الكلية التقنية كركوك

قسم هندسة تقنيات المساحة

منهاج المرحلة الدراسية الأولـــى /الفصل الأول **المادة / علـــم الأرض**

أسم المقـــرر	الساعات النظريـــة	الساعات العملية	عدد الوحدات
علم الأرض Geology	1	2	2

الهـــدف من المادة	تعريف الطالب بعلوم الجيولوجيا العامة وفروعها المختلفة وعلاقتها واستخداماتها في علم المساحة والمسوحات الطبوغرافية من خلال تعريف الطلبة على أنواع الصخور في المناطق الذين يقومون بمسحها وخاصة الصخور النارية والرسوبية والمتحولة والخواص الهندسية والميكانيكية لهذه الأنواع من الصخور والتعرف على الظواهر الجيولوجية الطبيعة الموثرة على طبوغرافية وشكل الأرض منها الزلازل والبراكين وحركات الكتل الصخرية والأنزلاقات الأرضية.

منهاج المادة النظريـــة **عدد الأسابيـــع / 15 أسبوعا"**

الأسابيع	مفـــردات المـــادة
الأول	تعريف علم الأرض ، فروع الجيولوجيا، علاقة الجيولوجي بالعلوم الأخرى وتطبيقاتها
الثاني	علاقة الجيولوجي مع المساحة وتطبيقاتها ، أصل أرض وكيفية نشؤها
الثالث	تركيب طبقات الأرض ومكوناتـــها ، قشرة الأرض وجبة الأرض ، لب الأرض ومكوناتها ، طبقات الغلاف ألأرضي.
الرابع	البلورات تعريف البلورات، الأوجه البلورية ، أشكال البلورات ، الأصناف البلورية وتسمية البلورات
الخامس	المعادن ، تعريف المعادن ، تكون المعادن . الصفات الفيزيائية للمعادن
السادس	الصخور ، تعريف الصخور ، كيفية تكون الصخور في الطبيعة وانواع الصخور
السابع	الصخور النارية ، تعريفها، أصناف الصخور النارية ،صفات الصخور النارية ،نظام تبلور المعادن من الصهير البركاني، تصنيف أنواع الصخور النارية.
الثامن	الصخور الرسوبية، تعريف الصخور الرسوبية، تصنيف الصخور الرسوبية ، معادن الصخور الرسوبية الفتاتية والغير الفتاتية ، أنواع الصخور الفتاتية والغير الفتاتية
التاسع	الصخور المتحولة تعريفها،صفات الصخور المتحولة . أنواع التحول ، تصنيف الصخور المتحولـــة
العاشر	دورة الصخـــور في الطبيعـــة، والبيئات والظروف المكونة للصخور المختلفة
الحادي عشر	الخواص الميكانيكية للصخور،أنواع مقاومات الصخور، المقاومة الأنضغاطية وحسابها، المقاومة الشدية وطرق حسابها
الثاني عشر	المقاومة القصيةللصخور وطرق حسابها . أنواع سلوك الصخور ،تعريف الأجهاد والأنفعال ، العلاقة بين الأجهاد والتشوهه
الثالث عشر	الحركات الأرضية ،أنواع الحركات الأرضية ، الزلازل وتعرفيها ، أحزمة الزلازل في العالم ، أسباب تكون الزلازل ، وطرق قياس الزلازل، الأثار الجيولوجية من نشوء الزلازل
الرابع عشر	البراكبن ، تعريف البراكين كيفية تكون البراكين وأنواعها ، ،انماط البراكين ، المواد التي تقذفها البراكين ، الأثار الجانبية بعد نشوء البراكين
الخامس عشر	حركـــات الكتل تعرفيها ، أنواع حركات الكتل ، العوامل المؤثرة في حركة الكتل ، الأنواع السريعة من حركات الكتل ، الأنواع البطيئة لحركات الكتل.

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علم الأرض Geology	1	2	2

منهاج المادة العمليـــة **عدد الأسابيـــع / 15 أسبوعا"**

الأسـابيع	مفـــردات المـــادة
الأول	عرض مقاطع فديو عن فروع علم الأرض وتطبيقاته
الثاني	عرض مقاطع فديو عن العلاقة بين علم الأرض والمساحة الحقلية
الثالث	عرض بوسترات عن طبقات تركيب الأرض
الرابع	عرض وشرح نماذج البلورات للطلبة وللأصناف المختلفة
الخامس	عرض النماذج من المعادن للطلبة وتوضيح الصفات الفزياوية للطلبة
السادس	عرض نماذج مختلفة من الصخور للطلبة
السابع	شرح أنواع الصخور النارية للطلبة وقيام الطلبة بتسجيل ملاحظاتهم عن الصخور المعروضة
الثامن	شرح أنواع الصخور االرسوبية للطلبة وقيام الطلبة بتسجيل ملاحظاتهم عن الصخور المعروضة
التاسع	شرح أنواع الصخور المتحولة للطلبة وقيام الطلبة بتسجيل ملاحظاتهم عن الصخور المعروضة
العاشر	مراجعة عامـة عن جميع أنواع الصخور النارية الرسوبية والمتحولة.
الحادي عشر	قيام الطلبة بزيارة مختبر الفحوصات للأطلاع على أجهزة المقاومة الأنضغاطية والشدية والقصية واجراء فحص بعض الماذج من قبلهم
الثاني عشر	قيام الطلبة بزيارة مختبر الفحوصات للأطلاع على أجهزة المقاومة الأنضغاطية والشدية والقصية واجراء فحص بعض الماذج من قبلهم وتكملة أجراء كافة أنواع الفحوصات
الثالث عشر	زيارة الطلبة لموقع المحطة الزلزالية في موقع جامعة كركوك للأطلاع أجهزة قياس الزلازل
الرابع عشر	عرض أفلام علمية عن البركين وأنواعها وأطلاع الطلبة على بض الصخور البركانية
الخامس عشر	عرض أفلام علمية عن الأنزلقات الأرضية والزحف الترابي

Geology Defined : المحاضرة الاولى

The word Geology has been derived from the Greek words, (Geo) meaning the earth and loges in meaning science.

Geology is the science of the earth; how it was formed, what it is made of, its history and the changes that take place on it and in it.

Branches of Geology:

The subject of Geology is divided on to several branches which are as follows

1- **Physical Geology** /it deals with the Geological processes which bring about changes in the crust

This includes:

a- **Structural or Tectonic Geology** :it deals with the different kinds of structures produced in the crust of the earth as the result of Tectonic movement

b- **Dynamical Geology**: this deals with the agencies both inside and outside .

c- **Geomorphology** : This deal with surface features of the earth (Topography)

2- **Mineralogy and Petrology** ,they deal with minerals and racks respectively (minerals formation)and association ,analysis

3- **Historical Geology** /it deals with the past history of the earth the chronology of events which occurred on the surface of earth

The evolutionary history of the earth as well as the animals and plants which lived on earth at different periods :

it includes the study :

a- **Stratigraphy** /dealing with the succession of rock formation

b- **paleontology** /dealing with the relics of ancient animals and plants called fossils

4- **Economic Geology:** it deals with the study of useful minerals and rocks, and application of the knowledge of geology in prospecting for these economic deposits .

5- **Engineering Geology:** the knowledge of Geology has also been utilised in some cases of engineering problems (selection of sites for Dams, railway, mining, ground water prospecting.

Further the Science of Geology is inter winned with some sister Sciences to form composite ones , such as Geophysics (based on Geology and physics mainly)and Geochemistry (based on geology and chemistry mainly) Geophysics is important in depicting the underground structures and Geochemistry is important for exploration of economic minerals .

The relation between Geology and other Science

The geology is application sciences which use physical theories and mathematics, chemistry equation to solve pure Geological problems for example:-

1- Geophysics (Geology and physics) from its methods of study has proved very useful in depicting the underground structures of area.
2- Geochemistry (geology and chemist) is important for using its processes in exploration for economic minerals and rocks.
3- Paleontology (based on geology and Biology) is important in study the history of the earth by using the fossils
4- Geomorphology (geology and Geography) it deals with the configuration of the earth (mountain and valleys).

-using of isotope in geology is useful in deter mention the age of rock and deposits.

5- Engineering Geology it deal with engineering and geological properties of rocks and deposits and their application in building, mining, Dames.
6- Petroleum Geology (relation between geology and engineering of petroleum in drilling oil boreholes and estimation the specific weight of oil.

(Relation between Geology and Surveying)

The Surveying processes is deal with distance and angles of points and drawing maps and sections and determination the elevation of points above or down of plane .

- **Therefore the Surveying man needs information and knowledge about the deposits type and distinguished them in field, and using the different Symbols of Lithology during the preparation of maps.**
- **Geomorphology (Topography)**
- **The Surveying needs some knowledge about geological fields such as engineering geology in building, mining, Dams which need precisely and detail surveying.**

Origin of the Erath and their occur ant

The earth being a member of the solar system .The origin of it is connected with that of the solar system there are many ideas to account for the origin of solar system.

Kant hypothesis: Kant proposed that the different parts of nebula, out of which the solar system.

Originated at first moved in different direction at different speed, at time this nebula. became a hot spinning and began radiate heat ,Gradual increase in the rate of revolution due to gradual contraction caused the separation of several rings from equatorial region and these rings in time condensed be from Planets, Meteorites.

The structure of the Earth : المحاضرة الثانية

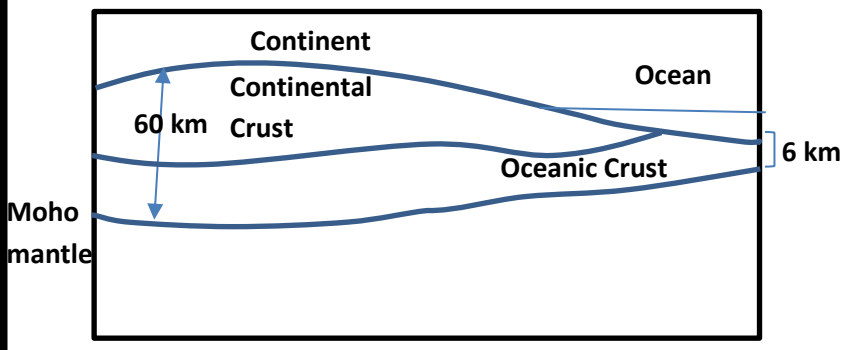
The Earth that we see is largely solid , the solid earth is made up of rocks which in turn are made of simple units called minerals .

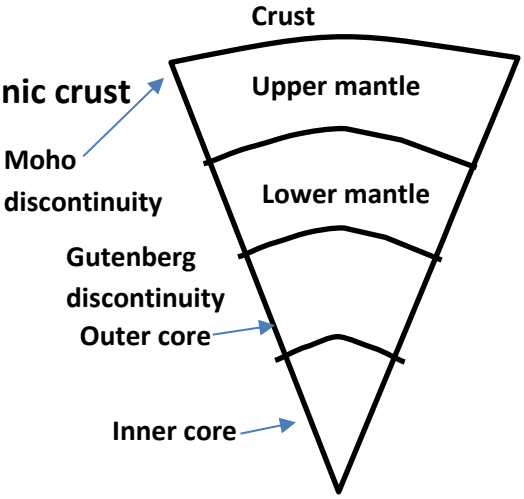
The earth is divided to three parts: as in finger (1) Section through the earth

1- Crust

The part of the earth above the Mohorovicic discontinuity It is less dense than the mantle the continental crust of the great

and areas is thicker ,less dense and older than the oceanic crust





it is essential to underset and that the crust beneath the continents is very different in both composition and thickness from the crust beneath the ocean floors.

2- **Felsic rock forms the upper part of the continental crust in a layer with an average thickness of perhaps (16km) this felsic rock is containing silica and alumina called sail and can also be described as granitic rock.**

3- **The mafic rock form the oceanic crust or represent the lower part of continental crust Largely of the composition of basalt and can us be described as basaltic rock .**

Mantle: the part of the earth between the crust and the core or between the moho and the Gutenberg discontinuity.

Mohorovicic discontinuity / a boundary that separates the crust above from the mantle below the moho is at depth of about 20-40 km below the surface of the continents and about (10)km below ocean floor there is a difference between the velocities of earth quake wave above and below the moho.

- at the base of the basaltic layer there is an abrupt change to a denser mantle rock which we interpret to be ultra-mafic rock with a composition resembling dunite.

- The surface of abrupt change form mafic to ultramafic rock is known as the Moho

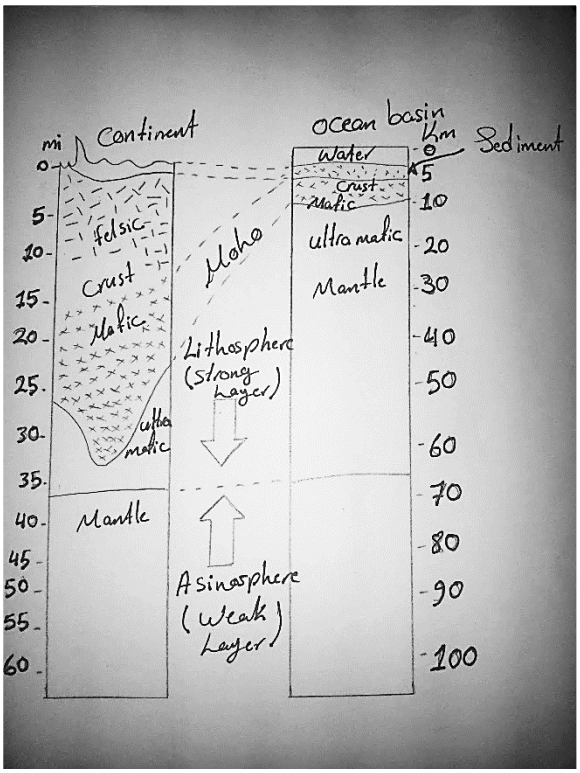
The upper part of mantle is composed from strong layer as well as the above crust called Lithosphere (the outer solid part of earth, the crust and upper part of mantle to a depth 100km ,the Lithosphere is stiffer than the asthenosphere , in the mantle after 200 km ,the rock is being soft because of the temperature is very close to its melting point this layer called asthenosphere .

Asthenosphere/ the part of the mantle from a depth of about (100km) to 250-300km it is not as story and stiff as the lithosphere .

Mesosphere / the part of the mantle below the asthenosphere from a depth of 250-300 km to the core .

Gutenberg discontinuity / a boundary that separates the mantle from the core at a depth of about (2900km) below the earth's surface ,the velocities of earth waves are different above and below the Gutenberg discontinuity .

Core / the central part of the Earth below the Gutenberg .discontinuity at depth of about 2900 km below the earth's surface the core is thought to consist almost entirely of iron mixed with some Nickel it can be divided in to the outer core. which may be liquid ,and the inner core ,which may be solid at a depth of s 5100km, the density of the core is more than the twice the density of the mantle.



Comparison of the crust and mantle under continent and ocean basins.

In the detailed composition of the earth's crust , it is element have combined to from minerals .

<u>The 10 most abundant elements in the earth's crust .</u>

Symbol	name	Weight %
O	Oxygen	46.60
Si	Silicon	27.72
Ai	Aluminum	8.13
Fe	Iron	5.00
Ca	Catenin	3.63
Na	Sodium	2.83
K	Potassium	2.59
Mg	Magnesium	2.09
Ti	Titanium	0.44
H	Hydrogen	0.14

Crystals and minerals المحاضرة الثالثة

A body with surface that are smooth ,flat and regular arranged the regular shape of a Crystal results from the regular arrangement of the atoms of which it is made

- **Crystal lattice: the regular arrangement of atoms in three dimensions in a crystalline solid.**
- **unit cell : The smallest complete Pease of a crystal lattice that shows the arrangement of the atoms in a crystal the unit cell contains a number of atoms arranged in a regular way .it is repeated in three dimensions to from the crystal lattice**

- **Face: a single flat surface on crystal in crystallography, it is not the sizes of faces that are important but the angles between them called the interfacial angles.**

- **Form: a form is a group of crystal face that are to a single face by the symmetry elements of a particular crystal class, for example, eight face makes up pyramid form in the cubic or tetragonal system the term crystalline implies a regular atomic structure there is another class called crypto crystalline,represent fine grained aggregates and their character is described under the microscope only.**

- **Non crystalline material is termed a amorphous which is rare among minerals (opal minerals)**

For reference purposes the vertical crystallographer axis is Labelled (C), the left to right one(b)and the back to font one (a),faces are named according to which axes they eat . for example

1- **face cutting all three axes is termed (a pyramid)**
2- **cutting two horizontal axes and parallel to one vertical axis (a prism)**
3- **cutting one horizontal axis and parallel to one vertical and one horizontal axis a (pinacoid).**

The relative development of different faces controls the habit of a crystal for example , a flat crystal is termed tabulat While one that is elongated is termed prismatic.

The form developed in the cubic system are special and sometimes complex because of the high symmetry ; they are grew special names such as cube ;octahedron, rhombdeducehadron (12 face) ,pyritohadron (24 face) which are not used in other system

Mineral : Substance having a definite chemical composition or a definite range of composition ,that has been formed naturally and occurs in the Earth's crust , Most minerals have a character is crystal form.

The physical properties of Minerals

1- **Color: color is an obvious property it is one of reliable test available many minerals have a variety of colors .such as (quartz) and fluorite while very few minerals have .constant color such as sulphur or malachite.**
2- **Streak: The colour of the powdered mineral which is obtained by scratching the mineral on a piece of unglazed porcelain called a streak plat the streak may be the color as that of the mineral, it may be colored but different from the color of the mineral .the mineral may be too hard to produce a streak (hematite gives a reddish -brown streak magnetite a black one and cassiteribe no streak.**
3- **Hardness : The hardness of mineral is measured by its ability to make a marks on the surface of another mineral .the scale of hardness that is use is due to mohos : ranging from 1 talc to 10 diamond ,the surface of minerals with hardness of less than 6 1/2 can be marked with a knife minerals with a hardness of 2 1/2 or less can be marked with a finger -nail**

1. talc 2. gypsum 3. calcite 4. fluorite 5.apati 6. orthoclase 7.Quartz 8.Topaz 9.corundum 10.diamond

4- **Luster :** it depend on the intensity of light reflect from the surface of a mineral specimen .luster may be:

a- adamantine as in Diamond
b- resinous like that of resin ,(opal)
c- pearly like that a pearl Talc
d- metallic like of metal (magnetite)Galena
e- Tortious or glassy like glass (obsidian), Quartz
f- silky like that of silk .(gypsum)
g- greasy (Graphite)
h- dull like that of earth (Cassirite)

5- **Cleavage** : is the property of breaking along Clearly marked smooth planes which are parallel to-possible .crystal faces (Cleavage)may be ;

a- perfect mica : when the broken surface is very smooth
b- Imperfect : when the broken surface is not so smooth
c- Absent : is broken surface is irregular or difficult

6- **Fracture** : The nature of the broken surface in any direction other than the cleavage direction may be :-

a- Conchoidal /when showing concave surface
b- uneven /showing irregular surface
c- even ,/showing smooth surface
d- hackly/showing much irregularly surface
e- splintery /breaking in splinter like parts

7- **Forms** : a- Granular (grains) b- friable henetit c-Nodular d- colitis e- Geoidal f- Reni form g- Lamellar h- Foliated i- Fibrous j- Dendritic k-bladed mica

Rocks can be broadly divided in to three main classes:

1. **Igneous** 2. **Sedimentary** 3. **Metamorphic**

Rocks /are naturally occurring aggregate of minerals and are units with which the earth's Crust is composed.

(Igneous Rock)

The word igneous is derived from the Latin word ignes meaning fire.

-The molten rock material together with the gas content is called magma.

The igneous Rocks are formed from the solidification of magma.

Characters of Igneous Rocks:

Such rocks originate generally at depth but sometimes are formed on the crust of the earth .therefore there have two distinct

Classes of igneous rocks : 1-plutonic or abyssal 2-Volcanic (extrusive)

1- **Plutonic rocks : are those which have solidified at some depth below the surface of the earth .they are seen only after long continued deep erosion the environment and condition under which plutonic rocks solidify are quite different from those under which volcanic rocks solidify .**

During the Crystallization of plutonic rock pressure act and therefore the rate of cooling is slow and dissolved gases cannot escape this produces a coarse grained or phaneritic texture.

2- **Volcanic rocks : rocks formed on the crust of the earth ,there is no effect of pressure and the gases also escape easily this produces a high rate of crystallization and consequent fine grained or aphanite texture**

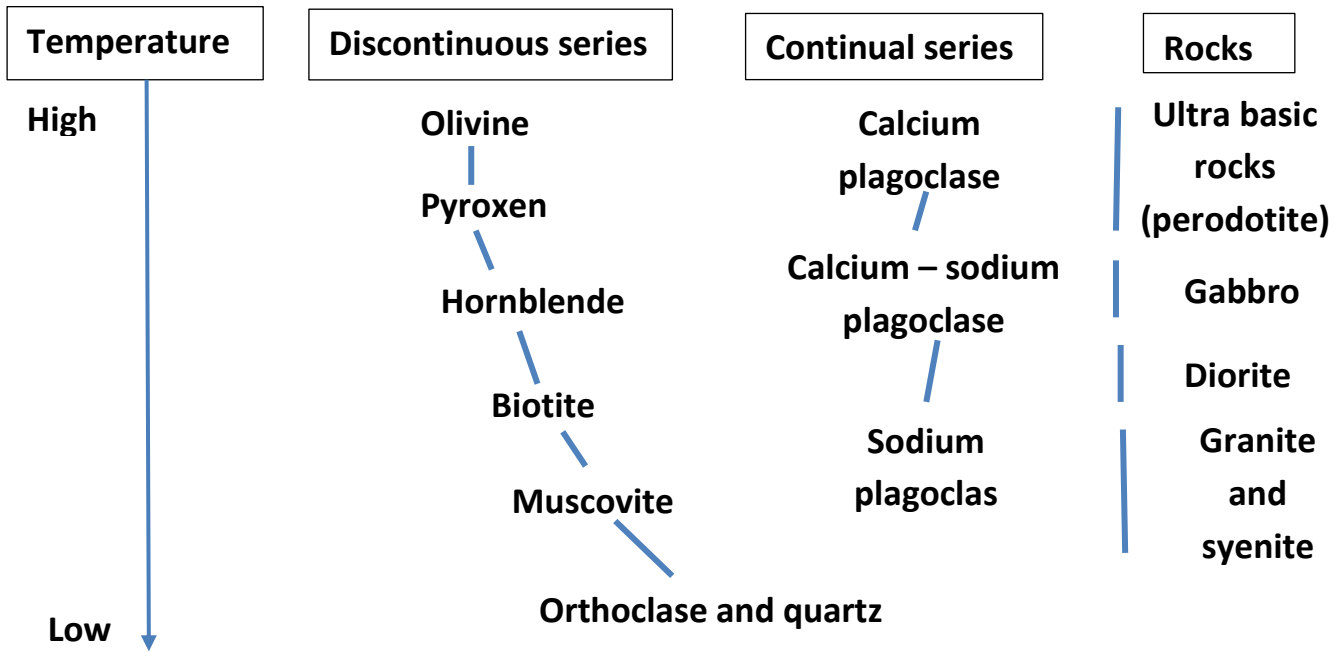
The demarcation line between these two group is not we Clear and commonly a third middle group is recognized :

these are the hypabyssal rocks :

Hypabyssal rocks : it is intermediate in its mode of origin between a plutonic And a volcanic rock ,its character is also intermediate between the two groups.

and which shows a medium grained texture Igneous rocks shows order of crystallization ,they present interlocking texture and massive and hard appearance ,they do not contain any fossils as the sedimentary rocks and nor any clear stratification ,the parallel arrangement of mineral peculiar to metamorphic rocks is also absent in the igneous rocks

One common order in which minerals crystallize from magma is shown in the diagram below, comprises two Series of minerals which crystallize independently of each other If fractionation were to remove crystals in this order from basic magma, the earliest batches would form ultrabasic rocks , such as Biotitic ,later batches would give gabbro and diorite and the final liquid residues would crystallize as a Granite.



Order of crystallization of minerals from magma
(Bowens reaction series)

Common Igneous rocks :

1- Acidic (Silica more than 65%) :

1- **Granite :-** It is medium to coarse - grained and light colored the silica percentage is quite high (65_80),this puts the rocks into the acidic group ,granite consist of quartz and Feldspar ,plagioclase may also be present ,Micas (muscovite and biotite)are frequent ,Accessory minerals include magnetite Rhyolite is the volcanic equivalent of granite.

2- **Pegmatite** :- are of granitic composition ,during the test age of crystallization of a magma the residual part be cores very rich in volatile matter ,Alkali and silica which produce big crystals ,commonly quartz ,orthoclase and vice are present and accessory minerals like apatite ,tourmaline topaz ,Lepidolite , beryle , cassiterite .etc....

2- Inter mediate (Silica 50-60%)

3- **Syenite**: it is a medium to coarse -grained rock ,very similar to Granite ,mineralogocally syenibes do not contain quartz or very little of it ,the silica percentage is lower (50-60) or the class is abundant ,plagioclase is frequent ,and rare of pyroxene and hornblende Accessory minerals include nepheline ,Leucite ,apatite magnetite etc.

- **Trachyte :**is the volcanic equivalent of Syenite

4- **Diorite** : it is medium to coarse grained rock dark in colour ,is similar to syenite ,but the distinction between syenite and diorite in the alkali percentage is lower in orthoclase is absent while plagioclase is present ,and Biodtite ;hornblende and pyroxene are also present Dacite and Andesite are the volcanic equivalents.

Basic (silica 45-50%)

5- **Gabbro :**It is medium to coarse grained plutonic rock of dark colour and low silica percentage (40-50) Plagioclase and pyroxenes are important minerals in Gabbro ,Olivine is a common accessory mineral

6- **Dolerite** : it is the hypabyssal equivalent of the gabbro type .it is medium to fine grained ,have the composition of Gabbro

7- **Basalt** : it is the volcanic equivalent of the Gabbro ,it is the most common volcanic rock Basalt is fine grained and dark in colour .it contain lime -rich plagoclase and pyroxene as primary minerals and accessory minerals include olivine ,sphere , ilmenite , leucite ,nepheline etc.

Ultra basic (silica less than 45%)

8- **Peridotite**: it is a coarse grained rock of dark color, it is very basic rock, consist of Ferro magnesia minerals, mainly pyroxenes, olivine and hornblende accessory minerals in clued, ilmenite, garnet, chromite sphere etc.

Table 6–2. Classification of igneous rocks

	Composition				
Texture	*Felsic*	*Intermediate*	*Mafic*	*Ultramafic*	*Mode of Emplacement*
Glassy	Obsidian Pumice	–	Basalt Glass	–	Extrusive
Aphanitic	Rhyolite[1] Felsite[2]	Andesite	Basalt	–	Extrusive
Aphanitic porphyritic	Rhyolite porphyry[1] Felsite porphyry[2]	Andesite porphyry	Basalt porphyry	–	Extrusive
Phaneritic	Granite	Diorite	Gabbro	Dunite Peridotite	Intrusive
Phaneritic porphyritic	Granite porphyry	Diorite porphyry	Gabbro porphyry	–	Intrusive
Fragmental		Tuff, volcanic breccia[3]			Extrusive

[1] Quartz visible.
[2] Quartz not visible.
[3] Fragmental rocks may have a composition ranging from felsic to mafic.

Sedimentary Rocks المحاضرة الخامسة

Sedimentary rocks are those rocks which have been derived from the consolidation of sediments .these sediment are the products of erosion both mechanical and chemical from some pre-existing rock masses ,the sediments are carried both in suspension as well as in solution and are deposited in basins like.

lakes and more commonly in seas and oceans ,in the case of marine deposit, remains of marine animals and plants also contribute to the accumulating mass ,the consolidation of the materials by pressure or by cementing materials like silica ,calcium carbonate ,iron oxide products hard rock called sedimentary rocks.

The sedimentary rocks can classify in two groups in depending on origins of the sediment constituting the rock:

1- Clastic 2- Non clastic

1- Clastic sediment : consists of particles broken away individually from a parent rock source, subdivided into groups

1- Pyroclastic sediments, this material called tephra.

2- Detrital sediments: mineral fragment's derived by the weathering of pre-existing rocks of any classification.

2- Non Clastic sediment : include two subdivisions:

1- Chemical precipitates: are inorganic compounds precipitate from a water solution in which that matter has been transported.

2- Organically derived sediments: consists of both the remains of plans or animals and mineral matter produced by the activates of plants and animals for examples, the shell matter secreted animals, which is true mineral.

The detrital sediments:

The most abundant particles of detrital sedimentary rocks consist of quartz, rock fragments, feldspar and clay minerals in addition to these minerals there is durable minerals which are highly resistant to physical abrasion and chemical alteration, because of their greater density, are compared with Quartz and called heavy minerals for example is magnetite, oxide of iron.

- **The naming of clastic Rock depends on the sizes ,the widely accepted scale is the went worth scale :**

Grate name	Diameter
Boulders	Cover 256
Cobbles	64-256
Pebbles	2-64
Sand	0.66-2
Silt	0.004-0.06
Clay	Under 0.004

(Went worth scale)

The clastic Rocks :

1- **Sedimentary Breccia: consist of large angular blocks in a matrix of finer fragments, these rocks represent ancient submarine landslides.**
2- **Volcanic Breccia : is the equivalent rock in the pyroclastic group**
3- **Conglomerate: consist of pebbles or pebbles, usually well rounded in shape, embedded in affine grained matrix of sand or silt.**
4- **Sand stone: composed of grains in the range from 2mm.to 0.06 mm. mainly composed of quartz and some heavy mineral and muscovite mica, this particles may be cemented by silica the Products rock is hard rock with great resistance of weathering and erosion or cemented by calcium carbonate.**

The sand stone types :

a- **Gray Wack** : is gray in colour ,composed of Quartz .and feldspar ,Ferro - magnesia minerals .which has been derived from some basic igneous rocks or argillaceous Rocks

b- **Grit**: is sandstone with corers grain and angular.

c- **Arkose**: it is sand stone with percentage of fled spare (orthoclase) more or less resembling granite is pink in colour.

5- **Silt stone:** the compaction and cementation of layers of silt materials give a compact fine grained rock the consisting materials have bigger size than shall and mud stone.

6- **Clay stone** : The consolidation of clay layer form clay stone

7- **mud stone** : The compaction of mixture of silt and clay form mudstone

8- **Shale**: is laminated mud and clay composition can easily break up in to small flakes and plates.

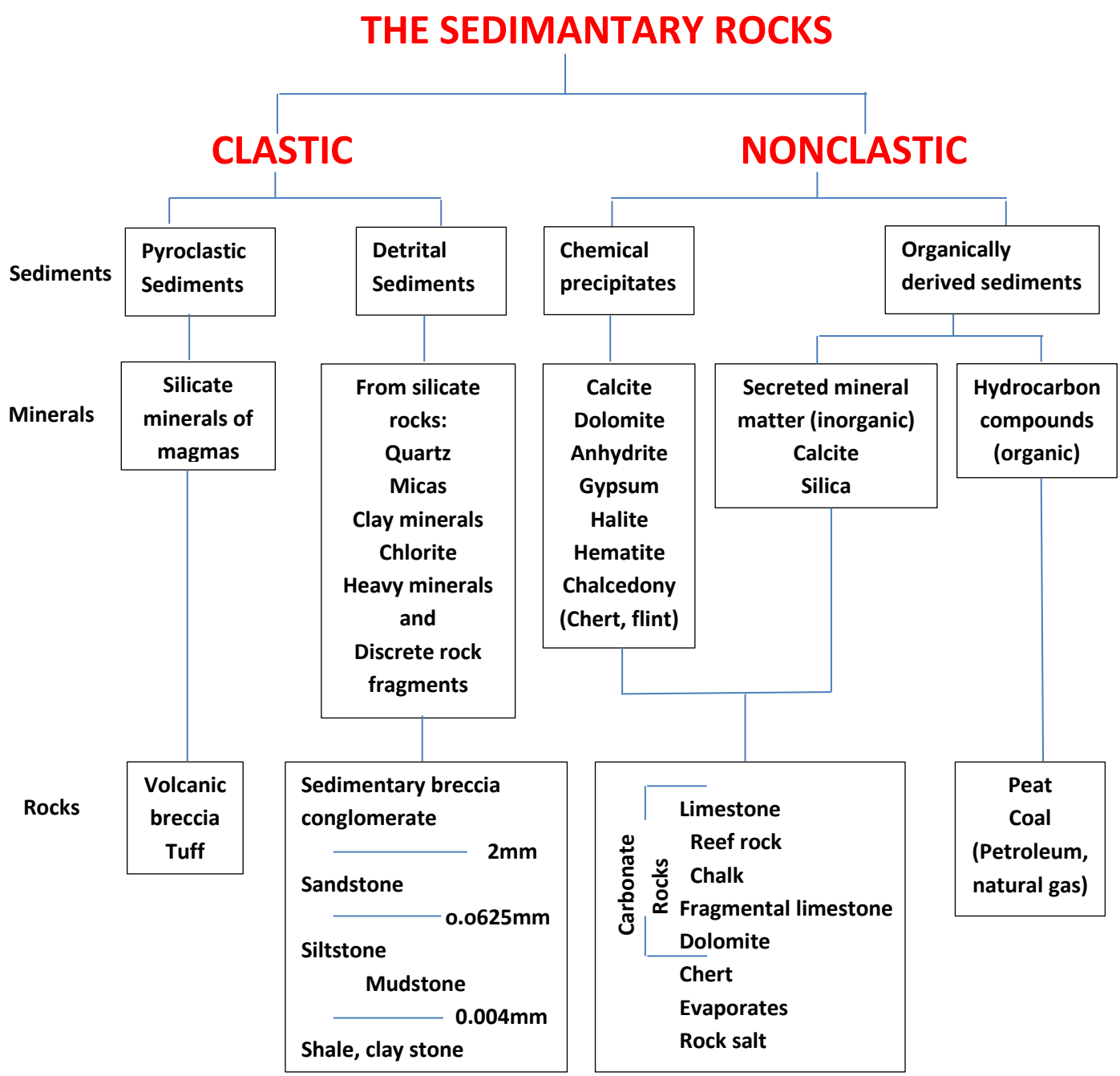


Figure 4.4 composition and classification of the sedimentary rocks.

The Non clastic sediment:

The most important minerals of the non clastic. Sediments class are the Carbonates, are compounds of the calcium ion or magnesium ion, or both

Calcium carbonate is the composition of one of the most abundant and wide spread of minerals calcite and an important chemical precipitate is dolomite.

Evaporite: is chemical precipitates, these are highly soluble salts deposited from salt water bodies when evaporation is sustained under an arid climate the important mineral of evaporates.

1- **Halite ⇨ sodium Chloride**
2- **Anhydrite and Gypsum ⇨ Sulfate compounds calcium.**

- **Two mineral important in non clastic sediment :**

1- **Hematite ⇨ oxide of iron**

2- **Chalcedony ⇨ a form of silica lacking bovines crystalline structure occur as nodules and layers is referred as chart.**

The Non clastic Rocks :

1- **Limestone : sedimentary deposit of calcium carbonate this deposition is either form solution or form the remains of the dead bodies if marine animals .makes the formation of limestone rocks**
2- **Chalk : it is a soft and loose variety of in which foraminifera shells are abundant**
3- **Coquina: it is shelly limestone in which the shells of animals cover 90%**
4- **OoLitic limestone: it is variety of limestone in which this small globules called oolite.**
5- **Marl: it is an impure variety of limestone containing besides calcium carbonate , amount of clayey material marl sometimes are used as cementing material**

6- **Dolomite: This is a Variety which contains a good change to dolomites, the original calcium carbonates changes to carbonates of calcium and magnesium by the percolation of magnesium salt solutions The composition of dolomite is CaCo3MgCo3.**

Metamorphic Rocks

The word metamorphic or metamorphosed means changed

Metamorphism :-the processes by which rocks are changed by the action of heat or pressure or both the rocks changed by metamorphic ,The changes brought about by metamorphism are in the mineral composition ,texture or structure of the rocks ,

- Changes that tack place at the Earth's surface (weathering or diagenesis) are not included under metamorphism

- The metamorphic Rocks are derived from igneous Rock called ortho metamorphic rocks and those derived from sedimentary rock are called Para metamorphic rocks.

The work of heat pressure and chemical solutions is to produce some well-defined characters in metamorphic rocks -

- Metamorphic rocks are generally coarsely crystalline which distinguishes them from the sedimentary rocks .

- there is some parallel arrangement of minerals (Foliation)which distinguishes them which are seen in metamorphic there are some minerals which are seen in metamorphic rocks ,the minerals are - kyanite , andalusite, sillimanite , Zoisite, wollastonite , staurolite etc.

Kinds of metamorphism

1. Regional 2. Contact 3. Cataclastic

1- Regional metamorphism: produced by heat and pressure affecting the rocks of a large area (thousands of square kilometers in extent), it is feit in two ways ;

1-original minerals recrystallize and new minerals are formed.

2- A new set of structures is imposed on the rock may replace or obliterate original bedding structures.

- Regional metamorphism (dynamo thermal) has affected enormous bodies of rock within the root Zones of mountain chains of the alpine type ,the effects are seen today in surface

rocks over large areas. The layered aspect in regional metamorphic rocks is called foliation

2. **Contact metamorphism: -** when a hot igneous body intrudes cooler rocks, the intruded rocks are likely to be recrystallized as the cooling magma loses its heat to its surroundings .This is called contact metamorphism.

-The Zone of contact metamorphism surrounding an igneous body is called the contact aureole.

-The aureole may range from a few cm.to several km wide.

-The contact metamorphic rocks possess a less obvious foliation or not foliation at all, because little directional pressure is applied by this process.

3. **Cataclastic metamorphism:** the mechanical breaking up of a rock by dynamic metamorphism

- Movement along faults at depths of several kms.in the earth results in crushing and grinding of rocks along the fault, Rocks affected in this way are subjected to intense pressure and heat derived from friction as a result the rocks are ground p.

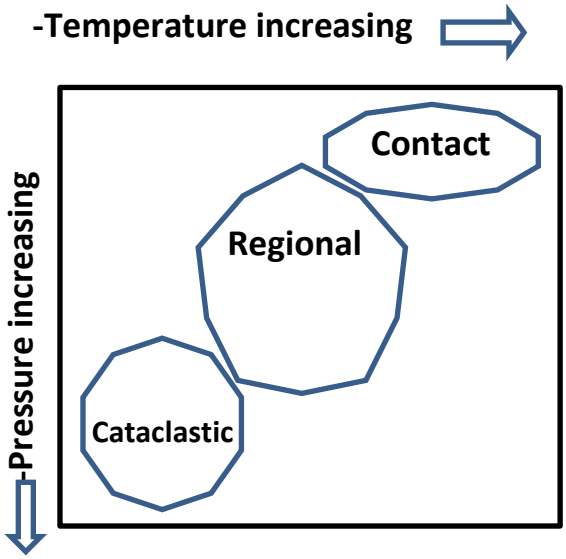


Table 10-2 classification metamorphic rocks

	Rock type	Precursor	Metamorphic process
Foliated	Slate	Shale	Regional contact
	Phyllite	Volcanic rocks	Regional
	Schist	Impure sandstone	Regional
	Gneiss	Plutonic igneous rocks	Regional
	Amphibolite	Mafic igneous rocks Impure carbonate rocks	Regional
Nonfoliated	Mylonite	Siliceous rocks	catalectic
	Phyllonite	Mica- and feldspar-rich rocks	catalectic
	Quartzite	Sandstone	Regional contact
	Marble	Limestone dolostone	Regional contact
	Hornfels	shale	Contact

Metamorphic Rocks and their Classification Foliated rocks;

1- **Slate:** results from regional metamorphism of shale. and other fin-grained rocks (mudstone, some volcanic rocks),possess a marked foliation ,the rock (mudstone) breaks ,this breakage direction is called salty cleavage

2- **Phyllite:** is a foliated rock in which the micas have recrystallized to a greater extent than those in a slate it forms by recrystallization of slate. Foliation surface in phyllite have a more shiny appearance than those of a slate the clay-mica grains of slates have recrystallized to muscovite , biotitic or chlorite but remain fine grained

3- **Schist :**in which mica and other minerals are completely recrystallized ,it is produced by regional metamorphism of phyllite ,and all major constituents of the rock should be visible to the unaided eye porphyrobiasts of garnet ,kynite ,staurotite and other minerals are common Instead of clays the micas muscovite and -Biotite and talc or chlorite may be the main constituent of this rock type.

4- **Gneiss** :in which different minerals may be segregated in to light and dark-colored bands Gneisses generally contain more feldspar and Quartz and fewer micas than schist ,results from high grade regional metamorphism of gray weak arkose and other plutonic igneous rocks such as granite diorite ,syenibe Gneiss contain lenticular or eye shaped porphroblasts is called an aujen gneiss

5- **Amphibolite**: is produce from regional metamorphism of mafic igneous rocks (basalt ,gabbro)may or not passes marked foliation ,they are composed mainly from amphibole hornblende and contain other minerals Such as biotitic ,plagioclase ,calcite and quartz.

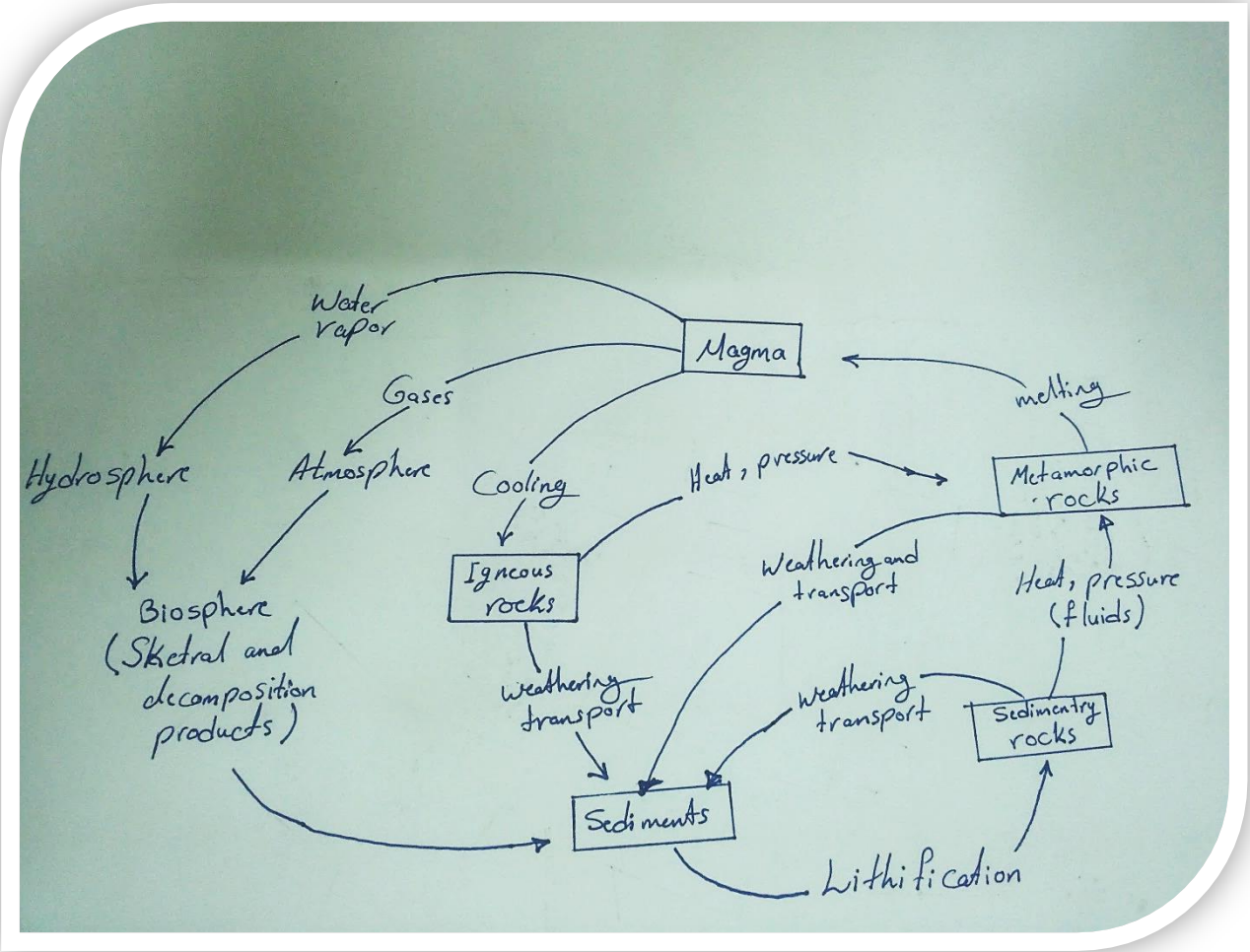
6- **Mylonite**: faintly to strongly banded fine grained rock formed by cataclastic metamorphism of other rocks ,mylonite very closely resembles the sedimentary rock (chert)because of high quartz content It may contain large crystals or fragments of the coarser material from which it was derived

7- **Phyllonite** : is a strongly foliated mica -rich rock formed by cataclastic metamorphism of coarser feldspar or micacous rocks ,micas are created from fled spare in Feld spathic rocks by cursing and reaction with water ,phyllonites closely resemble reaction but are not so common.

8- **Quartzite** : is produce from regional or contact metamorphism of sandstone sand grain are recrystallized and become welded to gather to produce Avery hard rock

9- **Marble** : produce by regional or contact metamorphism of limestone and dolostone, they may be fine to coarse grunted Although dark colored marbles exist most are of light color Crystals of garnet micas amphiboles ,pyroxenes ,talc and olivine appear during metamorphism of impure limestone

10- **Hornfels:** produced from contact metamorphism of fine grained clastic sedimentary rock (state), Hornfels is a gray fine grained, contains porphroblasts of biotite or other minerals, mainly composed of micas, Quartz feldspar.



Rocks cycle in nature:-

Igneous , Sedimentary and metamorphic rocks are the products of different environments ,the rock melts or marinas which later recrystallized in to igneous rocks originate at depths of 25 --200 km and temperatures of 1000c°,the minerals of rocks are stable at high temperatures .

Weathering of rocks exposed to the attack of atmosphere, water and organisms provides the row material of sediments Running water glaciers and wind carry away the detritus and by erosion expose new surface to attack Eventually ,the weathering products come to rest in some low-lying land or in river lake or seen sea ,they are buried ,compacted Lithifield ,the sedimentary rocks are formed within a temperature range of -30c°to 100c° ,the mineral of sedimentary rock are stable at these low temperatures and pressure The igneous and sedimentary rocks later may be subjected to heat and pressure

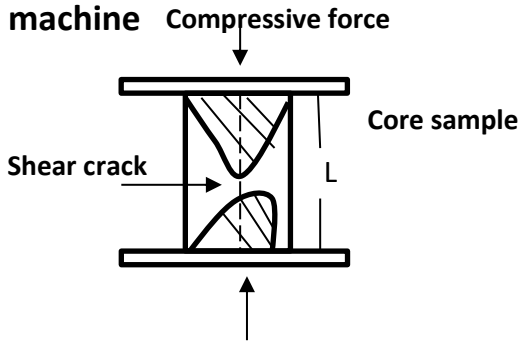
accompanying crustal movements .the effect of these is to change the character of the pre-existing rocks and in this Woy the metamorphic rocks result .

Rock Strength: may be divided to the following:-

1- Compressive strength
2- Tensile Strength
3- Shear Strength

1- **Compressive strength of Rock:** it mains the strength of the packed grains or crystals which composed the rock to external stress applied vertically to the rocks .if the internal strength of the rock increases to External stress ,that bring out the rock to be stable and no deformation but when become External stress is more than internal strength the Rock is subjected to fracture and failure the rock strength for vertical stress in failure point represent Compressive strength.

Oftunly measured in Laboratory by using compression machine



L=2D , L=Length , D= diameter

Compressive strength = $\frac{P}{A} = \frac{N}{mm^2}$

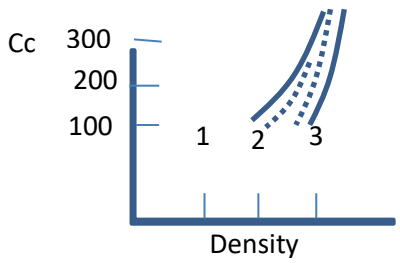
The factors affected to compressive strength of rocks

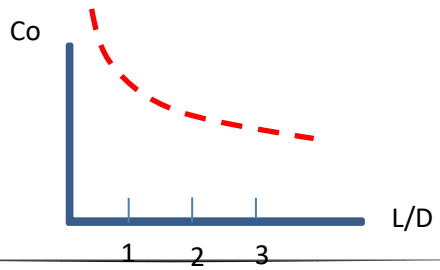
a- Rock type
b- void ratio and cementing material
c- sample dimension (L/D) if increased the compressive strength is reduce

$Cc = Co\ (0.8 + \frac{0.2}{L/D})$ Cc= Compressive strength amount

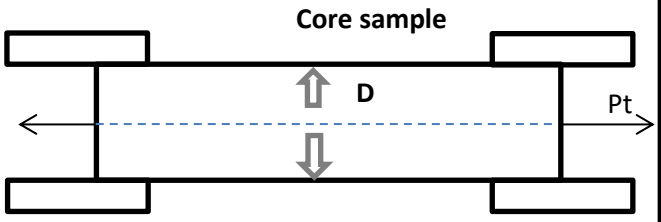
Co = standard Compressive strength when L/D=1

d- Rate of loading being less by reducing the density of rocks and increasing moisture





Tensits strength: Represent the Rock strength to tension stress applied externally and calculated in two ways:



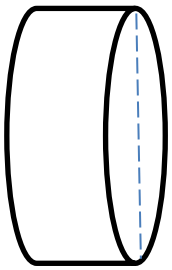
1- Direct method $Ct = \frac{Pt}{D}$

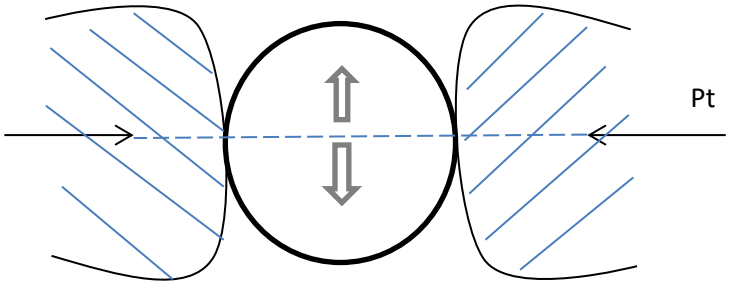
the failure plane is perpendicular to the applied stresses axis

2- Indirect method (Brazilians Disc method)

the sample (Rock)is cut as Disc with radio D/t =3and subjected vertically to the compressive machine as in diagram

$\frac{D}{t} = 3$





$Ct = \frac{2Pt}{\pi Dt}$ t=thickness , Pt=applied force , D=Diameter , Ct= tension strength

In the hard Rocks the rate between compressive strength and Tension strength may be arrive Ten once is referred by (k),k=Co/Ct

K in Igneous Rock is (8-10)

k in sedimentary Rocks (sand and limestone)and metamorphic Rock such as (Shute and schist)is (4=6)

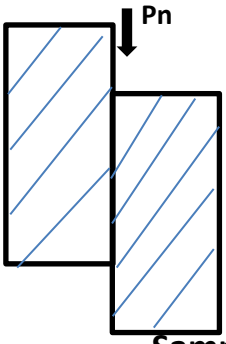
k in weak Rocks such as mudstone is less than 4

Shear Strength: it means the strength of Rock material when subjected to External stress in which the stress compound parallel to surface that required to calculate their shear strength.

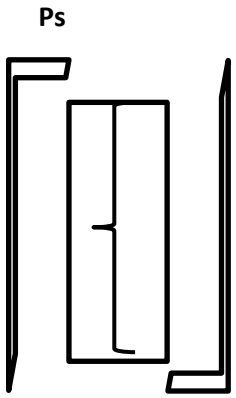
the geological structures of Rock like (fault planes ,joint planes, adding planes ,cleavages)is weakness plane in stratigraphy typically when these planes subjected to shear stresses suddenly such as (Earth quakes Volcanic)

Two method to account the shear strength amount (t) for Rocks

1- Direct shear method or unconfined



Sample with one shear surface



Sample box

Vertical force Pn

$$T = \frac{\mathrm{Pn}}{\mathrm{A}}$$

Pn vertical stress

Vertical stress 6n=Pn /A

Ps Shear force

Shear strength t=Ps /A

2- Triaxial Rock testing (confined shear strength)is used Triaxial confinement Cell, the sample coated with sleeve which prevent to penetrate the oil liquid in voide of Rock ,the sample is subjected to two force ,one from up and down of sample (Pn)and second from lateral side by hydraulic pressure of oil liquid (Pc).than the compact strength (C)is calculated between grains by drawing mohos circles which represent the relation between shear stress and vertical force on the shear plane.

Stresses and strains in Rocks

Stress is physical amount (6) results from force affect (p) on certain area (A) and equal P/A the rock in nature is under different affected stresses (compressive, Tension shear strength) when the placed stress is large than its strength, the rock may be failure and formed faults joints, and deformation.

Strain /the formed deformation from stress effect on the Rock, the strain may be in one side as in longitudinal strain($\mathcal{E}$ L) ,or in three side which change the shape of Rock mass and caused volumetric strain($\mathcal{E}$ V) .

$\varepsilon L = \Delta L / L$, ΔL : deformed length , L: original length

$\varepsilon V = \Delta V / V$, ΔV : deformed volume , V : original volume

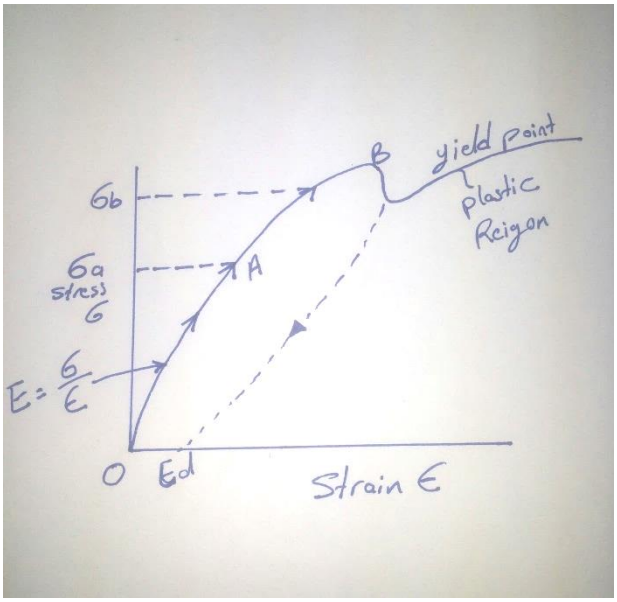
The Vertical strain (Deformation) εL may be more or less than horizontal deformation . εh when placed on different stresseswhich is called Poisson's ratio :is the ratio between horizontal strain and vertical strain is referred by (ϒ) $\Upsilon = \varepsilon h / \varepsilon L$

and these amount in all Rocks ranged from 0.25 -0.5 , the rock can divided in two essentially groups in there relation with stress and strain .

1- Elastic or Brittle rocks:

The rocks which located in this group characterized by linear relation between stress and strain if the stress is not too large .the strained material returns when the external stress are removed, the ratio between stress (6)and strain for Rock is represent constant amount for each Rock type is called young's modulus of Elasticity(E).
E= б (stress) /ε (strain)

The rock behavior in this group characterized by tacking place fracture or failure before their deformation when subjected to certain stress ,the rock may be subjected to simple deform but returns to their shape and size when the stress are removed If the stress value applied Less than (бa),the rock behavior



is Elastic Of the act of stress is removed in point (A)

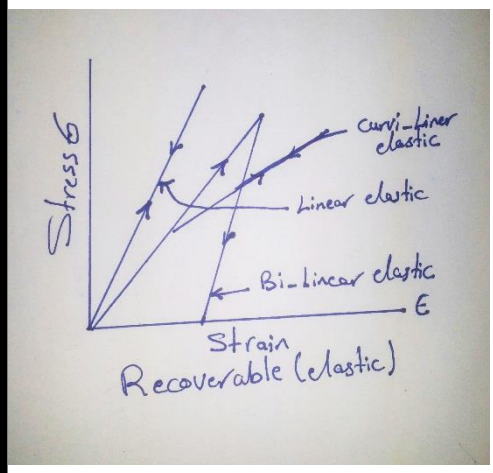
the strain value become zero .

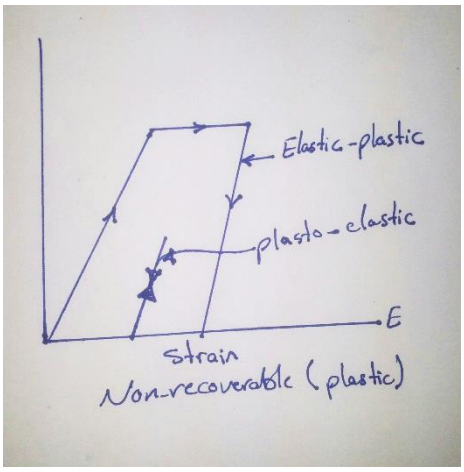
In point B which is Called yield point ,the rock behavior is plastic ,for this reason ,when the act of stress is removed in this point ,the deformation in rock body do not return to its origin nature ,it remain part of it in rock matter is called Permanent strain or Deformation.

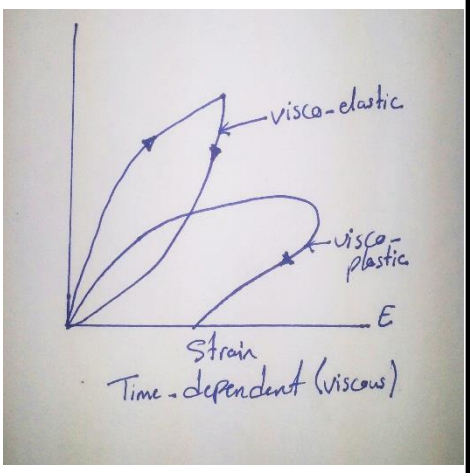
If the act of stress is continues on the rock after point B the rock behaviors becomes plastic and deformation being contain even the stress value is constant is called viscous behavior.

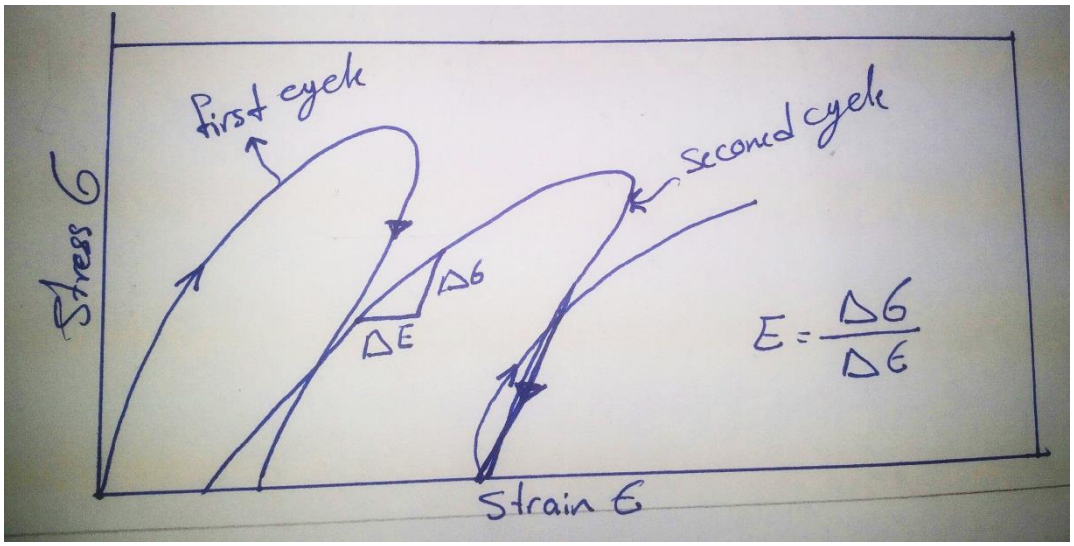
The rock behavior is divided to three state :-

a- Elastic behavior b-plastic behavior c-Viscous behavior







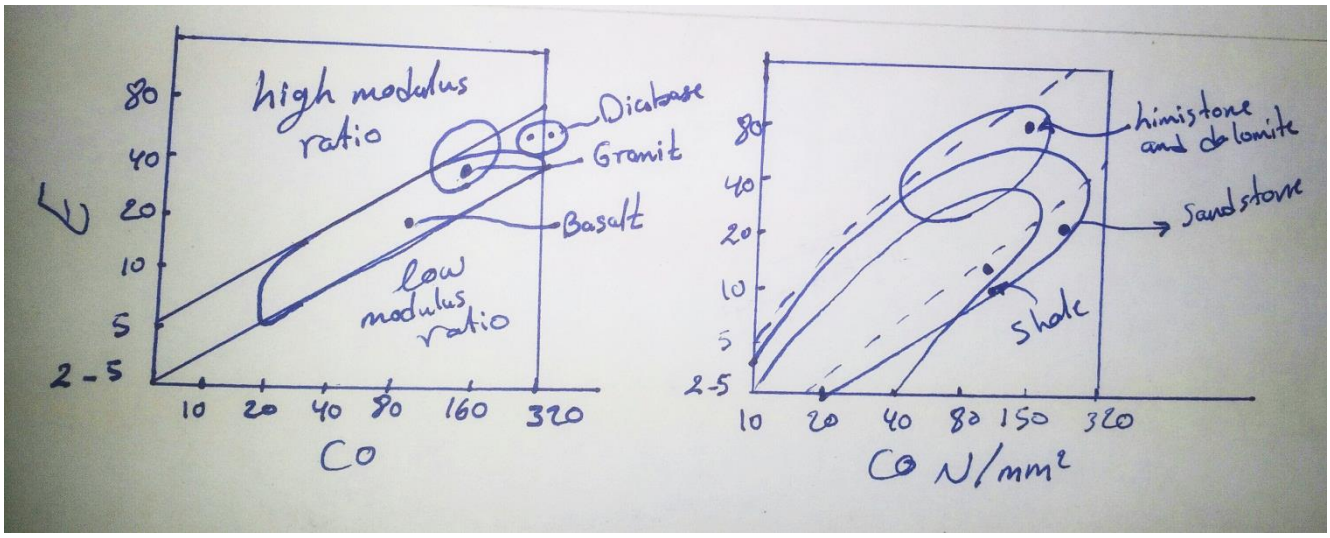


- **if E > 8000 N/m^2 hard Rock and with Elastic nature**
- **if 8000 >E=4000N/m^2 middle hard and Rock have semi -Elastic**
- **if E <1000N/m^2 Little hard and Rock have Non -Elastic nature**

The relation between (E)and Co is: E/Co =350

E/Co in igneous Rock with range between (500-200N/mm

E/Co in sedimentary rock (sand, clay stone) is less than 2000 except in some siliceous



limestone is more than 2000.

Strength of Different Rocks

Rock type	Co N/ mm^2	Ct N / mm^2	T N / mm^2
Granite	100-250	2-25	14-50
Gabbro	150-300	15-30	
Sand stone	20-170	4-25	8-40
Limestone	30-250	5-25	
Clay stone	5-100	2-10	3-30
Silt Stone	100-200	7-20	15-30

Earth movements:

The earth movement divided into two kind:

1.Sudden movement (Earthquakes , Volcanoes)

2.Slow vertical movement (Uplift and depression) + Mountain-building

-Earthquakes:

Earthquake is a jerking motion in the rocky shell of the earth's crust , which has considerable elasticity is set in to tremors by sudden blow from external and internal causes , and are caused by adjustments to strain in the crustal rocks , stresses accumulate locally in the rocks until breaking point is reached , when slip along the fracture occurs , followed by a small rebound , a very small movement on a fault (an inch) may produce a considerable shock because of the great masses of rock involved in the movement .

Earthquakes occur mainly in two belts on the earth's surface:

1.Which extends around the coastal regions of the pacific , from the East India , Philippine , japan , the Aleutian Isles -> Western coast of the North and South America .

2.Central Europe, Eastern Mediterranean, Himalayas and East Indies where it joins the first belt.

-Causes of Earthquakes:

1.Surface causes (Landslide, variation of temperature or variation the weight atmosphere etc.)

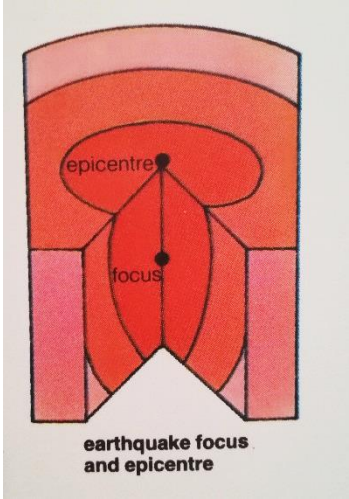
2.Volcanic causes (volcanic explosions)

3.Tectonic causes (displacement of the part of the earth's crust)

Earthquakes intensity:

1.Metrically scale (Ten division, descriptive type) -> intensity number / name of the shock / effects produced.

2. Richter's scale for earthquake.



-the magnitude of the intensity of an earthquake ha relation with the energy released on displacement of strata.

The scale have twelve division indicating different and unequal magnitude of earthquake intensity and is composed from (9) degree.

Geological Effects of Earthquake:

1.Change in drainage system of the area (Rivers)

2.New spring appear or old spring stop

3.Rock slides occur in hilly region , aid the mass wasting process

4.Changes of ground level (increase in the height of hills)

Volcanoes: are hill like masses formed around a pipe by the accumulation of molten rock materials and fragmental rocks which are the products of volcanic eruptions.

The explosion accompanied by the pouring of lava and volcanic gases and blowing of surrounding rock fragments, the type of volcanoes:-

1.Active volcanoes: which erupt very often

2.Dormant volcanoes: which show eruption with lapse of period between the eruptions.

3.Extinct volcanoes: which do not show any volcanic activity.

-Different styles of volcanic actions are distinguishes:

1.Fissure eruptions: from cracks in the earth surface with little gas, it is basic and mobile with low viscosity spreads rapidly.

2.Central eruptions: builds a volcano that has a cone with crater connected to the volcanic pipe.

Volcanic vent: the hole or pipe through which volcano send out lava.

Volcanic cone: the heap of volcanic material, solidified lava that forms round and above a volcanic vent.

-The extrusive material from volcanoes:-

1.Pyroclastic: pieces of material that have been thrown into the air by volcanic action.

2.Volcanic dust: very fine material in the form of particles less than 0.06 mm. in the diameters blown out by a volcano.

3.Volcanic ash: material in the form of small fragments from (0.06 to 4 mm.)in diameter.

4.Tuff: a consolidated volcanic ash.

5.Lapilli: small fragments from (4 to 32 mm.) in diameter blown out by a volcano.

6.Volcanic bomb: irregular or rounded block of lava more than (32 mm.) in diameter.

7.Pumice: a light-colored, glassy vesicular rock of acid composition.

-Origin of Volcanism:

1.The effect of pressure increases with depth keep the sub crustal region in a viscous state.

2.The magma when formed will find its way upward by the pressure of the overlying rocks through fissures, joints fault planes.

-Geologic effect of volcanoes:

1.Addition new land such as its eruption in seas (island).

2.Change in the relief or topography of adjacent area.

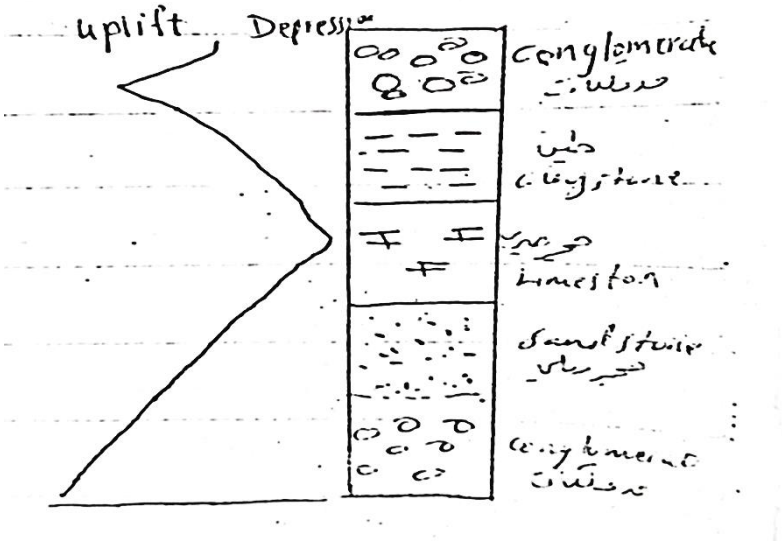
-Slow earth movement:

Uplift and Depression: Slow vertical movement such as depression of sea floor or uplift of the land can only be estimated relative to the datum (sea level), A large fall in the sea

level occurred everywhere during the Pleistocene glacial period caused appearance or raised beaches and the melting of the ice eventually restored the water to the oceans, the sea level rose again, which cause to submerged valley topography and forests.

The evidence of uplift: is the appearance of beach terraces.

The evidence of depression: (submergence) is the existences of a number of deep channels or canyons in the floor of ocean.



Mass movement:

The processes that involve downslope movement of material that the unstable masses of rock or loose material above their surrounding move downward to a more stable position.

-Factors Influenced Mass Movement:

1.Slope: the mass movement increases with steepness of the slope.

2.Water: the water has tendency to separate and lubricate particles of fracture surface.

3.Vegetation: roots of certain types of vegetation tend to stabilize slopes and to prevent sliding in many cases.

4.Rock type: clay, sand, limestone, granite.

5.Bed Rock structure: the inclination, or dip the layers or foliation in bed rock have an effect on slope equilibrium.

6.Weathering: the products of weathering are stable to mass movement.

The factors to set processes in motion:

1.Earthquake

2.Change in slope

3.Water

4.Change in properties of mass movement

Two major type of mass movement:

1.Slow types of movement: move so slowly that their motion is imperceptible to the eye at rates varying from (1 m per several years to several meters per day).

2.Rapid type of movement: move at speed ranging from (3 cm/sec to more than 30 m/sec).

•Slow types of mass movement

1.Creep: the very slow movement of soil at the surface down aslope.

2.Solifluction: is a mass movement processes related to annual thawing of upper surface (1-2 m) of the permafrost which move down slope.

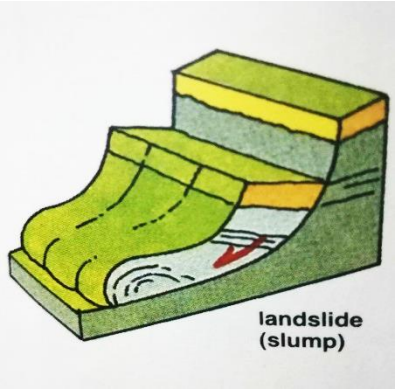
3.Rock glaciers: water percolate downward into accumulated rock resting on a steep slope if these water freeze will coated rock fragments and filling the voids, the rock fragment be loosed by freeze-thaw and flow under pressure.

4.Earth flow: movement of surface material that is faster than soil creep but slower than a mud flow, is flow in slides on a spoon-shaped surface and its upper end is a curved cliff, and its lower end is a swelling shape like tongue.

- ## Rapid types of mass movement

1.Slump: a landslide in which mass of rock (clay) moves on a curved surface (a shear surface).

2.Landslide: the movement of mass of rock down a slope different from earth flow in which that mass of rock remains more or less in one piece.



3.Rock fall: the free fall of pieces of rock from a cliff or steep slope called talus.

4.Mud flow: the rapid movement of the mixture of mud and water which flows like a liquid.

قسم هندسة تقنيات المساحة

منهاج المرحلة الدراسية الأولـــى /الفصل الثـــاني **المادة / علـــم الأرض**

أسم المقـــرر	الساعات النظريـــة	الساعات العملية	عدد الوحدات
علم الأرض Geology	1	2	2

الهـــدف من المادة	تعريف الطالب على كيفية تمييز الظواهر الجيومورفولوجية والتراكيب الجيولوجية الظاهرة على سطح الارض منها الطيات والفوالق والفواصل والتعرف عى أنواعها ودورها في تغيير طبوغرافية وتضاريس الأرض ومدى ثاثير عوامل التجوية على تراكيب هذه الصخور وتحويلها الى ترب بأنواعها المختلفة وكذلك دراسة أنواع أنماط الأنهار ومراحله وترسباتها واستخداماتها عند تفسير الخرائط والصور الجوية وكذلك تدريب الطلبة على كيفية رسم الخرائط الطبوغرافية والجيولوجية.

منهاج المادة النظريـــة **عدد الأسابيـــع / 15 أسبوعا"**

الأسـابيع	مفـــردات المـــادة
الأول	الطيات ، تعريف الطيات ، مستوي الطية ومحور الطية ، أنواع الطيات
الثاني	الفالق. تعريف الفالق، مستوي الفالق. أنواع الفوالق حسب الحركة ، وتصنيف الفوالق حسب الأزاحة
الثالث	الفواصل ، تعريف الفواصل ،أنواع الفواصل وكيفية تكونها في الطبقات الصخرية ، الأسباب المكونة للطيات والفوالق.
الرابع	علم الطبقات وتعرفيها، خواص الطبقة، مبادئ علم الطبقات.
الخامس	المستحاثات وتعريفها . انواعها و أهميتها ، صفات المستحاثات الدالة. واستخداماتها في ترتيب الطبقات الصخرية.
السادس	المضاهاة ، تعريف المضاهاة. كيفية أجراء المضاهاة الصخرية وعناصرها،العمود الطباقي الجيولوجي
السابع	الأنقطاعات الصخرية وتعرفيها.، دلائل الأنقطاعات الصخرية، أنواع الأنقطاعات الصخرية.
الثامن	التجوية ، تعريف التجوية ،أنواع التجوية ، العوامل المؤثرة للتجويـــة الميكانيكية ، التجوية الكيمياوية والعوامل المؤثرة في تكونها.
التاسع	التربة وتعريفها ، مراحل تكون التربة ، مقاطع التربة ومكوناتها،تصنيف التربة حسب طريقة تكونها ، تصنيف التربة حسب المسامية والنفاذية وسعة خزنه للماء
العاشر	التعرية وتعرفيها ، عوامل التعرية وانواعها ومسبباتها.
الحادي عشر	الأنهار وأنواعها ، مراحل الأنهار ، الظواهر الجيومورفولوجية للتعرية النهرية، والظواهر الجيومورفولوجية للترسيب النهري
الثاني عشر	تعريف مضرب وميل الطبقات وطرق قياسها في الحقل ، الخطوط الكنتورية وخواص الخطوط الكنتورية.
الثالث عشر	الخرائط الجيولوجية وتعريفها وكيفية رسم الخرائط الجيولوجية وعناصرها وكيفية تحديد الطيات والفوالق في الخرائط الجيولوجية
الرابع عشر	الرياح وتعريفها ،الظواهر الجيومورفولوجية الناجمة من التعرية الرياحية ، الظواهر الجيومورفولوجية الناجمة من الترسيب الرياحي. وأنواع التربات الرياحية.
الخامس عشر	المياه الجوفبة وتعريفها، مصادر المياه الجوفية وأنطقتها ،المسامية في الصخور وانواعها،تعريف النفاذية وتكونها في الصخور . أنواع الخزانات المياه الجوفية.

قسم هندسة تقنيات المساحة

منهاج المرحلة الدراسية الأولـــى /الفصل الثـــاني **المادة / علـــم الأرض**

أسم المقـــرر	الساعات النظريـــة	الساعات العملية	عدد الوحدات
علم الأرض Geology	1	2	2

منهاج المادة العمليـــة **عدد الأسابيـــع / 15 أسبوعا"**

الأسابيع	مفـــردات المـــادة
الأول	عرض أفلام علمية عن أنواع الطيات في الطبيعة تهيأ" لأخذ الطلبة الى الطبيعة للأطلاع الى أنواع الطيات
الثاني	عرض أفلام علمية عن أنواع الفولق في الطبيعة تهيأ" لأخذ الطلبة الى الطبيعة للأطلاع الى أنواع الالفوالق
الثالث	عرض أفلام علمية عن أنواع الفواصـــل في الطبيعة تهيأ" لأخذ الطلبة الى الطبيعة للأطلاع الى أنواع الفواصـــل
الرابع	عرض بوسترات عن عن المبادئ علم الطبقات تهيأ" لأخذ الطلبة الى الطبيعة للأطلاع الى أنواعها
الخامس	عرض أنواع مختلفة من المتحجرات الحيوانية والنباتية للطلبة وللأعمار المختلفة
السادس	عرض البوستر الخاص بالعمود الزمني الجيولوجي للطلبة من الأقدم للأحدث
السابع	عرض فلم علمي عن أنواع الأنقطاعات الرسوبيةتهيأ" لأخذ الطلبة الى الطبيعة للأطلاع الى أنواعها
الثامن	عرض فلم علم علمي عن أنواع التجوية الميكانيكية والكيمياوية
التاسع	تعليم الطلبة في المختبر عن ألية تحديد نوع التربة المأخوذة من الحقل
العاشر	عرض فلم علمي عن أنواع التعري وأنواعها
الحادي عشر	عرض فلم علمي عن أنواع الأنهار وترسباتها المختلفةتهيأ" لأخذ الطلبة الى الطبيعة للأطلاع الى أنواعها
الثاني عشر	تعليم الطلبة علة أجهزة قياس ميل ومضرب الطبقات وتعليمهم كيفية رسم الخطوط الكنتورية وكيفية رسم المقطع العمودي
الثالث عشر	أعطاء نماذج من الخرائط الجيولوجية للطلبة وتعليمهم كيفية رسم خطوط المضرب واتجه ومقدار ميل الطبقات عليها وتحديد التراكيب الجيولوجية على الخريطة
الرابع عشر	أعطاء نماذج من الخرائط الجيولوجية للطلبة وتعليمهم كيفية رسم خطوط المضرب واتجه ومقدار ميل الطبقات عليها وتحديد التراكيب الجيولوجية على الخريطة وتكملة الموضوع واعطاء واجب بيتي للطلبة
الخامس عشر	عرض فلم علمي عن الريام وتأثيرها وترسباتها المختلفة وكذلك عرض فلم عن الخزانات المائية وامواعها

كورس الثاني

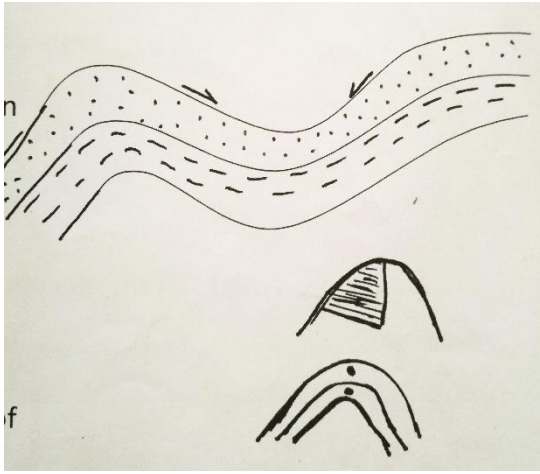
Folds - Faults - Joints

Folds: a bend in a rock mass like wavy form

A simple fold consists of two distinct parts---one convex part corresponding to the crest of a wave and the other concave part corresponding to the trough of a wave form. The crest (concave) part is caused a syncline.

--Anticline is a fold in which layers dip away from the center of structure; the oldest rocks are found in its cores and younger rocks are located on its flanks.

--Syncline is a fold in which layers dip toward each other, younger rocks found in the center and older rocks are located in the flanks.



--Axial plane: an imaginary plane that divides a fold into two equal halves.

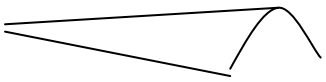
--Fold axis: an imaginary line that passes through the points where the axial plane of a fold cuts a bedding surface.

--Hinge line: A line may be drawn a long the top or crest of anticline separating that part of a layer which dips in the opposite direction.

--Plunge: if the axis of a fold is not horizontal it is said to plunge.

Types of fold: -

plunge

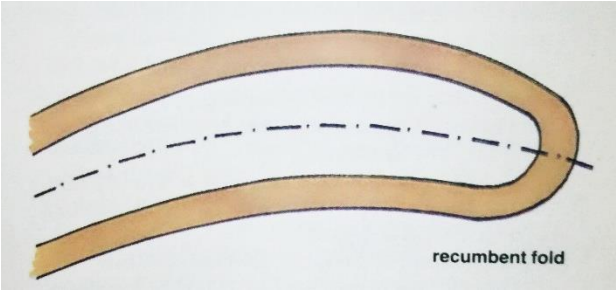


1-**Symmetrical fold**: In which an anticline or a syncline is symmetrical about the axial plane which is vertical in this case.

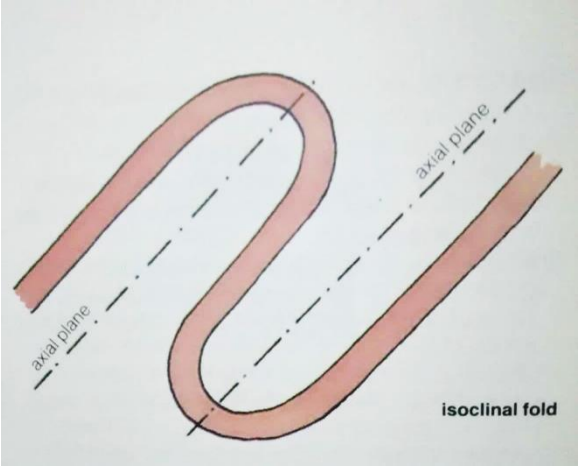
2-**Asymmetrical fold:** in which the symmetry about axial plane is lost.

3- **Overturned fold:** in which one limb or side of an anticline or a syncline, is inclined to a great extent towards the other.

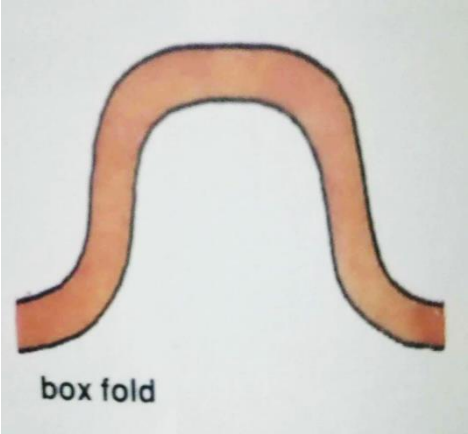
4-**Recumbent fold:** if the axial plane of fold is parallel to the horizontal position.



5-**Isoclinal fold:** this type shows parallel limbs which way either be vertical or inclined.



6-**Box fold:** a fold has square shape in its cross section with two hinge.



7-**Cheveron fold:** in which the limbs are straight and the hinges are sharp bends.

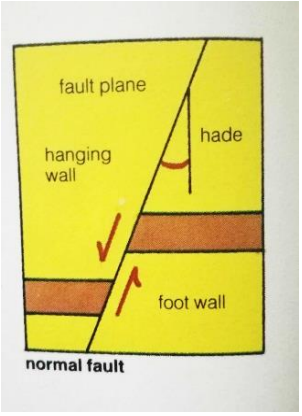
Faults: A break in the rocks along which movement has taken place.

Fault plane: the surface along which fault movement has taken place, Fault place may be smooth surface or a brooded zone.

Hanging wall: the rocks that lie an above the fault plane of a fault that is not vertical.

Foot wall: the rocks that lie below the fault plane of a fault that is not vertical.

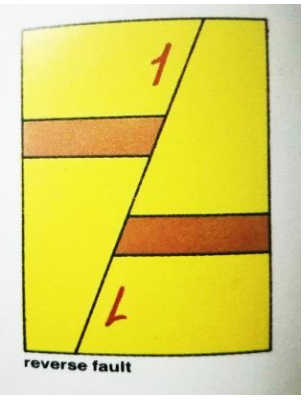
Hade: the angle between a fault plane and the vertical; it is equal to 90 minus the angle of dip of the fault.

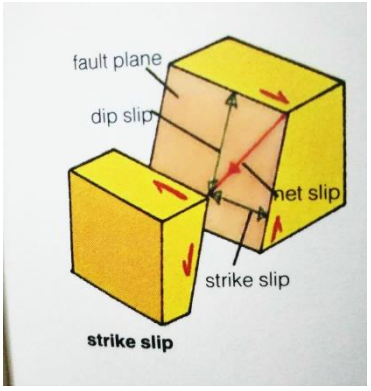


Types of fault

***Normal fault**: a fault in which the hanging wall has moved down ward in relation to the foot wall.

***Reverse fault**: a fault in which the hanging wall have moved upward in relation to the foot wall.





***Thrust fault**: a reverse fault in which the fault plane is at low angle to horizontal.

***Strike slip fault**: a fault in which the movement on the fault plane is parallel to the strike of the fault.

***Dip slip fault**: a fault in which the movement on the fault plane is parallel to the dip of the fault.

***Net slip**: the distance between two points that were next to each other before fault movement took plane.

*Causes of folding and faulting:

Compressional forces acting tangentially to the surface of the earth are responsible for the production of folds and also of reverse and thrust faults. Tensional forces produce normal faults. Breaking takes place due to tension and then displacement occurs as a result of the attracting due to gravity, if the force be suddenly applied faulting is the general effect whereas if the force be slowly applied folding may tack place.

Joint: a break or fracture in a rock a long which no movement has taken place.

Joint set: a series of joints that are more or less parallel to each.

1-Strik joints: which are parallel to strike directions.

2-Dip joints: which are parallel to the dip direction.

*Strike and dip joint are only seen in foiled and inclined rocks.

***master joints**: joints which traverse rocks for considerable distance.

***minor joints**: which are of short lengths.

Joint are caused as a result of contraction due to cooling or consolidation of rocks as take plow in the consolidation Basalt which cause to form Hexagonal joints called columnar joints.

*Sometimes they are caused by compression or by tension.

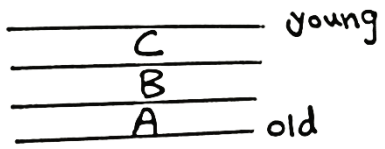
Stratigraphy, Fossils, Correlations

Stratigraphy: is a branch of historical geology dealing with the sequence of events in the earth's history as interpreted from evidence found in sedimentary rocks.

that **Strata, or Horizon**: a plane of stratification that was horizontal and continuous contains characteristic fossils or have distinct lithology.

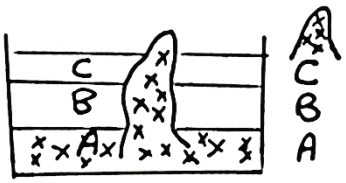
Principle of Stratigraphy

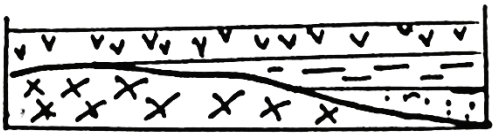
a) Law of superposition: The order in which the lower beds will be the older and upper beds will be the younger.

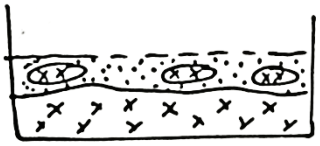


b) Cross cutting.

c) The younger beds take the configuration of the preexisting beds then will be horizontal.







d) Fragment of Rocks found in deposits which is older than this deposit.

UniformItalianism: The view that geological processes were of the same kind in the past as they are today and produced similar results.

(The present is the key of the past)

Fossils: The ancient plant and animal. Remains o impressions preserved by burial in sedimentary strata.

* the fossils of like species proved to be the same in one bed but the fossils species in beds above and below found to be distinctively different.

Index fossils: the fauna which have the following character.

* Short range.

* Wide geographic distribution

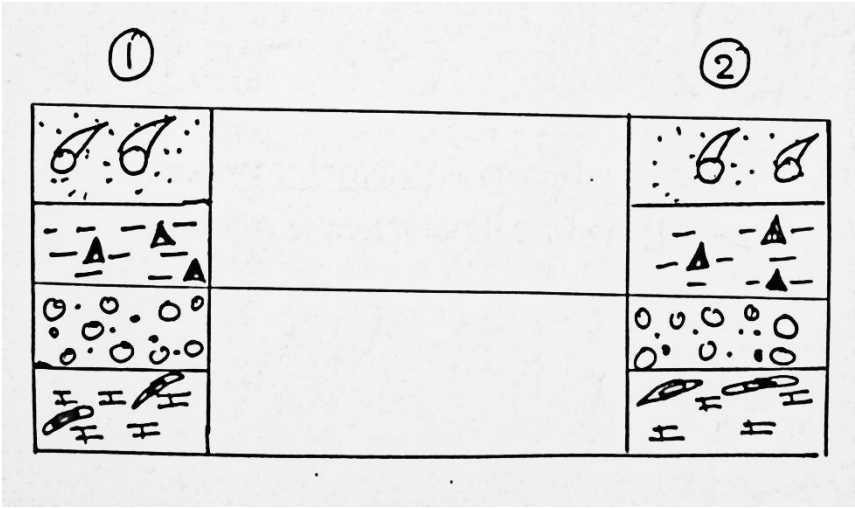
** The index fossils is used in determination of age of strata in depending on that all forms of plant and animal life have continually and systematically under gone changes with passage of time , that the each strata has a different fauna (or flora) from that in the strata above it and below it.

**Therefore each fossil has particular existing (rang) in geologic column.

Geological column: a diagram that shows the divisions Of geological time and the succession for a given area

For example : One distinctive fossils animal , the trilobite was an abundant in the Cambrian age, it is considered as guide fossils for the Cambrian Period throughout the world.

Correlation: is the matching of rocks of a particular age that are found in one place with other rocks found elsewhere by using the fossils (Index fossils) and lithology.



Quaternary
Tertiary
Cretaceous
Jurassic
Triassic
Permian
Carboniferous
Devonian
Silurian
Ordovician
Cambrian

Geological Column

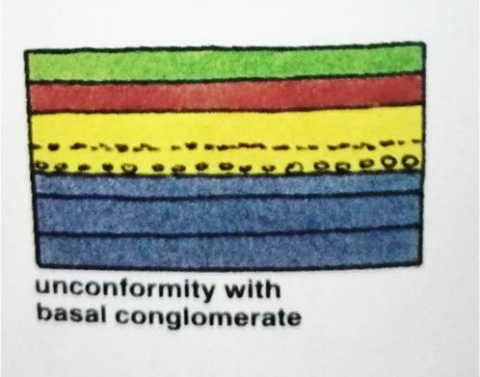
Unconformities:

A surface of erosion or non-deposition in the geologic record that separates older from younger rocks.

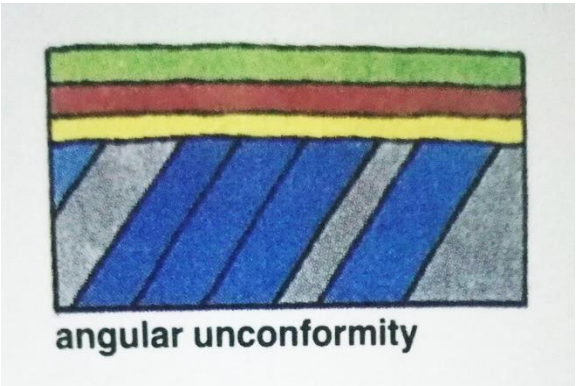
****The unconformity**: indicates that the forces have been operating because the unconformity formed during a period of uplift of a portion of earth crust and also represent a period in earth history that is not recorded in the rock record at that place**.**

****Kinds of Unconformities:-**

1-Disconformity /is an unconformity in which the rocks on both sides of the break are sedimentary and no difference in the orientation of the bedding planes, that is both sets are parallel, all rocks are sedimentary.



2-Angular unconformity / an unconformity with anon parallel relationship between the layering on either side, all rocks are commonly sedimentary



3-Nonconformity / is an unconformity in which rocks beneath are igneous or metamorphic, where those above are sedimentary.

Weathering

Weathering : the process by which rocks at or near the surface of earth are broken up to smaller particles by the action of wind, Rain and change in temperature, the effects of plants and animals.

When the products of weathering are removed from the place of formation, the process in called Erosion, but in weathering there is no transport.

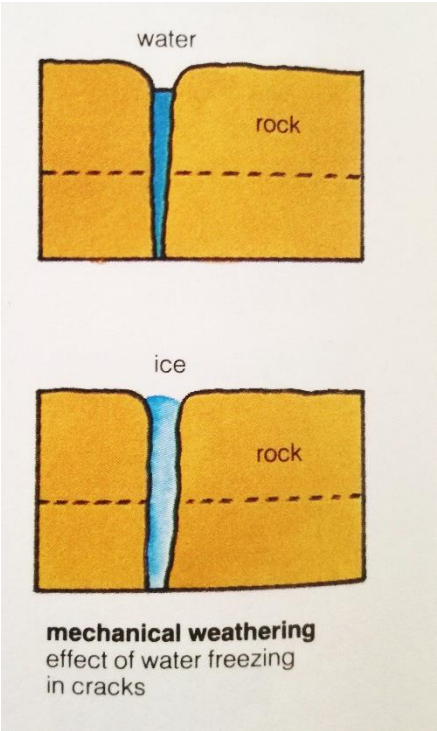
****Kinds of weathering**:-

1-**Mechsnical weathering**: weathering produced by forces that break up the rock physically, these forces usually result from changes in temperature, e.g. insolation, water freezing in cracks in a rock and forcing it a part, the growth of roots in cracks in the rocks.

****Mechanical proccess include**:-

A) Frost action (Freeze---thaw).

When water freezer in cracks of rocks will expand in its size by 9% over its original volume and this expansion is directed as a force in the sides of cracks then break the rock to more pieces.



mechanical weathering
effect of water freezing in cracks

B) Isolation (temperature change).

The effect of the sun's heat on rocks at the Earth surface, especially the effect of changes in temperature heating by the sun during the day causes rocks to expand when they cool at night they contract this causes the rock to break up.

Exfoliation/ the formation and breaking off of shells or sheets from the bare surface of rocks especially Granite and other igneous rocks.

C/ Action of granite / This help by exposing fresh surfaces of rocks by the removal of the weathered upper surfaces by slow down movement of the loosened particle by the attraction of gravity.

D/Wind abrasion/the wearing a way of a rock by rubbing e.g. by small particles of rock.

E/Water/ weathering action of running water is of great magnitude.

F/Plant roots/ plant roots grew in the cracks of rocks and this roots become larger directed a forces on either sides causes the breaking up of the rocks.

2-**Chemical weathering** / weathering caused by chemical action, usually when water is present for example, rain water containing carbon dioxide (co_2) in solution will dissolve limestone.

****chemical proccess include**:

1-**Water**/ water can dissolve many manual subs tainted, the water combination is called hydration which is accompanied by increase in volume as frost action.

**Iron mineral attacked with water and the result is the formation of If on thyroxin ($2FezO_3\ 3H_2O$)

**limestone / if the water contain Co_2

$CaCo_3+H_2O+Co_2= Ca\ (HCo_3)2$

Folds pare are easily attacked and clay minerals are form by de compassion of folds pare.

$K_2O+AlO_3+6SIO_2+H_2O+Co_2=>k_2co_3+Al_2o_32slo_2+2H_2O$ (Orthoclase)

2-**Carbon dioxide**: is importance in the solution of limestone.

3-**Oxygen**: chemical combination with oxygen is called oxidation, Iron minerals shows conspicuous color changes by oxidation.

Soil

The material produced by the effects of weathering and the action of plants and animals on the rocks at the Earth's surface.

The Development of a matur soil:-

1-The decomposition of the material from which the soil is to be formed.

2-Little vegetation grows on it, and their decay, supplies humus and this help the decomposition of rocks.

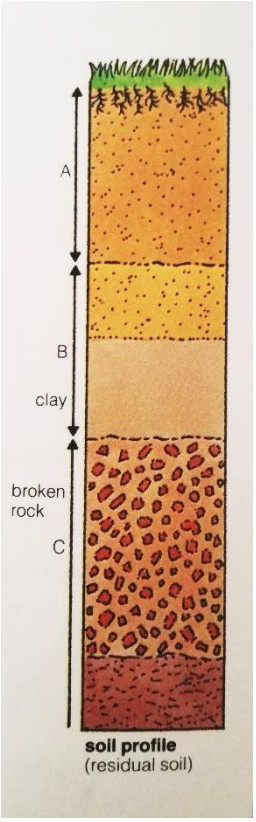
3-Bacteria will also help

As the process goes on a thin deposit of soil is formed.

4-Gradual decomposition of rocks and leaching of soluble rock materials increase the thickness of the soil zone.

5-Abundance of rain water helps the formation of soil as well as by supporting vegetation.

Soil profile:-



Soils may be divided vertically into different zone based on degree of weathering and composition of each zone.

1-**C horizon** :- is the lower most zone it occurs directly above bed rock, and contains partially decomposed fragments of underlying bed rock, may contain in some areas bed rock structures is called a Saprolite.

2-**B horizon**: - Complete decomposed of all bed rock material and without structure, enriched in clays, particular oxides or hydroxides, or calcium carbonate.

3-**A horizon**: - The top layer of soil, it is dark in colour and

contains organic material formed by the decay of vegetable matter it is thickness (50cm).

K horizon (caliches):- A thick hard layer attaining 50% or more $caco_3$ that forms beneath the B horizon in very dry regions

A2 horizon: - A whitish layer between the A and B horizons, most of the iron oxides have been removed from A horizon by water moving down through the soil.

Duri crust: - A hardened layer formed in the soils of very dry regions by the precipitation of salts from water in the soil.

**The soil may classified according to the mode of formation and the agencies involved in to.

1-**Soil in situ**:-

a) **Residual soil**: - Is the soil formed at the same place where it is found it shows clear connection with the parent rock mass below. With the same composition as in bed rock.

B) **Cumulose soil**:-Organic type soil, it is formed by accumulation of organic matter like peat it is formed in marsh's, lakes, drived rivers.

2-**Drifted soil**:-

C) **Colluvial or eluvial soil**: - Is formed from material accumulated at the base of a steep sided mountain or a hill by gravity, this type of soil is very stony.

D) **Alluvial soil:** It is formed from alluvium brought by rivers, it is a very fertile soil it shows slight stratification.

E) **Glacial soil**: Boulder clay, it shows no connection with the rock below in its rock composition because the materials have been transported from other place by moving glaciers the fragment is fine, angular.

F) **Aeolian soil**: Is formed by the action of wind, the loess deposits is very fine and rounded and is very fertile.

G) **Lacustrine soil**: The soil formed in the lakes are rich in organic matter.

H) **Marine soil**: Formed from sediments deposited on the coastal regions or on the continental shelf zone of the sea and later uplifted, shows stratification they are sandy and coarse grained.

I) **Volcanic soil**: Is formed from pyroclastic materials and lavas erupted during volcanism, is very fertile.

**According to texture, composition, porosity, permeability, moisture retaining capacity content of organic matter divided in to.

1-**sandy soil**: Abundant sand particles, Quartz is predominant, less clay material, is highly porous very little water retaining capacity.

2-**Loamy soil**: Contains equal of sand and clay materials, is very suitable for agriculture.

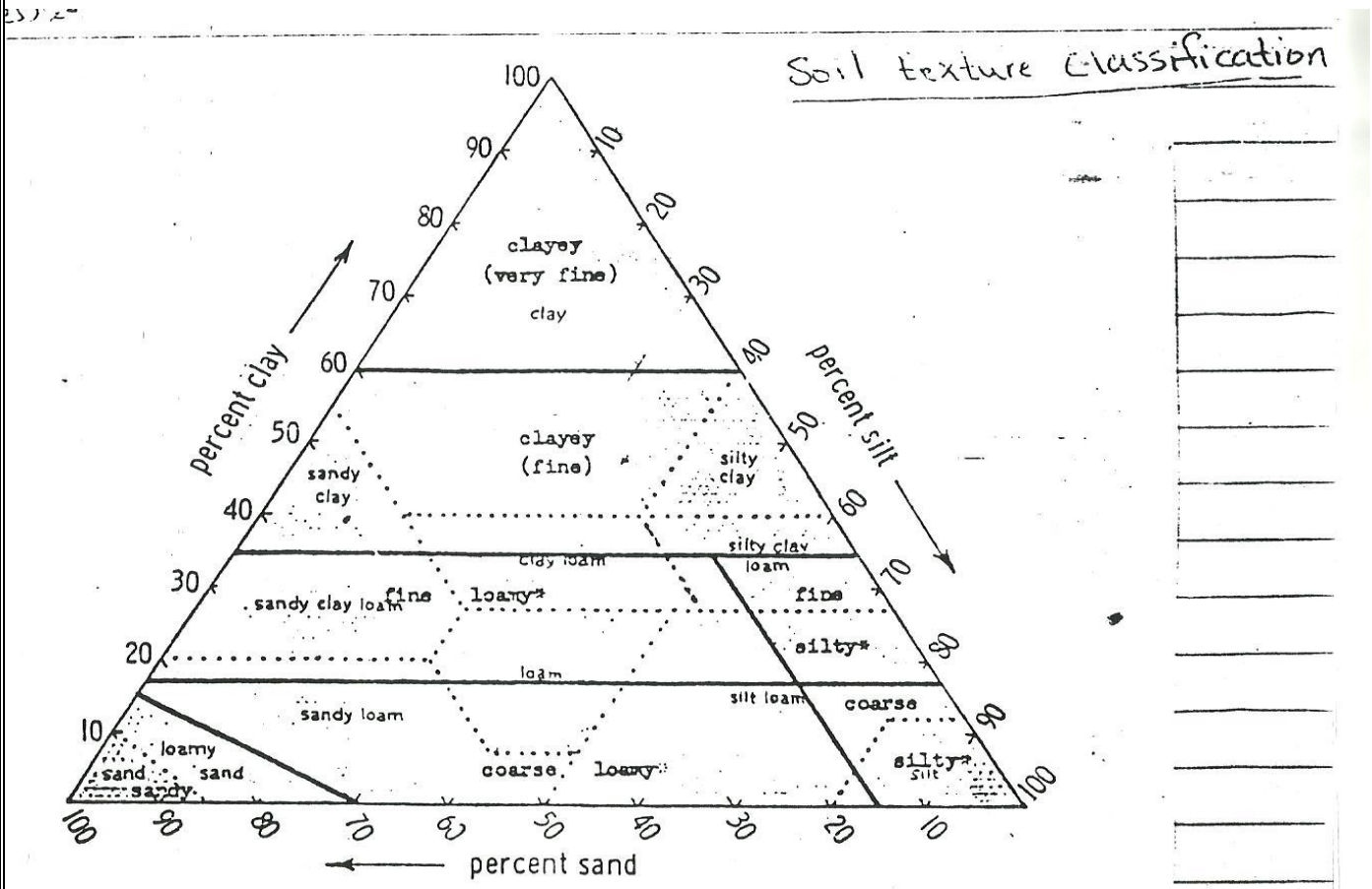
3-**Clayey soil**: clay is predominate, have high water capacity, if contain much limestone is called marly soil.

4-**Black soil or chernozem**: Black clayey soil from decomposition of basalts and contains high percent of oxide of aluminium, calcium, magnesium and humus, has high water retaining capacity, is highly fertile.

5- **Peat soil**: Contain little of clayey matter but mostly the decomposition products of vegetable matter it has good water retaining capacity.

6-**Pedsol**: Gray soil, has very little of iron and humus, it is mostly sandy and not fertile.

7-**Lateritic soil** : Brownish soil, contain hydroxides of iron, aluminium and hydrated oxide of manganese there is little of silica, mg, ca, and alkali matenals there is little of humus.



شكل (٢ – ٢) مثلث النسجة ، يبين نسب الطين (أقل من ٠,٠٠٢ ملم) ، الغرين (٠,٠٥ – ٠,٠٠٢ ملم) ، والرمل (٠,٠٥ – ٢ملم) الموضح اصناف نسجة التربة .

**Erosion

The process of breaking of rock to smaller particles and decomposition of rocks and this products transported to another place.

**the factors influenced in weathering is also have the same action in erosion.

**depending on the agent erosion may be.

1-fluvial erosion (by river water).

2-glacial erosion (by glaciers).

3- Wind erosion (by wind).

4-Marine erosion (by sea water).

**Rivers

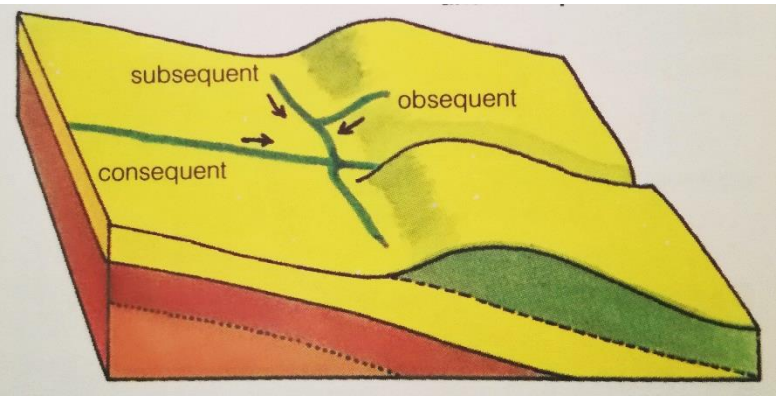
Type of Rivers:-

1-**Antecedent River**: an antecedent stream or drainage system cuts across a geological structure that has formed across its course.

2-**Consequent River**: is one that flows in the same direction as the downward slope on which it was originally formed.

3-**Subsequent**: these are tributary rivers that flow in to consequent river.

4-**Obsequent**: that flows in the opposite direction to the original consequent stream.



5-**Superimposed** : it results when a drainage system is formed on a younger series of rocks that rest with an angular unconformity on older rocks, the drainage is fitted to the younger series of rocks and is then superimposed when the streams cut down through them to the older rocks whose structure is not related to the drainage system.

****River Stages**: three stages can be distinct in the development of river.

1-**young stage** : the river has strong current flowing in a V-shaped, steep walled valley, caring small amount of load and the load is large in size, the young river has extra energy is used to down cut the stream bed.

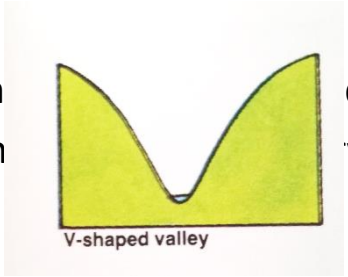
2-**Maturity stage**: in this stage the gradient of the stream decreases because of down cutting, the amount of energy also decreased which is stuffiest only to transport its load at this stage, the rate of widen the valley, flood plains appear and the stream begins to meander systematically.

3-**Old stage** : the stream approaches old stage when it is incapable of caring anything but fine debris, valley widening is dominant, the flood plains wider than meander belt, natural levees, oxbow lakes and meander sears are common.

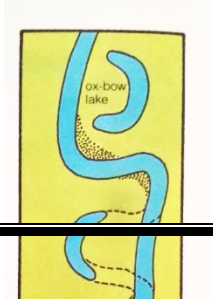
**The Geomorphological features accompanied the river erosion.

1-**V – shaped valley**: a valley with steep sides and in cross section like a letter V.V-shaped valleys are characteristics of young stream.

2-**Flood plain** : the flat area on either side of a stream ds when too much water is flowing for the stream chann y all of it.

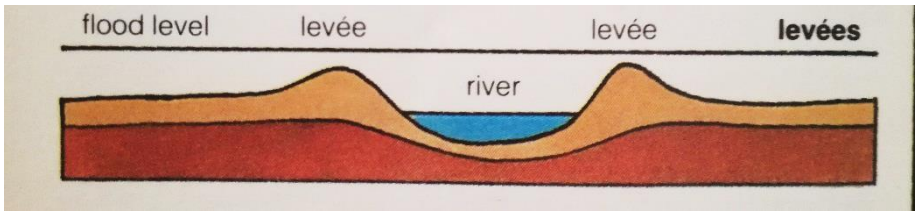


3-**Meander**: the curved path of a river, especially in a flood plain.



4-**Ox-bow Lake**: a lake shaped like a new moon that has been formed when a meander has been cut from the main stream by continuing erosion.

5-**Levee**: a natural wall that has been formed of sediment deposited at the sides of a river where it has flowed over its banks, Levee are usually found in the flood plain.



**The morphological features accompanied the river deposition.

1-**River terrace**: a flat area that borders a river valley a terrace marks the level of the floor of an earlier valley.

is caused by uplift of source area which cause the increase the gradient may increase the velocity of the river down cut again begins and the same cycles are repeated.

2-**Alluvial fan** : when a river abruptly falls on the plain from a mountain a deposition at once take place in the form of a fan, the vertex is at the place where the river falls on the plain, its thickness is maximum at the place and its widen and thins out at greater distance.

3-**Alluvial cone**: the same alluvial fan but the deposition in conical structure because the sediments absorbed the water.

4-**Piedmont alluvial plains:**

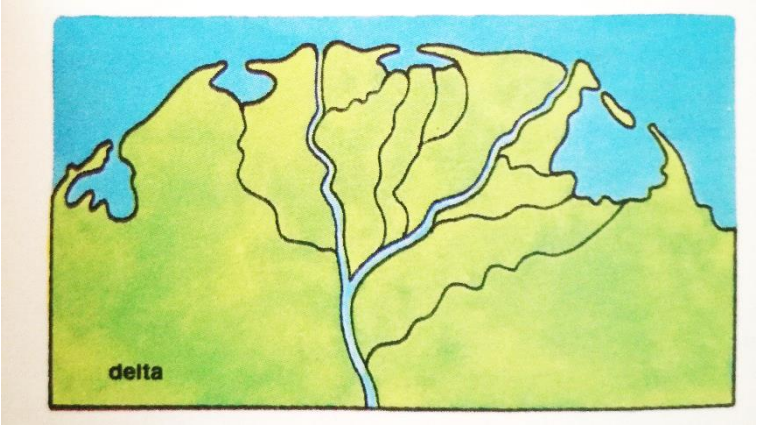
The union of several such fans makes continuous plain in the front of the mountain.

5-**Flood plain**.

6- **Natural levee**.

7-**Bars** : is load deposition in the channel of river in parallel with the edge of channel because of present ridge in the path of stream and high load of river with lasting its velocity support the formation of bars.

8-**Delta**: sediment laid down at the mouth of a river in the shape of letter delta (△) where it enters the sea or a lake.



Dip and strike

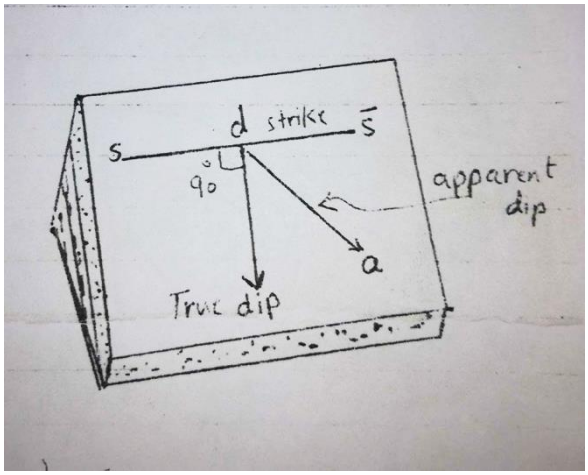
Strike: the direction in which a horizontal line can be drawn on a bedding plane or other structure surface at any particular point the strike is at 90° to the dip.

Dip: the angle that surface makes with the horizontal.

A- True dip: is measured at 90° to the strike.

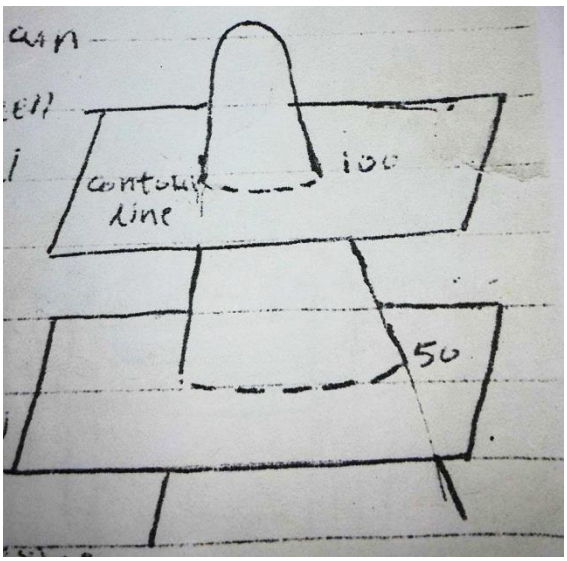
B- Apparent dip: is the angle as measured in any direction (in a vertical section).

Dip and strike are represent the geologists method of defining the attitude of a sloping stratum at any point, the dip placed on a map in the form of a short arrow (↘30) with its point, indicating the direction and amount of dip.



Contours line \ is the line of intersection of earth surface with horizontal level in certain height over the surface or sea level. Each line refer to certain height and the vertical distance between two line respectively is called

Contour interval**.**



**Contour line properties **

1- All points of contour line have the same level.

2- All contour line must close in the center of map except in the map edge.

3- The contour lines did not intersect with others.

4- If the distance between the contour lines is little, indicate to steep slope of the surface.

5- If the distance between lines increase refer to gentle slop.

6- When the contour lines intersect river course it form **V-**shaped, its head refer toward up valley. But the contour line intersecting with mountain or hill, the head of contour line towards to downward hill.

7- If the contour lines closed to their self in map may refer to anticline or syncline, is being anticline if the contour level increases from external to internal, but syncline is Vis versa.

Topographic map \ (contour map)

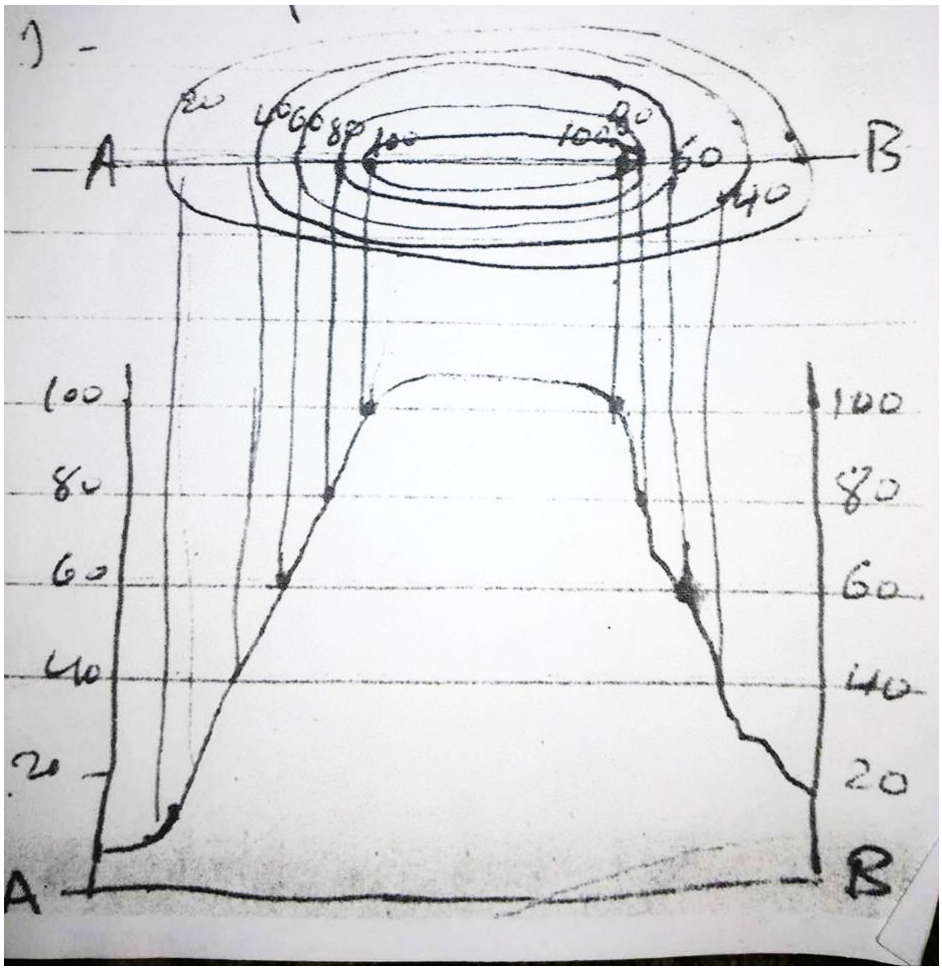
Is the map which shows horizontal draw for portion of earth surface with different level based on certain drawing scale, and it used as base map to project Geological features on it, the topographic map is drawn depending on : -

1- Knowledge of amount of height of points will projection on map.

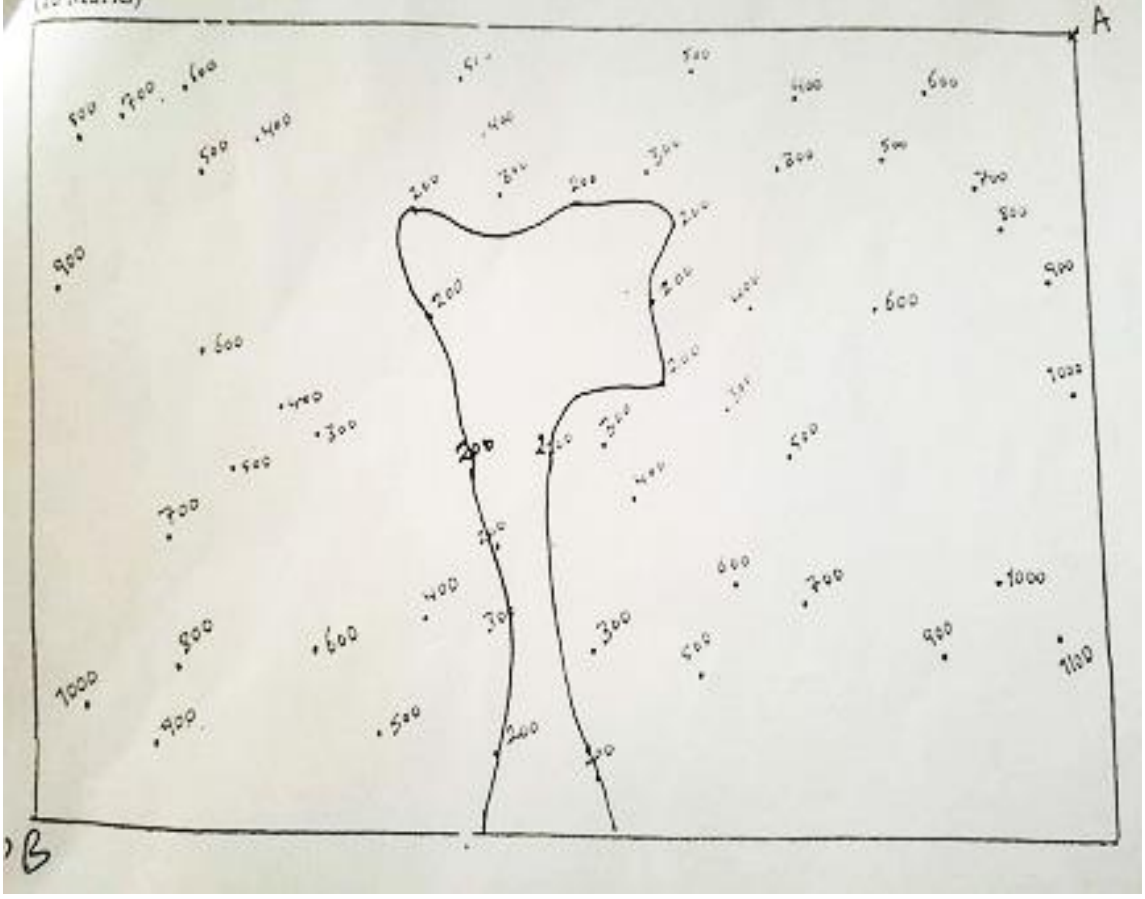
2- Drawing scale.

3- Using the contour lines which represent the natural shape (mountain, hill, and valley).

**Drawing topographic section **



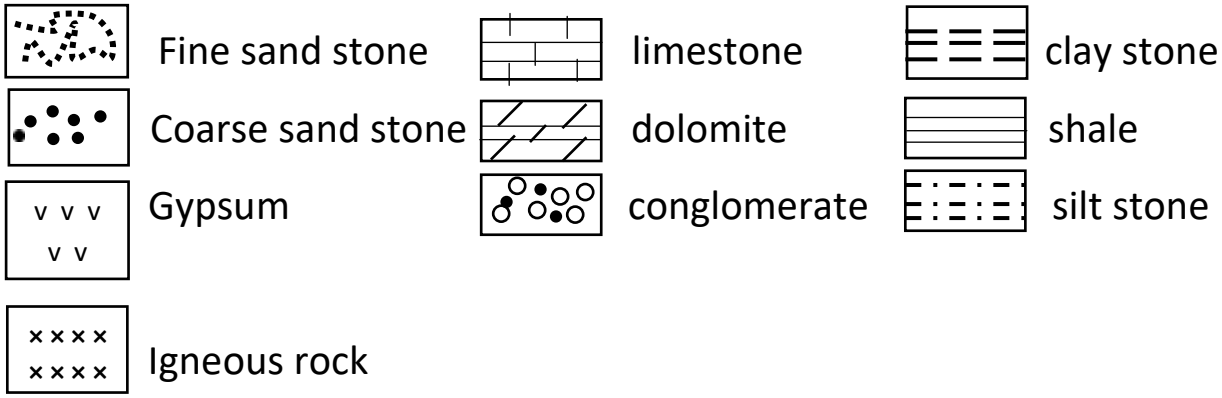
2:- Draw the contour lines (contour interval =100m.) then draw the drainage pattern on it. (10 Marks)



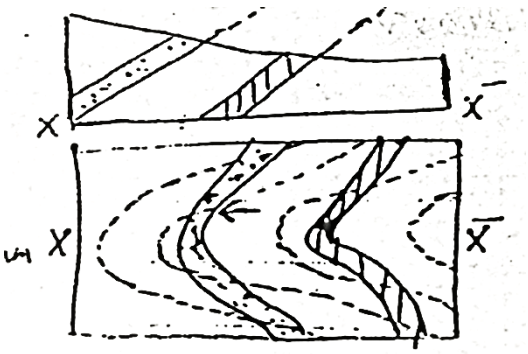
Geologic map الخريطة الجيولوجية

The purpose of geologic map is to provide a record of geological features on a topographic basis, it show by tints or shading the outcrops of different rocks .i.e. the areas over which they occur at or near earth surface, if the scale is suitable the map also shows any lines along which the rocks are arched up (folds), or along which they are broken (faults). The geological map is represented by contour lines (topography) and the outcrops of series of rock are shown as differently shaded or symbols.

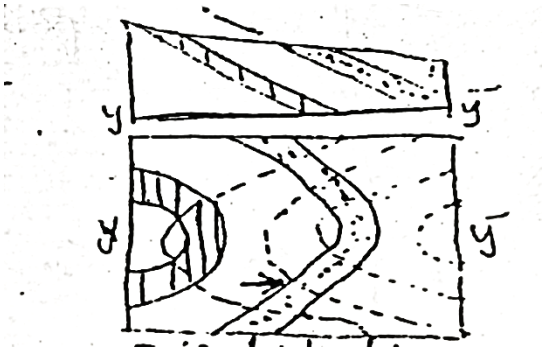
The geological symbols as following:



It is easy to remember that when the V points down streams the beds dip down the valley and this useful rule in map reading.

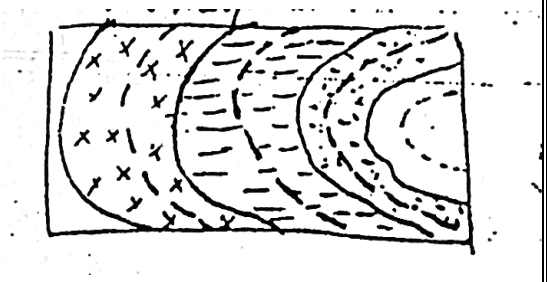


Dip upstream

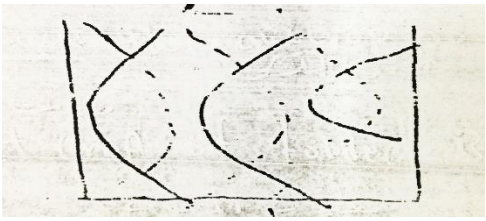


Dip downstream

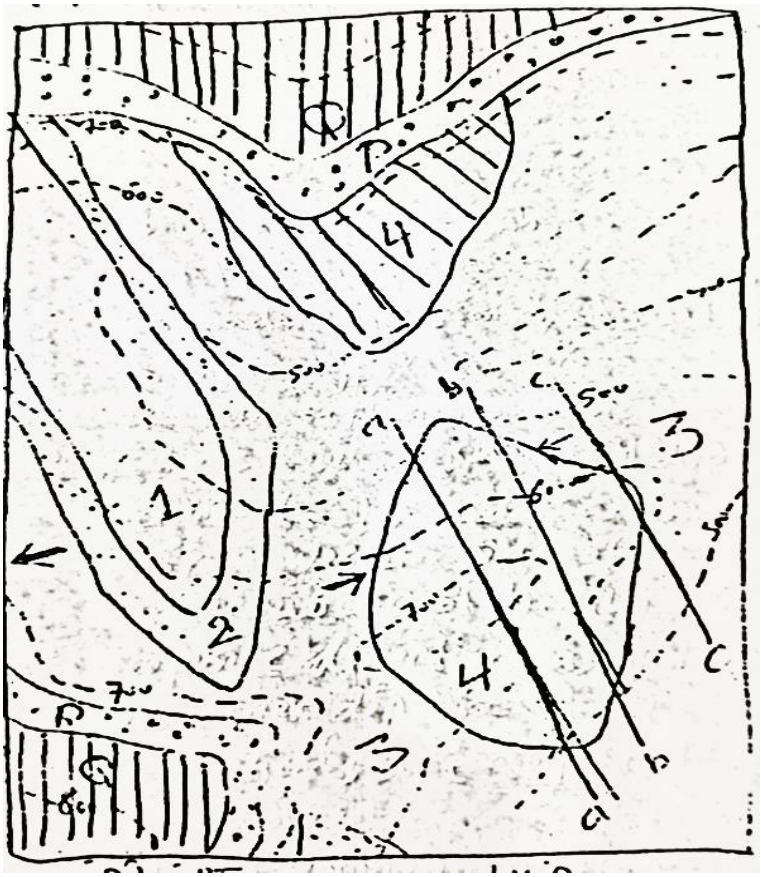
When bed are horizontal, i.e. their dip is zero, their outcrop run parallel to topographic contours on the map.



If the beds is inclined, the topographic contour will cut the outcrop boundaries.



Out crop of Folded Beds;



The strike of the beds can be found
from an inspection of the points
of intersection of outcrop boundaries with topographic contours, lines aa and bb, may drawn by intersect of the 500 contour with the boundary between bed 3 and 4 similarly line cc. The dip of strata from line cc toward bb as shown by dip arrow ( ), and
the same from western side of the same outcrop of bed 4 in opposite direction as indicate another dip down ( ) the beds are synclinal form.

Unconformity/ where the outcrop of abed cut across other outcrops on the map the relation is unconformable and the newer beds are those above the unconformity (P.Q)

Wind

Wind has got pronounced effect on weather and as a result it influence rain and snow falls which are again the prime factors in sea, wind generates sea waves and is responsible for coastal erosion this all described as indirect effect of wind action.

Wind also have several geological actions in the form of erosion, transport and deposition of materials upon the surface of earth these described as direct wind action. The direct action is seen in arid desert and semi-arid regions where vegetation is sparse and on bare coastal regions. But there effect is very obscure in humid regions.

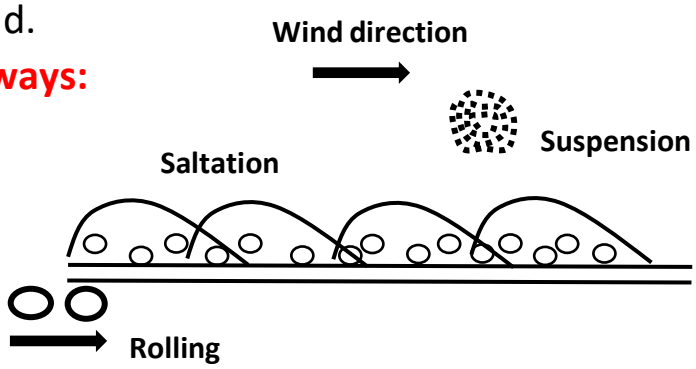
Wind action (erosion): consist three processes

1- **Deflation;** includes removal of dust and smaller particle and transporting them by saltation to some other place.
2- **Abrasion;** the loose particle that are blown away by wind form good erosion agents. These particles strike against the exposed bed rock in arid areas, as a result a great deal of erosion done on them and these erosion depend; 1) hardness of bed rock, 2) wind velocity, 3) nature of blown particles.
3- **Attrition;** the rock particles not only abrade the exposed bed rocks but they themselves are also abraded by colliding against one another, this product a rounded appearance of individual fragments.

Transport by wind / wind separates particles according to size, shape and weight, velocity of wind.

Wind transport matter in three ways:

1- In Suspension
2- By rolling
3- By saltation



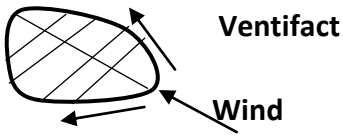
Some landforms or Geomorphological features produced through wind erosion;

1- Broad shallow depression in deserts where soil is blown by repeated movement of wind currents flowing in one direction.

2- Broad shallow caves in sides of sandstone cliffs where impact and abrasion of sand sculpts the sides.

3- Pedestal rocks: these structures are produced by wind abrasion on upstanding rock masses. This make the root region as cylinder shape while the head region remains less reduced.

4- Ventifacts: wind abrasion on a rock fragment rolls to another side then another face is cut by abrasion, in this way several smooth faces are developed on the rock fragment which meet at some angles with each other.



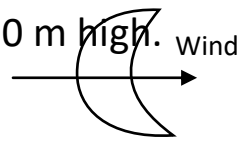
Wind deposition/

1- **Sheets:** are dust deposits spread over wide areas, thickness varies within sheets they are thick near the source region, thinning out farther away from the source is mainly composed of loess.

2- **Sand dunes:** a heap or bank of sand piled up by the wind in to a regular shape.

Type of sand dunes:-

1- **Barchans dune/** a dune shaped in plane like a crescent. The ends of the dune point in the direction in which the wind generally blows may be 50 m high.



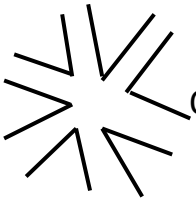
2- **Longitudinal dune/** longs narrow dune up to 80 km long and 200 m more high with its length parallel to the general direction in which the wind blows.

3- **Soil dunes/** a longitudinal dune with along sharp of edge at its top, one side of a soil is rounded, the other is a steep slip face, soils occur in chains.

4- **Transvers dun/** a dune with its length at 90° to the direction in which the wind generally blows.

5- **Parabolic dune/** a dune shaped in plan like the path of a ball thrown in the air (i.e. a parabola), the points of dune face the direction from which the wind blows are formed where there is thick grass or other plants covering the sand, the sand is blown away from an area without plants but the sand on either side is held by the plants there a parabolic dune is formed.

6- **Oghurd dune/** a large amount mountain's dune.



Oghurd dune

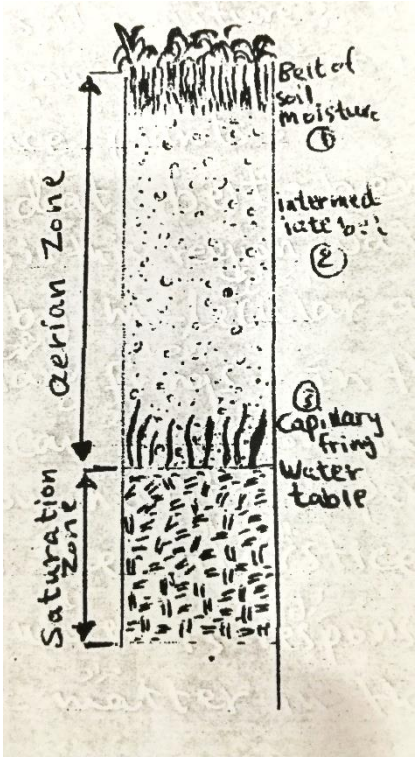
Loess/ a unconsolidated deposit of silt usually un stratified, carried by the wind.

Underground water

Part of water that reaches land surface in the form of precipitation infiltrates to become ground water.

Ground water occurs in openings in rocks and unconsolidated materials and moves under influence of gravity or pressure.

The source of underground water:



1- **Zone of aeration:** is subdivided in to three regions
   a) **Belt of soil moisture:** the upper most, the source of most water for surface plants.
   b) **Intermediate belt:** beneath the soil belt, in this region water is held securely by molecular attraction.
   c) **Capillary fringes:** in this region water can rise from the water table to various heights depending on the size of the interstices, the mixture of air and water is responsible of decay of organic matter in the soil in this zone.

2- Zone of saturation:

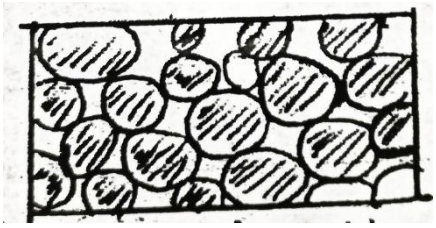
Much of the water continues down ward because of gravity and the weight of the water above it that all spaces between particles become filled with water and the water permeating this zone is ground water the surface between the zone of aeration and saturation is ground water table.

Meteoric water/ water at and below the surface of the earth that has come from the atmosphere, from precipitation.

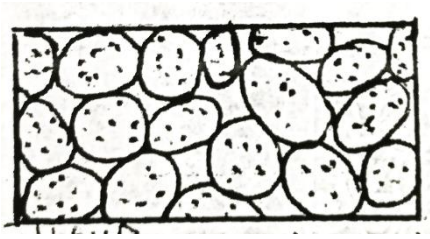
Connate water/ water in as sedimentary rock that is believed to have been trapped in the sediment at the time it was formed.

Juvenile water/ water in the earth crust that has come from magma.

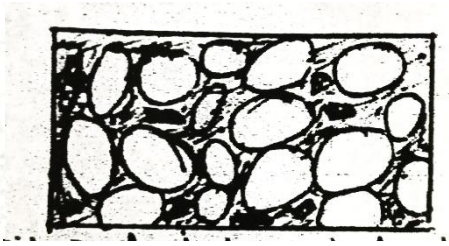
Porosity/ the volume of pore space in a rock, is measured by the amount of space occupied by these voids or cavities compared with the total volume of the rock, the amount of pore space will depended on size, shape, sorting and type of packing of rock components.



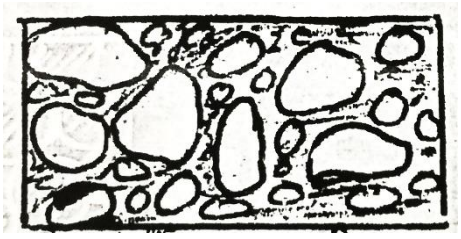
Well sorted sedimentary Deposit having high porosity



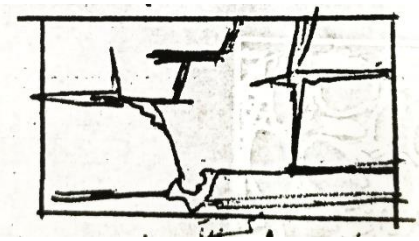
Well sorted deposit consisting of pebbles themself porous so that the deposit has a very high porosity



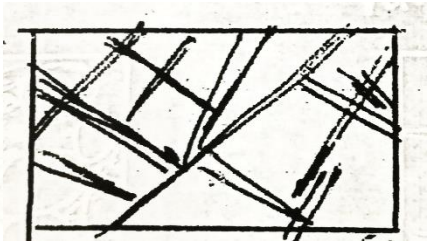
Poorly sorted deposit having low porosity



Well sorted deposit but the porosity has diminished by deposition of (calcite or limonite) in the interstices



Rock rendered porous by solution



Rock rendered porous by fracturing

Generally, unconsolidated materials have more spaces than solid rock, the openings are due to incomplete cementation of the grains or to fracturing or partial solution of the rock, opening in igneous and metamorphic rocks are due to faults and joints.

	Gravel	Sand	Clay	Sandstone	limestone	Igneous	metamorphic
Porosity %	30-40	35-40	45-55	20-40	1-10	0-40	0-40
Permeability gpd/ft²	1000-8000	100-3000	0.001-2	0.002-24	0.0001-0.1	0-35 highly variable	0-35

Permeability

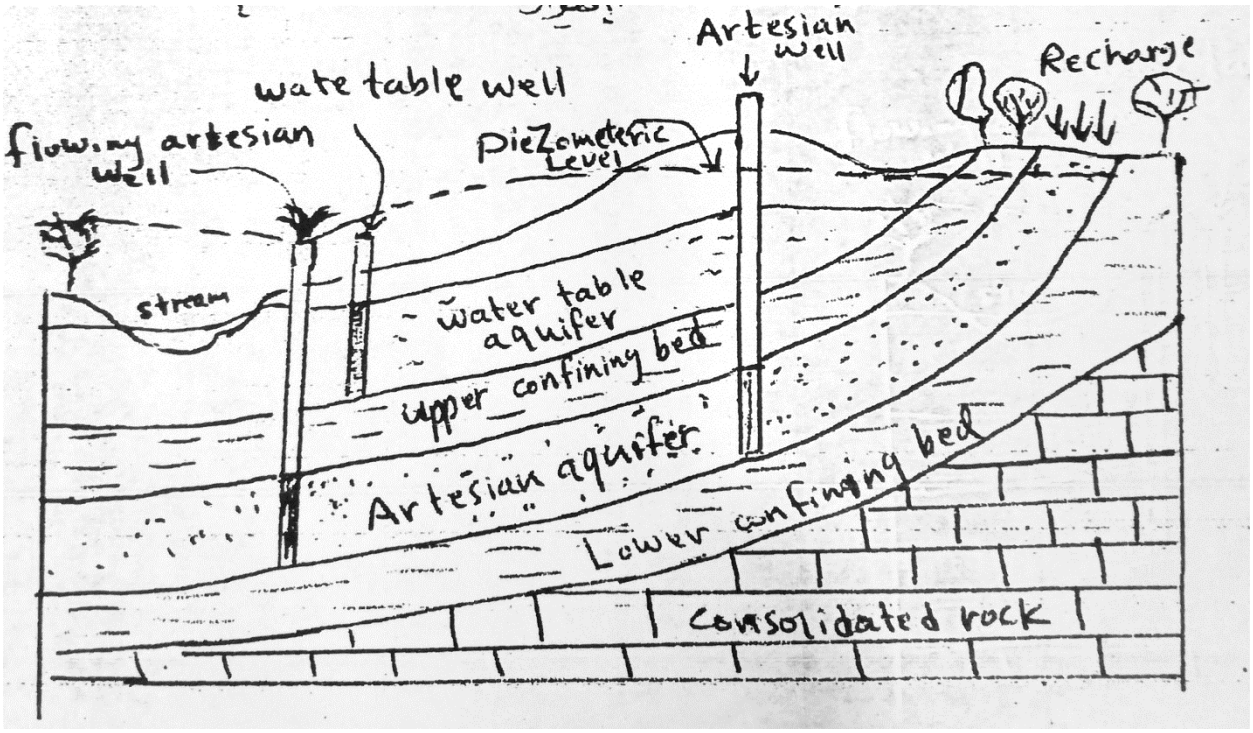
Is the measure of the ability of rock to transmit fluids and is the relative ease with which water will move through the rock under unequal pressure.

Permeability of unconsolidated sands and gravels is extremely high, while that of dens clays and shale is low, because clay and shale can be described as impermeable rocks for all particle purpose. But the permeability of sandstone may reduce if the pores closed by cementing material, the igneous and metamorphic rock gains it permeability by fracturing and joins.

Aquifers

Type of Aquifers:

1- **Unconfined aquifer:** is underline by a thick permeable and porous rock composed of granular material, the lower boundary is impermeable rock the upper contact of this saturated one of water is water table, the upper surface coincides with the surface of lakes, streams, and marshes.



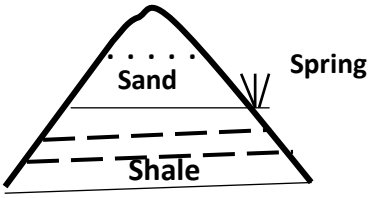
2- **Confined aquifer:**

Water becomes confined when it is trapped within a porous and permeable rock unit that has an impermeable rock formation below and above it.

When the aquifer is tapped by a well, water under pressure will flow from it, ground water that is under sufficient pressure to rise above the zone of saturation is artesian well.

Springs/ wherever the water table intersect the land surface, are also possible at the outcrop of an inclined previous bed such as sandstone underlain by an impermeable layer such as shale,

1- Fracture springe
2- Solution-opening springe
3- Contact springe
4- Depression spring



Wells// supply of water obtained from the wells which are drug sufficiently deep to reach below the water table.

1- Water table well
2- Artesian well