ENGINEERING GEOLOGY

(الجيولوجيا الهندسية)

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1-1Definition(التعريف):

Discipline of applying geologic data, techniques, and principles to the study both of:

A Naturally occurring rock and soil materials and surface and sub-surface fluids.

B The interaction of introduced materials and processes with the geologic environment so that geologic factors affecting the planning, design, construction, operation and maintenance of engineering structures, and the development, protection and remediation of ground-water resources are adequately recognized, interpreted and presented for use in engineering and related practice.

علم الجيولوجيا(علم الارض):

ان كلمة Geology كلمة لاتينية تتكون من مقطعين هما Geo وتعني الارض والمقطع logy وتعني علم وبذلك تعني "علم الارض". هو العلم الذي يهتم بدراسة المواد التي تتكون منها القشرة الارضية من حيث:-

1- التراكيب الكيميائية
2- الخواص الكيميائية
3- الخواص الفيزيائية
4- الخواص الميكانيكية
5- العمليات الداخلية والخارجية التي تؤثر على الارض.

1-2 The Rock Origin (اصل الصخور):

Rock is defined as the solid material forming the outer shell or crust of the earth. According to their origin, rocks are divided into three groups, namely, the igneous, metamorphic and sedimentary rocks.

A) **Igneous rocks (الصخور النارية او البركانية)** are formed when hot molten rock (الصهير) material called magma (المادة الصخرية المذابة) solidifies. Magmas are developed when melting occurs either within or beneath the Earth's crust. Igneous rocks are composed principally of silicate minerals. The silicate minerals are classified in to six families:

1- Olivines [$(Mg,Fe)_2SiO_4$].
2- Pyroxenes [e.g. augite, $(Ca, Mg, Fe, Al)_2(Al,Si)_2O_6$].
3- Amphiboles, [e.g. hornblende]

$(Ca,Na,Mg,Fe,Al)_{7-8}(Al,Si)_8O_{22}(OH)_2$].

4- Micas [e.g. muscovite, $KAl_2(AlSi_2)_{10}(O,F)_2$].

5- Biotite, $[K(Mg,Fe)_2(AlSi_3)O_{10}(OH,F)_2]$.

6- Feldspars [e.g. orthoclase, $KAlSi_3O_8$,albite,$NaAlSi_3O_8$, anorthite, $CaAl_2Si_2O_8$, silica minerals e.g. quartz, SiO_2].

Figure (1) shows the approximate distribution of these minerals in the commonest igneous rocks.

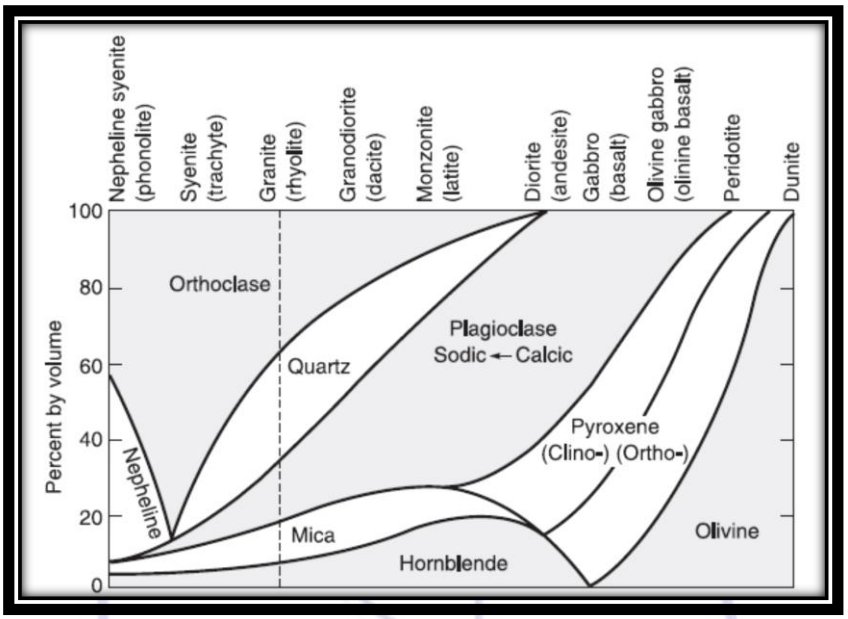

Figure (1): Approximate Silicate Minerals Distribution in Igneous Rocks

B) **Metamorphic rocks (الصخور المتحولة)** are derived from pre-existing rock types and have undergone mineralogical, textural and structural changes by the action of heat and pressure. The pressures are the primary causes affecting metamorphic reactions in rocks. There many types of metamorphic rocks such as calcite dolomite, marble, quartzite, and ….. etc.

C) Sedimentary Rocks(الصخور الرسوبية):

The sedimentary rocks form an outer skin on the Earth's crust, covering three-quarters of the interior areas and most of the sea floor, deposited from fluid medium; the products of weathering of other rocks in water. They vary in thickness up to 10 km. Nevertheless, they only comprise about 5% of the crust. There are many types of sedimentary rocks such as sandstone, mudstone, and ….. etc. When the environmental conditions change's, the rocks formed from phase to another within the process known as "Rock Cycle" as shown in figure (2) below.

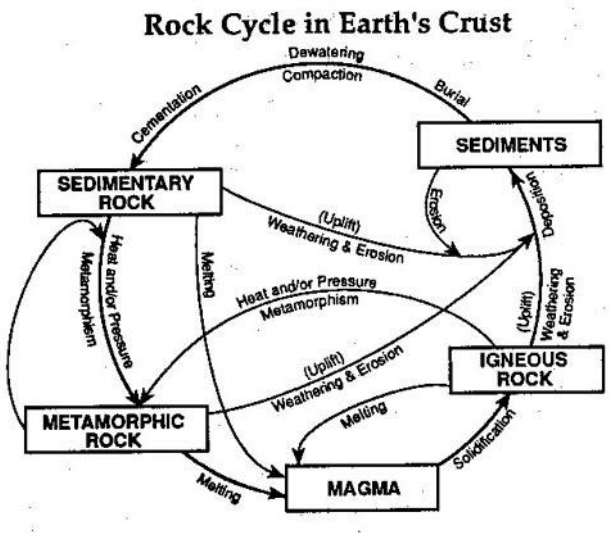

Figure (2): Rock Cycle

The engineering definition of "*Rocks*"

Rock is the hard and durable material

1-3 Basic Mineralogy of Rocks(المعادن الاساسية في الصخور):

Rocks are formed with minerals, in which characterized by the following:

- Naturally occurring chemical element or compound.
- Formed by inorganic processes.
- With an ordered arrangement or pattern for its atoms -crystalline structure.
- Possesses a definite chemical composition or range of compositions.

- عناصر او مركبات تكونت بشكل طبيعي.
- تشكلت عن طريق العمليات غير العضوية.
- تترتب من نمط او نموذج لذراته ضمن هيكلها البلوري.
- تمتاز بتركيب كيميائي محددة أو مجموعة من التراكيب.

Generally, it is convenient to express:

Mineral = Composition + Crystalline Structure

1-3-1Mineralogy Identification for Engineering Purposes:

تعريف علم المعادن للأغراض الهندسية:

From an engineering point of view, certain properties of minerals, especially when they are introduced into or encountered with another mineral, are of special concern to engineers. For example, gypsum in a limestone can become swelling when water presents; pyrite in shale can be declined by acid water; swelling clays in shale can become wetting and cause instability problem of a slope. Thus, fundamental mineralogical acknowledge is needed when identifying engineering material is required.

❒Minerals Can Be Identified by the Following:

1-Color (اللون)

Minerals are colored because certain wave lengths of light are absorbed, and the color results from a combination of those wave lengths that reach the eye. Some minerals show different colors along different crystallographic axes. Mineral identification by colors can be deceptive.

2-Hardness (الصلابة)

The hardness of a mineral is its "scratch ability", determined by **Moh's** hardness scale. The hardest mineral known, diamond, was assigned the number 10.

Mineral	Level of Hardness	Tool
Talc	1	
Gypsum	2	Finger nail
Calcite	3	
Fluorite	4	Copper rod
Apatite	5	
Orthoclase	6	
Quartz	7	Glass
Topaz	8	
Corundum	9	
Diamond	10	

3-Specific Gravity (الوزن النوعي)

Specific gravity is the "heaviness" of a mineral. It is defined as a number that expresses the ratio of the weight of a mineral and the weight of an equal volume of water. The specific gravity depends on:

- The kind of atoms that comprise the mineral.
- How the atoms are packed together.
- Common rock-forming minerals (quartz, feldspar, calcite, etc.) have specific gravity near 2.7.

4-Cleavage (الانشطار او الانشقاق)

Cleavage is the ability of a mineral to break along preferred planes. Minerals tend to break along certain planes where atomic bonds are weak. Minerals can have one, two plane or three plane cleavages.

5-Crystal forms (الاشكال البلورية)

Crystal forms are displays of well-formed crystal faces by a mineral. Crystal faces formed during crystallization process vs. cleavage faces formed when mineral breaks.

There are more than 2000 naturally occurred minerals have been discovered; only a little more than 100 are common and used in mineralogy. However, of the 100 common minerals only about 25 are available as rock-forming minerals. The main types of minerals are:

(a) Metallic Minerals
(b) Nonmetallic Minerals
(c) Carbonate Minerals
(d) Sulfate Minerals
(e) Sulfide Minerals
(f) Silicate Minerals
(g) Oxide Minerals
(h) Clay Minerals.

1-4 Rock Identification (التعرف على الصخور)

Rocks are identified mostly by the following characteristics:

- Textures(النسجة)
- Mineral Composition(التركيب المعدني)
- Field Relationships(الخبرة والعلاقات الحقلية)
- Color(اللون)
- Hardness(الصلابة)

- Specific Weight(الوزن النوعي)
- Crystal Form(التركيب البلوري)
- Magnetism(المغناطيسية)

1-5 Rock Properties for Engineering (خصائص الصخور للهندسة)

Rocks are significant for two major reasons in engineering:

(1)As Building Materials for Constructions.

(2)As Foundations on Which the Constructions are resting.

For the consideration of rocks as construction material the engineers concern about:

(A)Density to some extent (for calculating the weight, load to the foundation, …….etc.).

(B)Strength.

(C)Durability.

For the consideration of rocks as the construction foundation the geological engineers concern about the rock's:

(1)Density

(2)Strength

(3)Compressibility.

1-5-1 Engineering Considerations of Igneous Rocks

الاعتبارات الهندسية للصخور النارية:

(1)Fine-grained igneous rocks cannot be used as aggregates in ***Portland Cement*** due to volume expansion caused by the Alkali-silica reaction. The solutions include:

(A)Can be used in low alkali cement.

(B)Non-reactive aggregates go with the high alkali cement.

(C)Add pozzolans, coal-ashes, ….etc. in the aggregate-cement mixture to minimize the reaction.

(2)Coarse-grained igneous rocks (e.g., granite, syenite, …..etc.) are not for aggregates for constructions because its low abrasion resistance; but fine-grained igneous rocks (e.g., basalt) are good aggregates (e.g., basalt as paving aggregates goes with asphalt.

(3) Foundations of structures need to avoid weathered rocks (e.g., dams, bridge piers, etc.).

(4)Igneous rocks are good for dimension and architectural works because their resistance to weathering but need avoid fractures.

1-5-2 Engineering Considerations of Metamorphic Rocks

الاعتبارات الهندسية للصخور المتحولة :

(1) The metamorphic rocks have the Alkali-silica reaction problem when used as aggregates with Portland cement. The metamorphic rocks with this problem are argillite, phyllite, impure quartzite, and granite gneiss.

(2)For metamorphic rocks the stability of rock mass greatly affected by the foliation orientation.

(4)Marble as a metamorphic rock from carbonate sedimentary rocks can cause similar problems, e.g., leakage of reservoirs, sink-hole collapse, solution cavities, and channels.

1-5-3 Engineering Considerations of SedimentaryRocks

الاعتبارات الهندسية للصخور الرسوبية :

(1)The sedimentary rocks also have the Alkali-silica reaction problem when used as aggregates with Portland cement. The sedimentary rocks with this problem are chert and graywacke.

(2)Fine-grained sedimentary rocks like limestone and dolomite are the best for being used as aggregates; siltstone, shale, conglomerate, and quartz sandstone are not acceptable.

(3)Stream and gravel contains weak pieces, they are not good for aggregates in concrete. Weathered chert, shale, and siltstone can cause crakes or holes at the concrete surface after freeze-thaw cycles.

(4)Coarse-grained limestone is not good for aggregates by reducing particle size.

(5)Sinkhole problem in carbonate fields due to the high dissolvability of limestone and dolomite.