleozoic sucession of kashmir

INTRODUCTION The Precambrian, Palaeozoic, mesozoic and Quaternary sediments are developed in the Kashmir Valley. The Kashmir Palaeozoic-mesozoic 'basin', spread over an area of about 5,200 sq km, lies in an intermontane valley formed by bifurcation of the Great Himalayan Range west of the Ravi River. It occupies an ovalshaped depression between the Pir Panjal Range in the SW and Zanskar Range in NE. The Palaeozoic-mesozoic succession rests over the crystalline rocks of the Salkhala. The Salkhala Crystalline together with the overlying Palaeozoic-mesozoic sequence has been tectonically transported as a thrust sheet on the back of the Panjal Thrust. To the NE, the Kashmir Basin is separated from the Spiti-Zanskar Basin by anticlinal upwarp constituted of the rocks known as the Kishtwar-Giabal-NunkunSuru Crystallines. In the Kishtwar area, the quartzite sequence correlatable with the Rampur Group (ca 1900 ma) is exposed in a window, designated as the Kishtwar Window. Lydekker (1882) was the first geologist to have given a geological account of a section of the Pir Panjal area, which was thoroughly revised by middlemiss (1910), who divided the Palaeozoic-mesozoic succession of the Kashmir Basin in two subdivisions viz., ABelow the Panjal Volcanics and B-Above the Panjal Volcanics. He was not sure of the presence of the Cambrian rocks in Kashmir. Bion further elaborated the geological description of middlemiss (1910), particularly north and east of the Wular Lake. Wadia (1934) mapped the northwestern sector of Kashmir in parts of muzaffarabad and Baramula districts.

He recorded trilobite-bearing Cambrian sediments and an unconformity between the Silurian and middle Carboniferous.

Wadia (1934) also recognized an unconformity between the Salkhala Crystalline and the Cambrian 'Dogra Slate'. However, in some sections, Wadia (1910, 1934) also recorded an apparent gradation between these two rock series.

The Karewa Basin is considered to have come in existence due to uplift of the Pir Panjal range in post-Panjal Thrust time. The uplift caused damming of the drainage system and formation of a vast lake. Agarwal and Agarwal (2005) proposed that the Karewa Basin is a pop-down structure developed parallel to the strike of the orogen bounded by the Panjal Thrust in SW and the Zanskar Thrust in the NE. This basin received main sediment supply from elevated area towards the foreland. Godwin-Austin (1859) identified the lacustrine nature of the Karewa sediments. Wadia (1941) regarded the Karewa sediments to represent glacial and interglacial stages

Geology of Triassic of spiti:

Spiti, surrounded by high mountains on all sides, is located on the leeward side of the Trans-Himalayas. Its immediate neighbors are Ladakh, Tibet, Kinnaur & Kullu. The Himalayas are the youngest mountain range on the planet and have a fascinating geological past dating back millions of years. The Spitian Himalayas afford a fascinating insight into the geological past of the Himalayas.

The Spiti river, originating from the foot of a glacial peak marked K-III on old maps, flows approximately160km in a south-easterly direction up to its confluence with the Pare Chu at Sumdo (district border between Spiti and Kinnaur). It goes on to merge into the Satluj at Khab further downstream.

The river has carved out a unique storehouse of Shale. Rock faces in the area are veritable storehouses of the geological history of the Himalayas, dating back to 500 million years. The Spiti valley has an amazing proliferation of Precambrian/Cambrian era fossils. The valleys of the Lingti and the Pin rivers have long been frequented by fossil research scientists. A recent study by the Geological Society of America shows that Spiti houses various unique and rare fossils of marine life (Trilobites, of the Paleozoic Era are some of the earliest legged creatures, relatives of crabs, centipedes and spiders

Sivaliks Hills

The Sivalik Hills is a mountain range of the outer Himalayas. It is about 2,400 km (1,500 mi) long enclosing an area that starts almost from the Indus and ends close to the Brahmaputra, with a gap of about 90 kilometres (56 mi) between the Teesta and Raidak rivers in Assam. The width of the Sivalik Hills varies from 10 to 50 km (6.2 to 31.1 mi), their average elevation is 1,500 to 2,000 m (4,900 to 6,600 ft).

Geologically, the Sivalik Hills belong to the Tertiary deposits of the outer Himalayas. They are chiefly composed of sandstone and conglomerate rock formations, which are the solidified detritus of the Himalayas[4] to their north; they poorly consolidated. The remnant magnetization of siltstones and sandstones indicates that they were deposited 16–5.2 million years ago. In Nepal, the Karnali River exposes the oldest part of the Shivalik Hills.

They are the southernmost and geologically youngest east-west mountain chain of the Himalayas. They have many subranges and extend west from Arunachal Pradesh through Bhutan to West Bengal, and further westward through Nepal and Uttarakhand, continuing into Himachal Pradesh and Kashmir. The hills are cut through at wide intervals by numerous large rivers flowing south from the Himalayas.

They are bounded on the south by a fault system called the Main Frontal Thrust, with steeper slopes on that side. Below this, the coarse alluvial Bhabar zone makes the transition to the nearly level plains. Rainfall, especially during the summer monsoon, percolates into the Bhabar, then is forced to the surface by finer alluvial layers below it in a zone of springs and marshes along the northern edge of the Terai or plains.

North of the Sivalik Hills the 1,500–3,000 meter Lesser Himalayas also known as the Mahabharat Range rise steeply along fault lines. In many places the two ranges are adjacent but in other places structural valleys 10–20 km wide separate them.

Geological Time scale	Classification of the Siwalik Group		Standard European Equivalent	Age calculated from reversal stratigraphy (in Ma)	Continental equivalent
Pleistocene	Upper Siwalik	Boulder conglomerate	Cromerian	0.5 to 1.5	?
	Upper Siwalik	Pinjor	Villafranchian	2.47	Mid-late Villafranchian
	Upper Siwalik	Tatrot	Astian	5.5	Early Villafranchian –Ruscinian
Pliocene	Middle Siwalik	Dhok Pathan	Pontian	8.5	Turolian
	Middle Siwalik	Nagri	Sarmatian	10.8	L. Vellesian E. Turolian
Miocene	Lower Siwalik	Chinji	Tortonian	14.3	Oeningian
	Lower Siwalik	Kamlial	Helvetian	18.3	Pre- Oeningian
		Muree Group	Burdigalian		

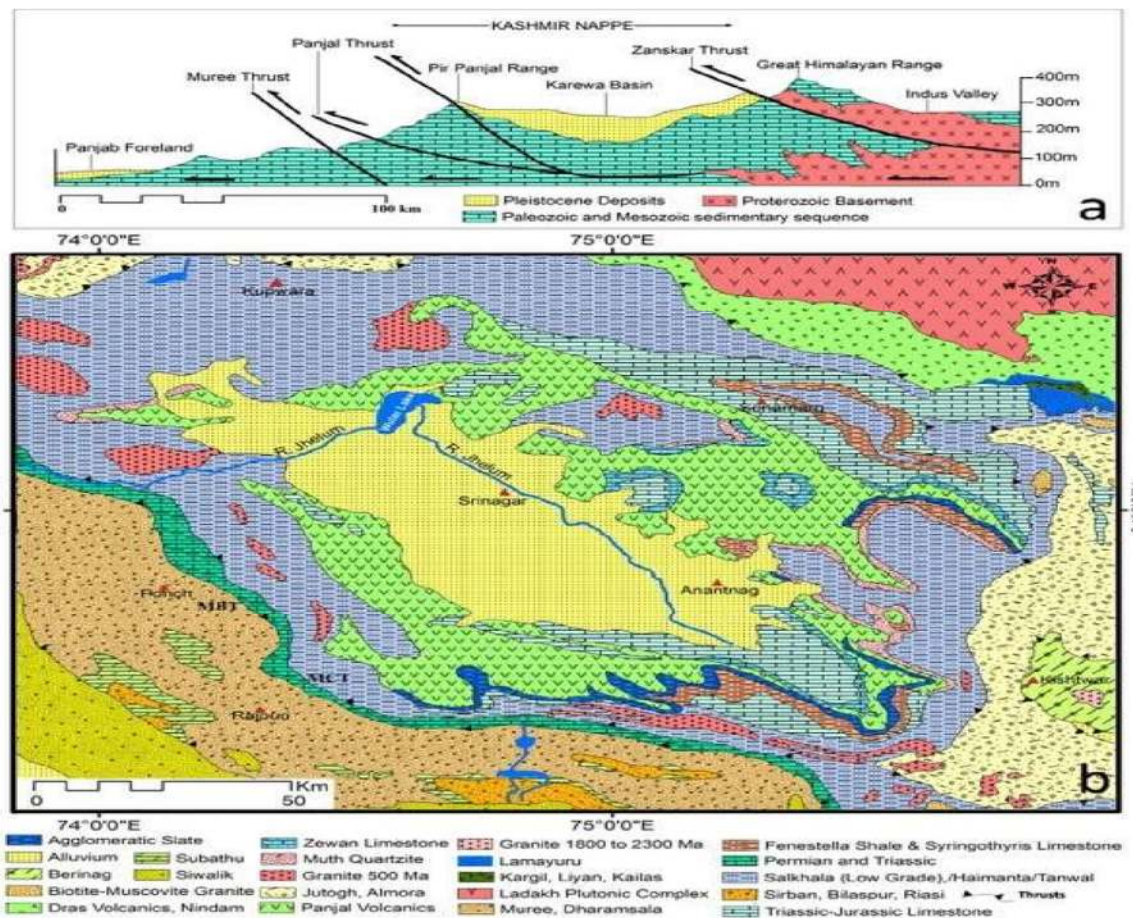
Chronostratigraphic division of Siwalik Succession
(Source: Tandon et al. 1998)

Karewas of kashmir

The Kashmir valley is an oval-shaped basin, 140 km long and 40 km wide, trending in the NNW–SSE direction. It is an intermountain valley fill, comprising of unconsolidated gravel and mud. A succession of plateaus is present above the Plains of Jhelum and its tributaries. These plateau-like terraces are called ‘Karewas’ or ‘Vudr’ in the local language.

Despite continuous erosion since millions of years, more than half of the valley is still occupied by the Karewa.

Thus, Karewas are lacustrine deposits (deposits in lake) in the Valley of Kashmir and in Bhadarwah Valley of the Jammu Division. These are the flat topped mounds that border the Kashmir Valley on all sides. They are characterized with fossils of mammals and at places by peat.



Karewas were formed during the Pleistocene Period (1 million years ago), when the entire Valley of Kashmir was under water. Due to the rise of Pirpanjal, the drainage was impounded and a lake of about 5000 sq. km area was developed and thus a basin was formed. Subsequently, the lake was drained through Bramulla gorge. The deposits left in the process are known as karewas. The thickness of karewas is about 1400 m.

The karewas have been elevated, dissected and removed by subaerial denudation to be in the present position.

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Department of Geology G.D.C Anantnag (Boys)

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