AL – NOOR COLLEGE UNIVERSITY
DEPARTMENT OF CONSTRUCTION ENGINEERING AND PROJECT MANAGEMENT
FIRST LEVEL / FIRST SEMESTER

Engineering Geology
1st Semester

ألجيولوجيا ألهندسية
Engineering Geology

علم الهندسة: يعرف على أنه العلم الذي يبحث في الطريقة الأمثل لتحويل الموارد الطبيعية لاستخدامات البشر باستخدام الرياضيات، والأدلة التجريبية والعلمية، من أجل اختراع وابتكار، وتصميم، وبناء، وتحسين هياكل، وآلات، وأدوات، ونظم، ومكونات، ومواد، وعمليات مختلفة.

أو يُعرَّف بأنه طريقة التطبيق الإبداعية للمبادئ والقوانين العلمية، وذلك لإنشاء الهياكل والآلات أو الأجهزة أو لتطويرها لتلبية ما يحتاجه البشر في حياتهم.

وكلمة الهندسة مشتقة من اللغة اللاتينية وتعني الذكاء، والتدبر، والابتكار.

علم طبقات الأرض أو الجيولوجيا Geology: هو فرع من فروع علوم الأرض المختص بدراسة بنية الأرض الصلبة، والصخور التي تتكون منها، والعمليات التي تحدث عليها مع مرور الزمن.

الجيولوجيا الهندسية: هو التطبيق العملي لعلم الجيولوجيا في مجال الهندسة، ويكمن الهدف من هذه العملية في الحرص على أخذ العوامل الجيولوجية بعين الاعتبار والتركيز عليها في الأعمال الهندسية المختلفة، حيث تؤثر هذه العوامل في اختيار الموقع، وعملية التصميم، ومرحلة البناء.

علم الهندسة الجيوتقنية: هو من علوم الهندسة المدنية . ويتألف من الدراسة الهندسية للتربة لتحديد خواصها وتصنيفها ومن ثم استعمال المعلومات الناتجة عن الدراسة في الدراسات الإنشائية للأساسات والمنشآت الأرضية والتدعيم آخذين بعين الاعتبار النواحي الاقتصادية والعلمية .

تتضمن الدراسات الكاملة للتربة والأساسات العناصر الثلاث التالية :

١- الأعمال الاستكشافية وأخذ العينات .

٢- التجارب المخبرية أو الحلقية .

٣- التقرير الهندسي للدراسة مرفقا" بالتوصيات الضرورية .

دور المهندس الجيولوجي:

أحد أهم الأدوار التي يؤديها المتخصص في الجيولوجيا الهندسية هو دراسة الأشكال الأرضية والعمليات الأرضية لتحديد المخاطر الجيولوجية المحتملة وما يرتبط بها من مخاطر من صنع الإنسان والتي قد يكون لها تأثير كبير على الهياكل المدنية والتنمية البشرية. توفر الخلفية في الجيولوجيا للجيولوجي الهندسي فهمًا لكيفية عمل الأرض، وهو أمر بالغ الأهمية للتخفيف من المخاطر المرتبطة بالبيئة.

أن يكون المهندس الجيولوجي (الجيولوجي الهندسي) يملك معلومات كافية عن علم الجيولوجي يتضمن طبقات الأرض وحركات الأرض البنائية بالإضافة إلى تضاريس الأرض والتراكيب المعدنية وأنواع الصخور. وعلى الجيولوجي أن يكون ذو معرفة كبيرة في جيولوجيا المياه السطحية والمياه الجوفية بالإضافة إلى المعرفة في بيئات الترسيب للصخور الرسوبية والطرق التي يتم فيها تشكل الصخور المتحولة أو تحولها وبذلك يكون على معرفة في التصنيف الحقلي للصخور الأرضية وأقسامها وما تملكه من صدوع وشقوق، كما أنه من الواجب على الجيولوجي الهندسي أن يكون لديه معرفة كبيرة في الخرائط الجيولوجية وعلم المساحة والجيوفيزياء والجيولوجيا التركيبية، وبذلك يكون لديه القدرة على دراسة تطبيقات الجيولوجيا الهندسية على سطح الأرض وما هي آثارها على تضاريسه.

إن أحد أهم الأدوار التي يقوم بها الجيولوجي الهندسي هو تفسير التضاريس، والعمليات الأرضية لتحديد المخاطر الجيولوجية المحتملة مثل وجود التكهفات (Karst) كما في الاشكال التالية، بسبب تعرض الصخور(مثل الصخور الجبسية) ذات قابلية الذوبان العالية بالماء و حركة الماء، والتي قد يكون لها تأثير كبير على الهياكل المدنية، والتنمية البشرية.

اهمية الجيولوجيا الهندسية:

يتطلب بناء المشاريع الهندسية المدنية الكبيرة معرفة جيولوجيا المنطقة المعنية المختارة التي سيتم فيها إتمام البناء أو تساعد أيضا على اختيار المنطقة الأكثر مناسبة من الناحية الجيولوجية لإنشاء المشاريع، تحدد جيولوجيا المنطقة موقع وطبيعة كل من الهياكل التالية:

السدود، أسس ألبناء، ألطرق وألسكك ألحديدية

فباختصار، الجيولوجيا الهندسية تساعد على ضمان نموذج مستقر للمشاريع الهندسية المختلفة وفعال من حيث التكلفة لمشاريع البناء. يعد جمع المعلومات الجيولوجية لموقع المشروع أمرًا مهمًا في مرحلة التخطيط والتصميم والبناء للمشروع الهندسي. إن إجراء مسح جيولوجي تفصيلي للمنطقة قبل بدء المشروع سيقلل التكلفة الإجمالية للمشروع. عادة ما ترتبط المشاكل الأساسية الشائعة في الخزانات والجسور والمباني الأخرى بشكل مباشر بجيولوجيا المنطقة التي تم إنشاؤها فيها.

يشمل العمل الجيولوجي في الهندسة المجالات التالية: تقييم المخاطر الجيولوجية، والهندسة الجيوتقنية، وخصائص المواد، وانزلاق الأرض وخطورة الميلان و التاكل والفيضانات، والدراسات الزلزالية، ونزوح أو نضوح المياه.

ويكمن الهدف الرئيسي من الجيولوجيا الهندسية في الحفاظ على حياة المواطنين وحماية ممتلكاتهم من الأخطار الناتجة عن الظواهر الجيولوجية المتعددة.

تخصص الجيولوجيا الهندسية يشترط فيه أن نكون على معرفة نشأة وتكون الأرض وأيضاً معرفة أنواع الصخور وكيفية تشكيلها وما هي أشكال الصخور البنائية، ولا سيما الخصائص الطبيعية (الفيزيائية) والخصائص الهندسية (الميكانيكية) الخاصة في الصخور والتربة.

تخضع الكرة الأرضية باستمرار لعمليات وظواهر جيولوجية متنوعة: انزلاقات - انهيارات - تصدعات – انخسافات في المناطق الكارستية ...إلخ. وبعض هذه الظواهر ذو آثار كارثية بشرية ومادية. ومثل هذه الحوادث في تزايد مستمر بسبب تزايد إخلال الإنسان بالتوازن الطبيعي وإفساده للبيئة.

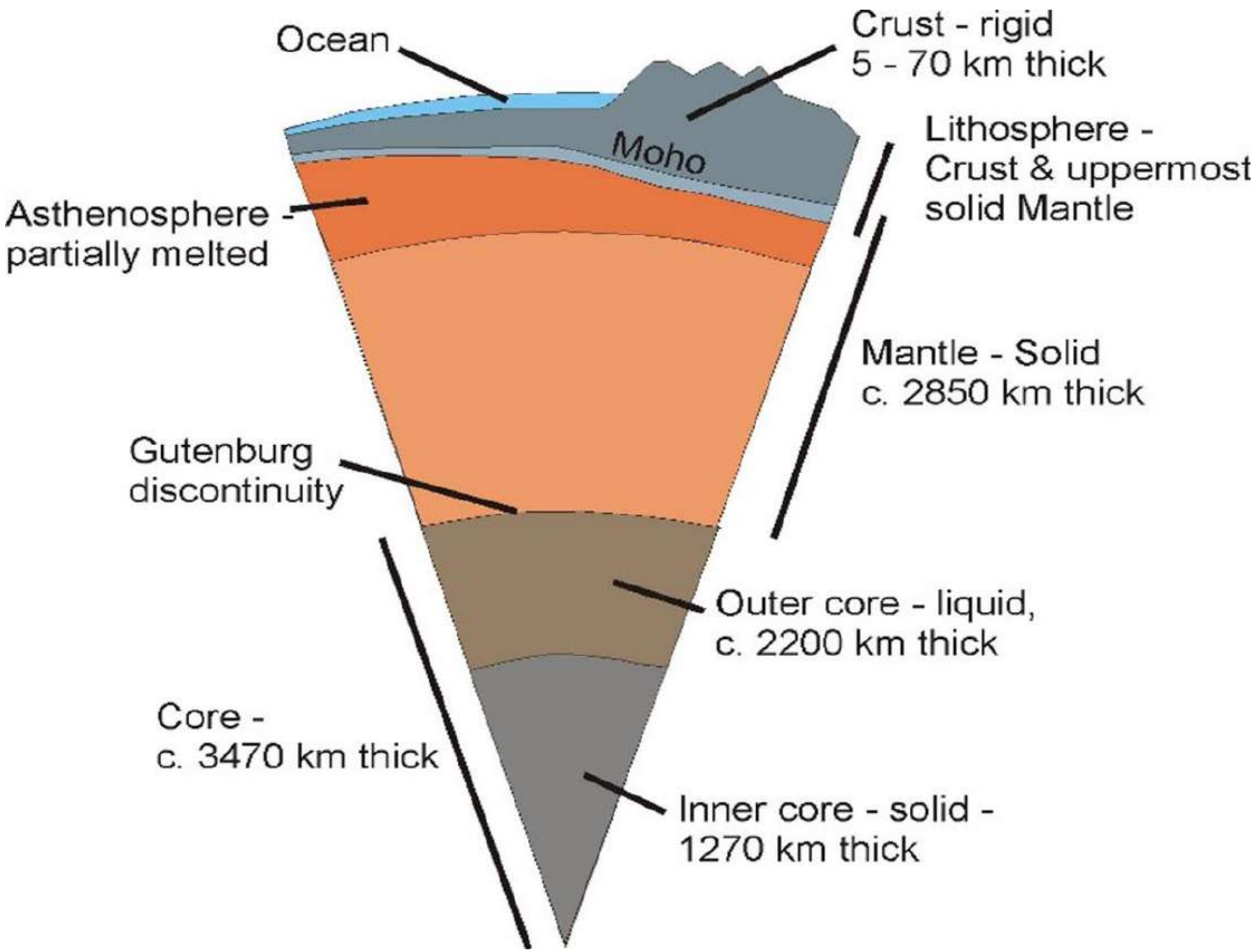
Earth structure :

Earth is the planet we live on, and the only known place in the universe to support life.

The structure of the earth is divided into four major components: the crust, the mantle, the outer core, and the inner core. Each layer has a unique chemical composition, physical state, and can impact life on Earth's surface. Movement in the mantle caused by variations in heat from the core, cause the plates to shift, which can cause earthquakes and volcanic eruptions. These natural hazards then change our landscape, and in some cases, threaten lives and property.

Earth is divided into three general layers. The **core** is the superheated center, the **mantle** is the thick, middle layer, and the **crust** is the top layer on which we live.

See the Fig. below:



Crust

- The Earth's crust ranges from 5–70 kilometres in depth and is the outermost layer. The thin parts are the oceanic crust, which underlie the ocean basins (5–10 km) and are composed of dense (mafic) iron magnesium silicate igneous rocks, like basalt. The thicker crust is continental crust, which is less dense and composed of (felsic) sodium potassium aluminium silicate rocks, like granite. The uppermost mantle together with the crust constitutes the lithosphere. The crust-mantle boundary occurs as two physically different events. First, there is a discontinuity which is most commonly known as the Mohorovičić discontinuity or Moho. The cause of the Moho is thought to be a change in rock composition from rocks containing plagioclase feldspar (above) to rocks that contain no feldspars (below). Second, in oceanic crust, there is a chemical discontinuity between ultramafic cumulates and tectonized harzburgites, which has been observed from deep parts of the oceanic crust that have been obducted onto the continental crust and preserved as ophiolite sequences.

Earth Mantel:

Earth's mantle extends to a depth of 2,890 km, making it the planet's thickest layer. The mantle is divided into upper and lower mantle separated by a transition zone. The lowest part of the mantle next to the core-mantle boundary is known as the (D-double-prime) layer. The mantle is composed of silicate rocks richer in iron and magnesium than the overlying crust. Although solid, the mantle's extremely hot silicate material can flow over very long timescales. Convection of the mantle propels the motion of the tectonic plates in the crust. The source of heat that drives this motion is the primordial heat left over from the planet's formation renewed by the radioactive decay of uranium, thorium, and potassium in Earth's crust and mantle.

Due to increasing pressure deeper in the mantle, the lower part flows less easily, though chemical changes within the mantle may also be important. The viscosity of the mantle, increasing with depth.

Earth core:

- Earth's outer core is a fluid layer about 2,400 km thick and composed of mostly iron and nickel that lies above Earth's solid inner core and below its mantle. Its outer boundary lies 2,890 km beneath Earth's surface. The transition between the inner core and outer core is located approximately 5,150 km beneath the Earth's surface. Earth's inner core is the innermost geologic layer of the planet Earth. It is primarily a solid ball with a radius of about 1,220 km , which is about 20% of Earth's radius or 70% of the Moon's radius.
- Seismic measurements show that the core is divided into two parts, a "solid" inner core with a radius of ≈1,220 km and a liquid outer core extending beyond it to a radius of ≈3,400 km. The densities are between 9,900 and 12,200 kg/m3 in the outer core and 12,600–13,000 kg/m3 in the inner core.

Magma:

Magma is a molten and semi-molten rock mixture found under the surface of the Earth. This mixture is usually made up of four parts: a hot liquid base, called the melt; minerals crystallized by the melt; solid rocks incorporated into the melt from the surrounding confines; and dissolved gases.

When magma is ejected by a volcano or other vent, the material is called lava. Magma that has cooled into a solid is called igneous rock.

Magma is extremely hot—between 700° and 1,300° Celsius . This heat makes magma a very fluid and dynamic substance, able to create new landforms and engage physical and chemical transformations in a variety of different environments.

How Magma Forms

Earth is divided into three general layers. The core is the superheated center, the mantle is the thick, middle layer, and the crust is the top layer on which we live.

Magma originates in the lower part of the Earth's crust and in the upper portion of the mantle. Most of the mantle and crust are solid, so the presence of magma is crucial to understanding the geology and morphology of the mantle.

Differences in temperature, pressure, and structural formations in the mantle and crust cause magma to form in different ways.

Geologic cycle:

The geologic cycle is a collective term used to describe the complex interactions between the component sub-cycles of tectonic, hydrologic, rock, and the biological cycling of elements known as the biogeochemical cycle. These various subcycles influence each other and has its own unique impact on the environment and may produce natural hazards and processes important to environmental geology such as *landslides, earthquakes, volcanic activity, flooding, groundwater flow, and weather.* The rock cycle is influenced by all the other geologic subcycles. For example, tectonic processes provide the pressure and heat necessary to recrystalize some or all of the minerals in a rock and transform it from one rock type to another.

A landslide **is the movement of rock, earth, or debris down a sloped section of land. Landslides are caused by rain, earthquakes, volcanoes, or other factors that make the slope unstable.**

What Causes Landslides?

Landslides have three major causes: geology, morphology, and human activity.

Landslide Movement •

There are several ways of describing how a landslide moves. • These include falls, topples, translational slides, lateral spreads, and flows.

In falls and topples, heavy blocks of material fall after • separating from a very steep slope or cliff. Boulders

tumbling down a slope would be a fall or topple. •

Why study landslides? •

Landslides are a serious geologic hazard common to almost • every State in the world and it is important to understand the nature of their potential exposure to landslide hazards, and how cities, towns, and counties can plan for land-uses, engineering of new construction and infrastructure which will reduce the costs of living with.

The Geological Cycle of Rock formation •

Geological cycle includes many processes acting • simultaneously. The most important of these begin with molten magma from within the earth forming into rock, then continue with rocks being broken down into soil, and that soil being converted back into rock.

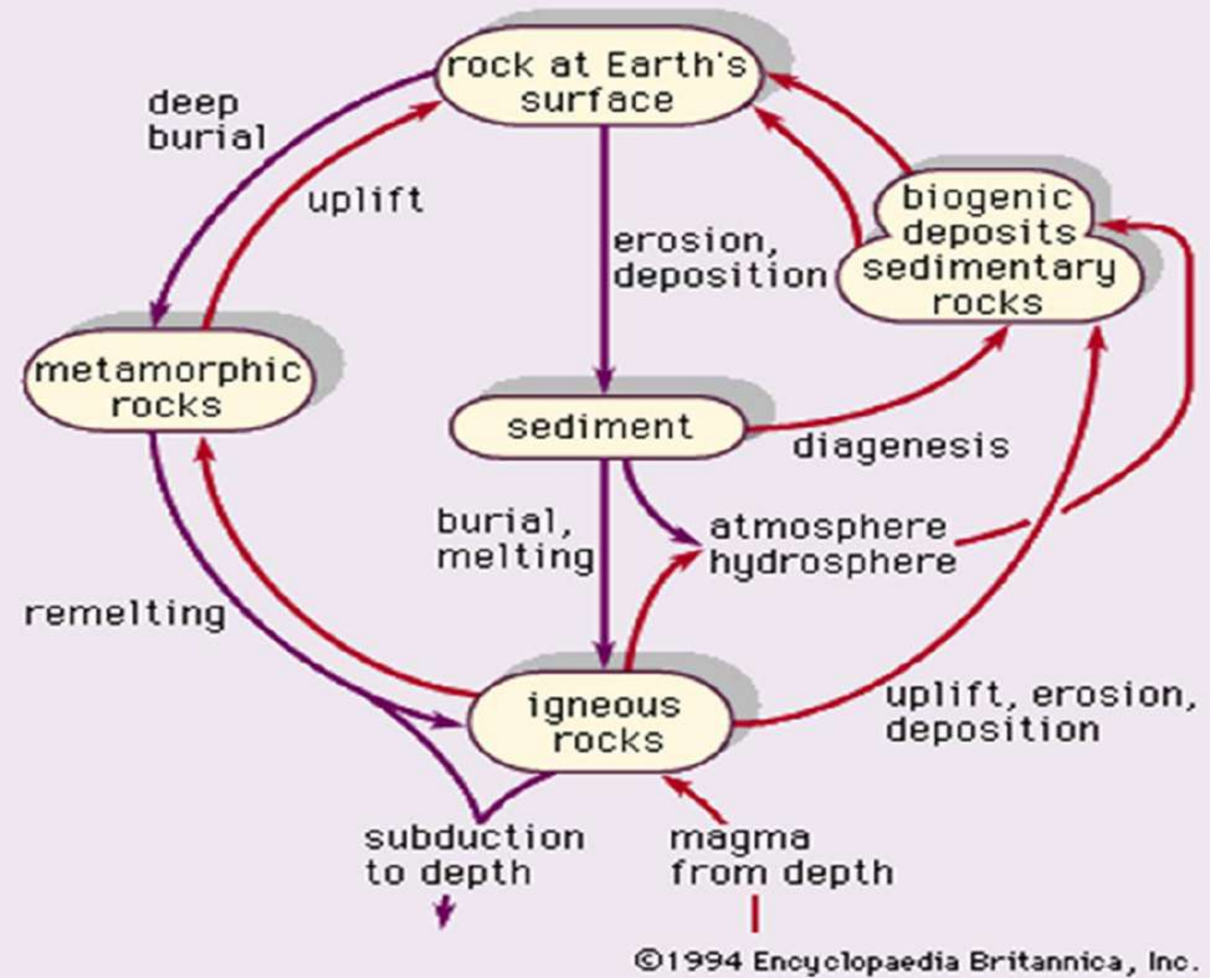
Rocks are classified according to their place in the geologic • cycle into three major categories:

Igneous •

Sedimentary and •

Metamorphic •

The Geological Cycle of Rock formation



Minerals:

A mineral is a solid, crystalline structure that naturally forms from ore deposits and cannot be broken down into different substances.

Mineral formation:

When magma or lava cools, the magma and ore carried within it crystallize to form tiny minerals in the newly-created igneous rock. Minerals found in such rock might include feldspar or mica.

Pressure and heat in the process of creating metamorphic rock can also result in the formation or transformation of minerals.

Distribution of mineral deposits is related to the transportation and release process. When gold minerals are released, typically they are so heavy that they are distributed to the bottom of riverbeds. Other minerals, such as feldspar, hornblende, or quartz, may be lightweight and drift in waterways until they are washed up on shores of riverbanks or coasts.

- Minerals in igneous rocks often form where magma has cooled over time. In this case, the mineral grains will be larger underground, where magma has not reached the Earth’s surface, and the cooling period is much longer.
- **Physical characteristics of mineral:**
- **Color**
- Color is sometimes an extremely diagnostic property of a mineral, for example olivine and epidote are almost always green in color. But, for some minerals it is not at all diagnostic because minerals can take on a variety of colors. These minerals are said to be allochromatic. For example quartz can be clear, white, black, pink, blue, or purple.
- **Streak**
- Streak is the color produced by a fine powder of the mineral when scratched on a streak plate.

Luster

Luster refers to the general appearance of a mineral surface to reflected light. Two general types of luster are designated as follows:

Metallic - looks shiny like a metal. Usually opaque and gives black or dark colored streak.

Non-metallic - Non metallic lusters are referred to as

vitreous - looks glassy - examples: clear quartz, tourmaline

resinous - looks resinous - examples: sphalerite, sulfur.

pearly - iridescent pearl-like - example: apophyllite

greasy - appears to be covered with a thin layer of oil - example: nepheline.

silky - looks fibrous. - examples - some gypsum, serpentine, malachite.

adamantine - brilliant luster like diamond.

Cleavage:

Crystals often contain planes of atoms along which the bonding between the atoms is weaker than along other planes. In such a case, if the mineral is struck with a hard object, it will tend to break along these planes. This property of breaking along specific planes is termed cleavage.

The cleavage can also be described in terms of its quality, i.e., if it cleaves along perfect planes it is said to be perfect, and if it cleaves along poorly defined planes it is said to be poor.

Tenacity

Tenacity is the resistance of a mineral to breaking, crushing, or bending. Tenacity can be described by the following terms:

Brittle - Breaks or powders easily.

Malleable - can be hammered into thin sheets.

Sectile - can be cut into thin shavings with a knife.

Ductile - bends easily and does not return to its original shape.

Flexible - bends somewhat and does not return to its original shape.

Elastic - bends but does return to its original shape.

Fracture •

If the mineral contains no planes of weakness, it will break along random directions called fracture. Several different kinds of fracture patterns are observed. •

Conchoidal fracture - breaks along smooth curved surfaces. •

Fibrous and splintery - similar to the way wood breaks. •

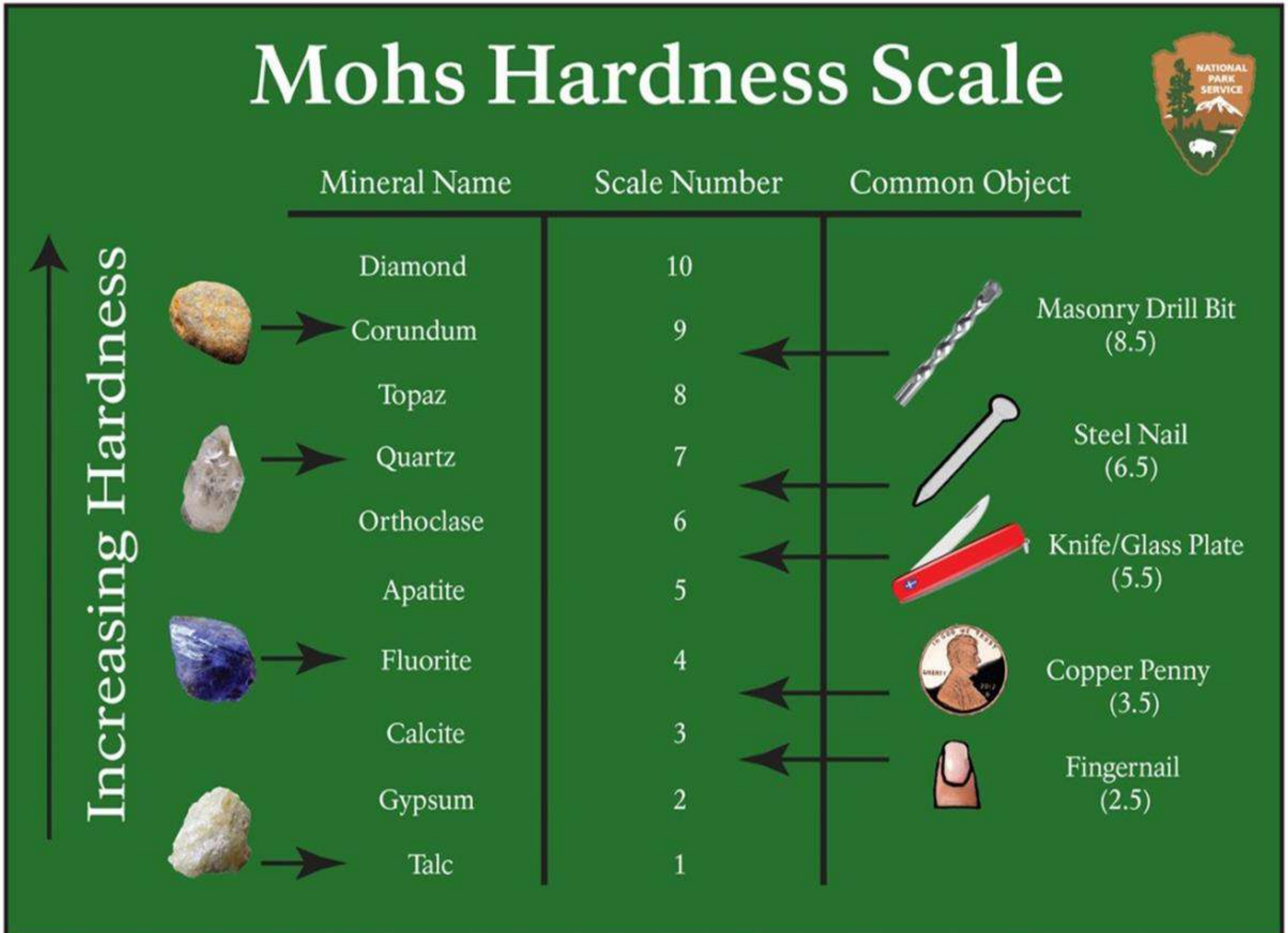
Hackly - jagged fractures with sharp edges. •

Uneven or Irregular - rough irregular surfaces •

Hardness:

Hardness is determined by scratching the mineral with a mineral or substance of known hardness

Mohs hardness. The Mohs scale is useful for identification of minerals in the field.



Mohs Hardness Scale
NATIONAL PARK SERVICE
Mineral Name
Scale Number
Common Object
Increasing Hardness
Diamond
10
Corundum
9
Topaz
8
Quartz
7
Orthoclase
6
Apatite
5
Fluorite
4
Calcite
3
Gypsum
2
Talc
1
Masonry Drill Bit (8.5)
Steel Nail (6.5)
Knife/Glass Plate (5.5)
Copper Penny (3.5)
Fingernail (2.5)

Gypsum CaSO4. 2H2O

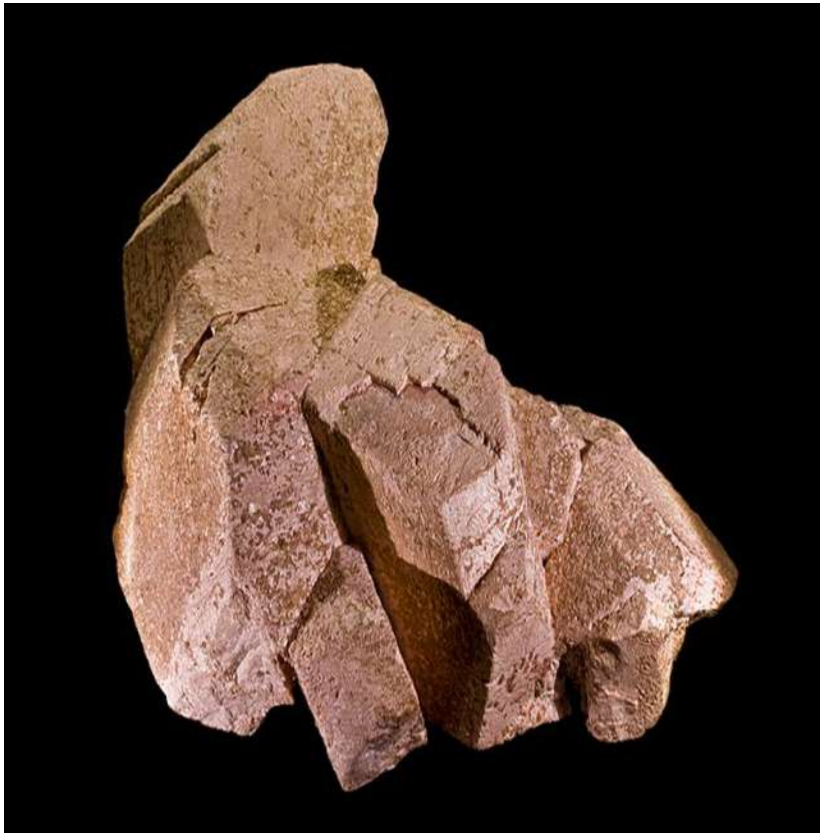
Talc /Soapstone $Mg_3Si_4O_{10}(OH)_2$

Beautiful yellow calcite crystals $CaCO_3$

Fluorite with crystal of Pyrite CaF_2

Apatite $Ca_5(PO_4)_3(OH^-,Cl^-,F^-)$

Orthoclase Feldspar $KAlSi_3O_8$



Quartz SiO_2

Topaz $Al_2SiO_4(OH^-, F^-)_2$

Corundum Al_2O_3

Diamond C

Crystal: •

If a mineral that is in the process of growth (as a result of • precipitation) is allowed to develop in a free space, it will generally exhibit a well-developed crystal form, which adds to a specimen's aesthetic beauty. grow of well-formed crystals, characterized by their smooth plane surfaces and regular geometric forms. •

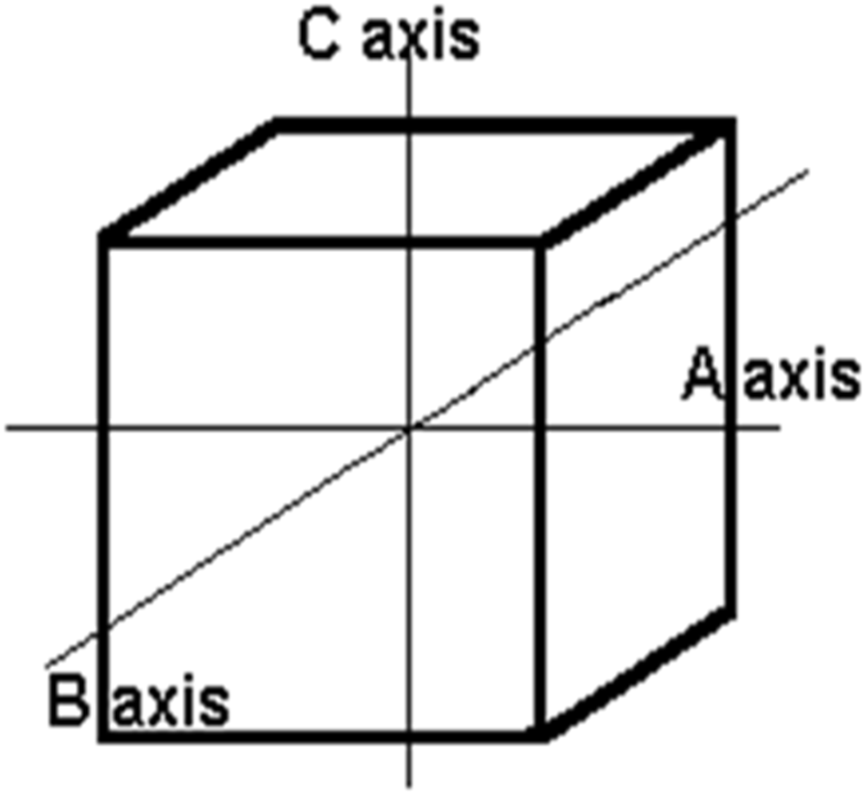
The external shape of a crystal reflects its internal atomic • arrangement. Of most importance is a crystal's symmetry.

"Symmetry is the order in arrangement and orientation of • atoms in minerals, and the order in the consequent distribution of mineral properties".

There are six crystal systems, and all minerals form • crystals in one of these six systems. Each system is defined by a combination of three factors:

- 1-How many axes it has?,
- 2-The lengths of the axes.
- 3-The angles at which the axes meet.
- An axis is a direction between the sides. The shortest one is A. The longest is C. There is a B axis as well and sometimes a D axis.
- **The Isometric System**
- The first and simplest crystal system is the isometric or cubic system. It has three axes, all of which are the same length. The three axes in the isometric system all intersect at 90º to each other. Minerals that form in the isometric system include: garnets, diamond, fluorite, gold, pyrite, and silver.

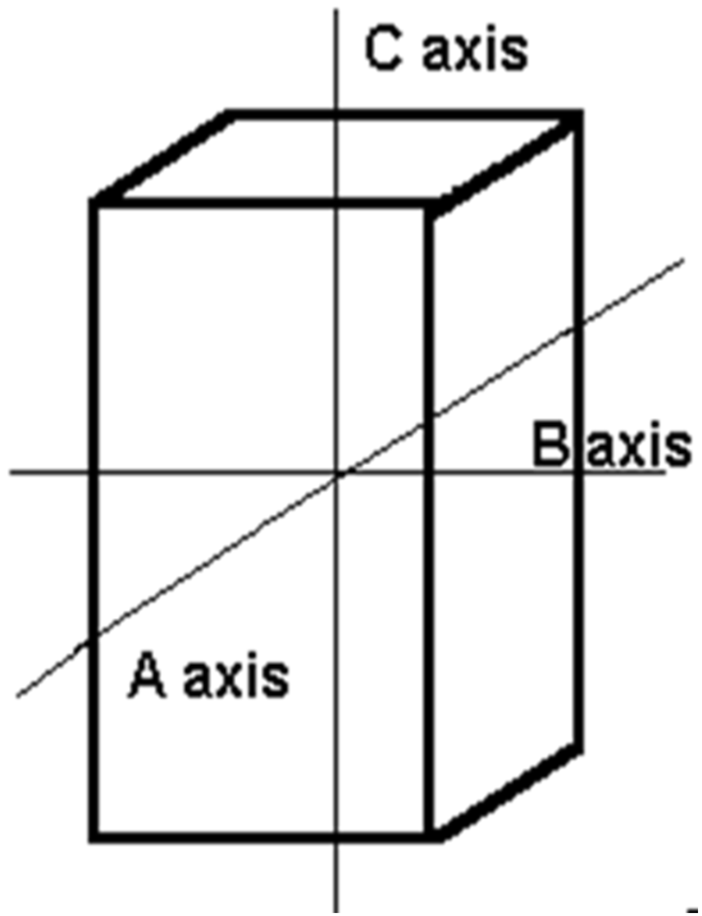
Cubic system



The Tetragonal System •

- The tetragonal system also has three axes that all meet at 90º. It differs from the isometric system in that the C axis is longer than the A and B axes, which are the same length. The tetragonal systems also contain three mutually perpendicular axes; two axes are of equal length (A and B) while the third (vertical) axis is either longer or shorter (c).
- Minerals that form in the tetragonal system include: rutile and zircon.

The Tetragonal System



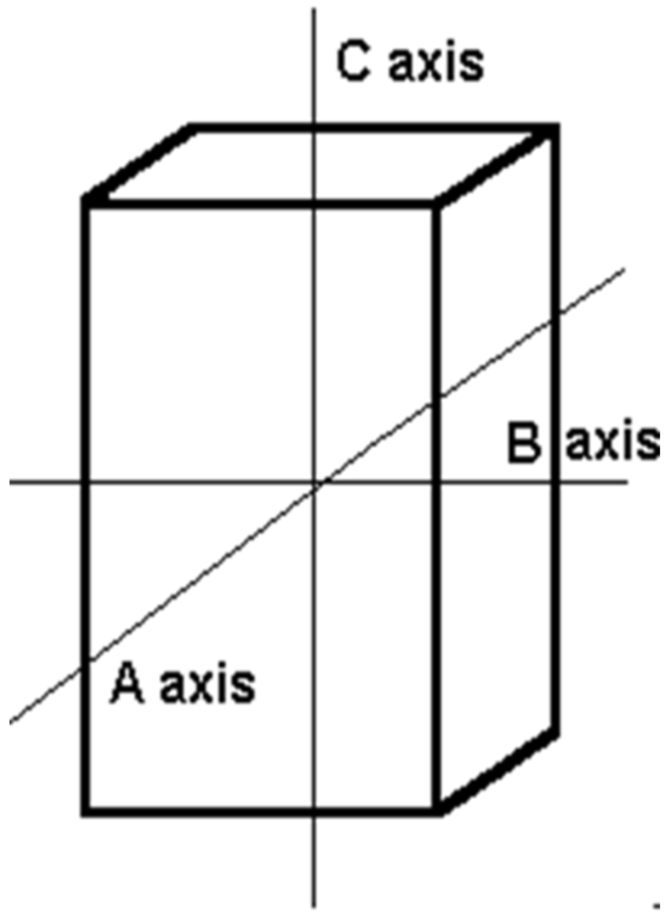
The Orthorhombic System

In this system there are three axes, all of which meet at 90º to each other. However, all the axes are different lengths. The orthorhombic also contain three mutually perpendicular axes; all the axes are of different lengths (a, b,

and c).

Minerals that form in the orthorhombic system include: andalusite, hypersthene, olivine, peridot, sulfur, and topaz.

The Orthorhombic System



The Monoclinic System •

The previously discussed crystal systems all have axes/sides that meet at 90º. In the monoclinic system, two of the axes, A and C, meet at 90º, but axis B does not. All axes in the monoclinic system are different lengths •

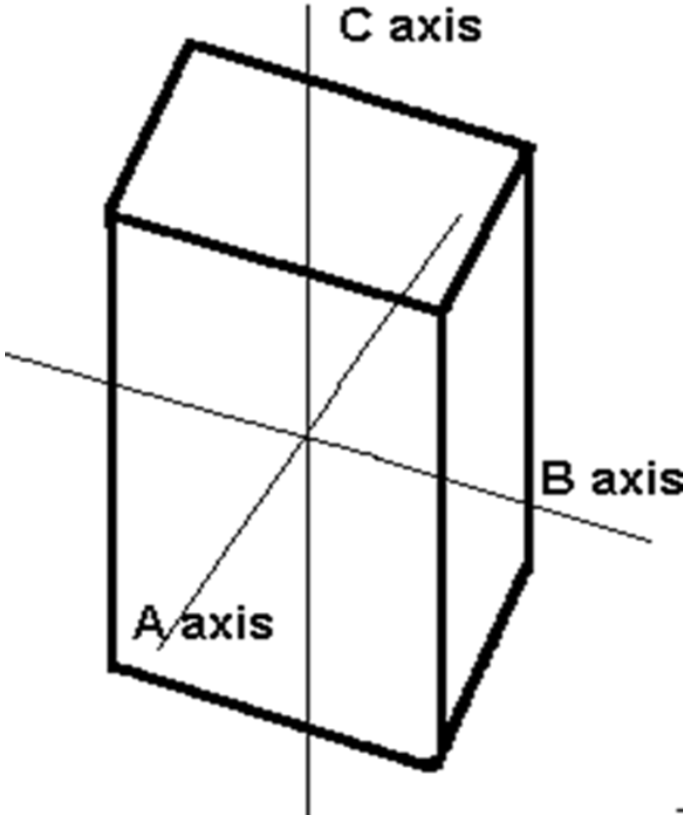
Minerals that form in the monoclinic system include: azurite, diopside, malachite, orthoclase feldspars (including albite moonstone). •

The Triclinic System •

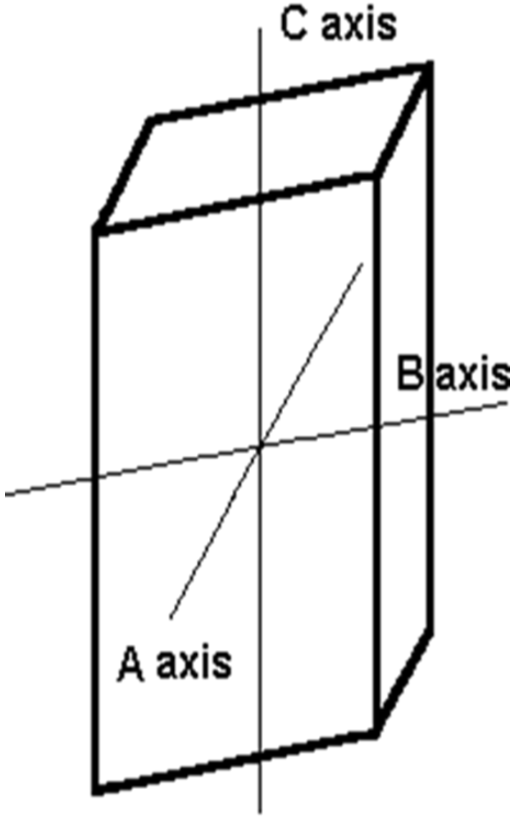
In the triclinic system, all the axes are different lengths. None of them meet at 90º •

Minerals that form in the triclinic system include: kyanite, microcline feldspar (including amazonite), plagioclase feldspars (including labradorite). •

The Triclinic System



The Monoclinic System

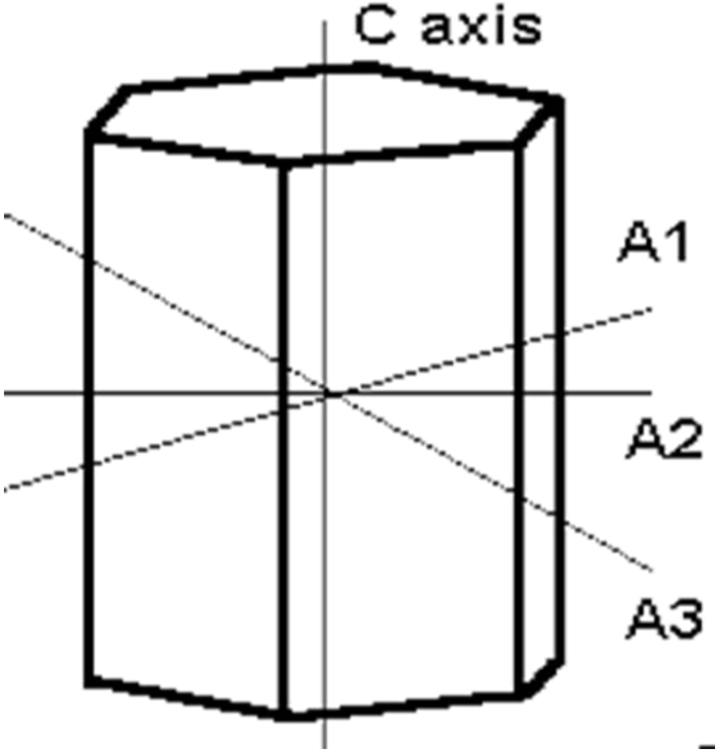


The Hexagonal System •

The crystal systems previously discussed represent every variation of four-sided figures with three axes. In the hexagonal system, we have an additional axis, which gives the crystals six sides. Three of these are equal in length and meet at 60º to each other. The C or vertical axis is at 90º to the shorter axes. •

Minerals that form in the hexagonal system include: apatite, beryl (including emerald, and morganite), and zincite •

The Hexagonal System



Rocks

- Rock, in geology, naturally occurring and coherent aggregate of one or more minerals. Such aggregates constitute the basic unit of which the solid Earth is composed and typically form recognizable and mappable volumes. Rocks are commonly divided into three major classes according to the processes that resulted in their formation. These classes are (1) igneous rocks, which have solidified from molten material called magma; (2) sedimentary rocks, those consisting of fragments derived from preexisting rocks or of materials precipitated from solutions; and (3) metamorphic rocks, which have been derived from either igneous or sedimentary rocks under conditions that caused changes in mineralogical composition, texture, and internal structure.

Types of Rocks and types of rock formations

- **Igneous Rock**: The geologic cycle begins with magma, a molten rock deep inside the earth. This magma cools as it moves upward toward the ground surface, forming igneous rocks.
- **Classification of Igneous Rock:** On the basis texture (size, shape and arrangement of mineral grains in a rock) and mode of occurrence, Igneous rock is divided broadly into two types:
- I**ntrusive** (also called plutonic rocks: form below the ground surface, where they cool slowly,
- **Extrusive** (also called volcanic rocks: arrive at the ground surface in a molten state, such as through volcanic eruption. This type of igneous rock cool very rapidly.
- **Hypabyssal Rock:** Hypabyssal rocks are formed when consolidation of magma takes place very close to the earth's surface in the form of smaller sheet like bodies (known as sills and dykes) that fill cracks inside other rocks.

Dike and sill

- Sill: A sill is igneous rock which vary in thickness from a few centimeter to several hundred meters. The sill is parallel to the bedding of rock and may be horizontal, inclined or vertical depending upon the strata.
- Dike: A dike is vertical wall-like igneous body that cuts the bedding of the rock. The thickness of the dike may vary from a few centimeters to a hundred meter or more.

Some common igneous rocks include:

Granite: is coarse grained, an intrusive rock. It the most common and familiar igneous rocks. Granite contains primarily orthoclase feldspar and quartz, with some biotite and amphibole. It is mostly light in color with a white or pink tint according to the color of the feldspar.

Engineering properties

Because of the minerals composition and interlocking of crystals, granite is hard and abrasion resistant. it can be concluded that granite can be used to support any load of ordinary structures.

Diorite: is coarse grained, an intrusive rock. It is mainly composed of plagioclase feldspar (more than 50 %) and hornblends.

Syenite: is grained igneous rocks composed essentially of potassium felspare (80-85 %). Biotite and hornblende are commonly present. Quartz is present in small amount.

- Some other types of igneous rocks are: Rhyolite, Pumice, Dolerite, Basalt and Gabbro.

Sedimentary Rocks formation •

Sedimentary rock is formed by deposition and consolidation of mineral and organic material and from precipitation of minerals from solution. The processes that form sedimentary rock occur at the surface of the earth and within bodies of water. Rock formed from sediments covers 70-80 % of the earth's land area, and includes common types such as limestone, chalk, sandstone, conglomerate and shale. •

Structural Features of sedimentary rocks •

Structural features of sedimentary rocks are of great value in; •

Stratification: The deposition of sediments into layer or beds is called stratification. The thickness of a single bed may vary from a few centimeters to stratification is formed due to the following:many meters. The •

Difference in the kinds of materials deposited for example shale and lime stone •

Difference in the size of particles deposited for example coarse grained and fine grained stand stone beds •

Difference in the color of the material deposited for example light grey and dark grey layers of limestone •

Lamination: Thin bedding, less than one centimeter in thickness, are called lamination. It is usually fined grained sedimentary rocks like shales. •

- **Cross-bedding:** It is also called current bedding or false bedding. Cross-bedding are the minor bedding or lamination which lie at an angle to the planes of general stratification. This structure is found in shallow water and wind formed deposits.

Different types of sedimentary rocks

Conglomerate: The pebbles and gravels on consolidation and cementation produce a rock known as conglomerate. **Sandstones**: Most sand is a water deposit. In arid regions, widespread sands have been laid down by wind action. Volcanic eruptions, glacial action, mechanical and chemical weathering, produce sands.

Argillaceous rocks: variously called mudstone, claystone, and shale (compacted or cemented) are among the most abundant of sedimentary rocks. It is a laminated fine grained sedimentary rock which is mainly composed of clay minerals and some silt-size grains of quartz.

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- **Carbonate rocks:** The carbonate rocks are chiefly the products of marine or fresh water sedimentation. They are predominantly chemical sediments either formed by metabolic process of organism or precipitated. Mineralogical, the carbonate rocks are comparatively simple. There are two main varieties; the limestone composed chiefly of the calcite, and the dolomite composed chiefly of dolomite.
- The carbonate rocks, particularly the limestones, have a very wide use in modern industry. The largest single use is as crushed stone. Limestone is one of the leading dimension stones being utilized both for internal and external work. Commercial lime is derived from the burning of limestone.

Weathering is the process of the weakening and breakdown of rocks, metals, and manmade objects. Water, ice, acids, salts, plants, animals, and changes in temperature are all agents of weathering.

There are two main types of weathering:

chemical weathering and

physical weathering .

An example of chemical weathering is acid rain. Caused mostly by the burning of fossil fuels, **acid rain** is a form of precipitation with high levels of sulfuric acid, which can cause erosion in the materials in which it comes in contact.

An example of physical weathering is wind blowing across the desert playas. This process causes rocks to form a specific pyramid-like shape.

How soils form

Soil is the thin layer of material covering the earth's surface and is formed from the weathering of rocks. It is made up mainly of mineral particles, organic materials, air, water and living organisms—all of which interact slowly yet constantly. The evolution of soils and their properties is called **soil formation**

Soil is a valuable resource that needs to be carefully managed as it is easily damaged, washed or blown away. If we understand soil and manage it properly, we will avoid destroying one of the essential building blocks of our environment and our food security.

Factors affecting soil formation

Soil forms continuously, but slowly, from the gradual breakdown of rocks through weathering. Weathering can be a physical, chemical or biological process:

Physical weathering—breakdown of rocks from the result of a mechanical action. Temperature changes, abrasion (when rocks collide with each other) or frost can all cause rocks to break down.

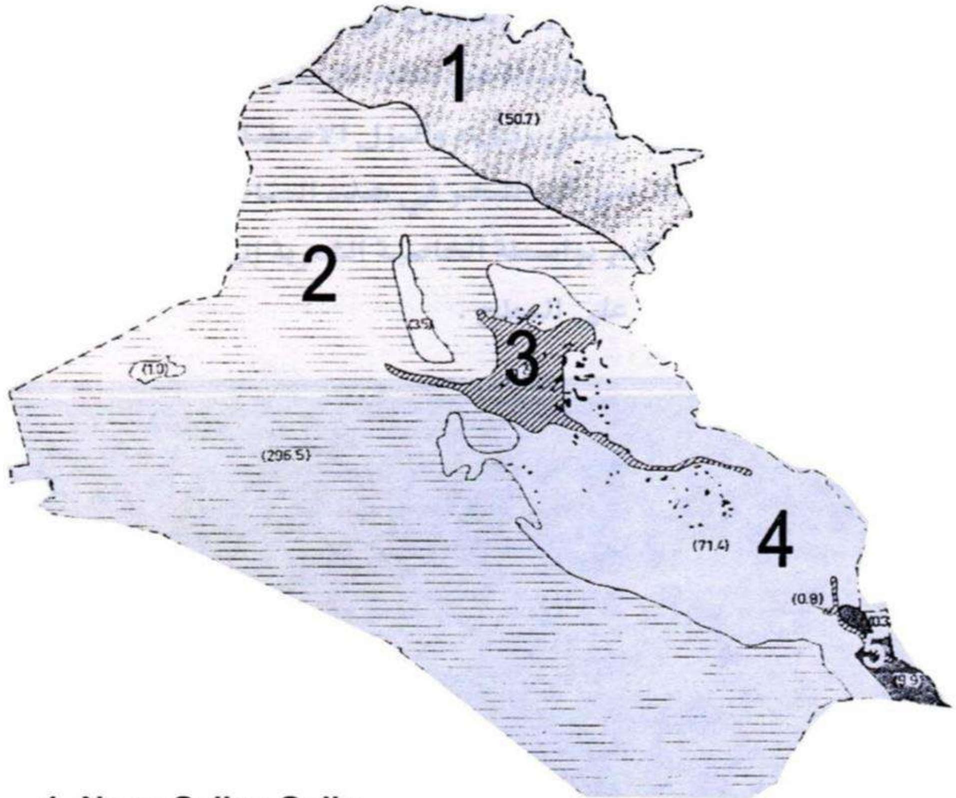
Chemical weathering—breakdown of rocks through a change in their chemical makeup. This can happen when the minerals within rocks react with water, air or other chemicals.

Biological weathering—the breakdown of rocks by living things. Burrowing animals help water and air get into rock, and plant roots can grow into cracks in the rock, making it split.

- **Soil classification** is the separation of soil into classes or groups each having similar characteristics and potentially similar behavior. A classification for engineering purposes should be based mainly on mechanical properties, e.g. permeability, stiffness, strength. The class to which a soil
- belongs can be used in its description
- Soils consist of grains (mineral grains, rock fragments, etc.) with water and air in the voids between grains. The water and air contents are readily changed by changes in conditions and location: soils can be perfectly dry (have no water content) or be fully saturated (have no air content) or be partly saturated (with both air and water present).
- **Soil as an engineering material**
- The term "soil" means different things to different people: To a geologist it represents the products of past surface processes. To a pedologist it represents currently occurring physical and chemical processes. To an engineer it is a material that can be:
- built on: foundations to buildings, bridges.
- built in: tunnels, culverts, basements.
- built with: roads, runways, embankments, dams.
- supported: retaining walls, quays.

- soils are classified into named Basic Soil Type groups according to size, and the groups further divided into coarse, medium and fine sub-groups:
- Very coarse soils: Boulders and cobbles; coarse, medium and fine
- Coarse soil : Gravel and sand; coarse, medium and fine
- Fine soil: Silt and clay; silt coarse, medium and fine
- A handful of soil rubbed through the fingers can yield the following:
- **SAND** (and coarser) particles are visible to the naked eye.
- **SILT** particles become dusty when dry and are easily brushed off hands and boots.
- **CLAY** particles are greasy and sticky when wet and hard when dry, and have to be scraped or washed off hands and boots.
- Engineers are primarily interested in a soil's mechanical properties: strength, stiffness, permeability. These depend primarily on the nature of the soil grains, the current stress, the water content and unit weight.

Soil of Iraq



1- None Saline Soils
2- Desert - with Low Saline Soils
3- Moderate Soil Salinity
4- Saline Soils
5- High Salinity Soils

Distribution of Saline Soils in Iraq, (Buringh, 1960)

- Soil survey is considered the first step in any development project and the basis of
- land evaluation
- Iraq can be divided into four main physiographic regions, each region has its specific geological, hydrological and climatologically conditions, and consequently specific soil condition.
- 1-Mountains Region
- 2-Undulating Region
- 3-The Mesopotamian plain
- 4-The Desert Region
- **The mountain region** extends mainly in the northern and north-eastern parts of the
- country.
- The mountains consist mainly of parallel anticline ridges separated by elongated synclinal valleys.

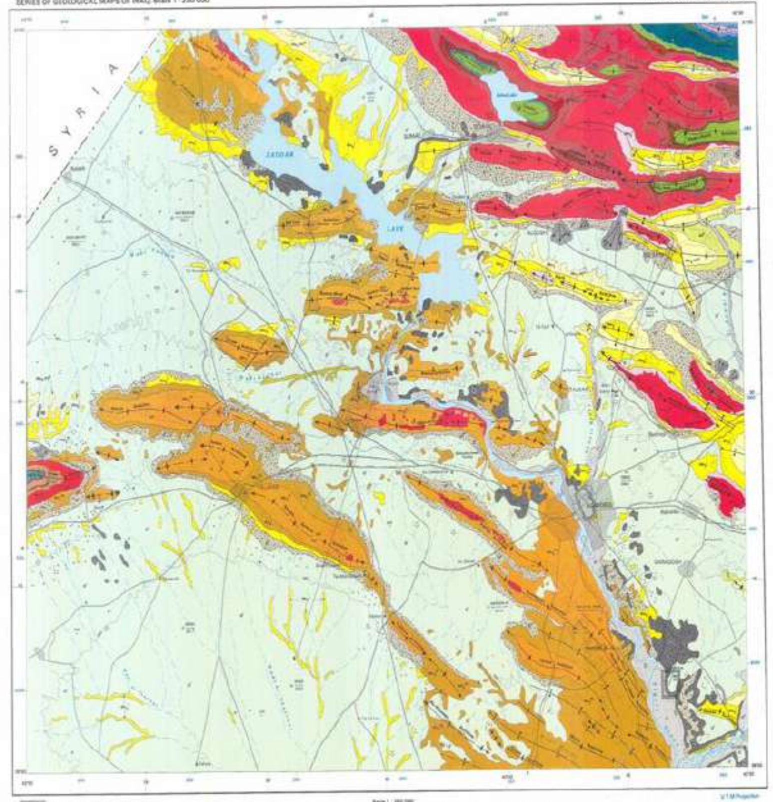
Undulating region:

This area is comprised of a fairly hilly landscape, located south and west of the mountain region. Although there are some similarities with the former region, general landscape differences stand sharp. The area is somewhat folded in the later phase of folding. It consists of low parallel hill ridges, wide shallow valleys and extensive plains , in which various streams have cut their valleys.

- **The Mesopotamian plain:** It is the plain of the twin rivers, the Tigris and the Euphrates.
- The plain is located in central and southern Iraq with a number of distinct landscapes. Geologically, the plain occupies the southern part of an extensive geosycline. It was filled up during the quaternary and recent geological periods.
- **Desert region:** This is the largest physiographic region in the country. The surface rises gradually from 120 m in the east to 700 m in the west. Within this very extensive region, there are a number of different plains; plains.Al-Widian (valleys), al- Jezira (island), al-Hijara (rock).

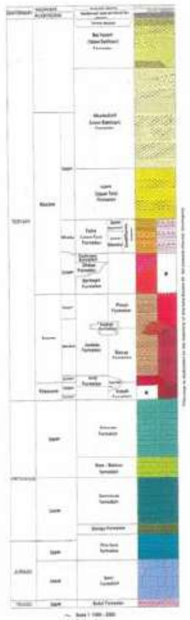
SERIES OF GEOLOGICAL MAPS OF IRAQ, Scale 1 : 250 000

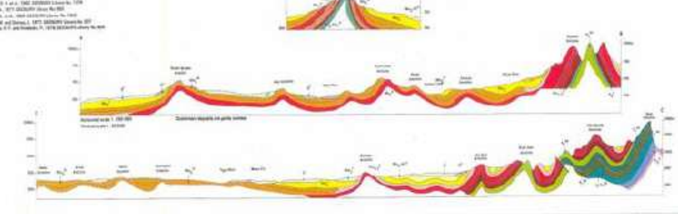
REPUBLIC OF IRAQ



STATE ESTABLISHMENT OF GEOLOGICAL SURVEY AND MINING

GEOLOGICAL MAP OF AL-MOSUL QUADRANGLE, SHEET NJ-38-13





Geological materials used in construction:

- Definition: A geological material is a material extracted from the earth as rock or sediment form

including rocks, clays, sands, limestone, and

Other industrial minerals.

Geological materials are typically of variable/unknown composition depending on their extraction

- location, and in some cases, the potential for impurities is related to specific sources or regions.
- Geological materials used in construction, derived from the Earth's crust and used in construction after appropriate processing make a genetically and functionally varied group of mineral resources.

Structural Geology:

- Movement in the mantle caused by variations in heat from the core, cause the plates to shift, which can cause earthquakes and volcanic eruptions. These natural hazards then change our landscape, and in some cases, threaten lives and property.
- Geologic structures are usually the result of the powerful tectonic forces that occur within the earth. These forces fold and break rocks, form deep faults, and build mountains. Most of these forces are related to plate tectonic activity.
- The very presence of faults and folds in the crust suggests that rocks, seemingly at rest, were once subject to forces that changed their original state by motion of one point relative to another. Structural geology is the study of the deformation of rocks. Structural geology is the study of the geometry, kinematics, and dynamics of rock structures.
- **Geometric analysis** is the descriptive or qualitative portion of structural geology.

Kinematic analysis requires a mathematical base for a rigorous treatment.

Dynamics is the study of the forces which caused the deformations studied during kinematic analysis.

Tectonic forces create three types of geologic structures: **faults, folds and joints.**

- **Faults:** Are fractures that have appreciable movement parallel to their plane. They produced usually by seismic activity. Understanding faults is useful in design for long-term stability of dams, bridges, buildings and power plants.
- Three types of stresses produce faults;
- 1-Tension 2- Compression 3- Shear
- One block has moved relative to the other block. The surface along which the blocks move is called a **fault plane**.

Parts of Faults: •

A fault line is the surface trace of a fault, the line of intersection between the fault plane and the Earth's surface. •

Fault plane: Surface that the movement has taken place within the fault. On this surface the dip and strike of the fault is measured. •

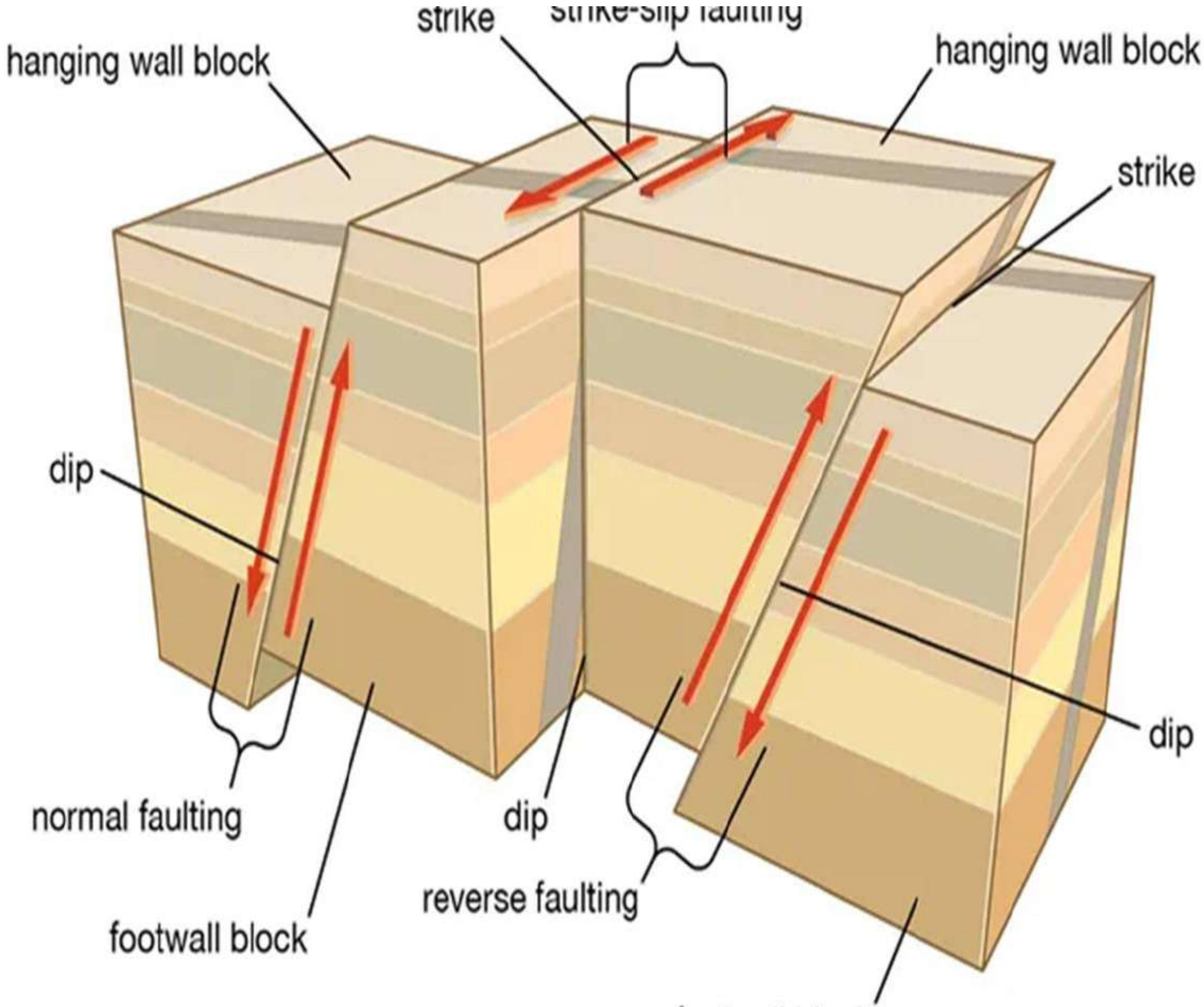
Hanging wall: The rock mass resting on the fault plane. •

Footwall: The rock mass beneath the fault plane. •

Slip: Describes the movement parallel to the fault plane. •

Dip slip: Describes the up and down movement parallel to the dip direction of the fault. •

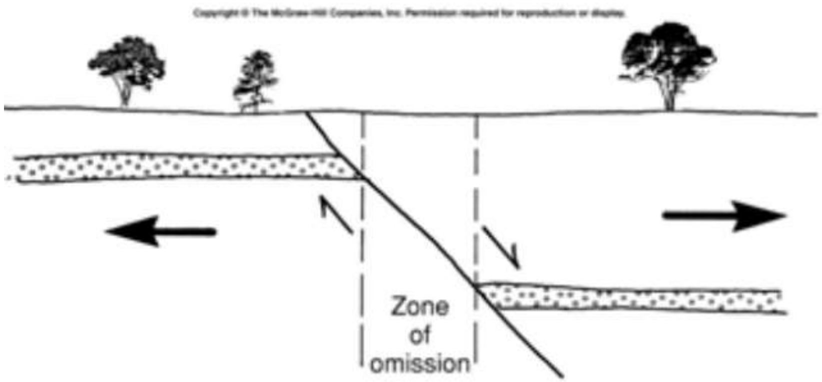
Strike slip: Applies where movement is parallel to strike of the fault plane. •


strike
strike-slip faulting
hanging wall block
hanging wall block
strike
dip
dip
normal faulting
dip
reverse faulting
footwall block

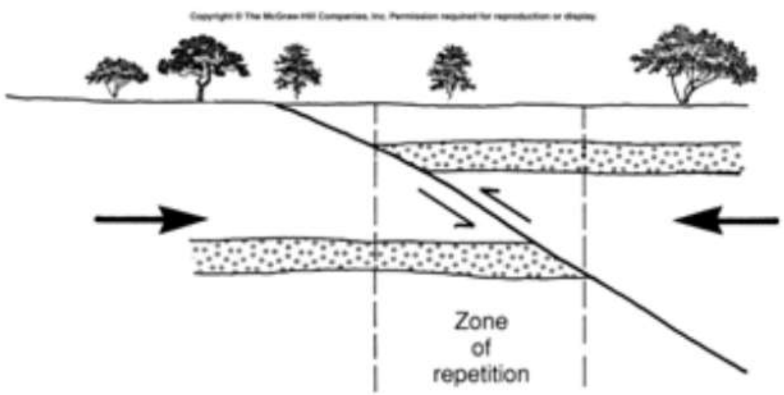
GEOLOGICAL CONCEPTS

TYPES OF FAULT

Normal and Reverse faults



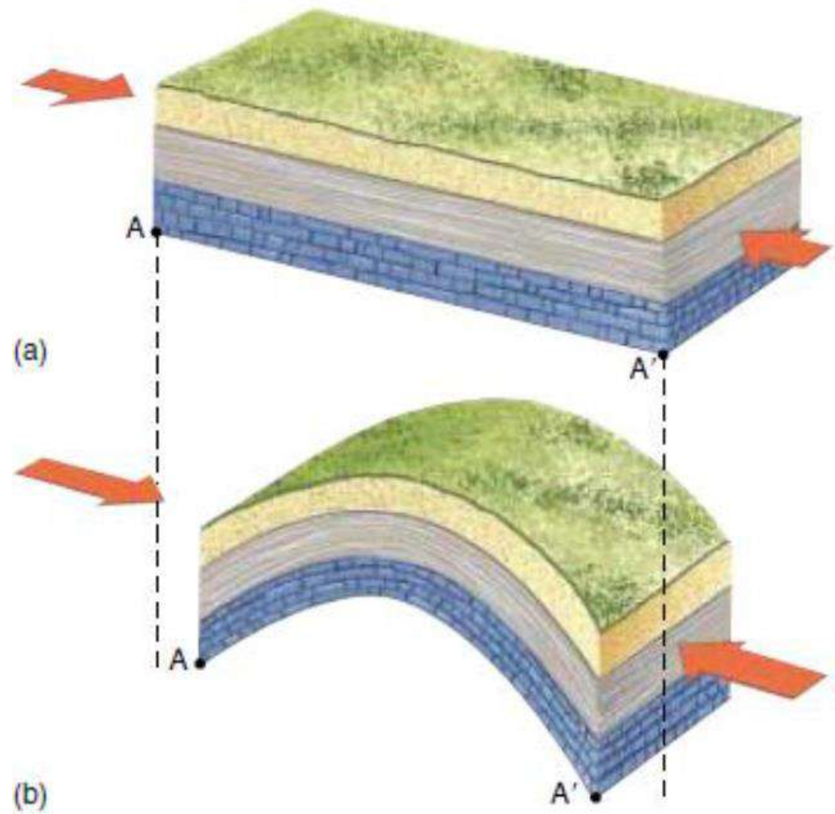
Cross section of a normal fault.
Hanging wall moved downwards.
Zone of omission indicates
extensional forces active



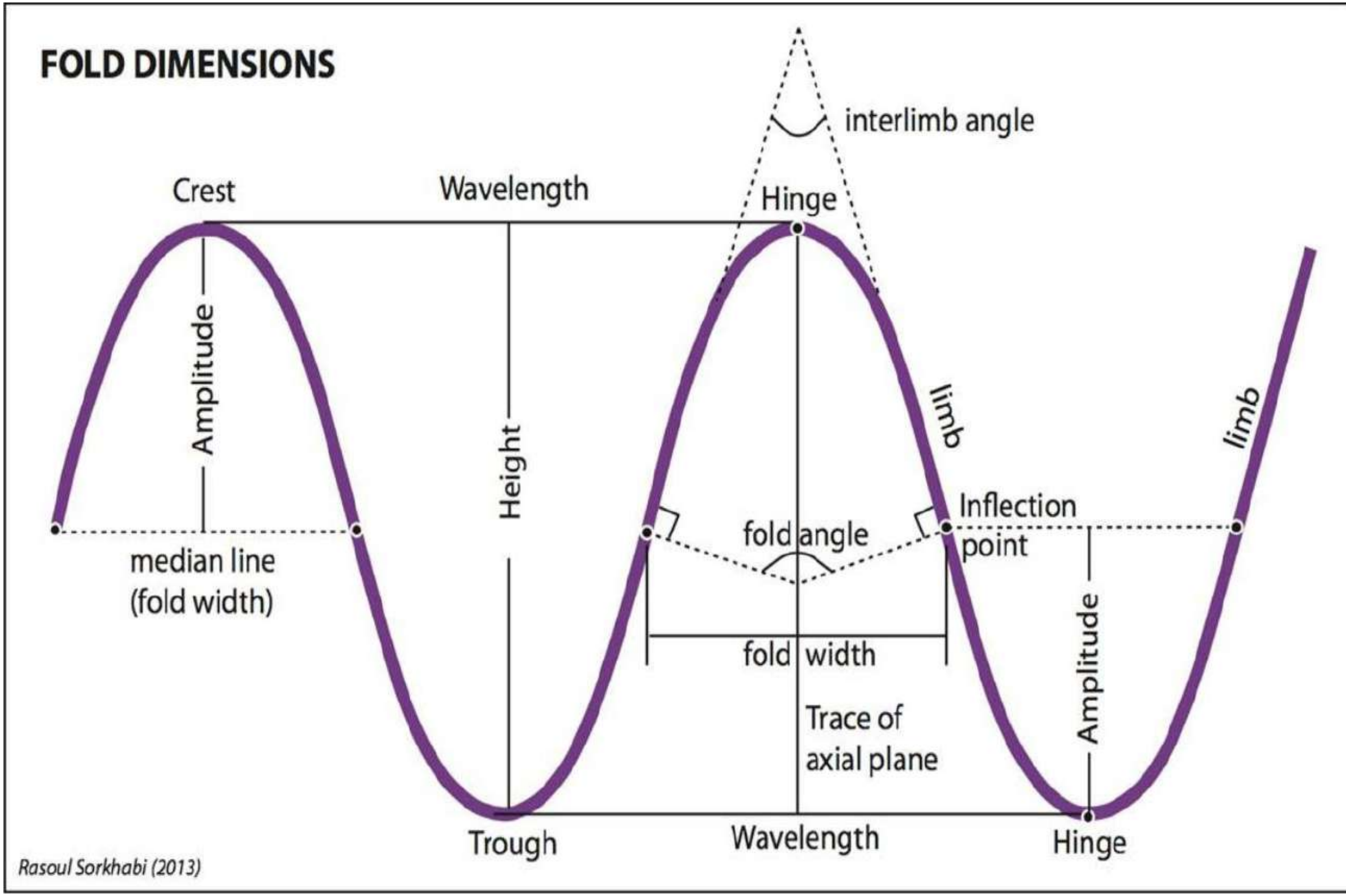
Cross section of a reverse fault.
Hanging wall has moved upwards.
Zone of repetition indicates
compressional forces active.

FOLDS

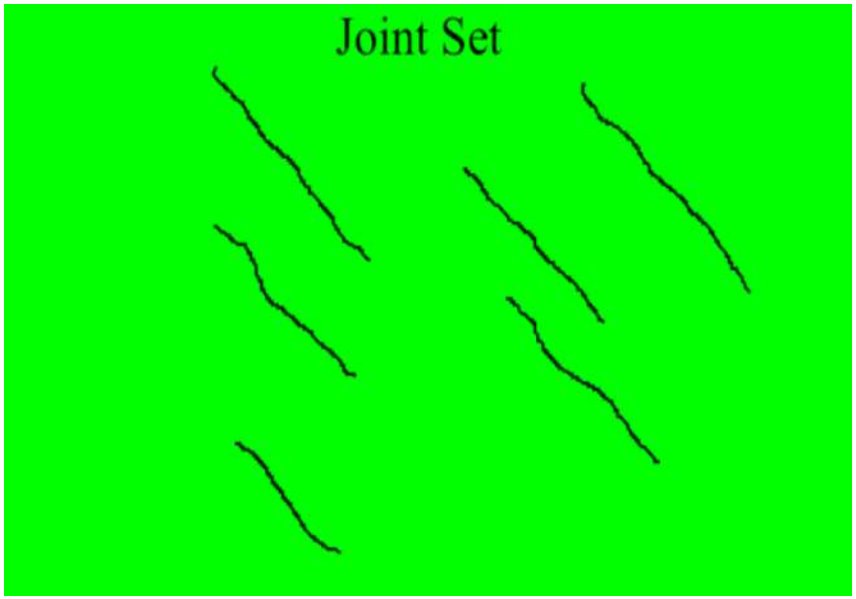
A fold is a bend in rock. Some folded rocks display little or no fracturing, indicating that the rocks deformed in a plastic manner.

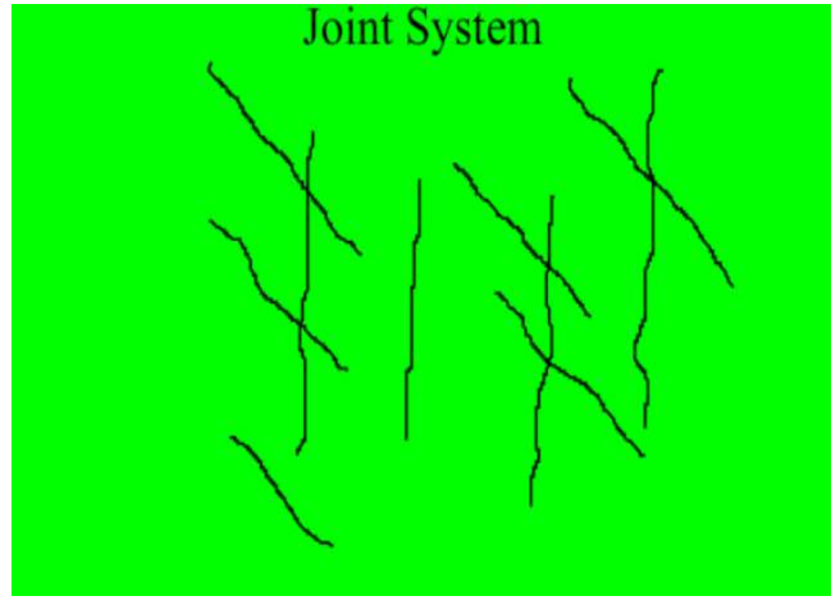


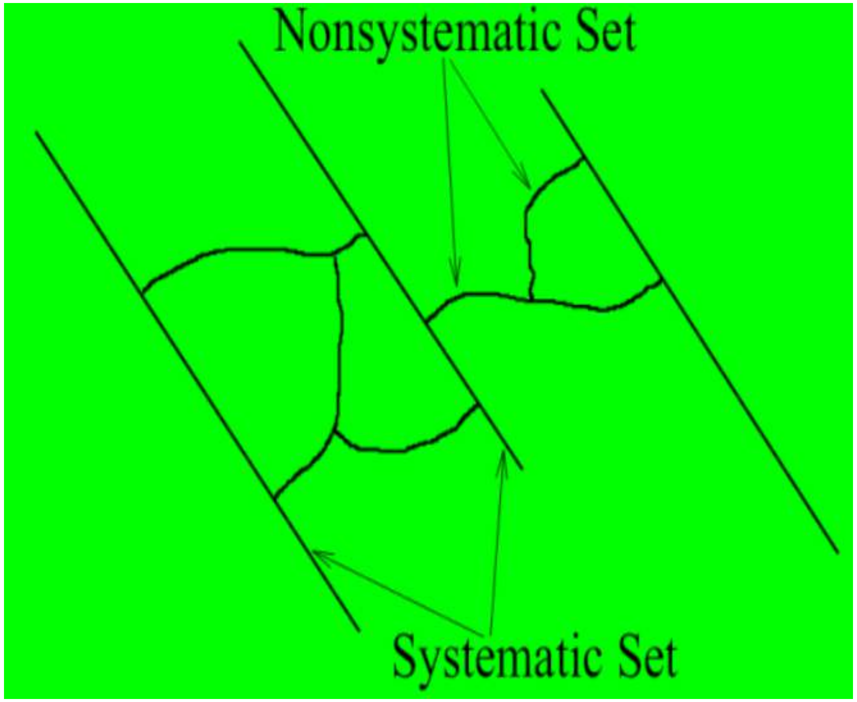
- Simple folds are divided into two types, that is, **anticlines and synclines**. in the former, the beds are convex upwards, whereas in the latter, they are concave upwards. In the anticline when we move toward the core we can show the oldest rocks in contrary to the syncline we show the youngest rocks. **The crestal line** of an anticline is the line that joins the highest parts of the fold, whereas **the trough line** runs through the lowest parts of a syncline.
- **Types of Folding**
- Corresponding to the dip angle of the limb and the axial plane the folds are classified to four types, the first is symmetrical if both limbs are arranged equally about the axial plane so that the dips on opposing flanks are the same; otherwise they are asymmetrical In
- **symmetrical folds**, the axial plane is vertical, whereas it is inclined in
- **asymmetrical folds.** As folding movements become intensified,
- **overturned folds** are formed in which both limbs are inclined, together with the axial plane, in the same direction but at different angles.
- **In a recumbent fold**, the beds have been completely overturned so that one limb is inverted, and the limbs, together with the axial plane, dip at a low angle to the same direction.


FOLD DIMENSIONS
interlimb angle
Crest
Wavelength
Hinge
Amplitude
Height
limb
limb
Inflection
point
fold angle
median line
(fold width)
fold width
Amplitude
Trace of
axial plane
Trough
Wavelength
Hinge
Rasoul Sorkhabi (2013)

- **Fracture:** is a planar or curviplanar discontinuity forms as a result of brittle rock failure under relatively low pressure and temperature condition in the earth crust. Rock fractures range in size from microcracks (fraction of mm) to faults which extend for hundreds of kilometers.
- **Joints:** are defined as dry fractures of geologic origin along which no appreciable displacement has occurred.
- **joint sets:** a group of fractures occurs in systematic alignment with similar strike and dip and arrangement.
- **Why are the Joints important?**
- 1-Provide a mass wasting surface failure plane; joint analysis typically done for slope stability, dam stability, tunnel stability.
- 2-Provide fracture porosity/permeability - hydrologic modeling, mineralization.
- 3-At deeper levels joints exert a control on the migration of geological fluids: water, petroleum and gas.


Joint Set

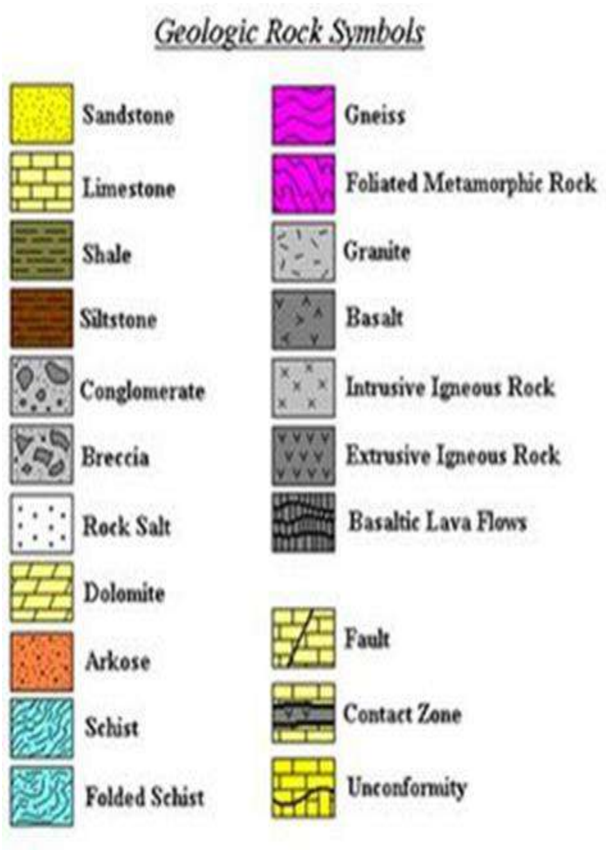

Joint System



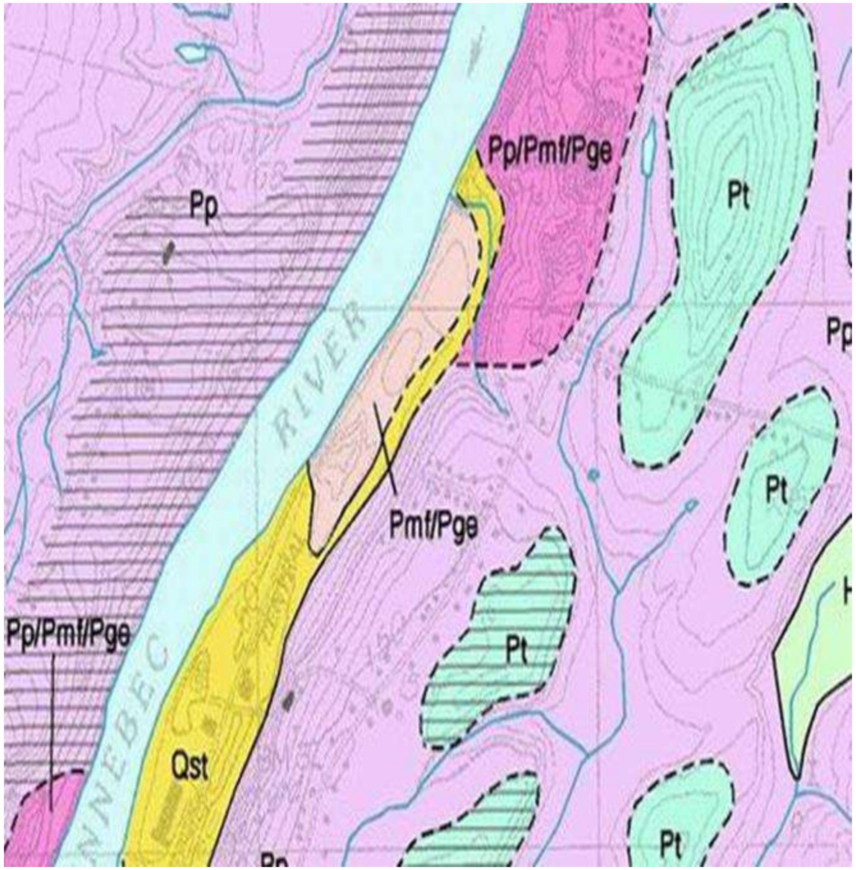
Nonsystematic Set
Systematic Set

Geologic Maps:

- Geology is the study of the Earth and all of its features. Geologists work in the field and in labs and offices and they use a lot of maps. There are three major types of maps they use: topographic, cross-sectional, and structural. Geological map is a medium of communication that uses graphic symbols to represent spatial relationships between geographical and geological features. The interpretation of geological maps is basically an attempt to visualize and understand the complex shapes of rock units in the subsurface.
- **Topography map:** Shows the height of a region in the form of contour height measured against the sea level.
- a topographical map is a map where locations of equal elevation are connected by lines called contour lines. The layout of the contour lines gives you an understanding of what the terrain looks like.



Legend

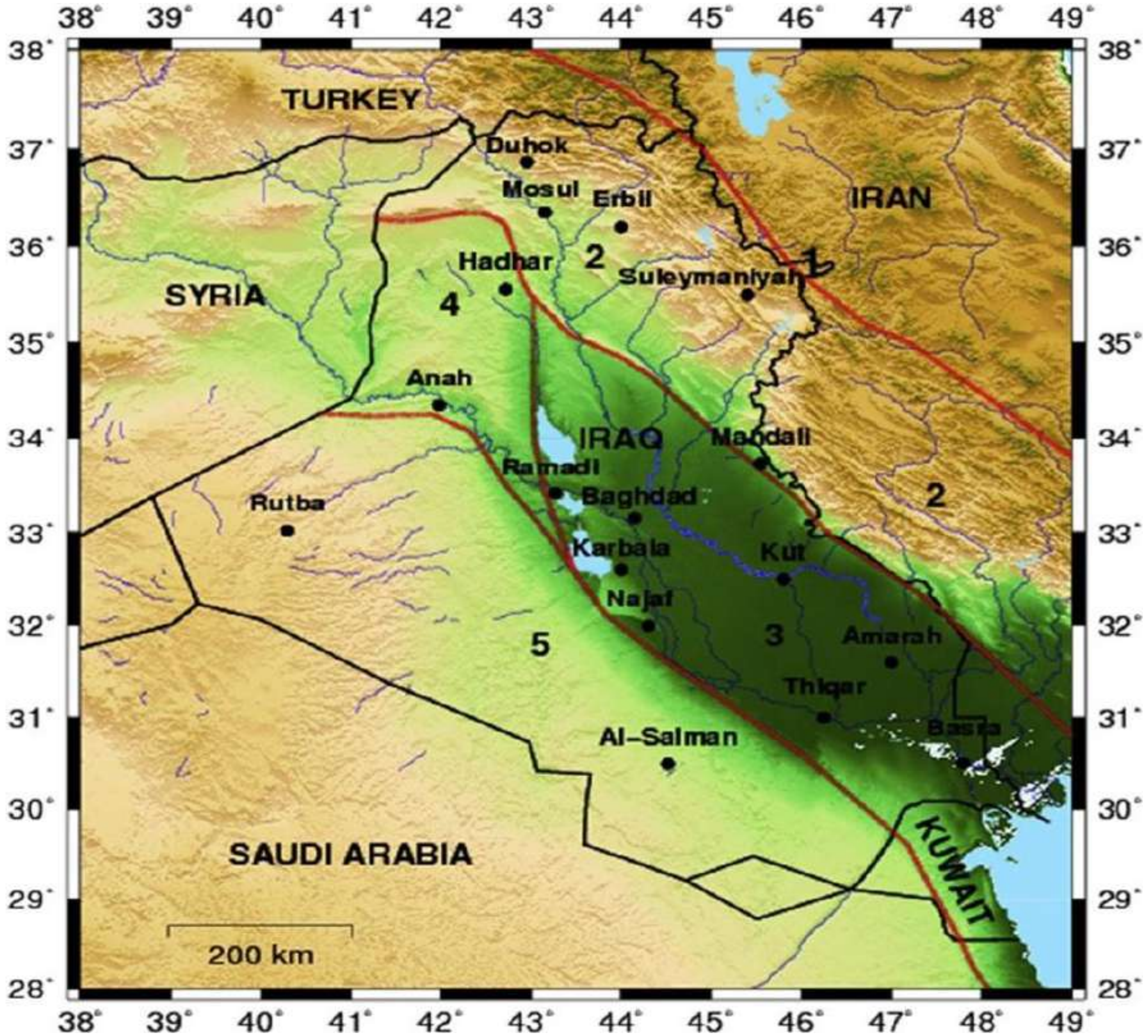


Geologic Map

- **Structure map:** The appearance of the depth lines explain certain layers under the surface.
- A structural map shows the geologic features of an area, including features such as the type of rocks and geologic structures that are in an area
- Structural geology, therefore, is a major cornerstone of the art of geological map interpretation. We can learn how to interpret geological maps and know the structures in them such as folds and faults.
- **cross-sectional map:** This map shows the cross-section from the side.
- A section line is a straight line drawn on a topographic map. Altitudes along this line are turned into a cross-section.

How to make a cross section:

Tectonic divisions of Iraq:



The main equipment needed for geological mapping: •

Base Map: Used to show an overview of the area that will be mapped. •

Compass and clinometer: Used to measure the strike and dip from rock and geological structure. •

Stationery and field notebook: Used to record and describe the characteristics of rocks found at the observation location. •

Hammer and chisel: Used to take rock samples. •

Hand lens: Used to observe the characteristics of rock that cannot be seen with the eye directly, such as the grain size. •

Gauge: Used is used to determine the length of an outcrop or structure. •

GPS: Used to determine the outcrop location •

The steps of geological mapping activity are:

- Make outcrop observation, and make a description of it.
- Measure the position of rocks (strike and dip), geological structure elements.
- Make a record observations in a field notebook
- Determine the outcrop location by using GPS

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AL-NOOR COLLEGE UNIVERSITY
DEPARTMENT OF CONSTRUCTION ENGINEERING AND PROJECT MANAGEMENT
FIRST LEVEL / SECOND SEMESTER

Engineering Geology
2nd Semester

Physical and engineering properties of rocks:

- Engineering properties of rocks are very essential properties to be determined in every project of civil engineering, construction engineering and structural engineering.
- In most of the engineering applications, rocks are used as building stones. A building stone may be
- defined as:
- a rock that can be safely used as a rough
- or slab or column or sheet in different situation in an engineering construction.
- **Physical Properties:**
- Saturated unit weight:
- Saturated unit weight, abbreviated as **γsat**, is the total weight of soil per volume of soil or when the soil voids are filled with water and no air.

SATURATED UNIT WEIGHT FORMULAS

$\gamma sat= Wt / Vt$----------1

$\gamma sat= (Ws+Ww) / (Vs+Vv)$ @

$\gamma sat= (Gs \gamma w + e \gamma w) / (1+e)$

$\gamma sat= ((Gs+e) \gamma w) / (1+e)$ •

Where:

γ_{sat} = saturated unit weight

G_s = specific gravity of soil

V_t = total volume of soil

W_t = total weight of soil

γ_w = unit weight of water

e = void ratio

Void Ratio:

Void ratio, abbreviated as (**e**):

a dimensionless number, is the ratio of the volume of voids to the volume of solids.

$e = V_v / V_s$--------------------1

$e = V_v / (V_t - V_v)$-------------2

$e = n / (1 - n)$-----------------3

$e = (w\ G_s) / S$--------------4

$e = [(G_s(1+w)\gamma_w) / Y] - 1$-----5

Where:

e = void ratio------------ Dimensionless

Y = bulk density Kg/m3

S = degree of saturation (expressed as %)-----Dimensionless

n = porosity --------Dimensionless

G_s = specific gravity of soil   Dimensionless

V_t = total volume of soil   m3

γ_w = unit weight of water   N

V_s = volume of solids   m3

V_v = volume of voids   m3

w = water content (% moisture content   Dimensionless

Density:

It is defined as weight per unit volume of a substance. But in the case of rock it is not only the solid

mineral matter which wholly accounts for the total volume of a given specimen. A part of the rock may

comprise of pores or open spaces, which may be empty, partly filled or wholly filled with water.

Accordingly, three types of density may be distinguished in rocks. They are:

a)Dry density,

b) bulk density, and

c) saturated density

Dry density: It is the weight per unit volume of an absolutely dried rock specimen, it includes the

volume of the pore spaces present in the rock

Bulk density: It is the weight per unit volume of a rock sample with natural moisture content where

pores are only partially filled with water

Saturated density: It is the density of the saturated rocks or weight per unit volume of a rock in which

all the pores are completely filled with water

The most engineering calculations, it is the

bulk density which is used frequently

Bulk density values in gram/cubic cm for some common building stones are granite-2.7, basalt-2.9

sandstone-2.6, and limestone-2.2 to 2.6

Porosity:

Porosity is an intrinsic property and is the ratio of the volume of openings (voids) to the total volume of material. Porosity can be calculated by:

Porosity =(V v (Pore volume)/ V0 (Bulk volume)) X 100

Mechanical Properties:

Rock deformation:

Deformation of Rock

Within the Earth rocks are continually being subjected to forces that tend to **bend** them, **twist**

them, or **fracture** them. When rocks bend, twist or fracture we say that they **deform** (change

shape or size). The forces that cause deformation of rock are area).referred to as stresses (Force/unit

explore these .So, to understand rock deformation we must first forces or stresses

Stress and Strain:

Stress : is a force applied over an area. One type of stress that we are all used to is a uniform

stress, called pressure. A **uniform stress** is a stress wherein the forces act equally from all

directions. In the Earth the pressure due to the weight of overlying rocks is a uniform stress,

and is sometimes referred to as **confining stress**.

If **stress is not equal from** all

directions then we say that the stress

is **a differential stress**. Three kinds

of differential stress occur:

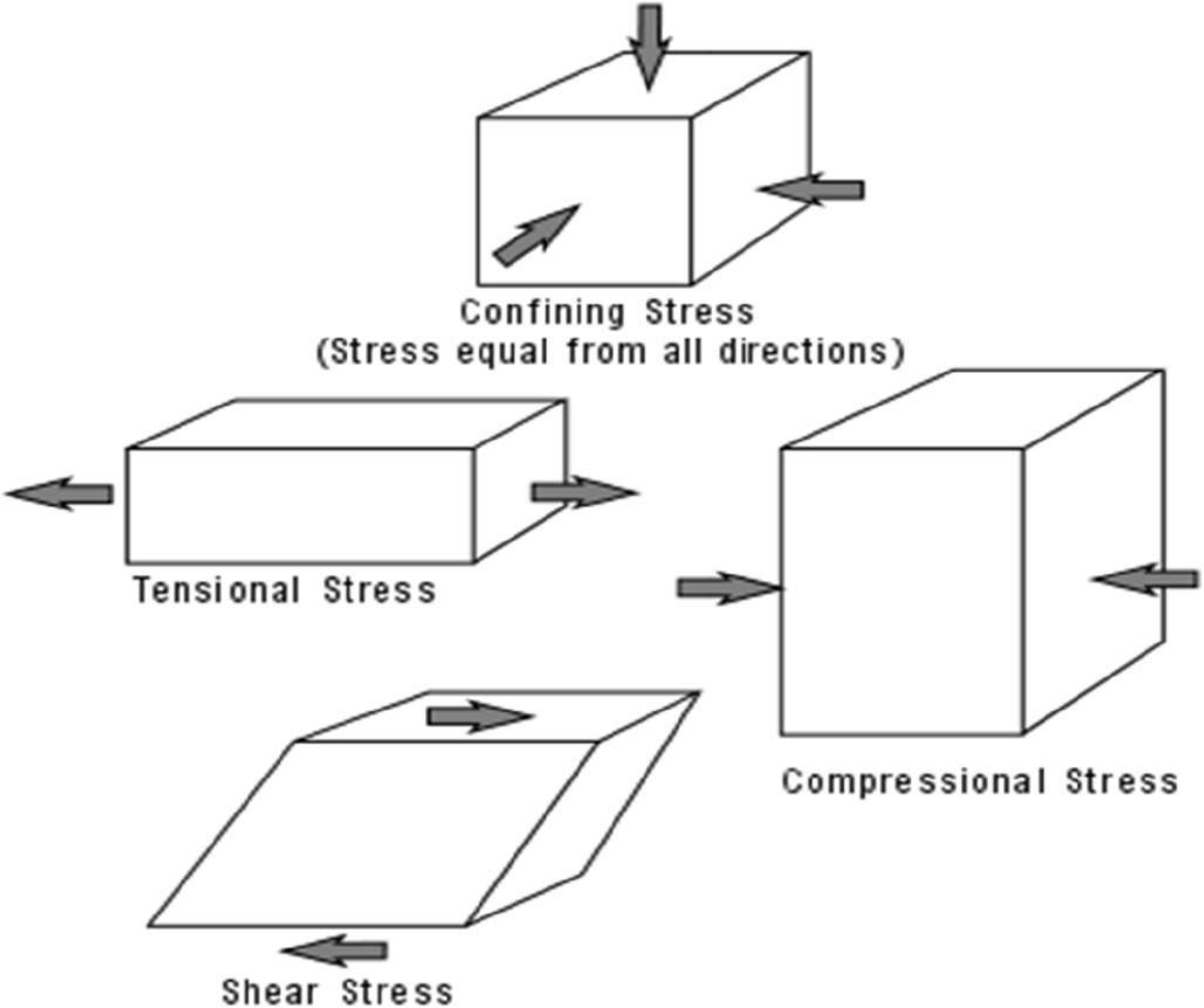
1-Tensional stress (or extensional stress), which stretches rock;

2-Compressional stress, which squeezes rock; and

3-Shear stress, which result in slippage and translation

When rocks deform they are said to **strain**.

When rocks deform they are said to strain. A strain is a change in size, shape, or volume of a material. We here modify that definition somewhat to say that a strain also includes any kind of movement of the material, including translation and tilting.



Confining Stress
(Stress equal from all directions)
Tensional Stress
Compressional Stress
Shear Stress

Shear strength:

is the resistance offered by a stone to shear stresses, which tends to move one part of a

specimen with respect to the other. It is obtained by using the relationship.

$$S = P/2A$$

Where P = load at failure; A = area of cross section of the specimen

It has been observed that shear strength of most common building stones ranges from 70 to 140 kg/cm2.

How a material behaves will depend on several factors. Among them are:

Temperature - At high temperature molecules and their bonds can stretch and move,

thus materials will behave in more ductile manner. At low temperature, materials are

brittle.

Confining Pressure - At high confining pressure materials are less likely to fracture

because the pressure of the surroundings tends to hinder the formation of fractures.

Strain rate -- At high strain rates material tends to fracture. At low strain Rate more time is available for individual atoms to ductile behavior is favored.

Composition -- Some minerals, like quartz, olivine, and feldspars are very brittle.

Others, like clay minerals, micas, and calcite are more ductile. This is due to the chemical bond types that hold them together. Thus, the **mineralogical composition** of the rock will be **a factor** in determining the deformational behavior of the rock.

Another aspect is presence or absence of water. Water appears to weaken the chemical bonds

and forms films around mineral grains along which slippage can take place. Thus Wet rock tends to behave in ductile manner, while dry rocks tend to behave in brittle manner.

Engineering Geology
2nd Semester
2021-2022
Dept. of Construction Eng. And Project Management

المحاضرة الثانية ١٤\٤\٢٠٢٢

Modulus of elasticity

- The modulus of elasticity is simply the ratio between stress and strain. Elastic Moduli can be of three types, Young's modulus, Shear modulus, and Bulk modulus.
- Shear Modulus (G): is the ratio of shearing stress to the corresponding shearing strain. Another name for shear stress is the Modulus of Rigidity.
- $(G = (F/A) / (\Delta x/L)$
- $= (F \times L)/ (A \times \Delta x$
- We also know that, Shearing strain = θ
- $G= (F/A) / \theta$
- Further, the shearing stress σs can also be expressed as:
- $\sigma s = G \times \theta$
- Young's modulus (Y): is the ratio of the tensile/compressive stress (σ) to the longitudinal strain (ε).

$Y = \sigma / \varepsilon$

We already know that, the magnitude of stress = FA and longitudinal strain = ΔLL. Substituting these values, we get:

$Y = (F/A) / (\Delta L/L)$

$\therefore Y = (F \times L) / (A \times \Delta L)$

Bulk modulus (B): is the ratio of stress to the corresponding hydraulic strain.

$B = -p/(\Delta V/V)$

The negative sign means that as the pressure increases, the volume decreases. Hence, for any system in equilibrium, B is always positive

Young's Modulus Y (10^9 N/m^2)	Materials
70	**Aluminum**
120	**Copper**
190	**Wrought Iron**
200	**Steel**

Bulk Modulus (B) 10^9 N/m^2	Material
72	Aluminum
61	Brass
140	Copper
37	Glass
100	Iron
260	Nickel
160	Steel

Shear Modulus (G) 10^9 N/m^2	Material
25	Aluminum
36	Brass
42	Copper
23	Glass
70	Iron
5.6	Lead
77	Nickel
84	Steel
150	Tungsten
10	Wood

- **Q1.** A structural steel rod has a radius of 10 mm and a length of 1.0 m. A 100 kN force stretches it along its length. Calculate:
- stress
- elongation
- the strain on the rod.
- Young’s modulus, of structural steel, is 2.0 × 1011 N/m2.
- Answer: To solve the problem, let’s assume that the rod is clamped at one end and a force F is applied at the other. This force is parallel to the length of the rod. Therefore, the stress on the rod is:

Stress = F/A = F/πr2

= (100×103N) / (3.14×(10−2m))

= 3.18 × 108 N/m

let's calculate the elongation ΔL

ΔL= ((F/A) L)/ (Y)

= (3.18×108Nm−2)(1m)2×1011Nm−2

= 1.59 × 10-3 m.

∴ ΔL = 1.59 mm

= 1.59×10−3m /1m = 1.59 × 10-3

Stress = Restoring force/ Area = F/A

Strain= Change in configuration/Origional Configuration

Young Modulus (Y):

Y= Normal Stress/ Longitudinal Strain

Bulk Modulus (B):

B = Normal Stress/Volumetric Strain

Compressibility, K = 1/B

Shear Modulus (Modulus Of Rigidity) **G**:

G = Shearing Stress/ Shearing Strain

Elasticity and Plasticity

Elasticity: Ability of a body to regain its original shape, on removing deforming force.

Plasticity: The inability of a body to regain its original size and shape on the removal of the deforming force.

Compressive strength CS: is the maximum compressive stress that, under a gradually applied load, a given solid material can sustain without fracture. The formula for calculating compressive strength is:

CS = F / A

Where in compressive strength (CS) is equal to the force (F) at the point of failure divided by the cross sectional area. Compressive strength tests must be forces on the test performed with equal opposing material. Test materials are normally in cylinders, cubes or spheres.


Force
Force

Some materials fracture at their compressive strength limit; others deform irreversibly. Compressive strength is a key value for designing structures. The compressive strength of concrete is the most common performance measurement used by engineers when designing buildings and other structures.

Tensile strength refers to the degree to which a material can withstand a perpendicularly applied pull force. The applied force is called **tensile stress**. At the maximum amount of tensile stress applied, a material will undergo failure in the form of breaking, fracturing and permanent deformation.

There are **three types** of tensile strength:

Ultimate strength: The measure of stress a material can withstand in total.

Yield strength: The measure of stress a material can withstand without permanent deformation

Breaking strength: The measure of stress coordinate on the stress-strain curve at the point of rupture where the material undergoes fracturing

Engineering Geology
2nd Semester
2021-2022
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المحاضرة الثالثة ١٨\٤\٢٠٢٢

Surface Water:

- Surface water is water located on top of the Earth's surface.
- Or Surface water is any body of water found on the Earth’s surface, including both the saltwater in the ocean and the freshwater in rivers, streams, and lakes. A body of surface water can persist all year long or for only part of the year.
- Rivers are a major type of surface water. Surface water is a key component to the hydrologic cycle.
- Surface water participates in the hydrologic cycle, or water cycle, which involves the movement of water to and from the Earth’s surface. Precipitation and water runoff feed bodies of surface water. Evaporation and seepage of water into the ground, on the other hand, cause water bodies to lose water. Water that seeps deep into the ground is called groundwater.

- There are **three types** of surface water:
- 1-perennial,
- 2-ephemeral, and
- 3-man-made.
- **Perennial**, or permanent, surface water persists throughout the year and is replenished with groundwater when there is little precipitation.
- **Ephemeral**, or semi-permanent, surface water exists for only part of the year. Ephemeral surface water includes small creeks, lagoons, and water holes.
- **Man-made** surface water is found in artificial structures, such as dams and constructed wetlands.

Hydrology;

- Hydrology is the study of the distribution and movement of water both on and below the Earth’s surface, as well as the impact of human activity on water.

Surface water movement includes rivers, streams, creeks, lakes, ponds, and human-made "flood" control. All surface water is trying to reach sea level due to gravity. As water flows in channels, the streambed and banks of the channel will resist the flow of water. The velocity of the water is dependent on steepness of the slope, type of rock or soil, amount of vegetation, shape of stream bed, and obstructions. Surface water provides the liquid where most evaporation takes place.

- **Runoff** is excess water that is not adsorbed by the surrounding area. Runoff can be created by rainfall, melting snow. A number of conditions determine whether water on Earth’s surface will infiltrate the ground or become runoff such as Vegetation that causes the soil to hold more water. More water enters ground if rainfall is gentle During heavy downpours, in this case, the rate of precipitation may exceed the rate of infiltration.

Discharge of river:

Discharge is the volume of water moving down a waterway per unit of time. It is most commonly expressed in cubic meter per seconds. To calculate discharge, multiply the area of water in a channel cross section by the average velocity of water in that cross section see the Fig..

In short:

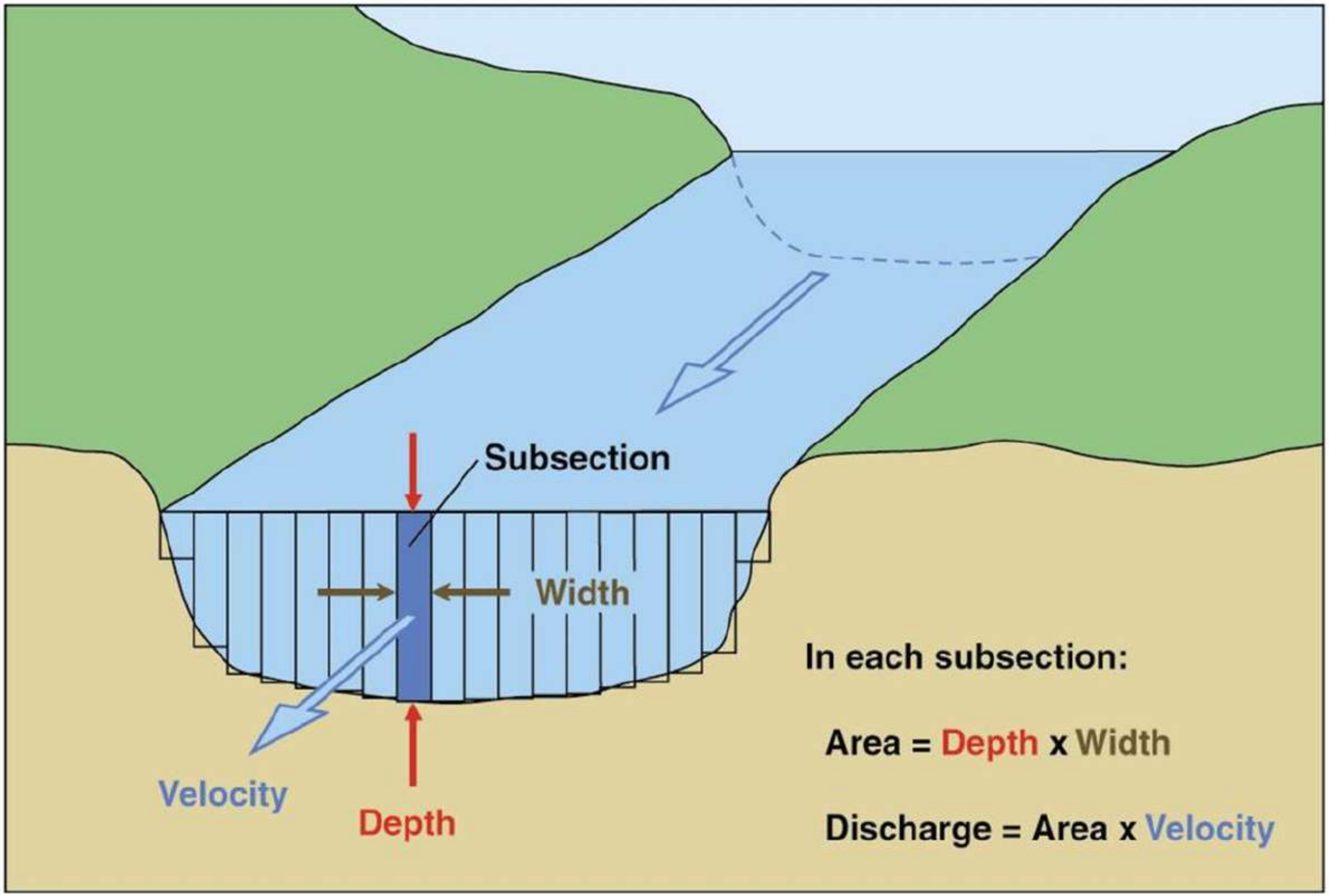
discharge = area X velocity

$Q = A \times V$

The simplest way to measure discharge is to divide the channel cross section into vertical rectangular subsections as shown in the fig. below. Once the area (width X depth) of each of these subsections is established and multiplied by velocity to determine subsection discharge, the results can be added together

to calculate total discharge.

Velocity, should be measured with a current meter.


Subsection
Width
In each subsection:
Area = Depth x Width
Discharge = Area x Velocity
Velocity
Depth

Discharge Calculation:

Two methods could be used to calculate discharge of a river or stream:

1-Mid - Section Method:

$$Q_{tot.} = \sum Q_1 + Q_2 + Q_3 \text{--------} Q_n$$

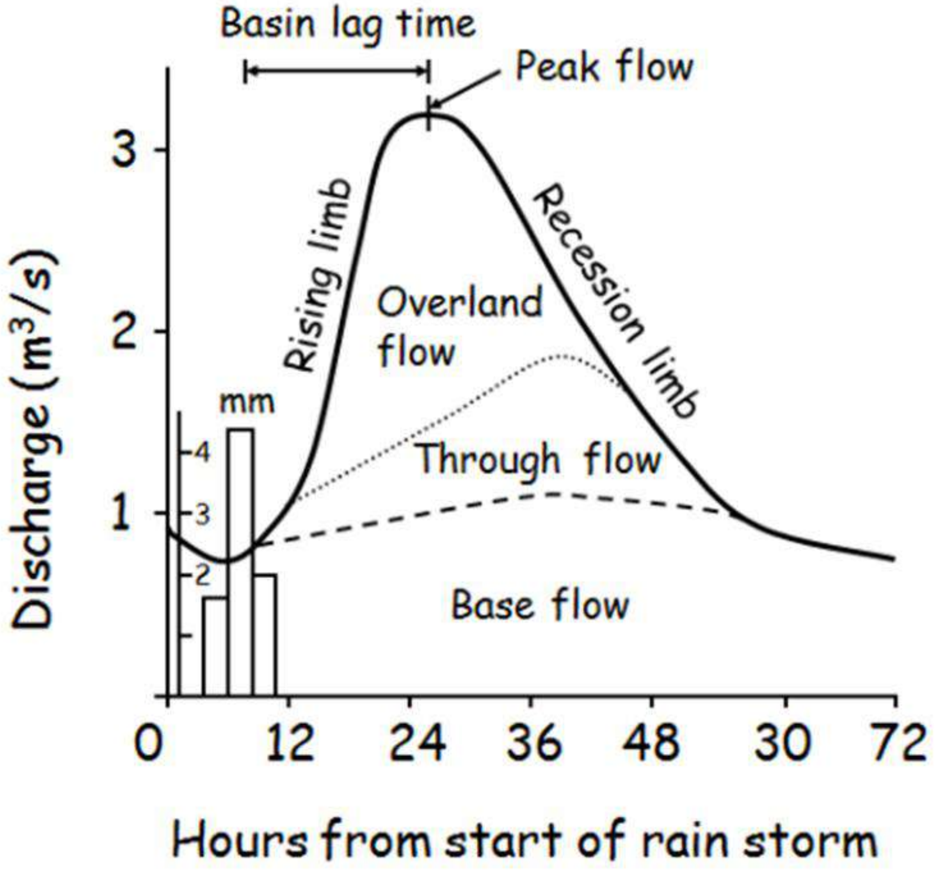
$$Q_{tot.} = \sum (A_1 \times V_1) + (A_2 \times V_2) + \text{----------} + (A_n \times V_n)$$

2-Mean - section method

$$Q_{tot.} = \sum Q_1 + Q_2 + Q_3 \text{--------} Q_n$$

$$Q_{tot.} = \sum [(d_0+d_1)/(2) \times W \times (V_0+V_1)/(2)] + [(d_1+d_2)/(2) \times W \times (V_1+V_2)/(2)] + \text{------} + [(d_{n-1}+d_n)/(2) \times W \times (V_{n-1}+V_n)/(2)]$$

Hydrograph:A hydrograph is a graph or plot that shows the rate of water flow in relation to time, given a specific point or cross section. These graphs are often used to evaluate stormwater runoff on a particular site.



River geologic work

River geologic works include 3 functions:

1-Erosion

2-Transportation

3-Deposition

1-Erosion

A river may erode in 4 ways

1-Abrasion/ corrasion

Load carried by a river will grind against its bed and sides.

This process slowly wears the bed and sides away.

2. Attrition

When thrown against the sides and bed of rivers, the load gets broken into smaller pieces.

3. Hydraulic action

The work of turbulence in the water.

Running water causes friction in the joints of rocks in a stream channel

Joints may be enlarged

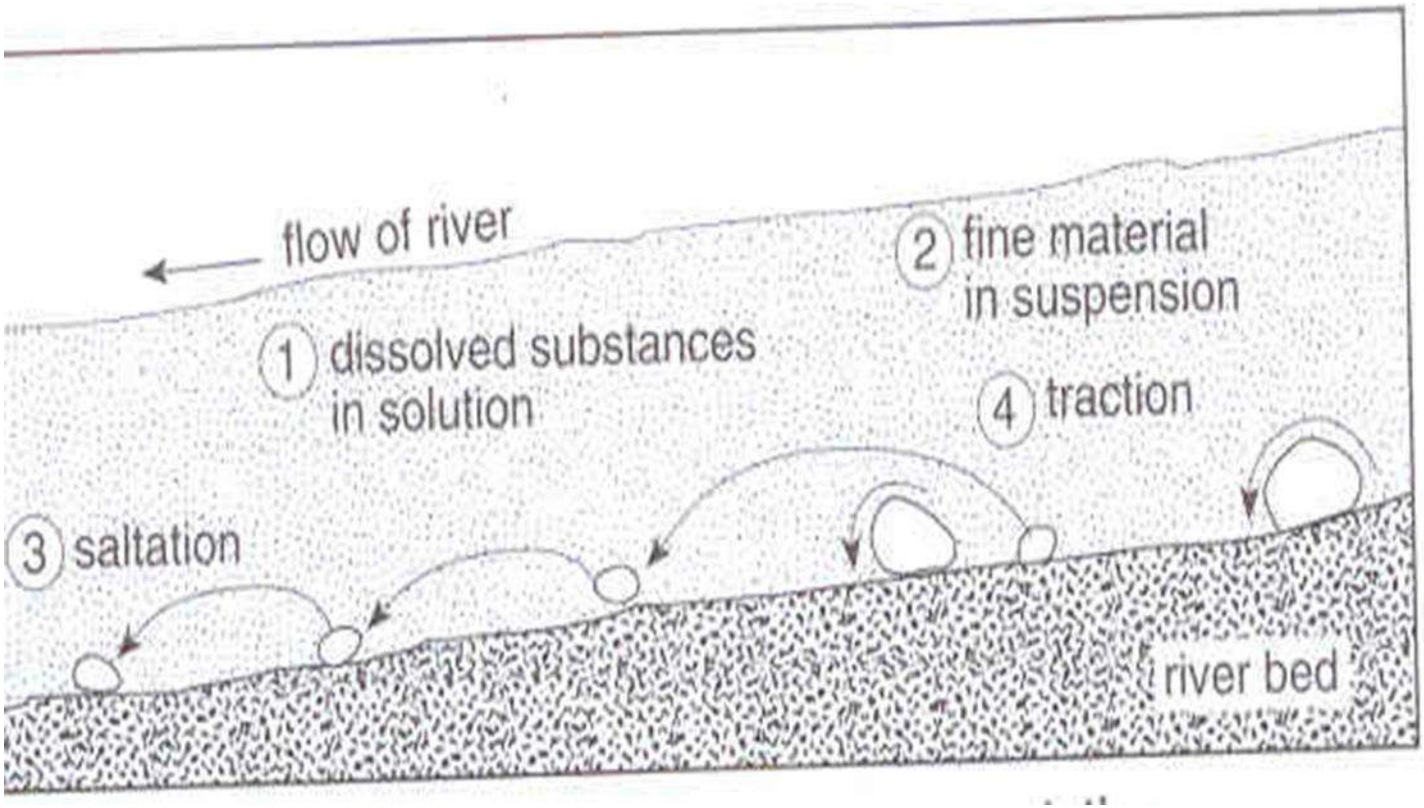
Loosened fragments of rocks get swept away.

4. Solution/Corrosion

Certain minerals in rocks like limestone can be dissolved in water.

Rocks are then eroded.

2-Transportation



A river has four way of transportation:

1-Traction

Larger and heavier rocks/gravels are dragged or rolled along the bed.

2. Saltation (saltim: by leaps/jumps)

Smaller and lighter rock fragments and sand hop and bounce along the river bed.

At times, the distinction between traction and saltation may be difficult to determine.

3. Suspension

Some of the load like silt and clay (fine-grained) will float along.

They may only be deposited when stream velocity reaches near 0.

Turbulence in the water is crucial in holding a load of sediments.

4. Solution

Some minerals are transported in dissolved form.

Especially chemical solution derived from minerals like limestone or dolomite.

3-Deposition:
A river will drop its load when:
1-Volume decreases
2-Speed decreases
1-A river’s volume decreases when
Dry season
Dry region with high evaporation
Presence of permeable rocks
Receding flood waters
2-A river’s speed decreases when
It enters a lake
It enters a calm sea
It enters a gently sloping plain

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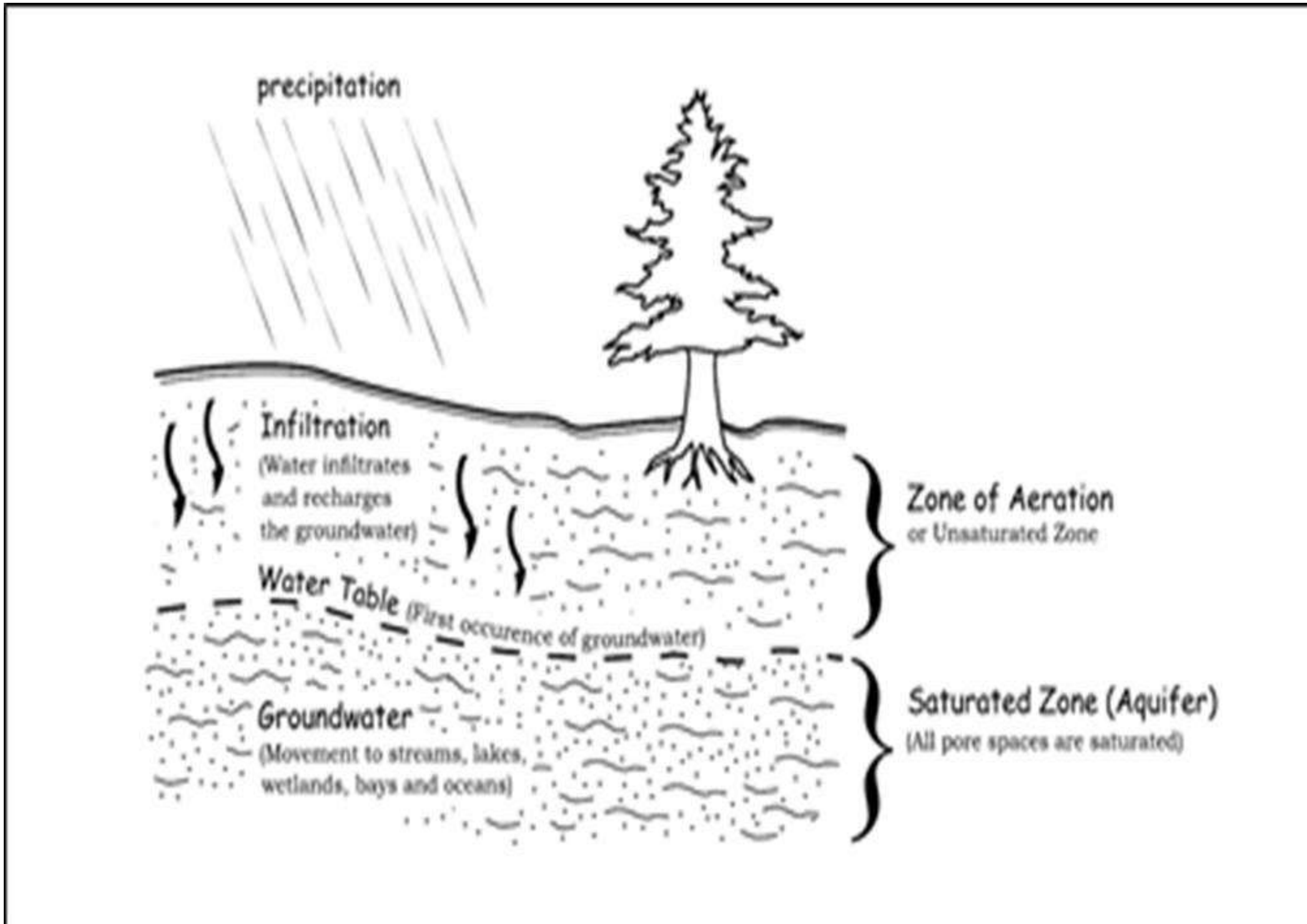
المحاضرة الرابعة ٢٥\٤\٢٠٢٢

Groundwater sources:

When rain falls to the ground, some of it flows along the land surface to streams, rivers or lakes, some moisturizes the ground. Part of this water is used by vegetation; some evaporates and returns to the atmosphere. Part of the water also seeps into the ground, flows through the unsaturated zone and reaches the water table, which is an imaginary surface from where the ground beneath is saturated (see illustration below).

Groundwater: all water found beneath the ground surface in the saturated zone. Groundwater represents about 30% of world's fresh water. Groundwater is a very important natural resource and has a significant role in the economy. It is the main source of water for irrigation and the food industry.

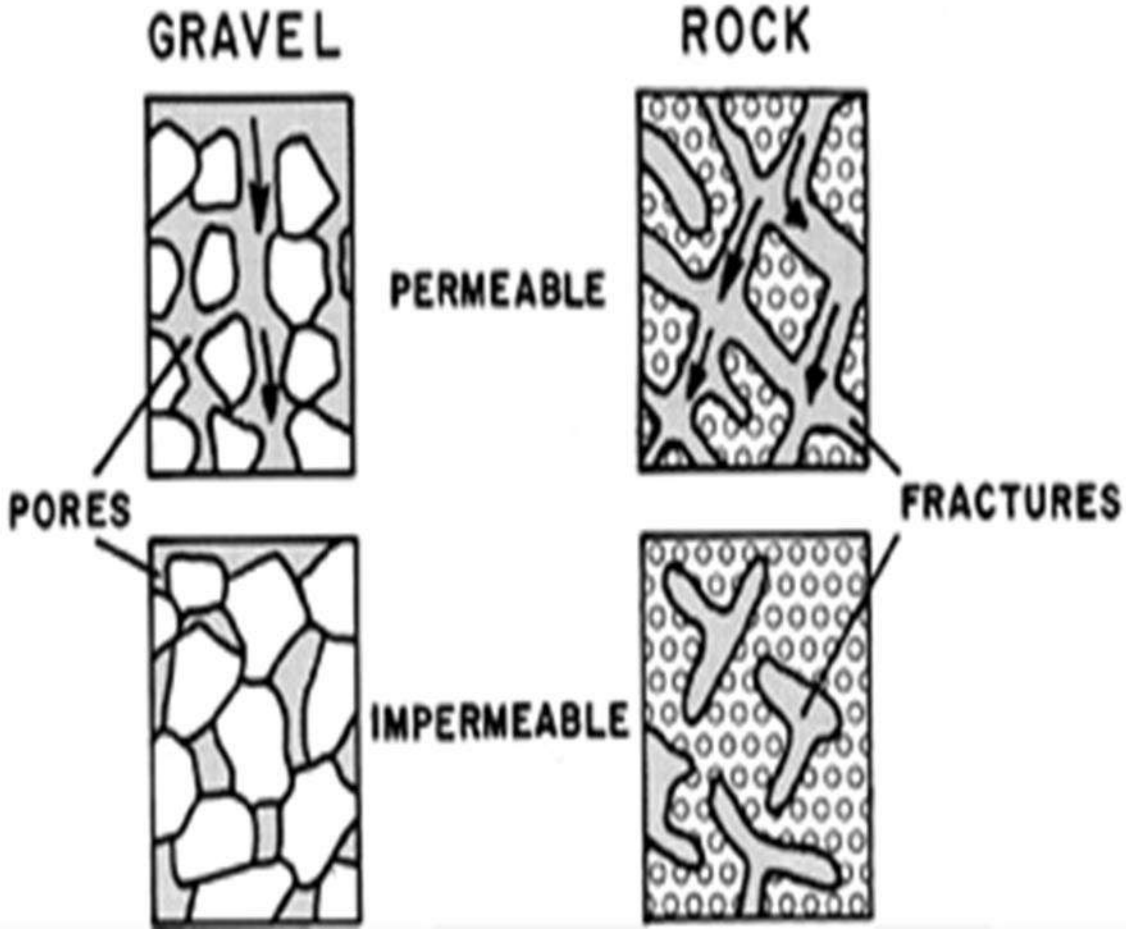

precipitation
Infiltration
(Water infiltrates and recharges the groundwater)
Water Table (First occurence of groundwater)
Groundwater
(Movement to streams, lakes, wetlands, bays and oceans)
Zone of Aeration
or Unsaturated Zone
Saturated Zone (Aquifer)
(All pore spaces are saturated)

Groundwater is contained in what are called ‘aquifers’. An aquifer is a geological formation or part of it, consisting of permeable material capable to store/yield significant quantities of water. Aquifers can consist of different materials: unconsolidated sands and gravels, permeable sedimentary rocks such as sandstones or limestones, fractured volcanic and crystalline rocks, etc.

Groundwater is (naturally) recharged by rain water and snowmelt or from water that leaks through the bottom of some lakes and rivers.

Heavy rains may increase recharge and cause the water table to rise. But in the other hand, an extended period of dry weather may cause the water table to fall.

To be able to store and yield groundwater, an aquifer needs to have certain physical characteristics. It needs to have empty space (pores or fractures) where groundwater can be stored and the spaces need to be connected to allow it to flow through. Technically speaking, when there are spaces and they are interconnected the geological formation is permeable. When there are no spaces or they are not interconnected, the geological formation is impermeable. The greater the aquifer's porosity and permeability are, the more groundwater is stored and yield by an aquifer.


GRAVEL
ROCK
PERMEABLE
PORES
FRACTURES
IMPERMEABLE

Groundwater is found almost everywhere and its quality is usually very good. The fact that groundwater is stored in the layers beneath the surface, and sometime at very high depths, helps protecting it from contamination and preserve its quality. The most important about using groundwater is to find the right balance between withdrawing and letting the aquifer’s level recover to avoid overexploitation and to avoid pollution of this crucial resource.

Porosity and Permeability:

Porosity: is a measure of the void spaces in a material

Permeability: a measure of the ability of a material (such as rocks) to transmit fluids

Porosity and permeability are related properties of any rock or loose sediment. Both are

related to the number, size, and connections of openings in the rock. More specifically,

porosity of a rock is a measure of its ability to hold a fluid. Permeability is a

measure of the ease of flow of a fluid through a porous solid. A rock may be extremely

porous, but if the pores are not connected, it will have no permeability. Porosity and permeability are both properties of rocks and soil. The main difference between porosity and permeability is that porosity is a measurement of space between rocks whereas permeability is a measurement of how easy it is for fluids to flow between rocks.

What is the relationship between porosity and permeability?

Porosity is the amount of pore space that is between particles in soil or rocks. Permeability takes this pore space and connects the voids together so that water can pass through. Porosity is more associated with storage of water, while permeability is more associated with groundwater movement and flow.

To calculate the permeability of a porous material, use Darcy's law equation:

1-Multiply together the fluid discharge rate, dynamic viscosity, and distance traveled.

2-Divide the result from Step one by the cross-sectional area of the material multiplied by the pressure difference on either side of the material.

What factors affect porosity and permeability?

Porosity and permeability are related properties of any rock or loose sediment. Both are related to the number, size, and connections of openings in the rock. More specifically, porosity of a rock is a measure of its ability to hold a fluid.

What rocks have high porosity and permeability?

General permeability and porosity characteristics of common rocks and sediments.

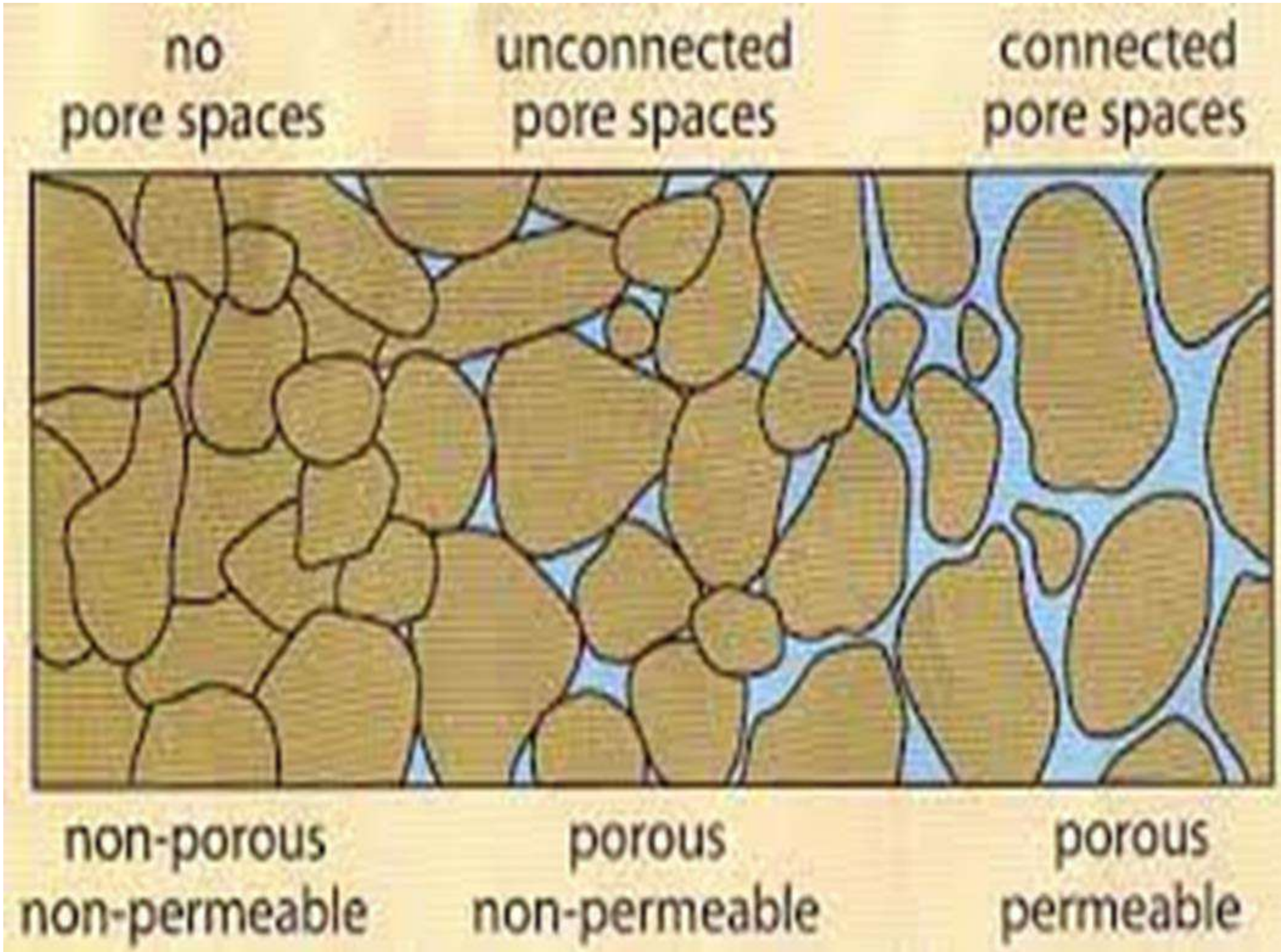
GRAVEL: high porosity; high permeability.

SAND: high porosity; medium permeability.

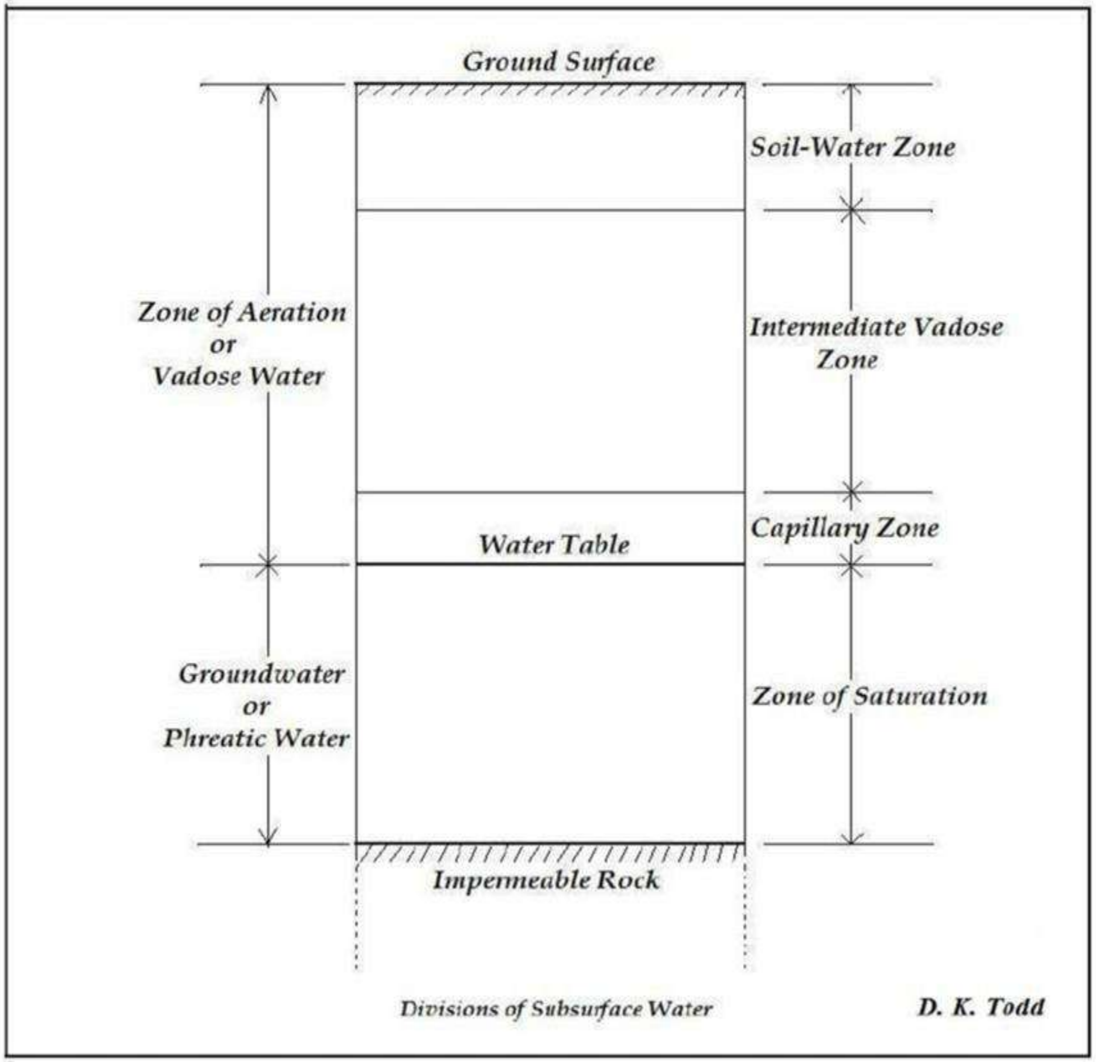
MUD: high porosity; low permeability.

GRANITE: very low porosity; very low permeability.

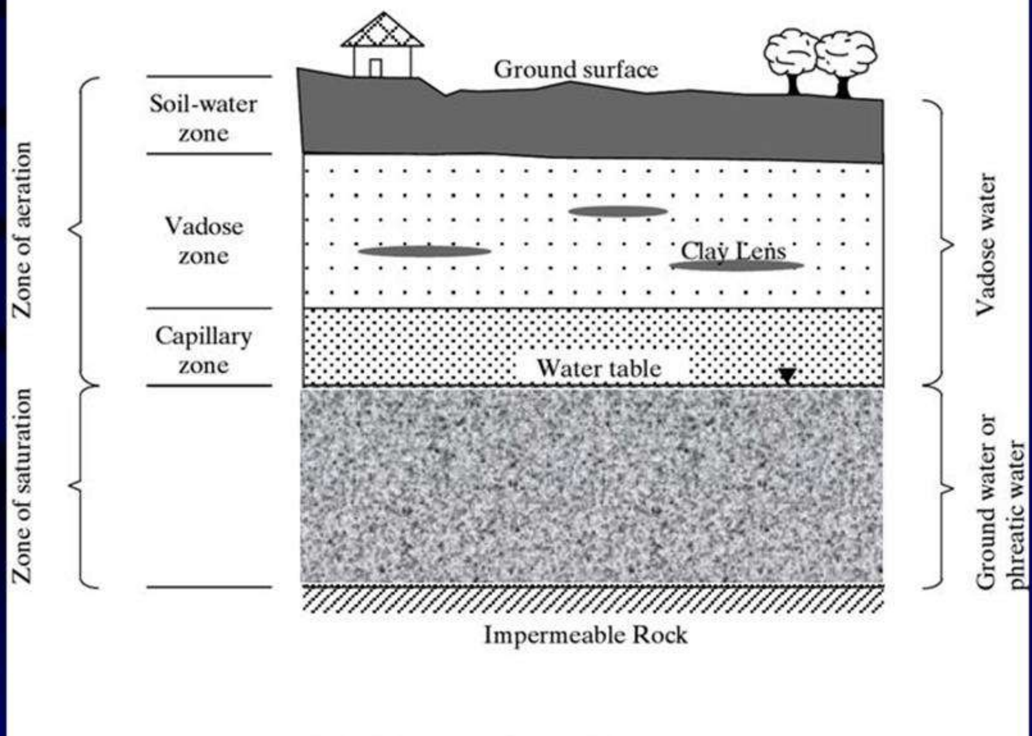
FRACTURED GRANITE: low porosity: very high permeability.


no
pore spaces
unconnected
pore spaces
connected
pore spaces
non-porous
non-permeable
porous
non-permeable
porous
permeable

Vertical distribution of groundwater



Vertical Distribution of Ground Water



Vertical zones of subsurface water.

Aquifer:

An aquifer is a bed or group of beds or a geological formation saturated with water and through which water can easily move. Aquifers must be both permeable and porous and include such rock types as sandstone, conglomerate, fractured limestone and unconsolidated sand and gravel. However, if these rocks are highly fractured, they make good aquifers.

A well is a hole drilled into the ground to penetrate an aquifer. Normally such water must be pumped to the surface. If water is pumped from a well faster than it is replenished, the water table is lowered and the well may go dry. When water is pumped from a well, the water table is generally lowered into a cone of depression at the well.

Types of aquifer:

1. Unconfined Aquifer:

An aquifer which is not overlain by any confining layer but has a confining layer at its bottom is called unconfined aquifer. It is normally exposed to the atmosphere and its upper portion is partly saturated with water. The upper surface of saturation is called water table which is under atmospheric pressure therefore this aquifer is also called phreatic aquifer.

2. Perched Aquifer:

It is a special case of an unconfined aquifer. This type of aquifer occurs when an impervious or relatively impervious layer of limited area in the form of a lens is located in the water bearing unconfined aquifer. As shown in Fig. 16.3 the water storage created above the lens is perched aquifer and its top layer is called perched water table.

3. Confined Aquifer:

It is also called artesian aquifer. It is a type of aquifer overlain as well as underlain by confining layers. The water within the aquifer is therefore held under pressure. It is sometimes called pressure aquifer also. If the aquifer has high outcrop laterally than the ground surface there will be positive hydrostatic pressure to create conditions for a flowing well. Water from such well comes to the surface without pumping. The imaginary level upto which the water will rise is called piezometric surface.

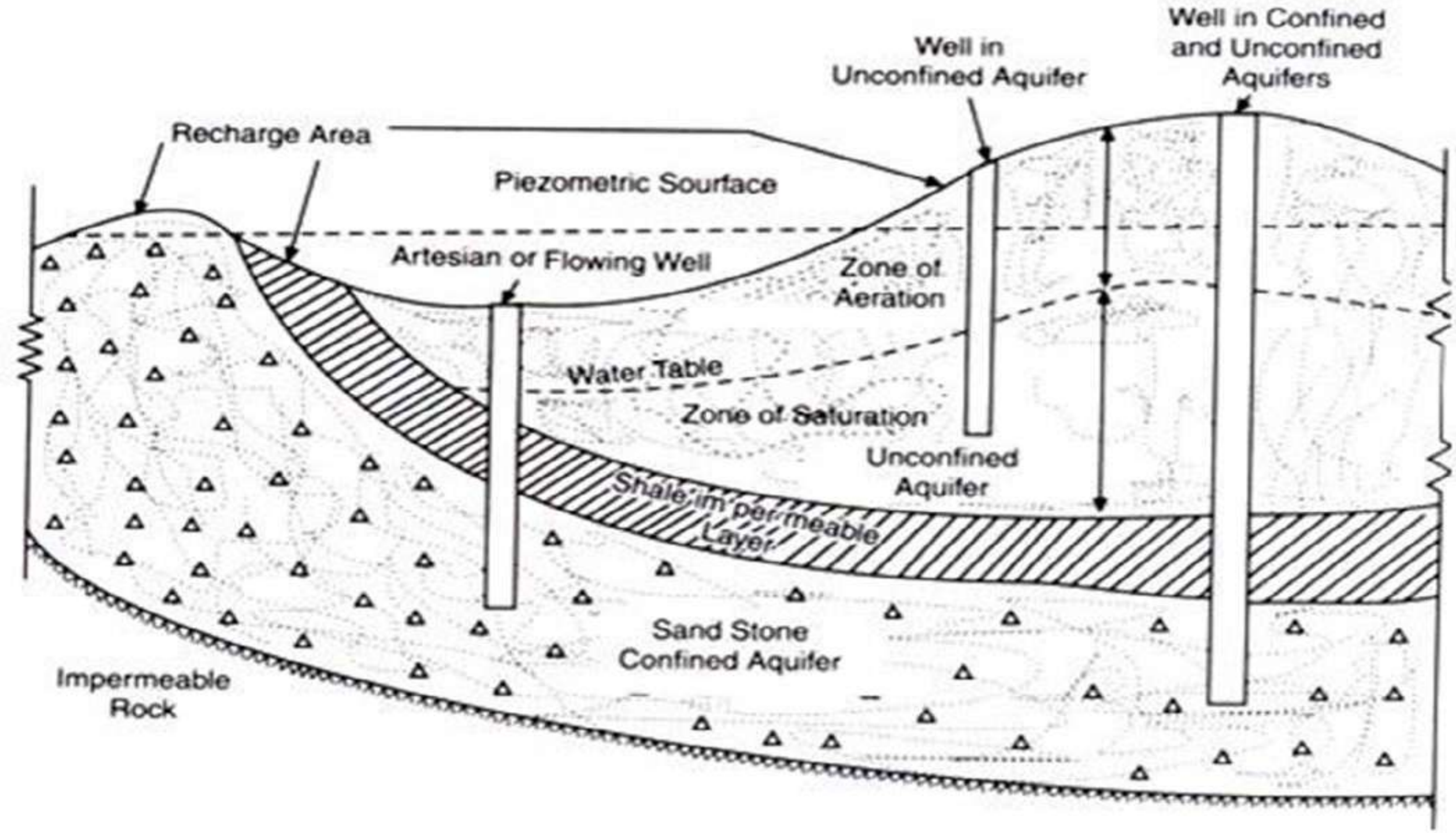


Fig. 16.4. Groundwater terminology model

Darcy Law

Darcy's law is an equation that describes the flow of a fluid through a porous medium. The law was formulated by Henry Darcy based on results of experiments[1] on the flow of water through beds of sand, forming the basis of hydrogeology, a branch of earth sciences.

A law in geology describing the rate at which a fluid flows through a permeable medium. Darcy's law states that this rate is directly proportional to the drop in vertical elevation between two places in the medium and indirectly proportional to the distance between them.

$V = Ki$

Where :

V= velocity

K= hydraulic conductivity

i= hydraulic gradient

Validity of Darcy's law:

Darcy's law is valid for laminar flow through sediments. In fine-grained sediments, the dimensions of interstices are small and thus flow is laminar. Coarse-grained sediments also behave similarly but in very coarse-grained sediments the flow may be turbulent. Hence Darcy's law is not always valid in such sediments.

Groundwater:

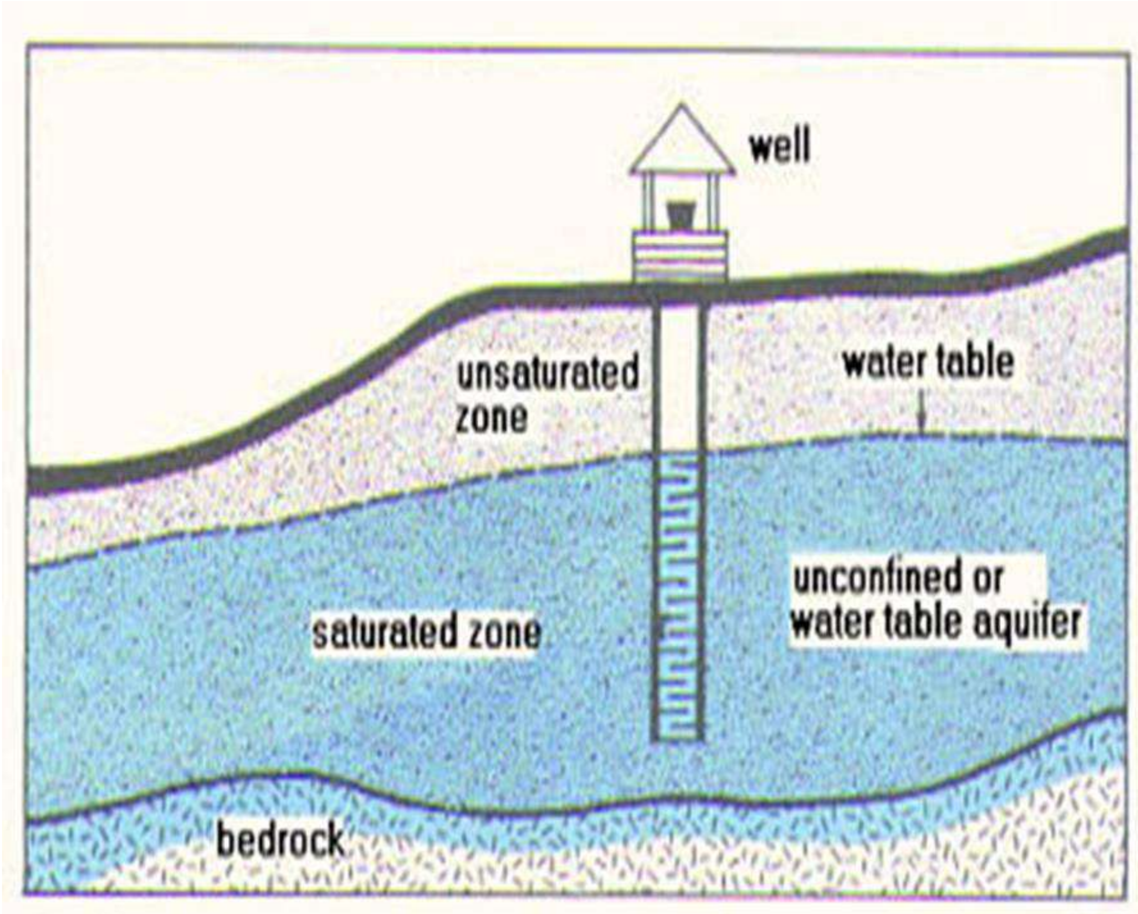
Groundwater is contained in what are called ‘aquifers’. An aquifer is a geological formation or part of it, consisting of permeable material capable to store/yield significant quantities of water. Aquifers can consist of different materials: unconsolidated sands and gravels, permeable sedimentary rocks such as sandstones or limestones, fractured volcanic and crystalline rocks, etc.

Groundwater is (naturally) recharged by rain water and snowmelt.

Unconfined Aquifer:

An aquifer which is not overlain by any confining layer but has a confining layer at its bottom is called unconfined aquifer. It is normally exposed to the atmosphere and its upper portion is partly saturated with water. The upper surface of saturation is called water table which is under atmospheric pressure therefore this aquifer is also called phreatic aquifer.

A water table--or unconfined--aquifer is an aquifer whose upper water surface (water table) is at atmospheric pressure, and thus is able to rise and fall.



well
unsaturated
zone
water table
unconfined or
water table aquifer
saturated zone
bedrock

Groundwater movement effect of Geological Structures:

The geological structures play a major role in the groundwater flow and quality-related problems. The geologic structures like dykes, lineaments, and fractures act as both carriers as well as barriers for groundwater flow.

Topography and geology are the dominant factors controlling groundwater flow. Storativity describes the property of an aquifer to store water. Hydraulic conductivity is measured by performing a pumping test, i.e. by pumping one well and observing the changes in hydraulic head in neighboring wells.

Hydrogeologists and geologists are now actively exploring the role of groundwater and other subsurface fluids in such fundamental geologic processes as crustal heat transfer, ore deposition, hydrocarbon migration, earthquakes, tectonic deformation, diagenesis, and metamorphism.

Spring:

Spring is a place where water moving underground finds an opening to the land surface and emerges, sometimes as just a trickle, maybe only after a rain, and sometimes in a continuous flow.

It comes from groundwater, which is water that exists underground in an aquifer that sits at or below the earth's natural water table. As water naturally flows to the ground's surface, it's collected at the opening of a spring.

A spring is a point of exit at which groundwater from an aquifer flows out on top of Earth's crust (pedosphere) and becomes surface water. It is a component of the hydrosphere.

Classification of Springs:

1-Artesian Springs. Occur when the groundwater, under pressure, finds its way to the land surface.

2-Gravity Springs. ...

3-Perennial Springs. ...

4-Intermittent Springs. ...

5-Tubular Springs. ...

6-Seepage Springs. ...

7-Thermal Springs

Site investigations and geophysical exploration:

Geophysical investigation is an indirect approach to the investigation of ground or built structure. Geophysical techniques can be used, for example, to measure the variation of the physical properties of subsurface materials, eg compressional and shear wave velocities, electrical conductivity and resistivity.

geophysical methods are essential in the search for minerals, oil and gas and other geological and environmental problems. These methods are: Gravity method. Seismic method. Electromagnetic method. Or in other words;

Geophysical methods include seismic techniques, gravity techniques, magnetic techniques, electrical techniques, electromagnetic techniques, borehole techniques, and remote sensing techniques. Geophysical techniques tend to give average soil and rock properties of large masses.

The method(s) selected will depend on the type of information needed, the nature of the subsurface materials and cultural interferences.

Geophysics and Civil Engineering are strongly connected. Geophysical methods have been used in civil engineering for decades. The main field of application is - to no surprise –

in geotechnical projects from site characterization to foundation quality assurance. For more than 25 years, ground

penetrating radar (GPR) and seismic methods have found applications in structural engineering. Recently introduced

geophysical methods have been adopted to ultrasonic investigations in various fields. They help to improve the quality of

structural imaging and to detect small changes in concrete. An overview of the history and current use of geophysics in

civil engineering is given. Selected examples of new concepts include advances in wave based imaging, quality

assurance for foundations, detecting small changes in concrete as well as moisture and corrosion detection are discussed.

The combination of geophysical data and geotechnical measurements may greatly improve the quality of buildings under construction in civil engineering.

Geological problems related to civil engineering:

Soil creep defines the slow mass wasting process of soil on a slope, under the influence of gravity .

usually occurs during and after rain.

Creep is indicated by curved tree trunks, bent fences or retaining walls, tilted poles or fences, and small soil ripples or ridges.

The effects of soil creep can be seen on the landscape. Fences and trees bend downhill in the direction of the soil movement. As the soil moves downhill it causes walls to bulge and eventually collapse. Four kinds of creep were identified by Sharpe (1938): soil creep, talus creep , rock-glacier creep , and rock creep.

A landslide is the movement of rock, earth, or debris down a sloped section of land. Landslides are caused by rain, earthquakes, volcanoes, or other factors that make the slope unstable.

The impact of a landslide can be extensive, including loss of life, destruction of infrastructure, damage to land and loss of natural resources. Landslide material can also block rivers and increase the risk of floods.

Avalanches of rocks or soil are often called landslides. Snowslides, the most common kind of avalanche, can sweep downhill faster than the fastest skier. A snow avalanche begins when an unstable mass of snow breaks away from a slope.

Erosion is the geological process in which earthen materials are worn away and transported by natural forces such as wind or water. A similar process, weathering, breaks down or dissolves rock, but does not involve movement. Erosion can be caused by natural elements such as wind and glacial ice. Example of erosion: Wind carries small pieces of rock away from the side of a mountain.

Deposition is the geological process in which sediments, soil and rocks are added to a landform or landmass. Wind, ice, water, and gravity transport previously weathered surface material, which, at the loss of enough kinetic energy in the fluid, is deposited, building up layers of sediment.

Deposition occurs when the forces responsible for sediment transportation are no longer sufficient to overcome the forces of gravity and friction, creating a resistance to motion.

All civil engineering structures assessed experienced the impact of underground water especially those that is very close to the river. The effect of underground water observed on buildings are:

water saturated wall,

deep cracks in walls,

discoloration of walls,

wall plastering

and paint film flaked off.

Drinking contaminated groundwater can have serious health effects. Diseases such as hepatitis and dysentery may be caused by contamination from septic tank waste. Poisoning may be caused by toxins that have leached into well water supplies. Wildlife can also be harmed by contaminated groundwater.

Other Phenomena

Volcanoes:

More than 80% of the earth's surface is volcanic in origin. The sea floor and some mountains were formed by countless volcanic eruptions. Gaseous emissions from volcano formed the earth's atmosphere. There are more than 500 active volcanoes in the world.

A volcano is a rupture in the crust of a planetary-mass object, such as Earth, that allows hot lava, volcanic ash, and gases to escape from a magma chamber below the surface. On Earth, volcanoes are most often found where tectonic plates are diverging or converging, and most are found underwater. Volcanoes are openings, or vents where lava, tephra (small rocks), and steam erupt on to the Earth's surface. Sixty percent of all active volcanoes occur at the boundaries between tectonic plates. Most volcanoes are found along a belt, called the “Ring of Fire” that encircles the Pacific Ocean.

Explosive eruptions are so powerful, they can shoot particles 20 miles up (32 kilometers), hurl 8-ton boulders more than a half mile (0.8 kilometers) away, and cause massive landslides. Explosive eruptions also create an avalanche of hot volcanic debris, ash, and gas that bulldozes everything in its path.

The three main causes of volcanic eruptions are: The buoyancy of the magma. Pressure from the exsolved gases in the magma. Increase in pressure on the chamber lid.

Earthquakes:

An earthquake is what happens when two blocks of the earth suddenly slip past one another. The surface where they slip is called the fault or fault plane.

The tectonic plates are always slowly moving, but they get stuck at their edges due to friction. When the stress on the edge overcomes the friction, there is an earthquake that releases energy in waves that travel through the earth's crust and cause the shaking that we feel.

Land shaking, surface faulting, ground collapse, and, less frequently, tsunamis are all consequences of earthquakes. Earthquakes can lead to: Death of humans and animals. Buildings, lakes, and bridges have all been destroyed. Landslides and Floods, Tsunamis.

Earthquakes can do significant damage to buildings, bridges, pipelines, railways, embankments, dams, and other structures.

Earthquakes can have immediate and long-term impacts on health. Immediate health impacts include: trauma-related deaths and injuries from building collapse; trauma-related deaths and injuries from the secondary effects of the earthquake, like drowning from tsunamis or burns from fires.

Effect of Geological Structures on Structural Projects:

Geological structures like folds, faults, joints, discontinuities make the construction and design of a structure very complex. Along with the complexity these geological structures make the engineering structures unstable thus rendering the structure unsafe. Groundwater condition also plays a vital role during the construction of any engineering project.

Geologic structures are usually the result of the powerful tectonic forces that occur within the earth. These forces fold and break rocks, form deep faults, and build mountains. Most of these forces are related to plate tectonic activity.

Structural geology is a critical part of engineering geology which is interested in the physical and mechanical properties of rocks. It provides major concepts for trying to understand the rock and lithosphere deformation.

Faults: Are fractures that have appreciable movement parallel to their plane. They produced usually by seismic activity. Understanding faults is useful in design for long-term stability of dams, bridges, buildings and power plants.

A fault is a break or fracture between two blocks of rocks in response to stress.

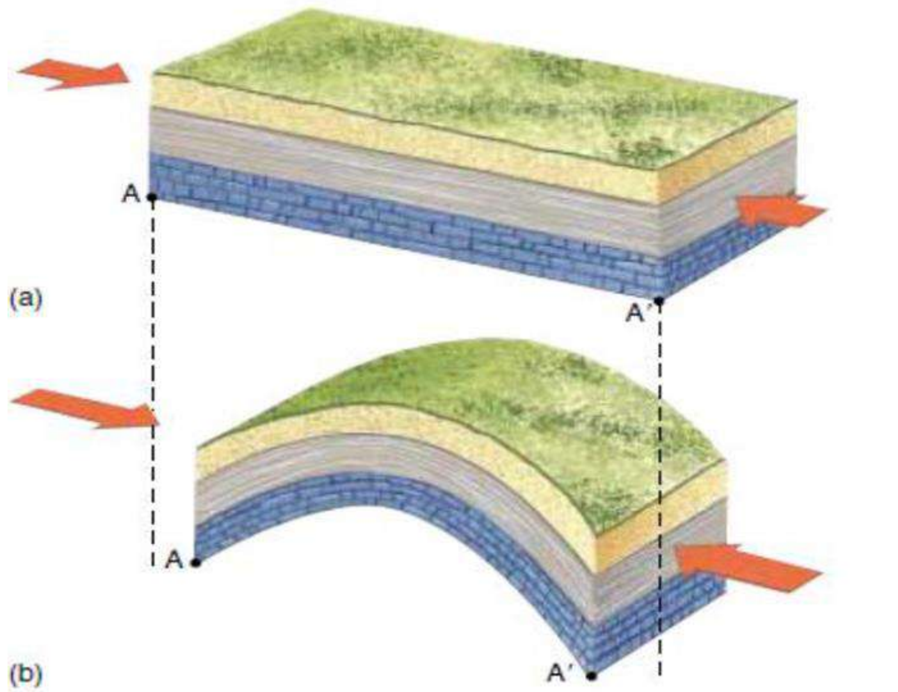
Three types of stresses produce faults;

1-Tension 2- Compression 3- Shear

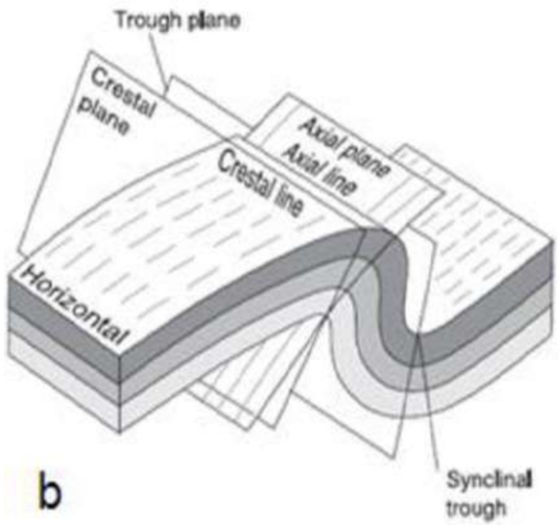
One block has moved relative to the other block. The surface along which the blocks move is called a fault plane.

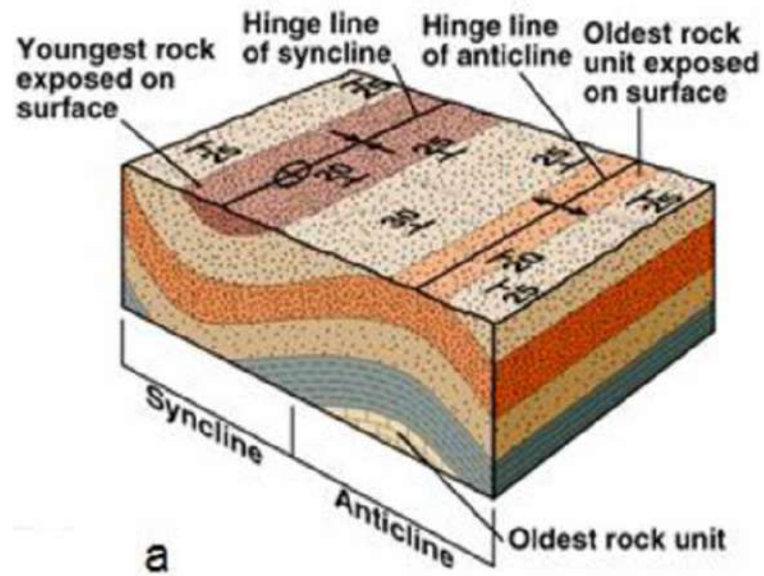
FOLDS

A fold is a bend in rock. Some folded rocks display little or no fracturing, indicating that the rocks deformed in a plastic manner.



Simple folds are divided into two types, that is, anticlines and synclines. in the former, the beds are convex upwards, whereas in the latter, they are concave upwards.





Fracture: is a planar or curviplanar discontinuity forms as a result of brittle rock failure under relatively low pressure and temperature condition in the earth crust. Rock fractures range in size from micro cracks (fraction of mm) to faults which extend for hundreds of kilometers.

Joints: are defined as dry fractures of geologic origin along which no appreciable displacement has occurred.

joint sets: a group of fractures occurs in systematic alignment with similar strike and dip .and arrangement.