

EWCE341: Principles of Soil Mechanics

3.00 Credit Hours
3 Hours per Week



Military Institute of Science & Technology
Department of Civil Engineering



CE341: Principles of Soil Mechanics

Rationale of the Course

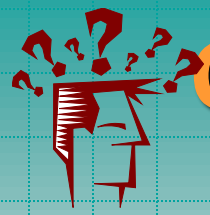
This course will enable the students to learn soil mechanics aspect of geotechnical engineering with an aim to acquire the basic knowledge of the geotechnical parameters needed for the purpose of designing foundations/ substructures of any civil engineering infrastructure, earth retaining and earth structures or any other structures resting on the surface and within the ground.



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Course Outcomes

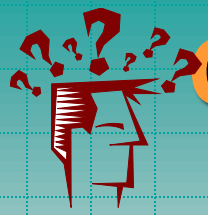
CO1: To acquaint with the attributes of geotechnical engineering especially soil mechanics and to acquire the knowledge of soil formation, physical and index properties of soil including weight volume relations, grain size analysis and consistency limits for the purpose of engineering classification of soils.



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Course Outcomes

CO2: To acquire the knowledge and to evaluate the engineering properties of soil including shear strength, compressibility, various stresses induced within the soil mass, and permeability of soil.



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Course Outcomes

CO3: To understand and assess the compaction aspect of shallow depth ground improvement.

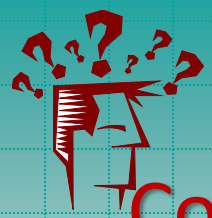


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THEME STATEMENT

Nearly every Civil Engineering structure – building, bridge, highway, railway, tunnel, wall, retaining structures, tower, canal, or dam must rest and be founded in or on the surface of the earth. As such, Civil Engineers must be concerned with the interaction of structure and soil underneath. That is, the strength, deformation and permeability characteristics of foundation soil.

Needs the Study of Soil Mechanics



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Course Teachers

Dr. Md. Zoynul Abedin

Brig. Md. Feerozur Rahman

Recommended Reference Books

- **Foundation Engineering** – Peck, Hanson & Thornburn
- Principles of Geotechnical Engineering: B.M. Das & K. Sobhan
- Geotechnical Engineering Soil Mechanics – J.N. Cernica
- An Introduction to Geotechnical Engineering – R. D. Holtz, W. D. Kovacs and T. C. Sheahan.
- Geotechnical Engineering Principles and Practices – D. P. Coduto.



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Syllabus: 1

- Introduction to Geotechnical Engineering
- Formation, Type and Identification of Soils
- Soil Structure and Fabric
- Index Properties of Soils
- Engineering Classifications of Soil
- Stress-Strain-Strength Characteristics of Soils



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Syllabus: 2

- Soil Composition
- Soil Compaction
- Principles of Total & Effective Stresses
- Permeability & Seepage
- Compressibility and Settlement Behaviour of Soils



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What is Mechanics?

What are the different branches of Mechanics?

"Mechanics" may be defined as that part of physical science that treats of the action of forces on masses.

There are many branches of mechanics, each applicable to a particular kind of mass or classification of matter.



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What are the different branches of Mechanics?

There are many branches of mechanics, each applicable to a particular kind of mass or classification of matter.



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What are the different branches of Mechanics?

- Mechanics pertaining to astronomical bodies is called celestial mechanics.
- The mechanics of gases is called pneumatics.
- The mechanics of water is hydraulics.
- The mechanics of solid bodies in motion is called dynamics.



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What are the different branches of Mechanics?

- The mechanics of solid bodies at rest is statics;
- The mechanics of heat-energy transfer is called thermodynamics; and so on.
- Similarly, the branch of mechanics that deals with the action of forces on soil masses is called soil mechanics, and on rocks, rock mechanics.



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Soil Mechanics is a subset of the broad subject Geotechnical Engineering

Geotechnical engineering is a specialty of civil engineering that deals with the properties, behaviour and use of earth materials and underground water in engineering works

The earth materials referred to here include both soil and rock . The term geotechnical is a derived from Swedish word ‘Geotekniska’ meaning ‘we know it today’.



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↓ Geotechnical Engineering Requires Integrated Knowledge of Many Disciplines

Geotechnical Engineering

- Geology
- Material Science & Testing
- Mechanics
- Hydraulics
- Environment Science & Engineering



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↓ Aspects or Branches of Geotechnical Engineering

Geotechnical Engineering

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Synonymous to Soil Mechanics

- Soil Mechanics
- Rock Mechanics
- Engineering Geology
- Soil Engineering
- Rock Engineering
- Foundation Engineering
- Geo-environmental Engineering



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↓ Aspects or Branches of Geotechnical Engineering

Definitions

1. Soil Mechanics: that concerns with the Engineering Mechanics and properties of soil. It applies the basic principles of Mechanics of materials, Fluid mechanics and Hydraulics to soils.

2. Rock Mechanics: that concerns with the engineering mechanics and properties of rock. It also uses the basic principles of Mechanics of Materials, Fluid mechanics and Hydraulics to rocks, but not necessarily bed rocks.



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↓ Aspects or Branches of Geotechnical Engineering

Definitions

3. Engineering Geology: that deals with the formations and features of earth crust including earthquake that concerns the design and performance of civil engineering structures.

4. Soil Engineering: that applies the knowledge of Geology, Soil mechanics and Structural engineering to the design and construction of foundations of any engineering structures.



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↓ Aspects or Branches of Geotechnical Engineering

Definitions

5. Rock Engineering: that applies the knowledge of Geology, Rock mechanics and Structural engineering to the design and construction of foundations of any engineering structures constructed on or with rocks

6. Foundation Engineering: that covers a broader area to include both Soil Engineering and Rock Engineering.



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↓ Aspects or Branches of Geotechnical Engineering

Definitions

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↓ Aspects or Branches of Geotechnical Engineering

Definitions –

7. Geo-environmental Engineering: considers the **environmental effects like earthquake, rainfall, ground water, gravitational movements, waste disposal, chemical etc. on the properties of soil and rock.**



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Scope of Geotechnical Engineering

- Foundation of structures
- Underground and earth retaining structures
- Embankment, excavation and dam
- Pavement
- Soil subsidence, Soil heave, Frost action, Soil erosion, Shrinkage and Swelling



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↓ Development of Geotechnical Engineering

Ancient Civil Engineering Structures of Geotechnical Importance

- Pyramids of Egypt (2630-2611 BC)
- Hanging gardens of Babylon (605-562 BC)
- The great wall of China (220 – 206 BC)
- The leaning tower of Pisa in Italy (1175 AD)
- Large public buildings, harbours, aqueducts, bridges, roads and sanitary works of Romans
- Soil subsidence, Soil heave, Frost action, Soil erosion, Shrinkage and Swelling



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↓Development of Geotechnical Engineering

History of Soil Mechanics

1. Pre-classical Soil Mechanics (1700 to 1776 AD)
2. Classical Soil Mechanics- Phase I (1776 to 1856 AD)
3. Classical Soil Mechanics- Phase II (1856 to 1910 AD)
4. Modern Soil Mechanics (1910 to 1927 AD)
5. Recent Soil Mechanics (After 1927 AD)



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↓Development of Geotechnical Engineering

1. Pre-classical Period of Soil Mechanics (1700-1776 AD)

Henri Gautier **(1660-1737),** a Frenchman studied the natural slopes of soil when tipped to a heap

Bernard Forest de Belidor **(1671-1761),** a Frenchman, published a textbook in 1729 for military and civil engineers. He proposed a theory for lateral earth pressure on retaining wall

Francois Gadroy **(1705-1759),** another Frenchman, observed the existence of slip plane in the soil at failure



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↓Development of Geotechnical Engineering

2. Classical Period of Soil Mechanics: Phase I (1776 to 1856 AD)

Wedge theory of earth pressure given by a Frenchman, Coulomb (1736-1806) in 1776, and his works on shear strength parameters of soil and bearing capacity of foundation soil

Extension of Coulomb's theory by a Frenchman Poncelet (1788-1867) in 1840, a German Culmann in 1866 and an Austrian Rebhann in 1871

Stoke's (an Englishman) law of falling velocity of particles in a fluid media, 1845



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3. Classical Period of Soil Mechanics: Phase II (1856 to 1910 AD)

- Darcy's (Frenchman) law of fluid flow through soil mass in 1856
- Rankine's (1820-1872), a Scottish, theory of earth pressure in 1857
- Pauker's (a Russian) bearing capacity theory, 1859
- Boussinesq's (a Frenchman) theory of stress distribution, 1885
- Mohr's (a German) work on graphical analysis of stresses in 1887 and failure hypothesis of real materials in 1900



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↓Development of Geotechnical Engineering

4. Modern Period of Soil Mechanics: (1910 to 1927 AD)

- Consistencies of soil and their limits by Atterberg 1911
- Double shear test in clay by Frontard in 1914
- Bell's bearing capacity theory, 1915
- Slip circle analysis of saturated slope by Fellinius in 1918
- Prandtl's theory of bearing capacity, 1920
- Terzaghi's theory of one dimensional consolidation, 1925



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↓Development of Geotechnical Engineering

5(a). Recent Soil Mechanics (After 1927 AD)

- Terzaghi's bearing capacity theory, 1943
- Cassgrande's works on Atterberg limits, consolidation, seepage, soil classification etc. 1932-1975
- Compaction of soil by Proctor, 1933
- Stability analysis of slope by Fellenius, 1936; bearing capacity theory, 1939
- Taylor's theory on stability of earth slope, 1937; consolidation curve
- Newmark's chart for computation of stresses in elastic foundations, 1942



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↓Development of Geotechnical Engineering

5(b). Recent Soil Mechanics (After 927 AD)

Terzaghi's Significant Contribution; Known as Father of Soil Mechanics

- Bearing capacity theory by Meyerhof, 1951
- Skempton's bearing capacity theory, 1951; pore pressure parameters, 1954
- Dynamics of bases and foundations by Barkan, 1962
- Stress path concept of Lambe and Whitman, 1969
- Vibrations of soils and foundations by Richart, 1970



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↓ Definitions in Geotechnical Engineering

Soil is used by different professionals and their definitions are understandably different

Geologist

All the materials mantling the earth crust are unconsolidated sediments overlying solid bed rocks called regolith or soil

Agriculturist

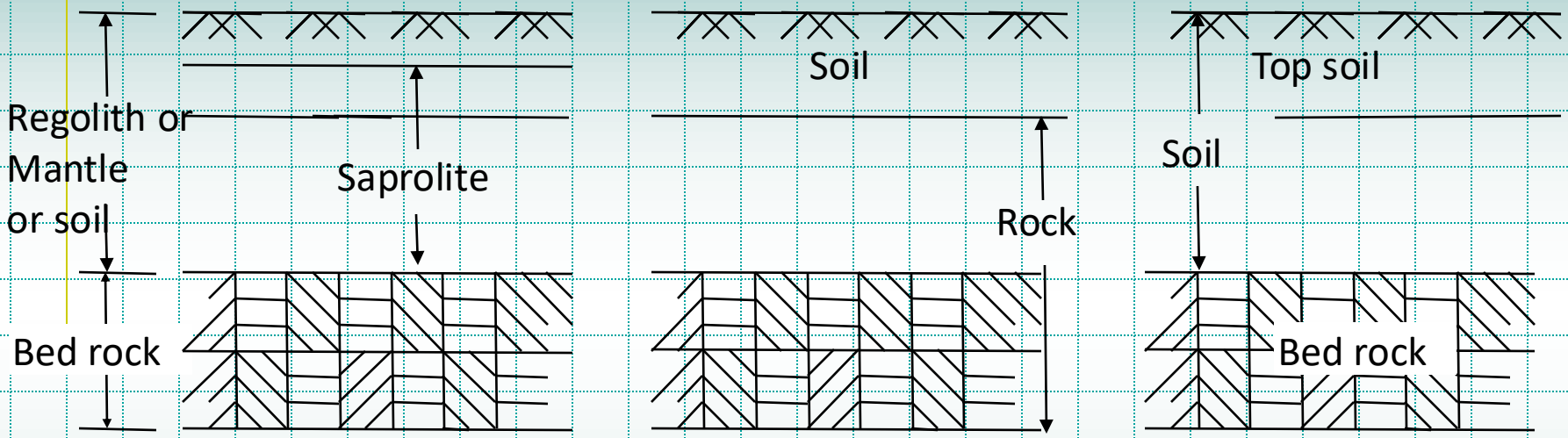
Soil is a thin layer of loose surface materials of the earth crust, which is a portion of regolith or engineering soil, where plants grow

Geotechnical Engineers

Soil is considered to include all naturally occurring loose or soft deposit overlying solid bedrock. It is formed by disintegration of rocks and decomposition of organic matter

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↓ Definitions of Soil



(a) Geologist (b) Agriculturist (c) Geotechnical Engineer

Fig. 1 Definitions of Soil by Various Professionals



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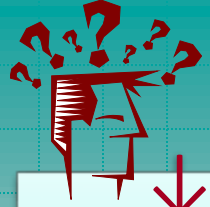
↓ Formation of Soil

Soil is a product due to disintegration and/or decomposition of rocks and organic matters

Disintegration process is known as weathering

The earth's crust consists of both rock and weathered rock (as soil) up to an approximate depth of 20 km.

A rock is formed of mixture of several minerals. Minerals have fixed properties and are formed of several chemical elements



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↓Formation of Soil: Earth Mass: Consists of 3 Major Layers

Crust	Mantle	Core

Rock: 3 types of rock formed of several minerals

Igneous: 95% of earth crust in volume	Sedimentary: 80% of surface area	Metamorphic

Minerals

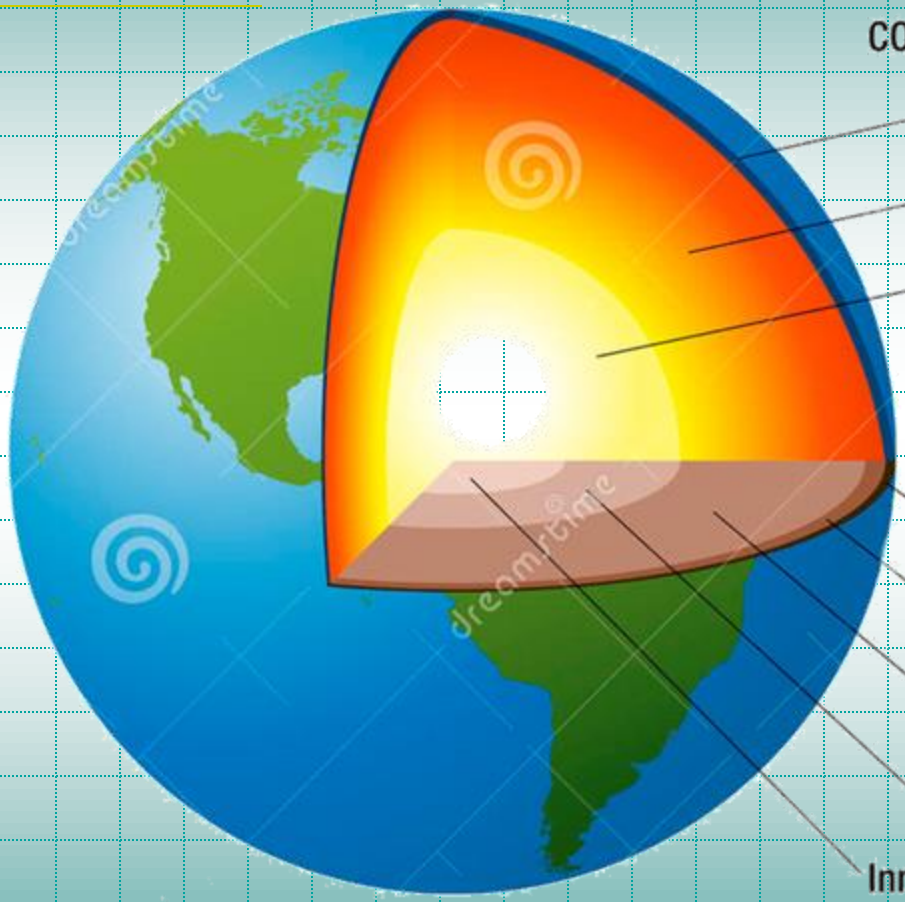
More than 4150 Minerals	Rock forming minerals = 8

Elements

Basic elements = 118	98% of earth crust is made of 8 elements

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↓ Earth Crust Model 01



COMPOSITIONAL LAYERS

Crust: *0-100 km (silicates)*

Mantle: *100-2900 km (silicates)*

Core: *2900-6370 km (iron, nickel)*

MECHANICAL LAYERS

Lithosphere: *0-100 km (rigid)*

Asthenosphere: *100-350 km (soft plastic)*

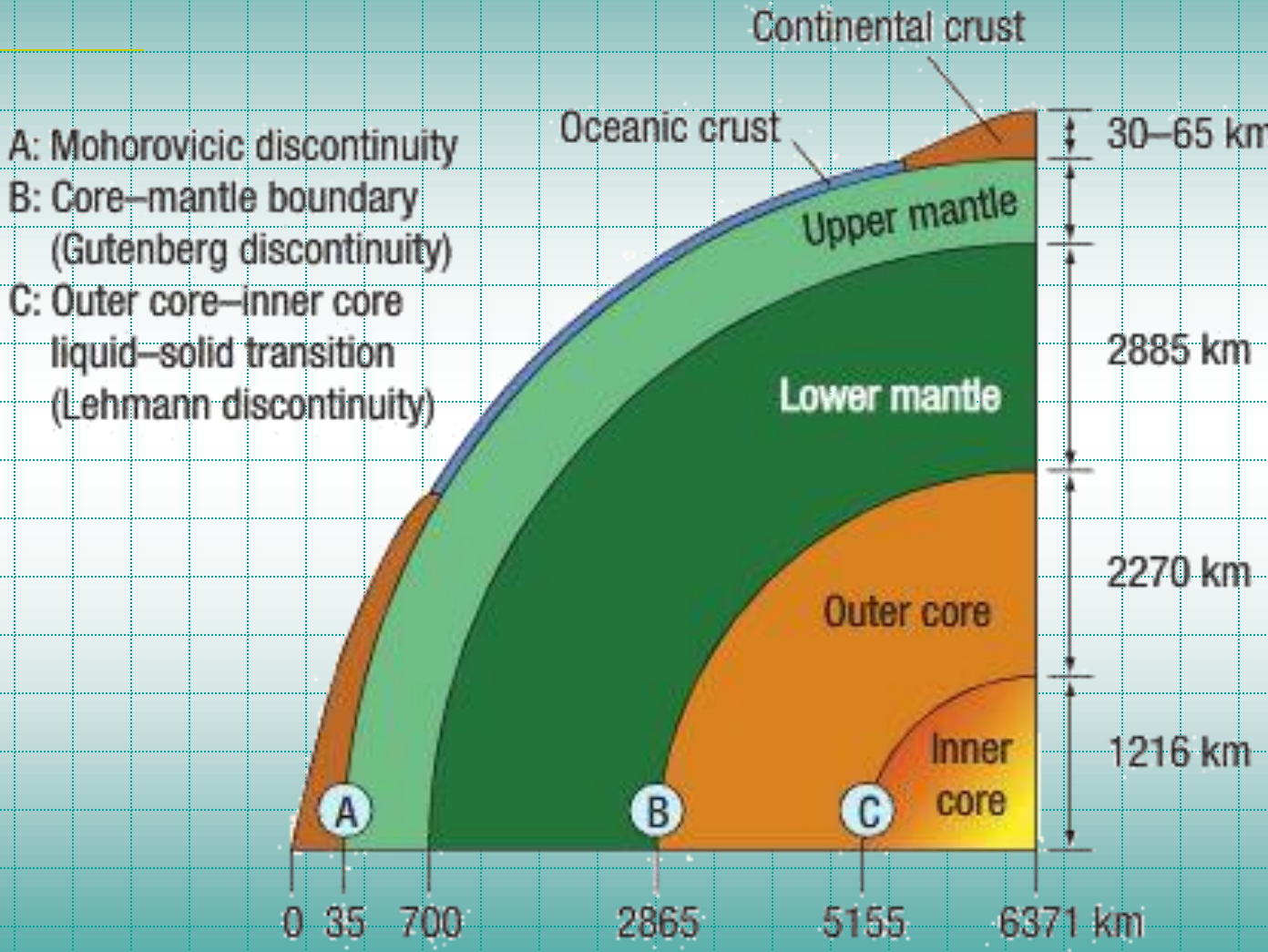
Mesosphere: *350-2900 km (stiff plastic)*

Outer core: *2900-5100 km (liquid)*

Inner core: *5100-6370 km (solid)*

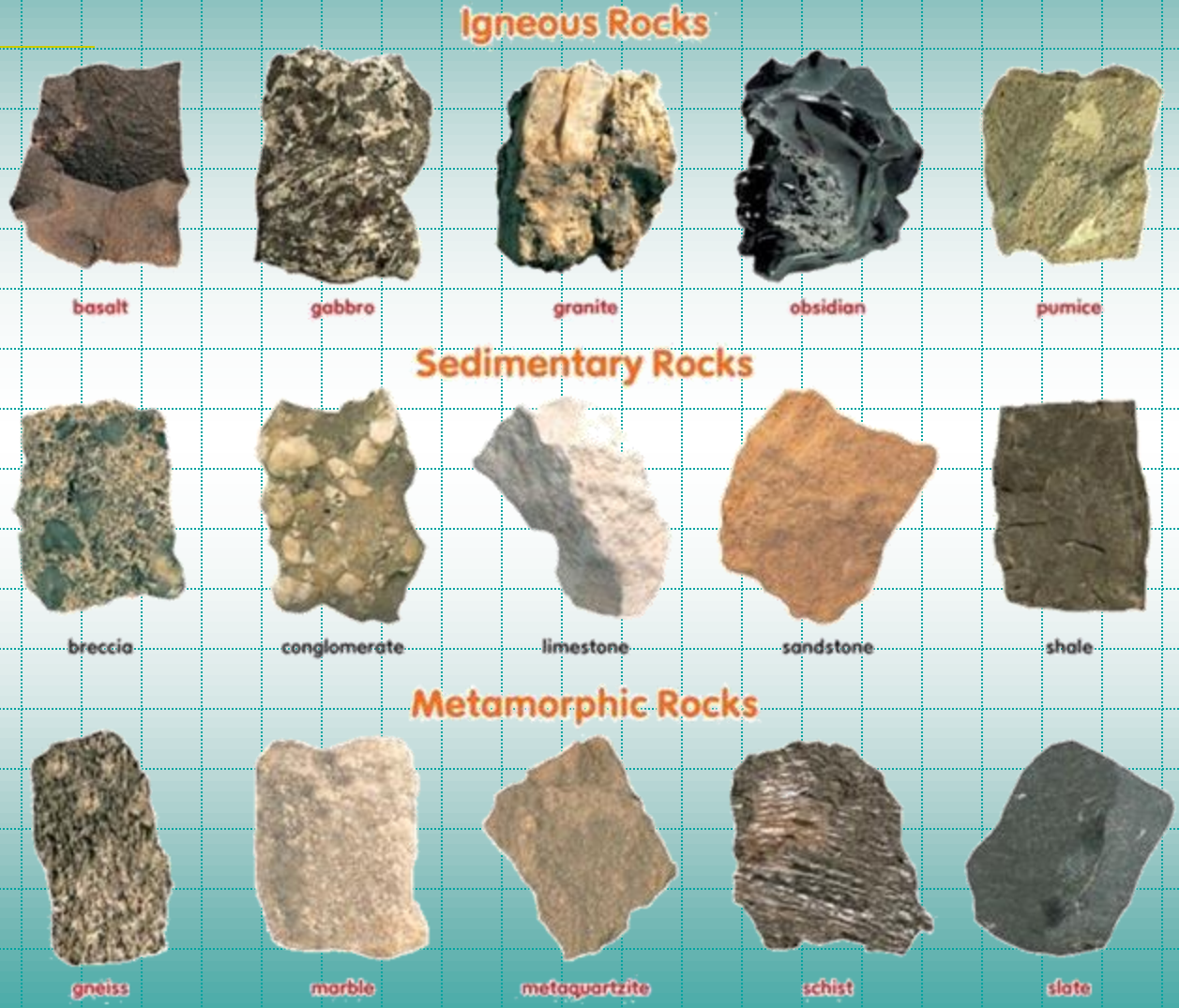
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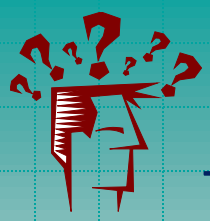
Earth Crust Model 02



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↓Rocks and Minerals





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Table 1.1 Common Rock-Forming Minerals (after Beavis, 1985)

Mineral Group	Species	Structural Class	Composition
Quartz	Quartz	Tektosilicate	SiO_2
Feldspar	Orthoclase	Tektosilicate	$(K, Na)AlSi_3O_8$
	Plagioclase		$NaAlSi_3O_8$ - $CaAlSi_2O_8$
Mica	Muscovite	Phyllosilicate	$KAl_2(AlSi_3O_{10})$ - $(OH)_2$
	Biotite		$K_2(MgFe)_6(SiAl)_8O_{20}(OH)_4$
Amphibole	Hornblende	Inosilicate	$(NaCa)_2(MgFeAl)_5(SiAl)_8O_{22}(OH)_2$
Pyroxene	Augite	Inosilicate	$Ca(MgFeAl)(AlSi)_2O_6$
Olivine	Olivine	Neosilicate	$(MgFe)_2SiO_4$
Clays	Kaolinite	Phyllosilicate	$Al_4Si_4O_{10}(OH)_8$
	Illite		$KAl_2(AlSi_3)O_{10}(OH)_2$
	Montmorillonite		$Al_2Si_4O_{10}(OH)_2nH_2O$
Carbonates	Calcite	--	$CaCo_3$
	Dolomite		$CaMg(CO_3)_2$

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↓Rocks and Minerals



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↓Rocks and Minerals





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Table 1.2 Crustal Abundance of Elements (after Carlson et al., 1985)

Element	Symbol	Percentage by Weight	Percentage by Volume	Percentage of Atoms
Oxygen	O	46.6	93.8	60.5
Silicon	Si	27.7	0.9	20.5
Aluminum	Al	8.1	0.8	6.2
Iron	Fe	5.0	0.5	1.9
Calcium	Ca	3.6	1.0	1.9
Sodium	Na	2.8	1.2	2.5
Potassium	K	2.6	1.5	1.8
Magnesium	Mg	2.1	0.3	1.4
All other elements		1.5	—	3.3



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↓Elements in the Earth

Estimates of the chemical composition of Earth's crust are based on many chemical analyses of the rocks exposed on Earth's surface. Table 1.2 lists the generally accepted estimates of the abundance of major 8 elements in the Earth's crust.

Most rocks are composed largely of oxygen, as it is the most abundant element in the Earth's crust. Unlike the oxygen gas in air, oxygen in minerals is strongly bonded to other elements. By weight, oxygen accounts for almost half the crust, but it takes up 93% of the volume of an average rock. This is because the oxygen atom takes up a large amount of space relative to its weight. It is not an exaggeration to regard the crust as a mass of oxygen with other elements occupying positions in crystalline structures between oxygen atoms.

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↓Elementary mathematics

Earth

Minerals, the building blocks of rocks, are inorganic crystalline solids with a specific internal structure and a definite chemical composition (varies only within a narrow range).

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↓Rocks and Minerals

Minerals can be formed under a variety of conditions, such as:

- During the cooling of molten materials (steel, from lavas, igneous rocks).
- During the evaporation of liquids (salt, sugar, reference to evaporites)
- The cooling of liquids (saturated solution)
- At high temperatures and pressures new crystals may grow in solid materials (diamonds from coal, metamorphism)



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↓Rocks and Minerals

Rock is a naturally occurring solid aggregate of one or more minerals or mineraloids.

For example, the common rock granite is a combination of the quartz, feldsper and biotite minerals. The Earth's outer solid layer, the lithosphere, is made of rock.

Three major groups of rocks are defined: igneous, sedimentary and metamorphic.

There is a geological rock cycle taking place on the earth that results in the formation of soil.

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↓Rocks and Minerals

Classification of Major Igneous Rocks

Chemical Composition			Granitic	Andesitic	Basaltic	Ultramafic
Dominant Minerals			Quartz Potassium feldspar Sodium-rich plagioclase feldspar	Amphibole Sodium- and calcium-rich plagioclase feldspar	Pyroxene Calcium-rich plagioclase feldspar	Olivine Pyroxene
TEXTURE	Coarse-grained		**Granite**	**Diorite**	**Gabbro**	**Peridotite**
	Fine-grained		**Rhyolite**	**Andesite**	**Basalt**	**Komatiite** (rare)
	Porphyritic		"Porphyritic" precedes any of the above names whenever there are appreciable phenocrysts.			Uncommon
	Glassy		**Obsidian** (compact glass) **Pumice** (frothy glass)			
Rock Color (based on % of dark minerals)			0% to 25%	25% to 45%	45% to 85%	85% to 100%



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↓Rocks and Minerals

Classification of Sedimentary Rocks

Clastic Sedimentary Rocks

Texture (grain size)		Sediment Name	Rock Name
Coarse (over 2 mm)		Gravel (rounded fragments)	Conglomerate
		Gravel (angular fragments)	Breccia
Medium (1/16 to 2 mm)		Sand	Sandstone
Fine (1/16 to 1/256 mm)		Mud	Siltstone
Very fine (less than 1/256 mm)		Mud	Shale

Chemical Sedimentary Rocks

Composition	Texture (grain size)	Rock Name	
Calcite, $CaCO_3$	Fine to coarse crystalline	Crystalline Limestone	
		Travertine	
	Visible shells and shell fragments loosely cemented	Coquina	Biochemical Limestone
	Various size shells and shell fragments cemented with calcite cement	Fossiliferous Limestone	
	Microscopic shells and clay	Chalk	
Quartz, SiO_2	Very fine crystalline	Chert (light colored) Flint (dark colored)	
Gypsum $CaSO_4 \cdot 2H_2O$	Fine to coarse crystalline	Rock Gypsum	
Halite, NaCl	Fine to coarse crystalline	Rock Salt	
Altered plant fragments	Fine-grained organic matter	Bituminous Coal	

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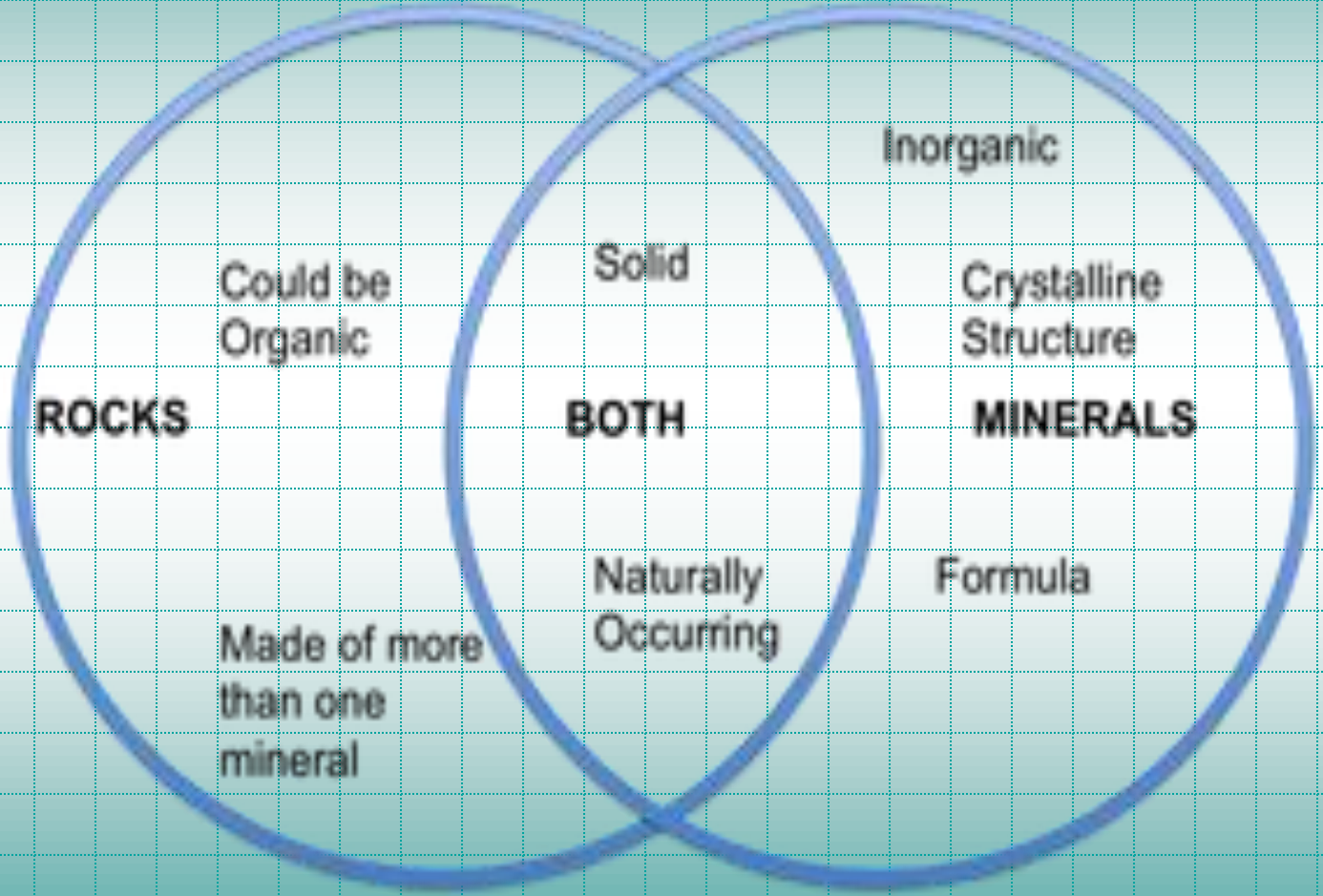
↓Rocks and Minerals

Classification of Metamorphic Rocks

Rock Name		Texture		Grain Size	Comments	Parent Rock
Slate	Increasing Metamorphism ↓	Foliated		Very fine	Smooth dull surfaces	Shale, mudstone, or siltstone
Phyllite				Fine	Breaks along wavy surfaces, glossy sheen	Slate
Schist				Medium to Coarse	Micaceous minerals dominate	Phyllite
Gneiss				Medium to Coarse	Banding of minerals	Schist, granite, or volcanic rocks
Marble		Nonfoliated		Medium to coarse	Interlocking calcite or dolomite grains	Limestone, dolostone
Quartzite				Medium to coarse	Fused quartz grains, massive, very hard	Quartz sandstone
Anthracite				Fine	Shiny black organic rock that fractures	Bituminous coal

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↓Rocks and Minerals





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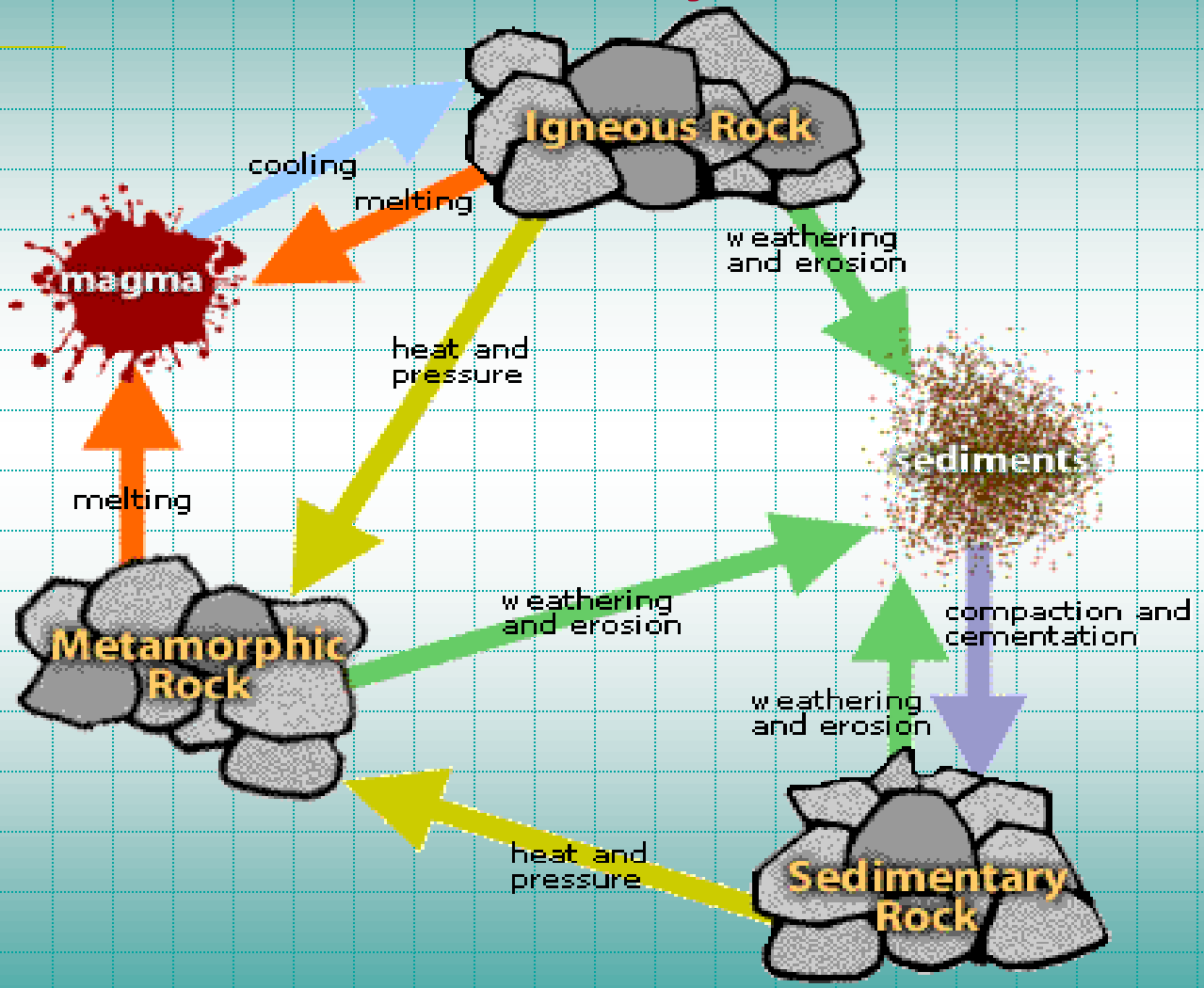
↓Rocks Cycle

There is a geological cycle continually taking place on the surface of the earth that modifies the earth's surface, destroys the old rock, creates new rock, adds to the complexity of ground surface and results in the formation of soils.

The cycle of events consists of weathering, transportation, deposition, compaction, lithification, upheaval and again followed by weathering.

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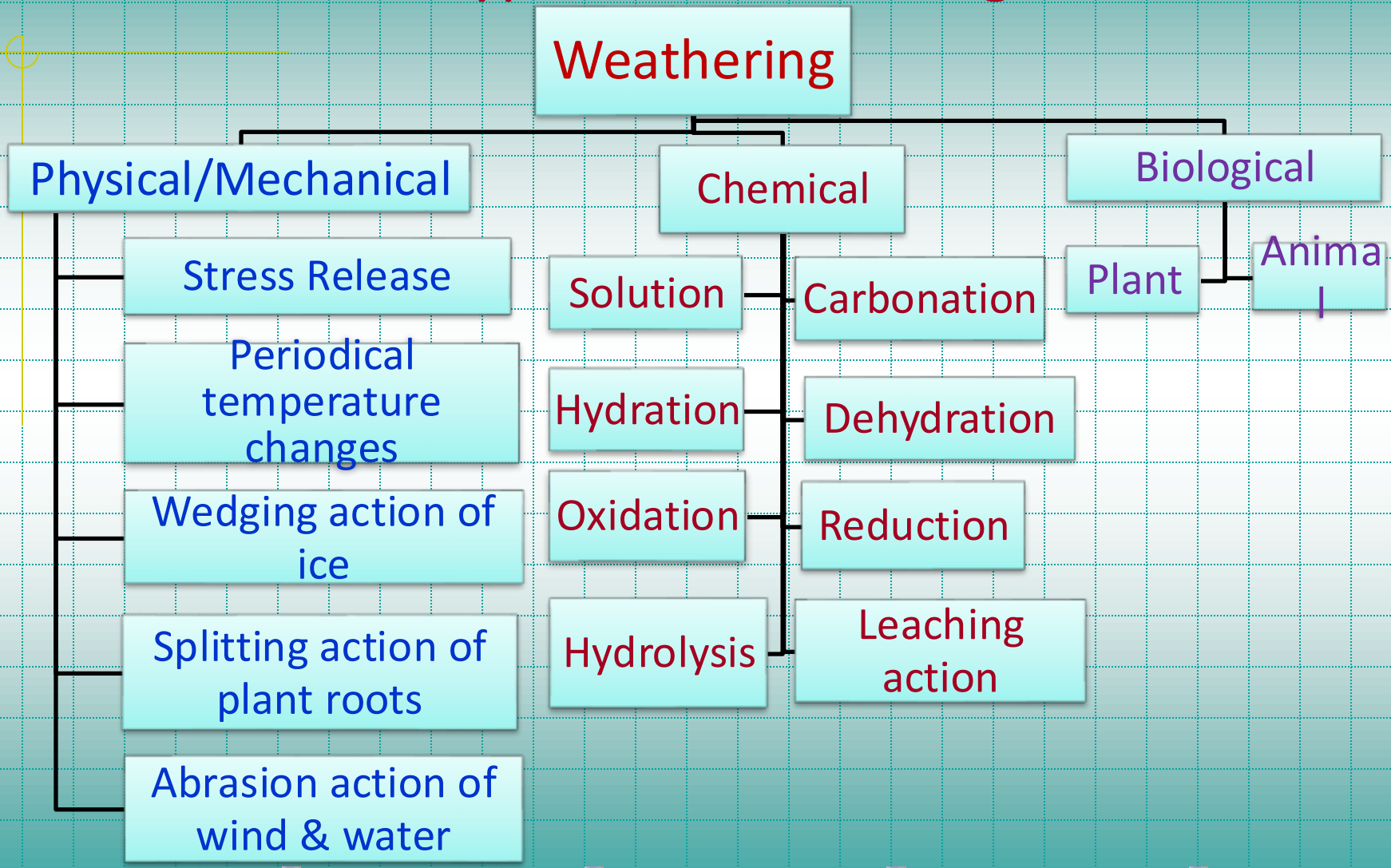
↓Rocks Cycle





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↓Types of Weathering



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Weathering

- Physical or Mechanical Weathering
  - Accomplished by physical forces that break rock into smaller pieces without changing the rock's mineral composition
  - Coarse Grained Soil
- Chemical Weathering
  - Involves breaking down rock components and internal structure and forming new components
  - Fine Grained Soil
- Biological Weathering
  - Accomplished by the action of plants & animal due to their secretion of enzymes (weak acids) for their nutrients
  - Fine Grained Soil

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↓Types of Weathering

Factors Affecting Weathering

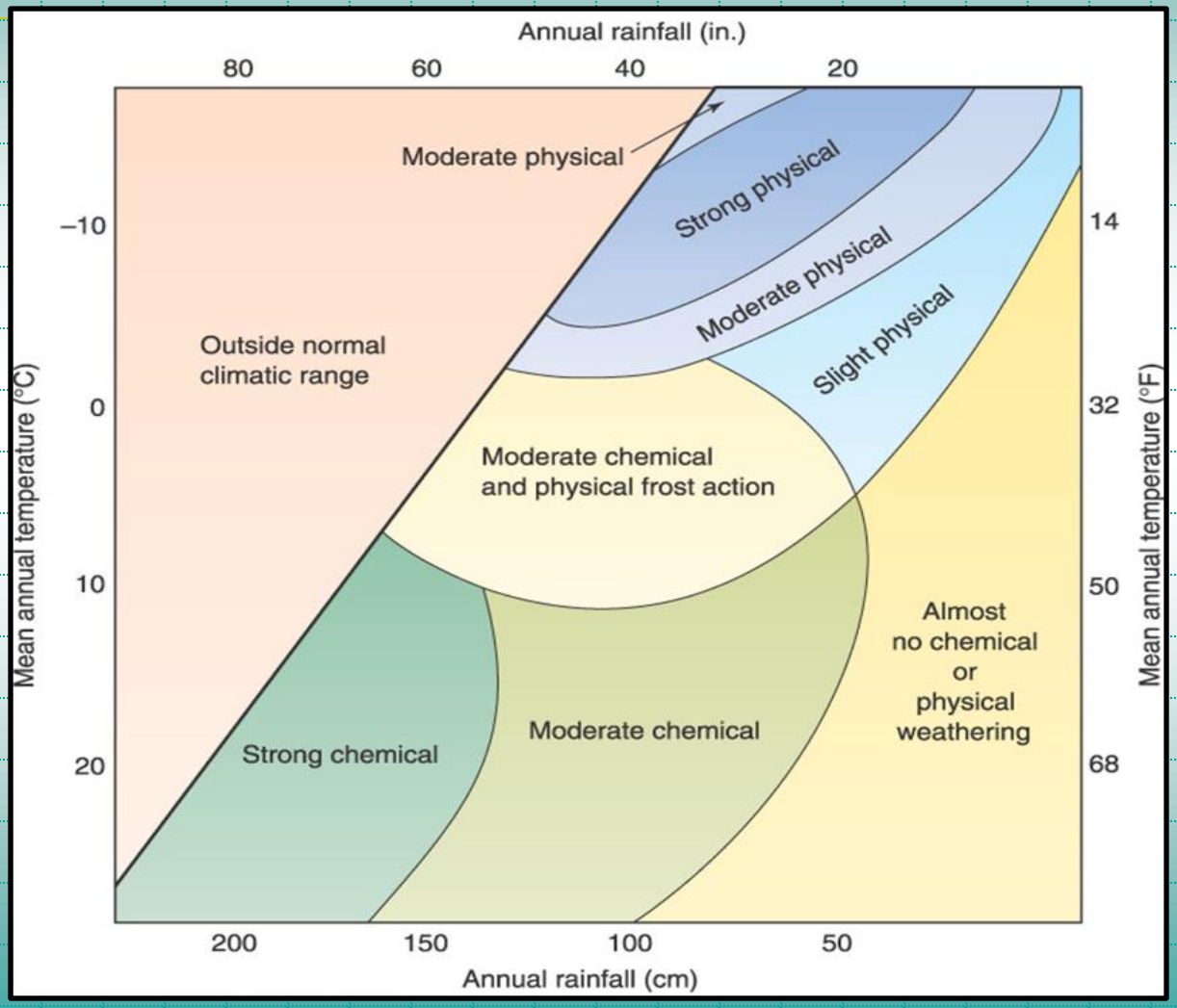
The types and intensity of weathering processes, particularly physical and chemical, depend on the climatic conditions of the area

Climatic Conditions

Temperature	Precipitation

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↓Types of Weathering



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↓ Physical Weathering: Stress Relief



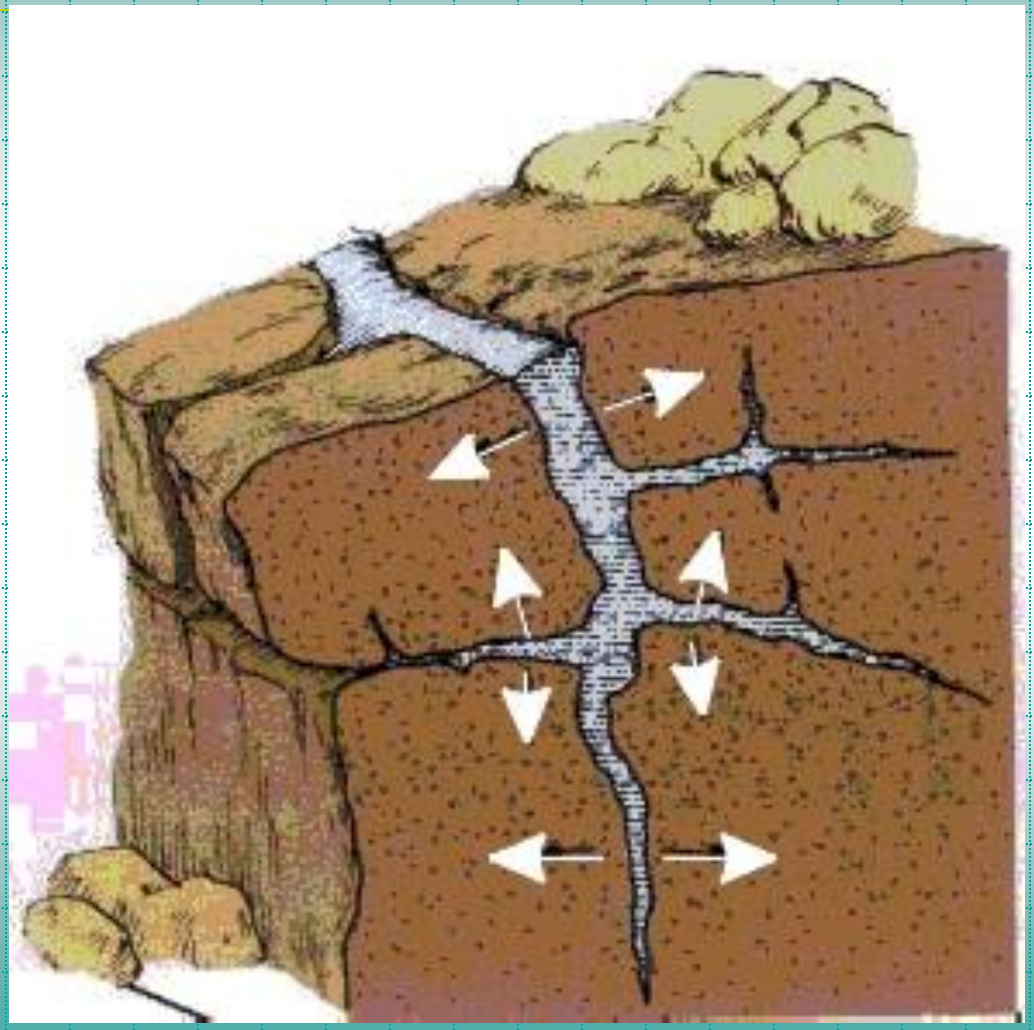
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↓ Physical Weathering: Temperature Changes- Exfoliation



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↓ Physical Weathering: Wedging Action of Ice



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Physical Weathering: Splitting Action of Plant Roots



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↓ Physical Weathering: Splitting Action of Plant Roots

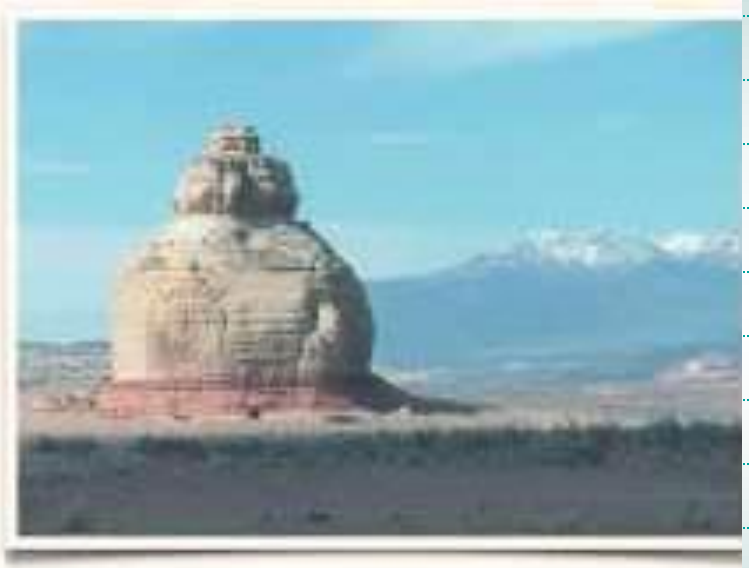


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↓ Physical Weathering: Abrasion of Water & Wind



(a) Water Abrasion



(b) Wind Abrasion

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Physical Weathering: Abrasion of Wind & Water





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↓ Chemical Weathering: Facts and Process

The processes of chemical weathering, or rock decomposition, transform rocks and minerals exposed to water and air into new chemical products.

A mineral that crystallized deep underground from a water-deficient magma may eventually be exposed at the surface, where it can react with the abundant water there to form a new, different mineral. A mineral containing very little oxygen may react with oxygen in the air, extracting oxygen atoms from the atmosphere and incorporating them into its own crystal structure, thus forming a different mineral. These new minerals are weathering products.



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↓ Chemical Weathering: Facts and Process

The following processes are involved in chemical weathering.

- Hydration
- Hydrolysis
- Carbonation
- Oxidation
- Reduction
- Solution/ Dissolution
- Leaching Action



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↓ Chemical Weathering: Facts and Process

Hydration

- Hydration is one of the most common processes in nature and works with secondary minerals, such as aluminum oxide and iron oxide minerals and gypsum. Soil forming minerals in rocks do not contain any water and they undergo hydration when exposed to humid conditions.

- a) $2Fe_2O_3 + 3HOH \rightarrow 2Fe_2O_3 .3H_2O$
- (Hematite) (Red) (Limonite) (Yellow)
-

- b) $Al_2O_3 + 3HOH \rightarrow Al_2O_3 .3H_2O$
- (Bauxite) (Hyd. aluminum Oxide)



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↓ Chemical Weathering: Facts and Process

Hydrolysis

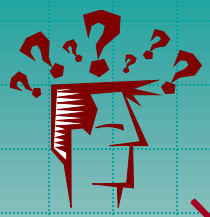
- Hydrolysis is the most important process in chemical weathering. It is due to the dissociation of H_2O into H^+ and OH^- ions which chemically combine with minerals and bring about changes, such as exchange, decomposition of crystalline structure and formation of new compounds.

- $KAlSi_3O_8 + H_2O \rightarrow HAlSi_3O_8 + KOH$
- (Orthoclase) (Acid silt clay)

- $HAlSi_3O_8 + 8\ HOH \rightarrow Al_2O_3 .3H_2O + 6\ H_2SiO_3$
- (Recombination) (Hyd. Alum. oxide) (Silicic acid)

- Some substances present in the rocks are directly soluble in water. The soluble substances are removed by the continuous action of water and the rock no longer remains solid and form holes, rills or rough surface and ultimately falls into pieces or decomposes. The action is considerably increased when the water is acidified by the dissolution of organic and inorganic acids.

- $NaCl + H_2O \rightarrow Na^+, Cl^-$

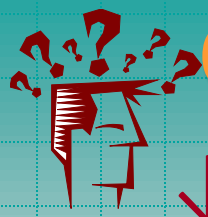


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↓ Chemical Weathering: Facts and Process

Carbonation

- Carbon dioxide when dissolved in water it forms carbonic acid.
- $2H_2O + CO_2 \rightarrow H_2CO_3$
- This carbonic acid attacks many rocks and minerals and brings them into solution. The carbonated water has an etching effect up on some rocks, especially lime stone. The removal of cement that holds sand particles together leads to their disintegration.
- $CaCO_3 + H2CO_3 \rightarrow Ca(HCO_3)_2$
- (Calcite) (Ca bi carbonate)



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↓ Chemical Weathering: Facts and Process

Oxidation

- Oxidation is the process of addition and combination of oxygen to minerals. The absorption is usually from O_2 dissolved in soil water and that present in atmosphere. The oxidation is more active in the presence of moisture and results in hydrated oxides.
-
- $4FeO$ (Ferrous oxide) + O_2 → $2Fe_2O_3$ (Ferric oxide)
- $4Fe_3O_4$ (Magnetite) + O_2 → $6Fe_2O_3$ (Hematite)
- $2Fe_2O_3$ (Hematite) + $3H_2O$ → $2Fe_2O_3 .3H_2O$ (Limonite)

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↓ Chemical Weathering: Facts and Process

Reduction

- The process of removal of oxygen and is the reverse of oxidation and is equally important in changing soil color to grey, blue or green as ferric iron is converted to ferrous iron compounds. Under the conditions of excess water or water logged condition (less or no oxygen), reduction takes place.

- $2Fe_2O_3$ (Hematite) - $O_2 \rightarrow 4FeO$ (Ferrous oxide)

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↓ Chemical Weathering: Facts and Process

DISSOLUTION

- Dissolution occurs when rocks and/or minerals are **dissolved** by **water**. The dissolved material is transported **away** leaving a space in the rock. One consequence of this process is the formation of caves in limestone areas.
- Several common minerals dissolve in water
  - halite
  - calcite
- ***Limestone*** and ***marble*** contain calcite and are soluble in acidic water
- Marble tombstones and carvings are particularly susceptible to chemical weathering by dissolution.



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↓ Chemical Weathering: Facts and Process



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↓ Chemical Weathering: Facts and Process



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↓ Chemical Weathering: Facts and Process



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↓ Biological Weathering: Facts and Process

- Biological weathering is the actual molecular breakdown of minerals. There are things called **lichens** (combinations of fungi and algae) which live on rocks. Lichens slowly **eat** away at the **surface** of rocks.
- Lichens, fungi, and other micro-organisms
- Chemically and physically change rock





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↓ Biological Weathering: Facts and Process





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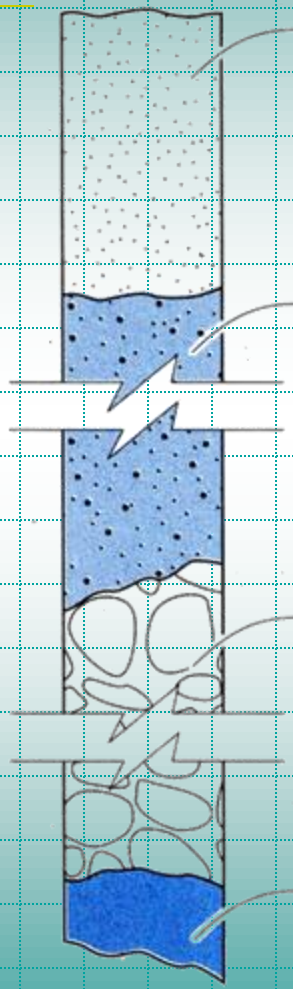
↓Soil Profile and Soil Horizon

Soil formed due to the process of weathering may either stay on the parent rock or deposit to somewhere else by some transporting agents like water, wind, glacier and gravitational forces etc. In the former case it is known as residual soil; whereas, the later is transported soil.

When vertical changes are caused in transported soils, the resulting layers are called strata; while in case of residual soil, they are called horizons. The set of horizon, from soil surface to the original or physically unaltered parent rock, is known as the profile.

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↓Soil Profile and Soil Horizon



A Horizon

Zone of intensive weathering and organic accumulation. Usually it has undesirable characteristics as a foundation stratum. It is generally very compressible, elastic, and unstable.

B Horizon

Zone of moderate weathering with an accumulation of many products, including clay and other small-particle aggregates. This is a relatively stable stratum, although it can possess some undesirable engineering characteristics at times.

C Horizon

Zone of slightly weathered parent material. It may be weathered rock or unconsolidated elements. It is a relatively stable stratum and desirable, in many respects, as a foundation.

D Horizon

Zone of massive rock

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↓Soil Profile and Soil Horizon

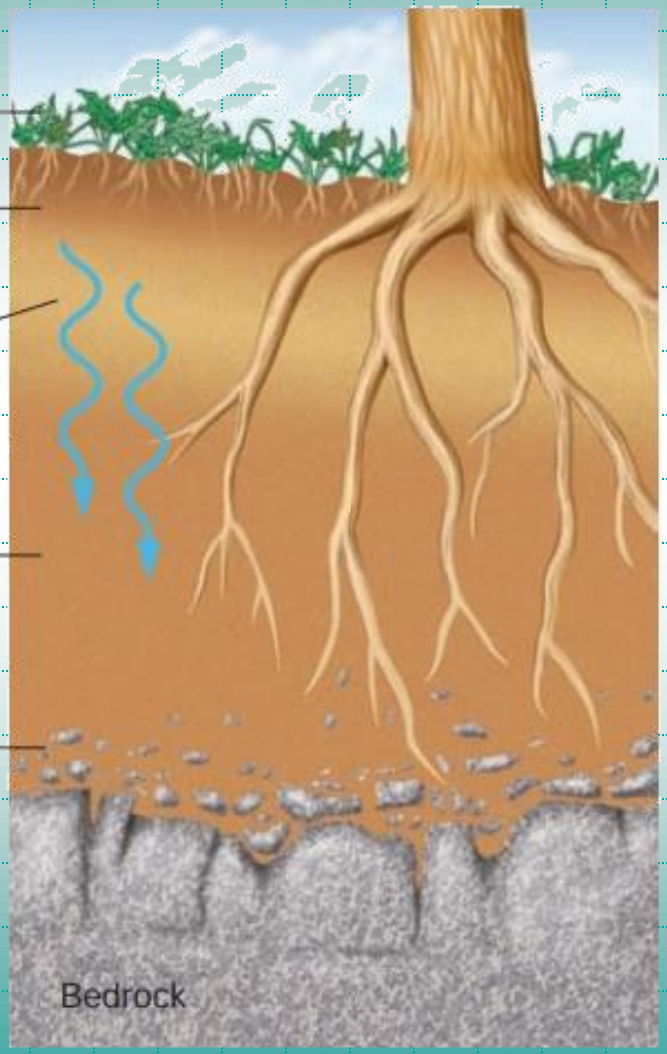
O Organic matter

A Organic matter mixed with mineral material

E Leaching by downward-percolating water

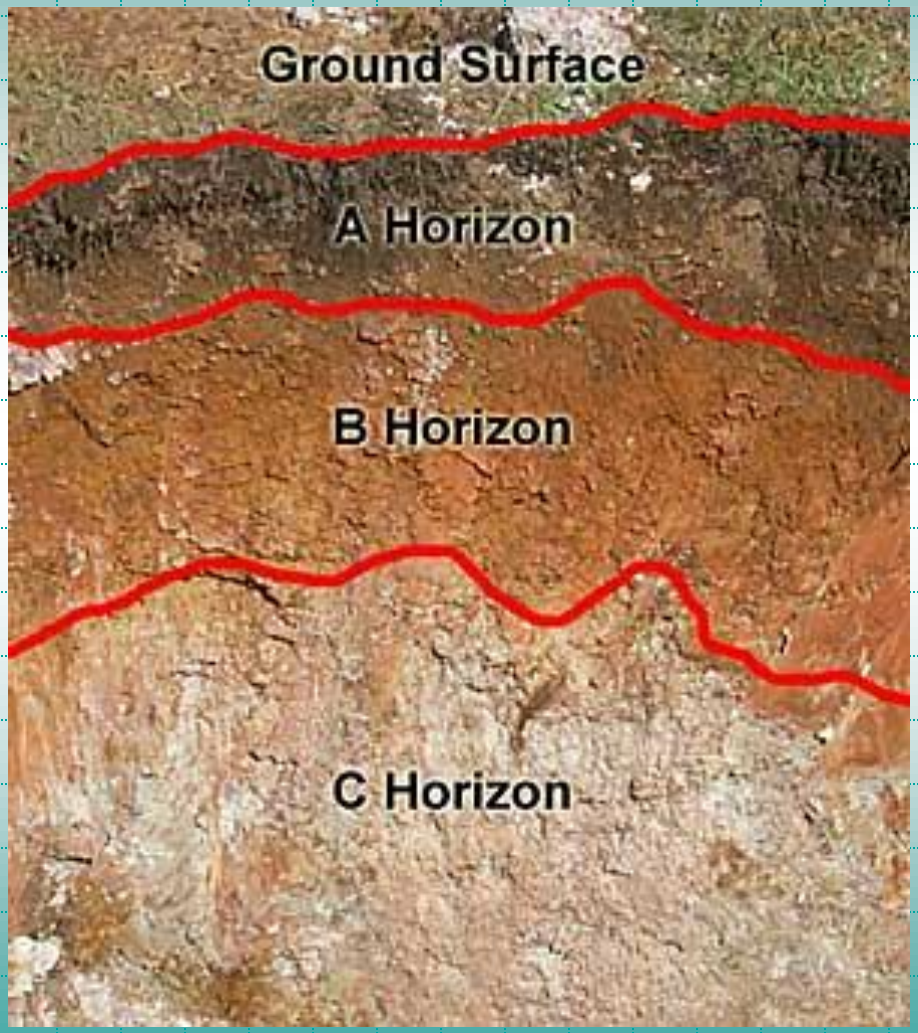
B Accumulation of clay minerals, Fe oxides, and calcite

C Fragments mechanically weathered from bedrock and some partially decomposed



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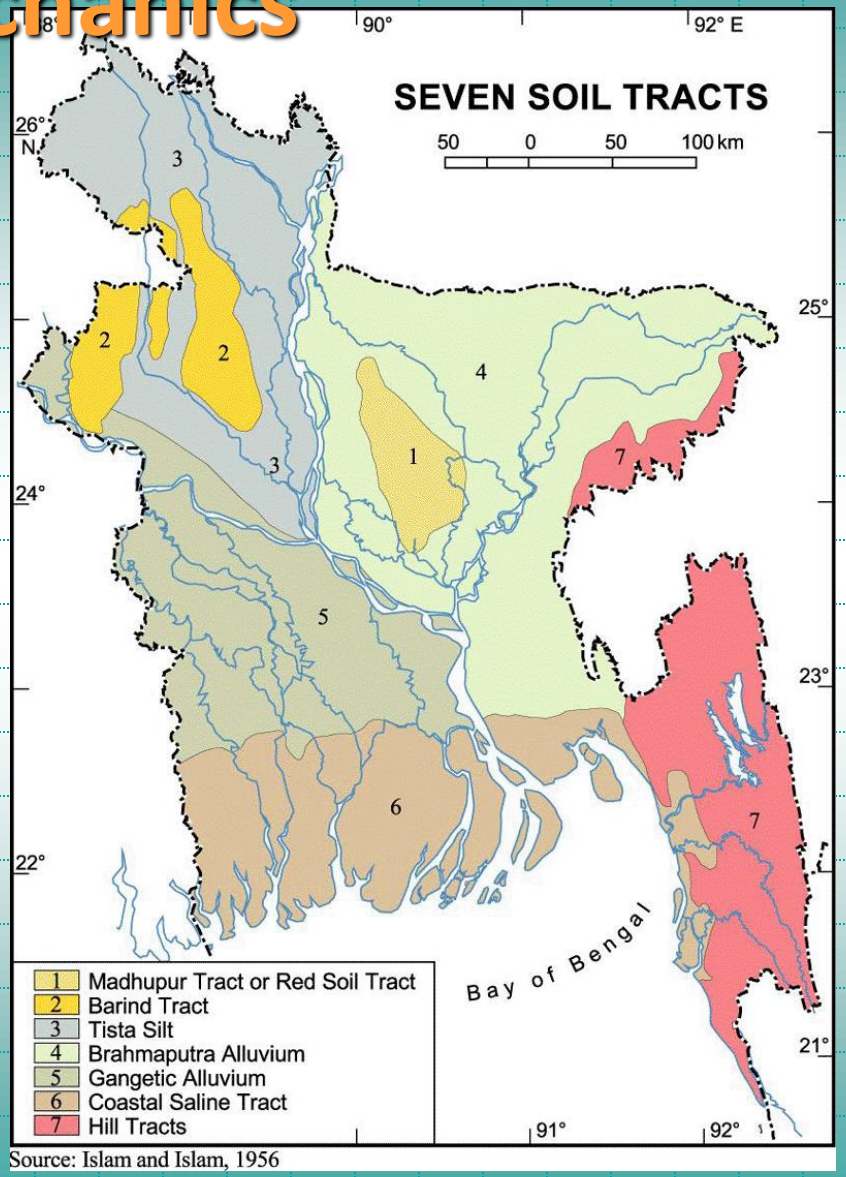
↓Soil Profile and Soil Horizon



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↓ Soils of Bangladesh

- Seven Soil Tracts
  - Madhupur Tract or Red Soil Tract
  - Barind Tract
  - Tista Silt
  - Brahmaputra Alluvium
  - Gangetic Alluvium
  - Coastal Saline Tract
  - Hill Tracts



Source: Islam and Islam, 1956



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↓ Soils of Bangladesh

1. Modhupur Tract	
10,000 sq km	**Dhaka, Mymensingh** and some isolated areas in **Chittagong, Cumilla and Sylhet**

2. Barind Tract	
13,000 sq km	**Rajshahi, Dinajpur** and **Bogura. This tract belongs to an old alluvial formation**

3. Tista Silt	
16,000 sq km	**Rangpur, Dinajpur, Bogura** and **Pabna**



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↓ Soils of Bangladesh

4. Brahmaputra Alluvium

40,000 sq km	Cumilla, Noakhali and Sylhet except the hilly areas of greater Mymensingh, Dhaka and Chattogram

5. Gangetic Alluvium

27,000 sq km	Jesohore and Kushtia and some parts of Rajshahi, Pabna, Faridpur, Khulna, Barishal and Dhaka

6. Coastal Saline Tract

20,000 sq km	Barishal, Patuakhali, Khulna, Noakhali and Chattogram



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↓ Soils of Bangladesh

7. Hill Tract

15,000 sq km	Chattogram Hill Tracts and the Garo Hills of the former greater Mymensingh district

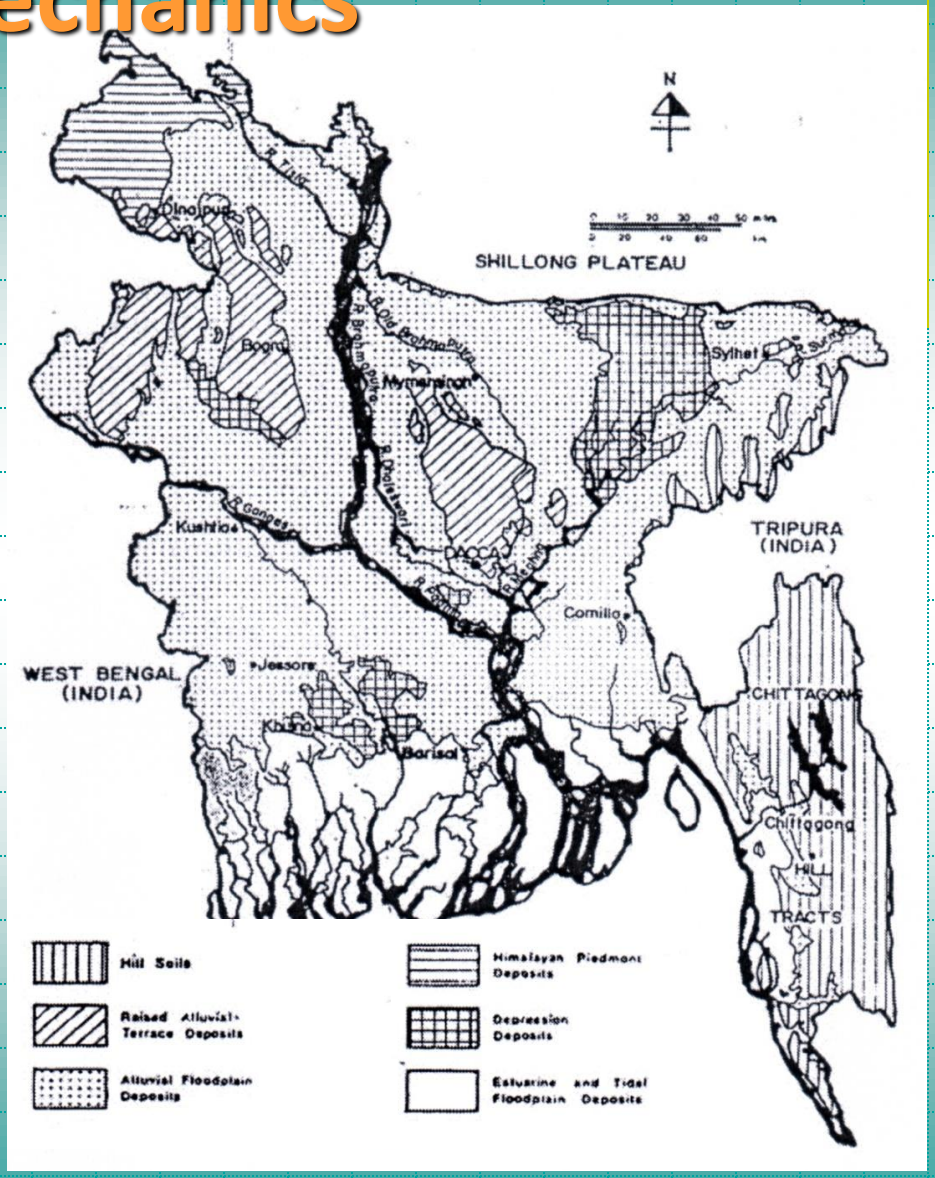
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Soils of Bangladesh

Six Types of Deposits

- Hill Soils
- Raised Alluvial Terrace Deposit
- Alluvial Flood Plain Deposit
- Himalayan Piedmont Deposit
- Estuarine and Tidal Flood Plain Deposit
- Depression Deposit





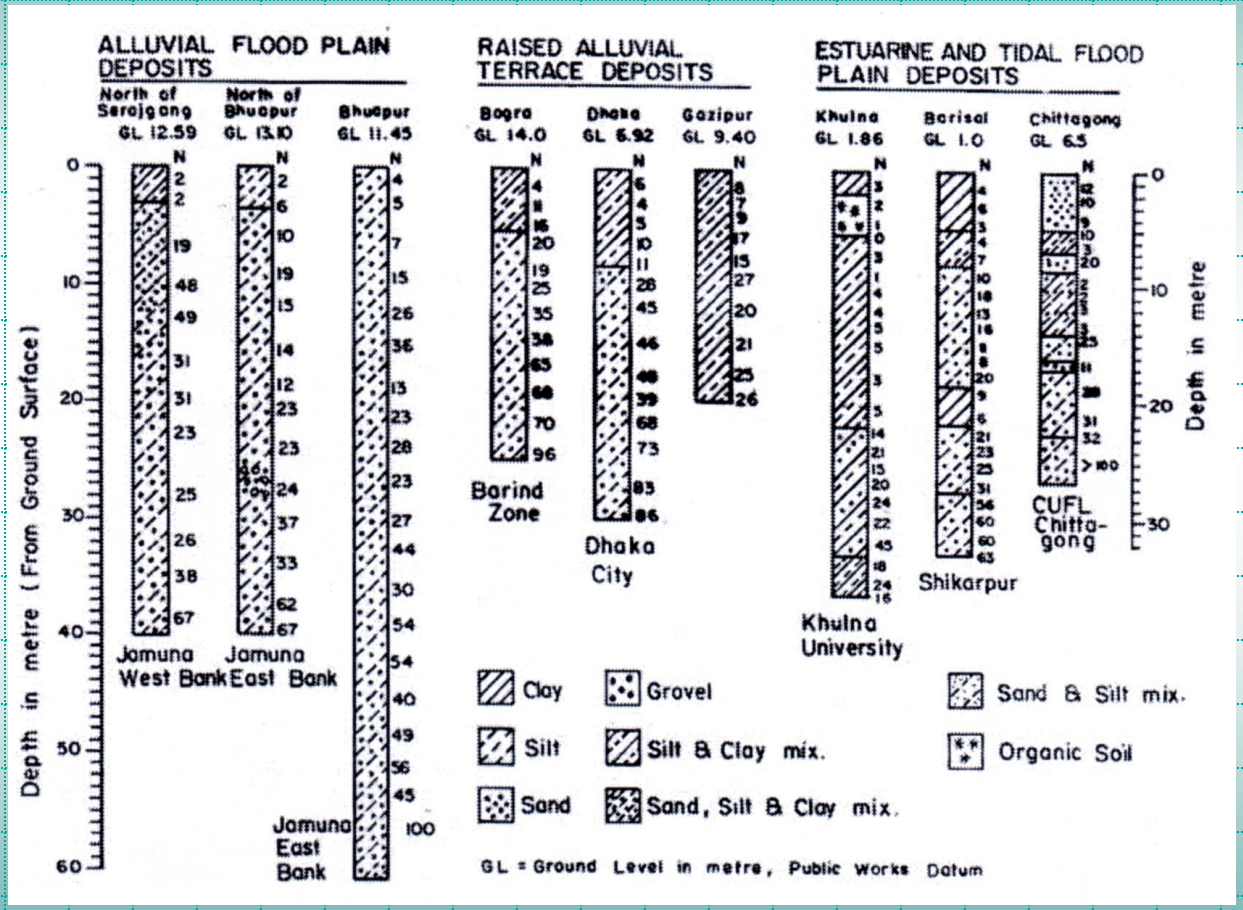
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↓ Geotechnical Soils of Bangladesh

Distribution of soils in Bangladesh is complex and are usually heterogeneous both in vertical and horizontal direction. Soils consist of wide varieties of material ranging from gravel, poorly graded sand to silt and clay. In general there is a predominance of silt size materials.

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↓ Geotechnical Soils of Bangladesh



Typical Soil Boring Logs of Three Major Deposits