1.1-Geology:

It is a science that looks at the earth and their covers, in terms of the composition and the factors affecting them and their history.(Fig.1.1).

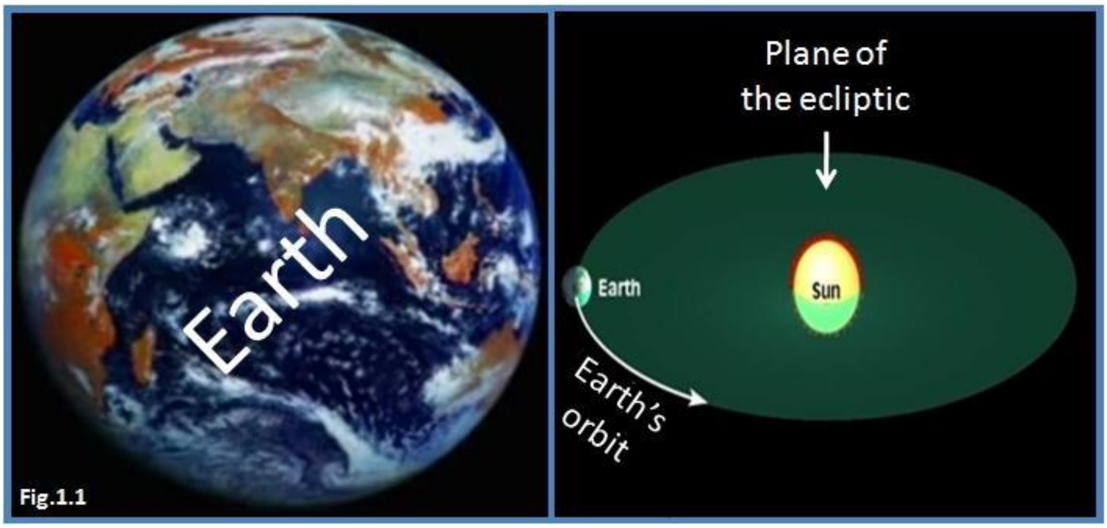


Fig.1.1

1.2-The importance of geology:

1- Disclosure of sources of energy such as oil, natural gas and minerals.
2- Determining the appropriate places for construction of dams , bridges and other Construction projects. (Fig.1.2).1.
3- Prospecting for natural mineral resources such as gold, silver, copper, lead, iron, aluminum, nickel, phosphate and halite.2.
4- Relocate the raw materials for construction such as sand, gravel, limestone, marble and chemical industries, such as sulfur, calcium, sodium and chlorine, which are used in the manufacture of drugs and pesticides and fertilizers.
5- The large increase in the number of the population, especially in the arid and desert areas has led to the search for other sources such as undergroundwater.

6- The possibility of the cause of the occurrence of natural disasters such as volcanoes, earthquakes and floods, as well as the prevention of landslides and buildings cracked. 7- Identify natural barriers as well as the best ways to move soldiers and military vehicles and identify suitable sites for digging trenches and building military bases.

1.3- A brief summary of geology:

The Greeks of the oldest philosophers interested in studying geological phenomena on the earth's surface such as mountains, high and low seas, volcanoes and earthquakes .They include:

- Thales (636-546 B.C):

- Considered the earth flat disk surrounded by water. - He believes that water is the source of all the materials in the earth through the river sediments in estuaries. He imagined that the movement of water caused earthquakes**.**

- Anaximander:(610-547 B.C):

-He thinks that the earth is a cylindrical shape. -The development of human and animal originally from Fish.
-Making the first map of the known world in his day.
-Think the air is the source of all materials.

- Xenophanes (540-510 B.C):

Concluded that the fossils out of the sea and the land and sea were integrated within a specific period of time.

- Plato (427-347 B.C) and **(Pythagoras 582-500 B.C)**:

They were believed that the form of the ground ball and the spherical shape is the optimal shape.

- (Aristotle 384-322 BC):

Concluded the same truth about the spherical earth during Note spherical Earth's shadow on the moon during a lunar eclipse.

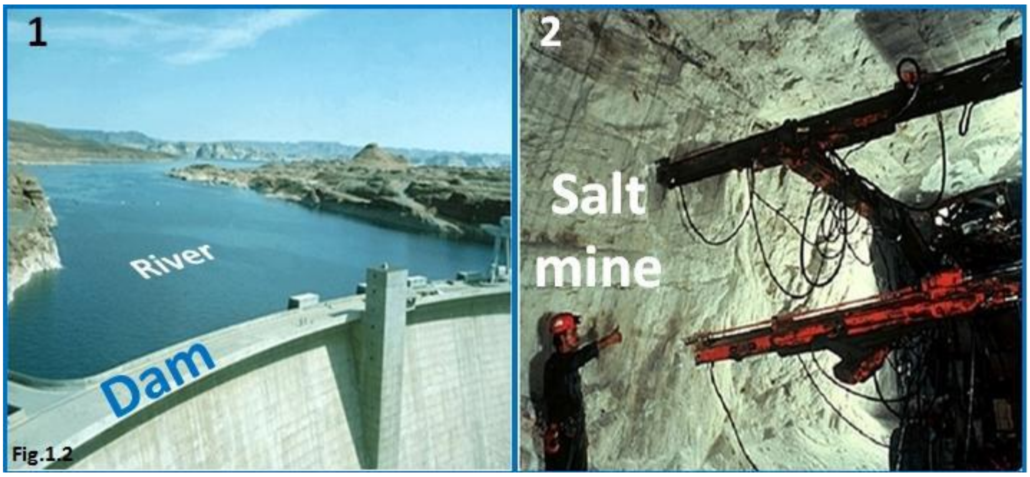


Fig.1.2

- Some Greeks philosophers are aware of the facts and the most prominent of the earth's surface has been exposed to the ups and downs and it is constantly changing.

-At the time of the Roman Empire (27 BC -935 AC), Romans did not show sufficient attention to the natural sciences. Greek Considered pure science fiction. Among the most prominent scientist of the Romans (Pliny) in the first century AD and has a (73) books in the natural sciences which (5) to study minerals.

- (Dark period in Europe 500-1100 AD):

During this period, books disappeared philosophers of the Greeks in the midst of chaos and ignorance, rivalry and sorcery and the peoples of Europe remained under the whip as slaves and the oppression and tyranny**.** On the other side of the world in Baghdad, Cairo and Cordoba dawned the light of learning, knowledge and civilization and rose through the voices of values and logic, philosophy, and contributed to the dissemination of progress and prosperity landmarks.

- Geology in the Arab civilization:

Arab scientists benefited of Greece theories (Greeks), which were based on the philosophy and logic. The Arabs added to a lot of scientific knowledge-based views of various natural phenomena and interpret scientific ways.

The most famous Arab scholars:

-Ibin Siena (Abu Ali Hussein 980-1037 AD):

The first Arab scientist in geology. Said his letter (Minerals and effects upper) in the book (labrum) sources of scientific task that was adopted by the Arabs after the Middle Ages has been translated into Latin Year (1068 AD).

He was the first in his theory (that the origin bullet rocks and water).Possible Ibn Sina considered the founder of the law of succession of layers. Gave Ibn Sina time factor role in transforming the different sediment to the different rocks. Has also been among that reason mountains configuration is as a result of sea sediments. He has also messages about Earthquake in match some of them with modern ideas.

Ibn Siena Put Minerals in four sections:

1 - Precious.

2 - Fuses (minerals that are fused).(Fig.1.3).

3 - Alkabart (metal burning).

4 - Salts.

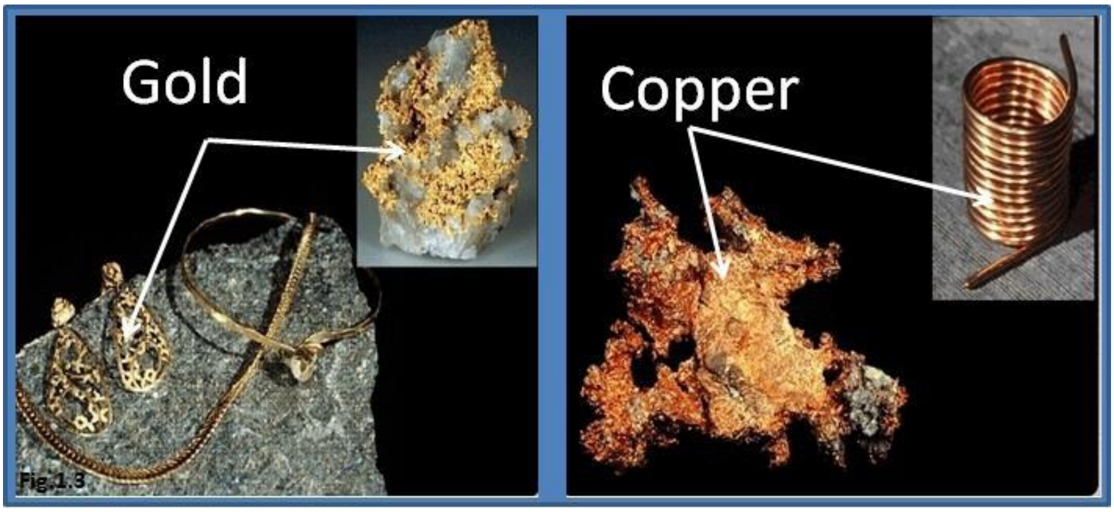


Fig.1.3

- Biruni (Abu Rayhan – died in 1271 AD): He studied the movement of the earth around the sun, the shape, and dimensions and extracted the radius of the Earth (Biruni equation) and reached results close to the results of the present. He found specific weight accurately to (18) of minerals and gemstones. He classified a group of metals on the basis of hardness and qualitative forms. He has contributions in Stratigraphy and paleontology in his book (Aljamaher in knowledge of gems).

- Al-Masudi (Abu Hassan Ali Bin Al Hussein):

He wrote a lot of books including a book (promoter gold and jewels metals) and explains the Earth rotated the flow of rivers, the water cycle in nature and touched the earth's rotation.

-Al- Kindy (Abu Yusuf):

He wrote in the types of precious gems and stones types and internal factors that affect the earth and has other messages, including two in geology.

- Al-Addressee (Sharif died in 1164 AD):

He wrote several books on oceanography. He used Arab terminology for the first time and can be used in all languages.

- Al-Raze (died in 845 AD):

Contributed in a lot of science, including geology. Among the most famous books (Secrets of Secrets), in which class metals to (6) sections by mineral properties and methods of preparation and purification materials.

There are a lot of scientists and thinkers do not have the space to explain their achievement and suffice by mentioning their names, including:

- Zakaria AL-Quzwine (died in 1283 AD).

- Al-Khazeny (Abo-Mansour).

1.4- Branches of the geology:

1- Crystallography:

Looking at the crystallization of minerals in terms of composition and chemical and physical characteristics and conditions of their existence and its benefits.

2- Mineralogy:

Specializes in the study of minerals through knowledge of their natural (physical) and chemical properties, Classification and the conditions of its existence and its benefits.

3- Petrology:

Study the rock types in terms of the origin and composition, characteristics and classification and the conditions of their existence.

4- Dynamic geology (physical):

Interested in studying the internal and external factors that lead to the formation of the natural and geological phenomena such as mountains, rocks and minerals in the earth's surface.

5-Paleontology:

Looking to find out the remnants of ancient organisms or effects of animals and plants that lived in the previous geologic time.

6- Historical geology: Specializes in studying the order of rock layers from the earliest times to the present day, where studying fossils characteristics of each layer of the sequences and arrange the calendar of the land and divided into epochs and ages and times of sequential terms by which knowledge of the distribution of water and land through different of geological ages.

7- Stratigraphy:

Is the science that studies the laws and deposition conditions and places of various sedimentary rock layers, and after it is fragmentation from different rocks and transported by water and air.

8- Structural geology:

Interested in studying the current construction and evolution of the earth's crust through geological ages, and explains the science reasons to configure different geological structures such as faults, fractures and joints in the rock layers as well as the reasons for the formation of the mountains.

9- Geophysics:

One of important branches in the science of the earth that specializes in the study of the underground layers of different geological formations and a private study invisible structures that could contain oil and mineral deposits of economic and water. (Fig.1.4).

10- Geochemistry:
Specialized study of minerals and rocks by chemical means and the distribution of the constituent elements of the earth's crust, as well as determine the type and proportion of mineral ores in the earth's crust.

11 - Economic Geology:
Is an applied science concerned with the search for economic resources and identified and evaluated for the purposes of benefit.

Economic Geology includes several branches, Some of them are: - Petroleum Geology.
- Mining Geology. - Engineering Geology. - The geology of mineral deposits
-The geology of radioactive isotopes.

12- Hydrogeology:
Is interested in studying the sources of surface water and groundwater and the characteristics of the physical and chemical water and study the layers of the earth containing groundwater.

13- Engineering Geology:
This includes knowledge of the mechanical and engineering properties of Earth crust and for the purpose of building bridges, dams and various facilities such as high buildings and others.

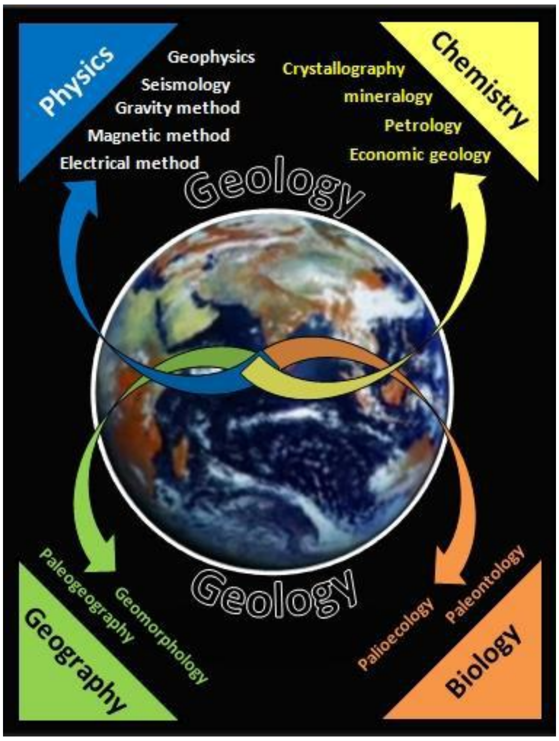
There are many disciplines that fall within the minute branches already mentioned:

a-Geomorphology.
b-Remote sensing.

c- Seismology.
d-Topographic surveys.
e- Geological Survey.
f- Volcanology.
g- Military Earth Science
h- Oceanography.
i- The study of rocks and soil of moons and planets in space.
j- The use of automated computer in earth science studies and mapping and geological sectors.
k- Earth Science military

1.5-Relationship between geology and other Sciences:

Note of the classification of some of the branches of Earth Science that this science develops in conjunction with other sciences such as chemistry, physics, biology, astronomy and engineering sciences as shown below:



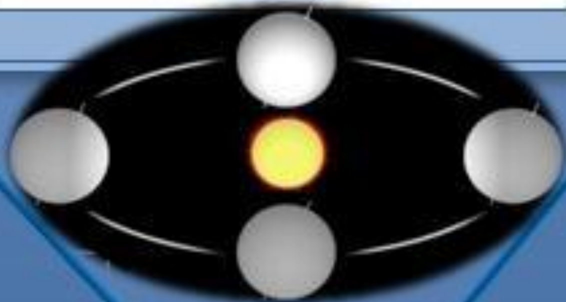
1- Define Earth Science (Geology).
2- Write five main branches and three of secondary in Earth Science.
3- Compare between: A- Historical geology and Paleontology B- Stratigr1aphy and Petrology.
4- What is the role of geology in the planning stage of the construction of dams in Iraq?
5- What is the importance of satellite imaging and remote sensing of Earth Science?
6- What is the nature of geologist during prospecting for oil?

7- There is a close relationship between geology and the others science. Discuss this statement.
8- Mention the most important shares of the Arab scientists in the geology?
9- What are the benefits of the study of the earth science?

Chapter two
الفصل الثاني

The earth and the solar system

الأرض والمجموعة الشمسية



-Earth site in the universe.
-Planets of the solar system.
-How the solar system formed?
-Weight and time in planets.
-Earth's Moon.

-موقع الأرض في الكون.
-كواكب المجموعة الشمسية.
-كيف تكونت المجموعة الشمسية؟
-الوزن والزمن في الكواكب.
-قمر الأرض.

2.1 Earth site in the universe

The sun is the center of a huge round about system of old eight planets and it's natural moons, and many small asteroids, comets, meteorites, and dwarf planets. (fig.2.1).

The sun is a big gaseous ball, surface temperature reaches to about 6000 degrees Celsius, and it is composed of the same material consisting of the planets, but in different proportions. Hydrogen and helium Composed about 99% of the mass of the sun. Sun Star is medium-sized when compared with other stars that spread across the infinitesimal universe is finite. Sun appears to us great with respect for the rest of the other stars because it is the closest of the earth. Away from the earth, sun 149.6 million km. 1,390,549 km in diameter is equivalent to 109 times the diameter of the Earth.

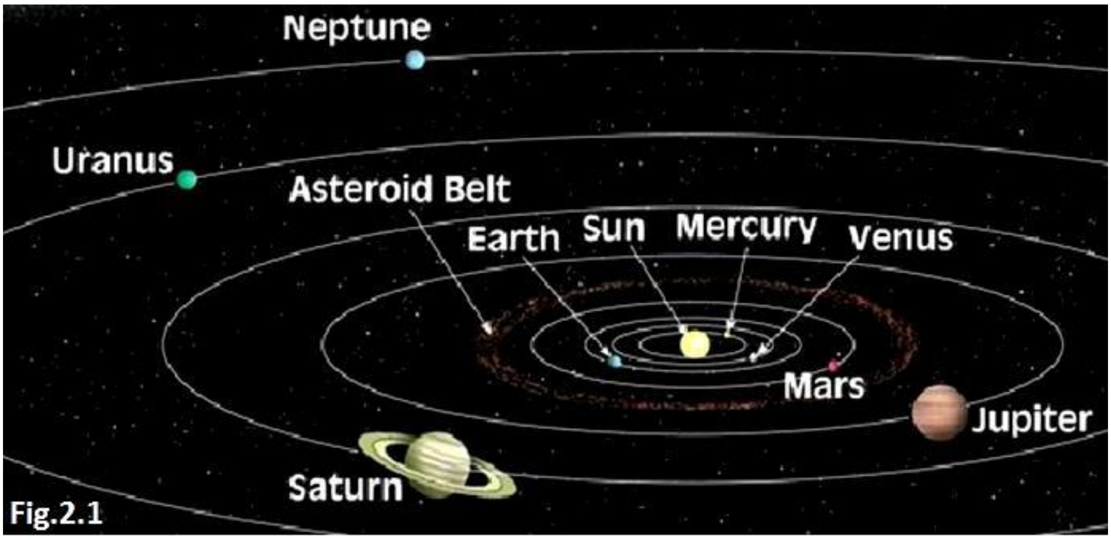


Fig.2.1

2.2- Planets of the solar system :

Plants are divided into two groups:

A- The inner planets are:

Mercury, Venus, Earth and Mars.

They are closest to the Sun and follow slightly elliptical paths.

The inner planets are also called **terrestrial** (earth-like) because they are similar in size and mineral makeup to earth (fig.2.2).

Fig.2.2

B- The outer planets are:

Jupiter, Saturn, Uranus and Neptune.

They are much farther from the sun and thus, They are much colder than the inner planets. (Fig. 2.3).

The outer planets are also referred to as the **Jovian planets** (Jupiter-like) or as **giants** because of their size.
(Fig. 2.4).

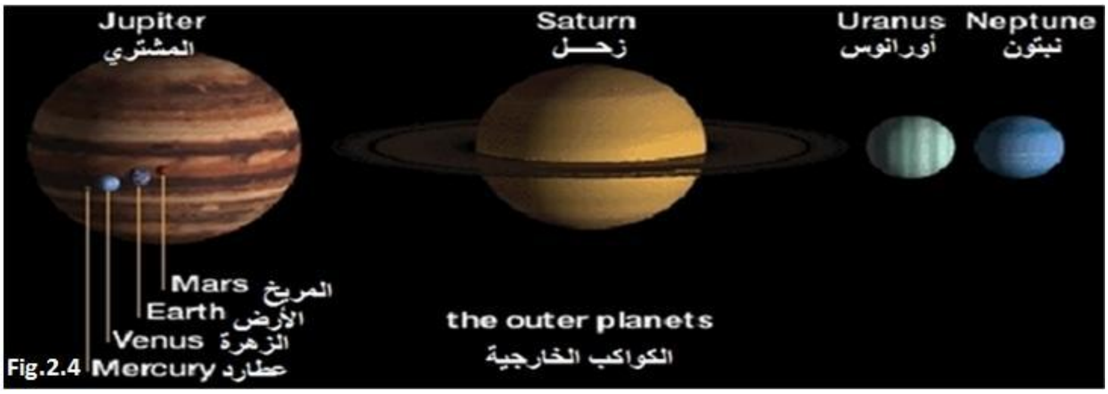


Fig.2.4

Because small size of **Pluto** and similarity to other icy bodies found in the outer solar system, **Pluto** was demoted to **dwarf planet** status. (Fig.2.5).

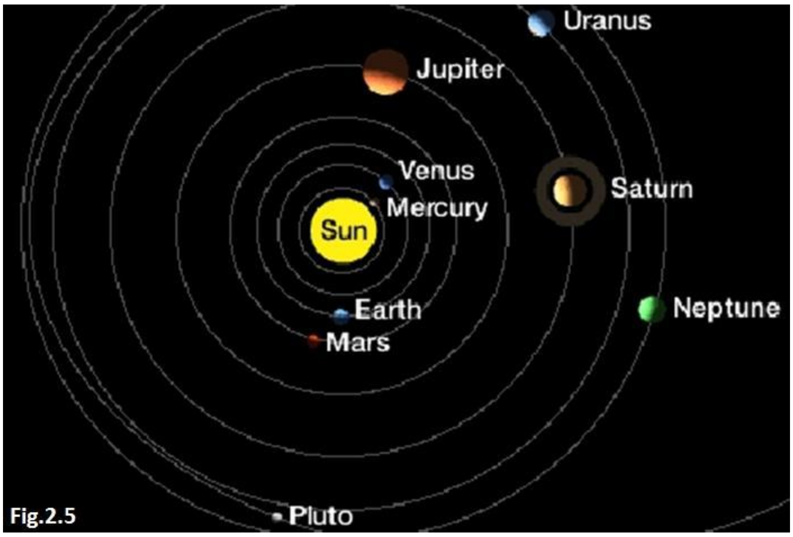


Fig.2.5

The substances that make up both the inner and outer planets are divided into three groups: Gases, Rocks and Ices based on their melting points.

1- 273C°).
2- Rocks are principally silicate minerals and metallic iron, which have melting points exceeding 700 C°.
3- Ices include ammonia (NH_3), methane(CH_4), carbon dioxide(CO_2), and water(H_2O).They have intermediate melting points(for example, H_2O has a melting point of (zero C°).

The inner planets: are composed of rocky crust and mantle, and metallic core made mostly of iron. Compared to the outer planets, these planets contain very small amounts of ice and gases.

(Fig. 2.6).

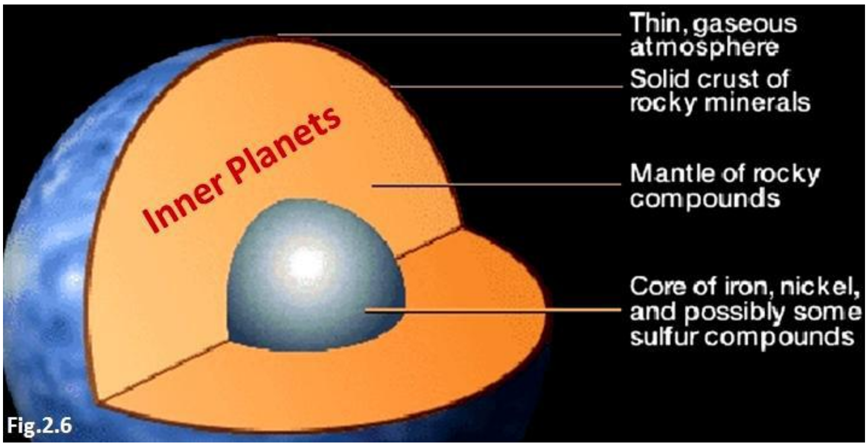


Fig.2.6

The outer planets: on the other hand contain large quantities of gases (hydrogen and helium) and ices. They also contain a small core composed of rocky material and metallic iron. (Fig. 2.7).

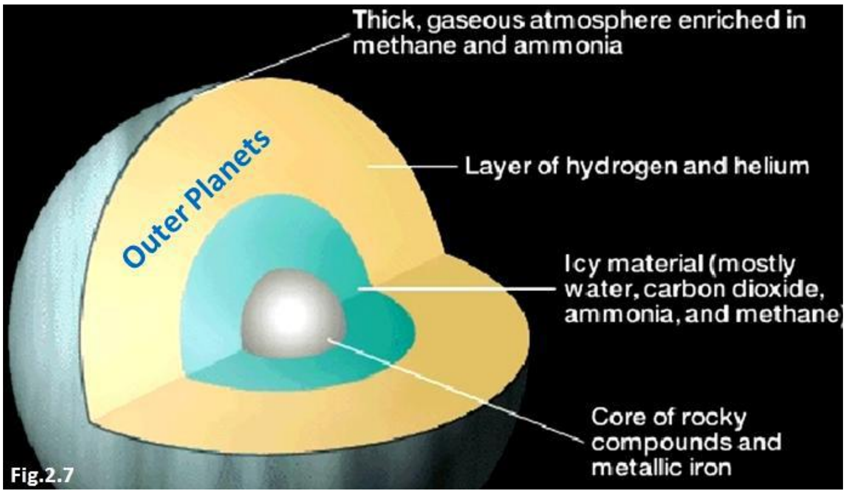


Fig.2.7

Because of differences in chemical makeup, the inner planets have densities that average about 5 times that of water, whereas the outer planets have densities that average less than 1.3 times of water.
(Fig.2.8) and (table.2.1)

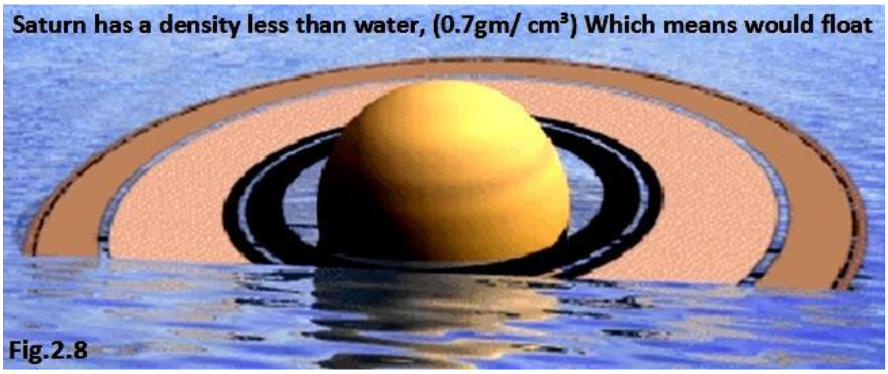


Fig.2.8

Inner Planets الكواكب الداخلية

Average Density(g/cm³)

Outer Planets

Average Density(g/cm³)

Mercury 5.4 Jupiter 1.3 Venus 5.2 Saturn 0.7 Earth 5.5 Uranus 1.2 Mars 3.9 Neptune 1.7

To understand why the outer planets are so much larger than the inner planets we must first examine:

2.3- how the solar system formed?

According to the **(nebular hypothesis**) the solar system formed when a huge, rotating cloud composed of minute rocky fragments and gases (mostly hydrogen and helium) began to contract. (Fig.2.9).

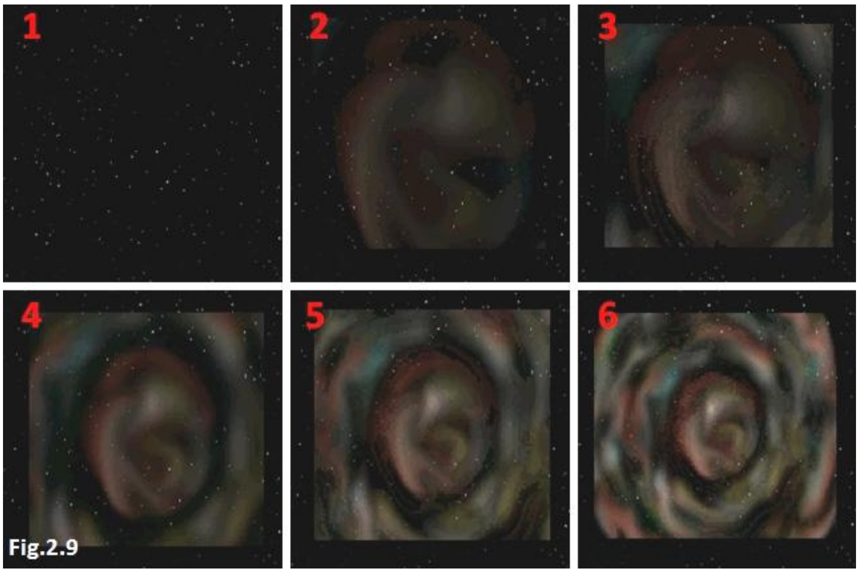


Fig.2.9

Most of the material, (over 99%) was pulled by gravity toward the center, forming the sun. rotation caused the remaining rocky fragments and gases to form a flat, rotating desk. (Fig.2.10).

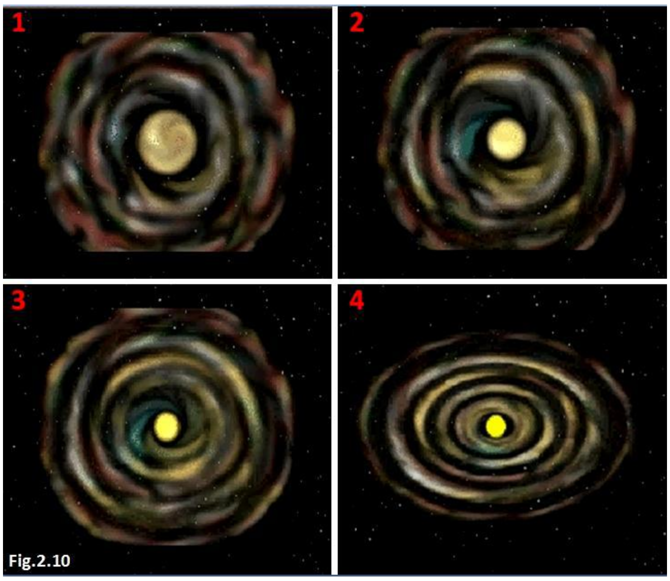


Fig.2.10

Repeated collisions caused these fragments to join together into larger asteroid - sized bodies called planetesimals, which accreted (grew larger) and ultimately formed the planets. (Fig.2.11).

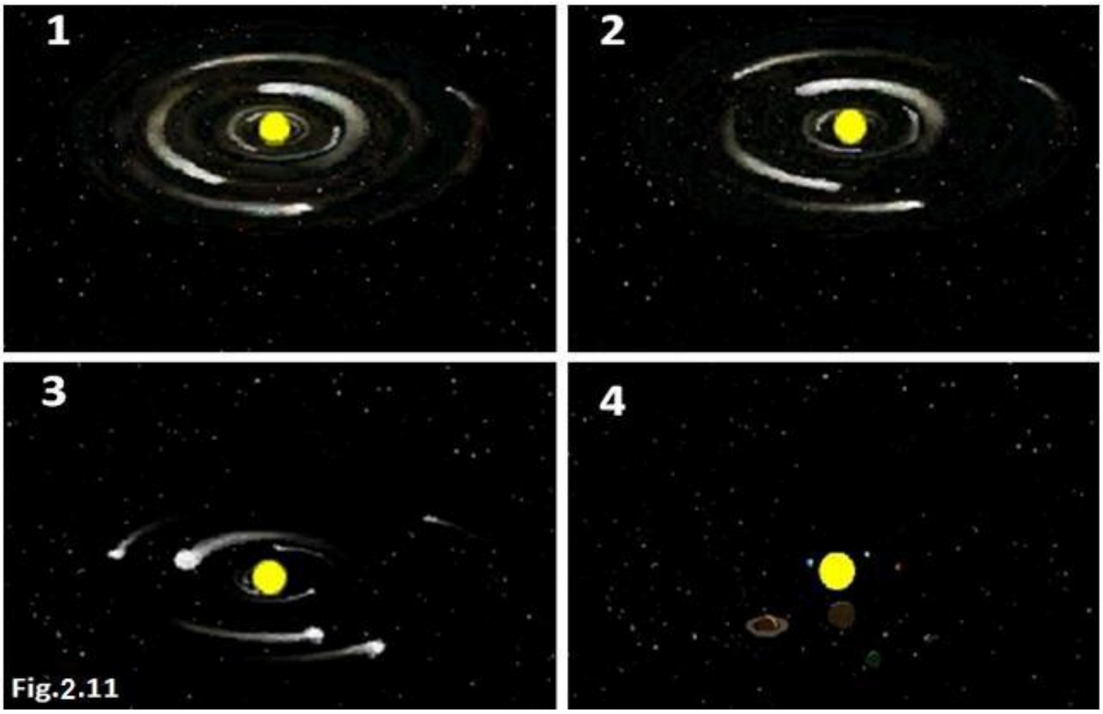


Fig.2.11

In the inner solar system, the temperatures were so high that only metals and silicate minerals could form solid grains.
Thus, the earthly planets (terrestrial) grew mainly from high melting points substance. (Fig.2.12).

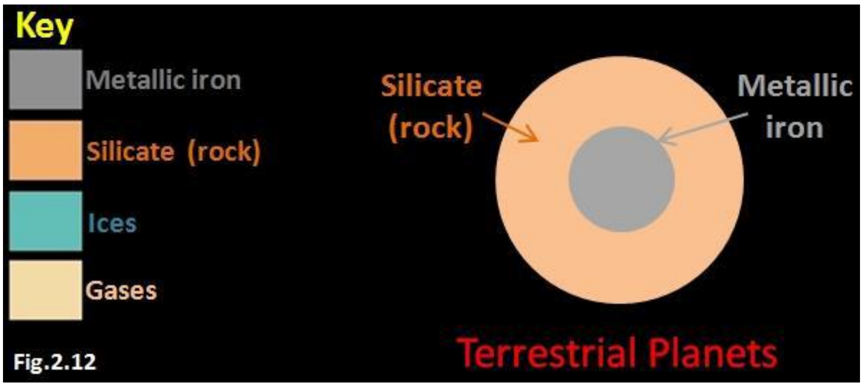


Fig.2.12

Because of the frigid temperatures far from the sun, the outer planets (Jupiter, Saturn, Uranus and Neptune) collected huge quantities of ices (water, Carbone dioxide, ammonia and methane) which greatly added to their sizes. (Fig.2.13).

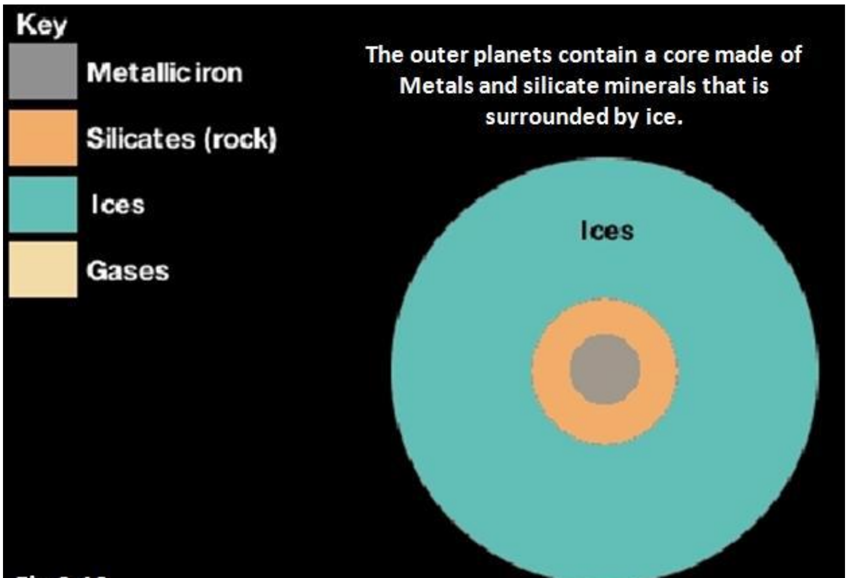


Fig.2.13

The outer planets, particularly Jupiter and Saturn, grew large enough to gravitationally attract and hold large quantities of the lightest elements…….hydrogen and helium (fig. 2.14)

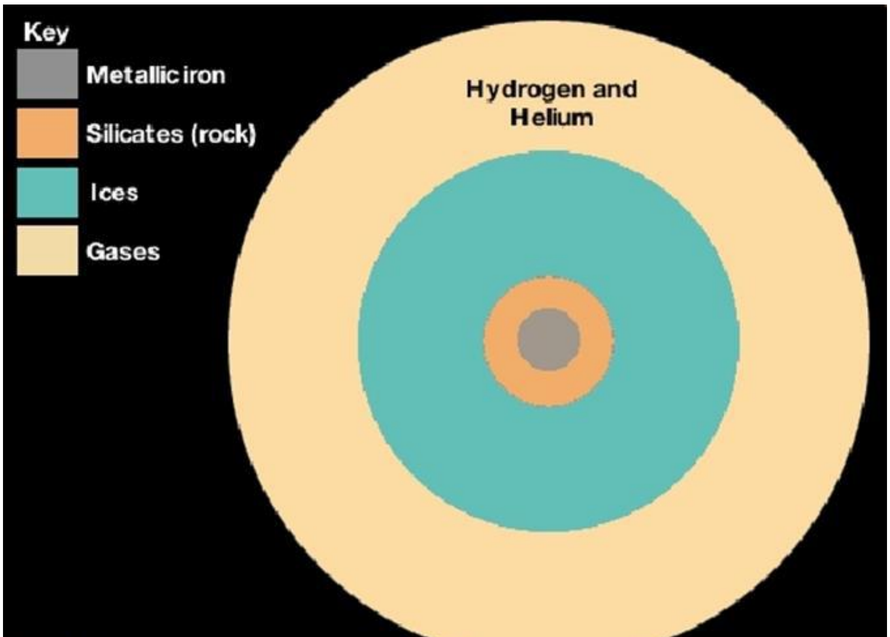


Fig.2.14

As a result, the solar system is composed of:

- **Large outer planets.**
- **And smaller inner planets**.

(Fig.2.15).

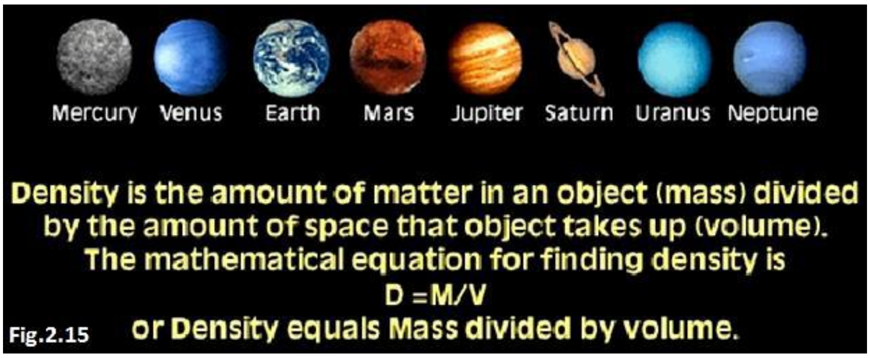


Fig.2.15

2.4-Weight and time at planets:

In this section you will learn how to calculate your weight and age on other planets. Further, you will be able to examine the solar distance as well as the relative size of the planets. (Fig.2.16).

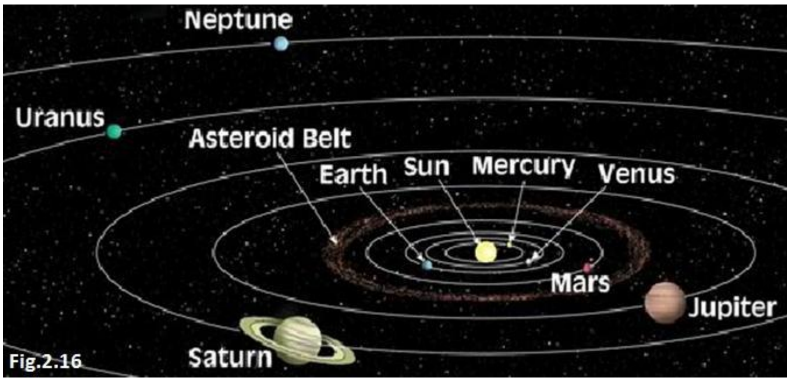


Fig.2.16

To determine your weight on other planets, you simply multiply your (earth weight) by the force of gravity exerted by the planets in question requirement. (Fig.2.17)

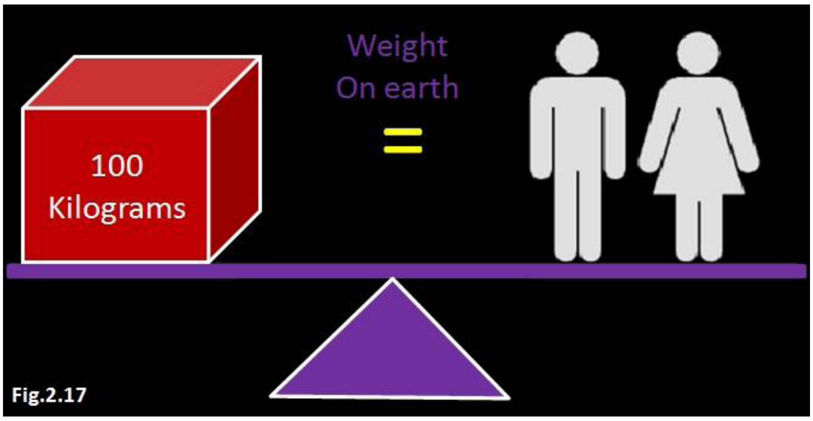


Fig.2.17

For example, if you weight 100 kg on earth, you would weight only 38 kg on mercury. This is because mercury is smaller (less massive) than earth and thus has a weaker gravitational force. (Fig.2.18).

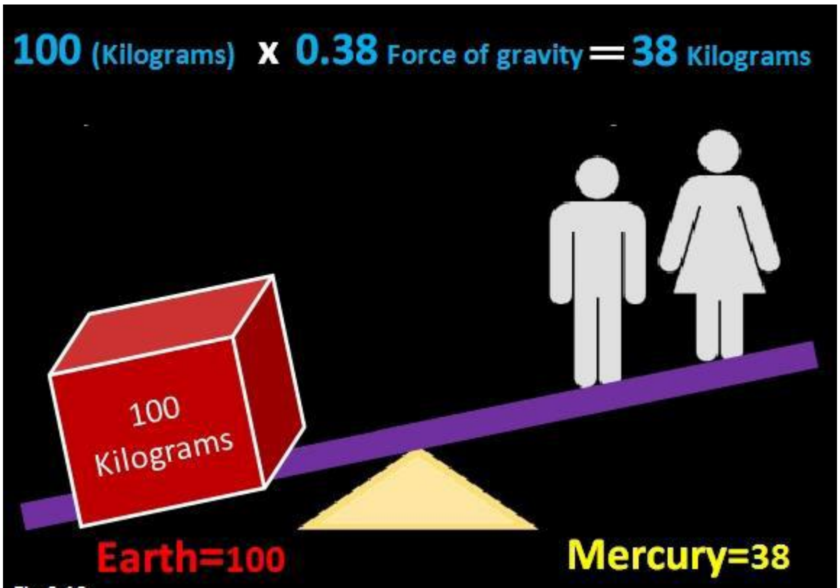


Fig.2.18

You can calculate your age on other planets by knowing how long it takes the planets to travel around the sun. (Fig. 2.19).

Fig.2.19

For example, if you are 20 earth years old and you live on mercury, you would be 83 years old, because mercury goes around the sun 4.15 times in an earth year. (Fig.2.20).

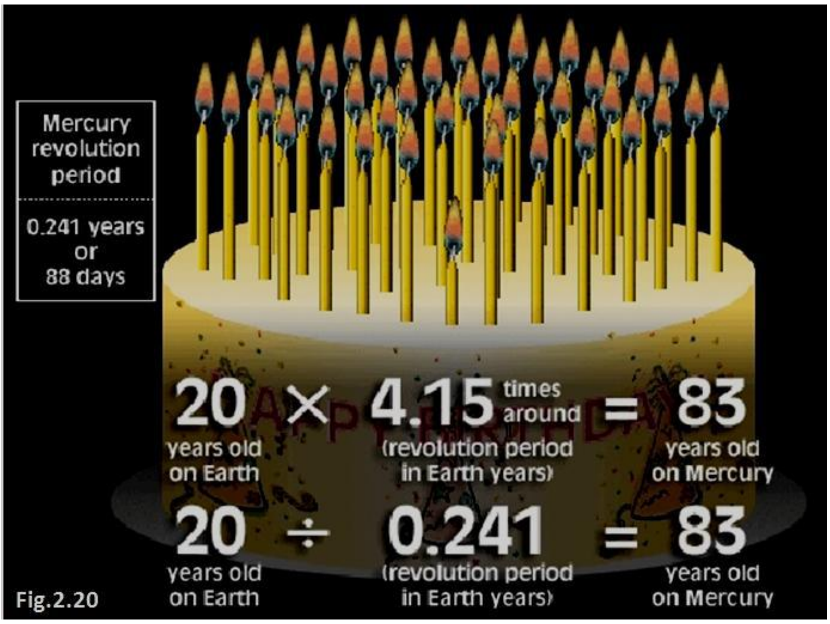


Fig.2.20

2.5- Earth's Moon:

The moon is earth's only natural satellite, and the only body in the solar system other than earth, to be studied firsthand.
The gravitational attraction on the lunar surface is one-sixth (1/6) that of earth's. Therefore, astronauts can carry their "heavy" life-support system with relative ease.
Because the moon rotated on its axis once for every revolution, the same side always faces earth. (Fig.2.21)

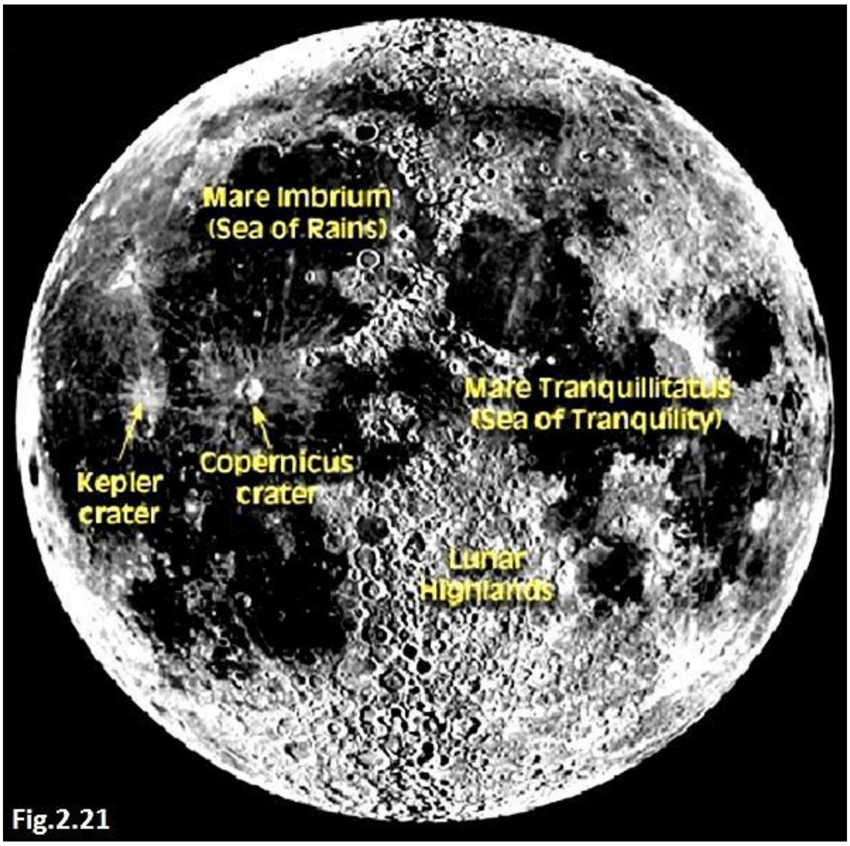


Fig.2.21

On the earth-facing side of the moon we can easily pick out its two major topographic regions:

A- highlands: The brighter and heavily cratered areas.

B- Maria: Dark, nearly flat regions are called (Latin for sea). (Fig. 2.22).

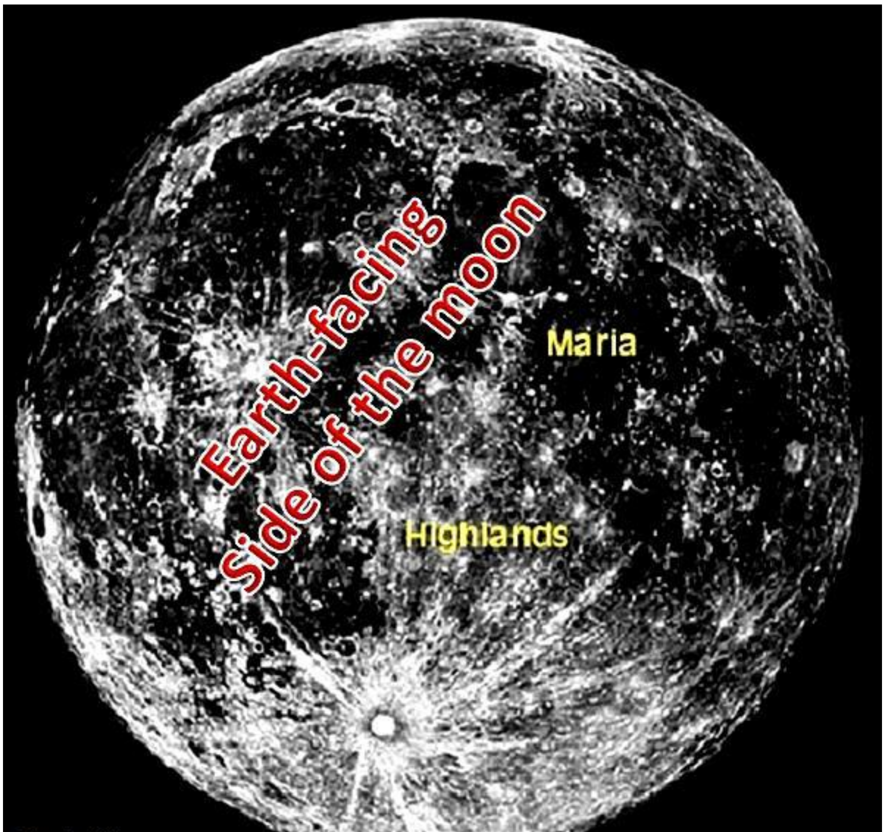


Fig.2.22

The most widely accepted hypothesis for the origin of the moon suggested that a large mass-sized body impacted earth. This event apparently occurred shortly after earth formed.

The impact would have produced immense heat and sent a huge amount of debris into orbit around earth where it coalesced to form the moon.

(Fig. 2.23).

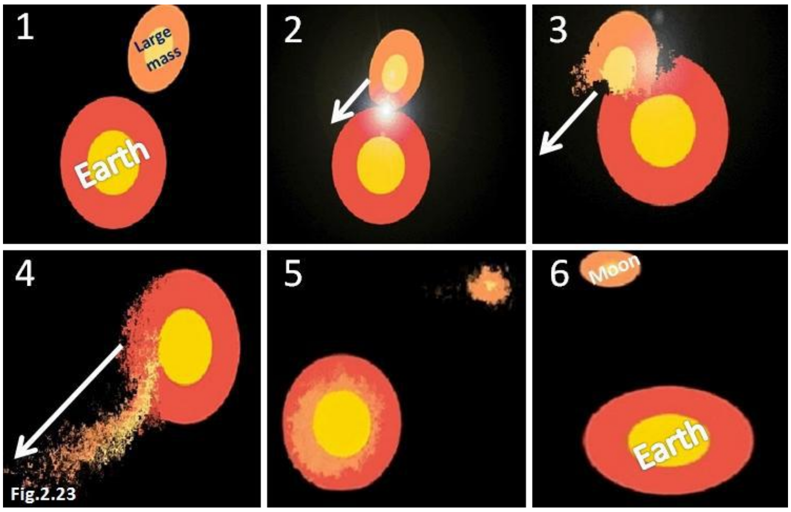
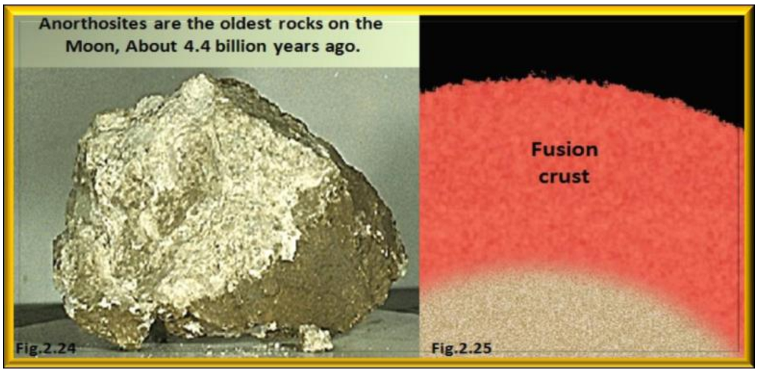
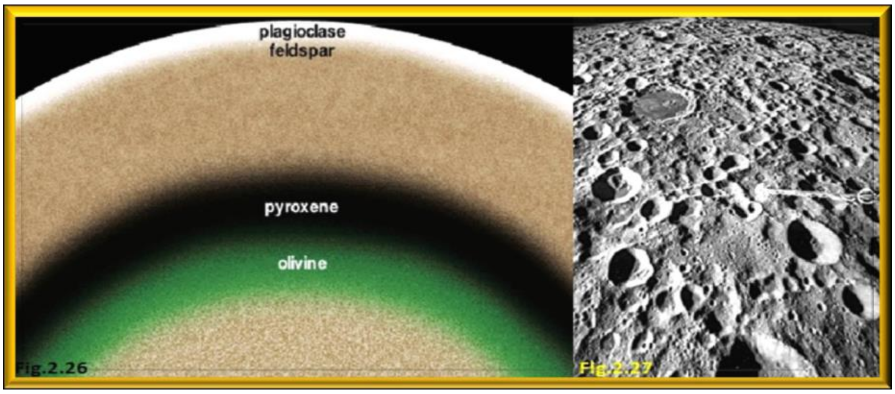


Fig.2.23

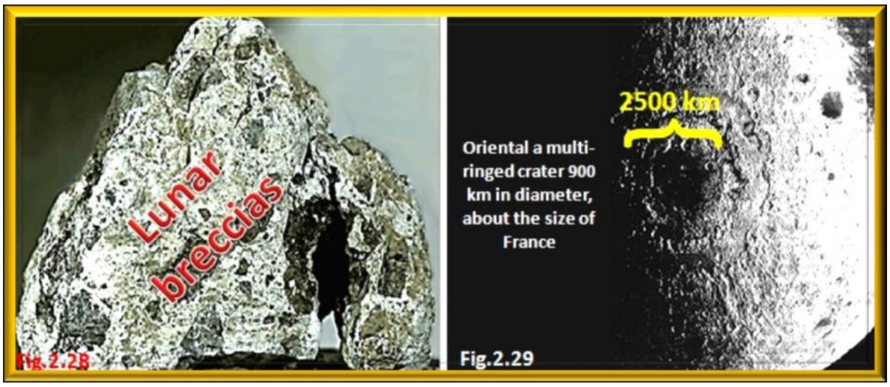
Planetary geologists were able to piece together the early history of the moon from samples of the rock **anorthosite**. In addition to being the oldest moon rocks, anorthosites are unique because they are composed almost entirely of one mineral, plagioclase (feldspar). (Fig. 2.24).
The discovery that a single mineral, plagioclase feldspar, was the major component of the moon's initial crust, led researchers to conclude that the moon's outermost layer was once molten. (Fig.2.25).



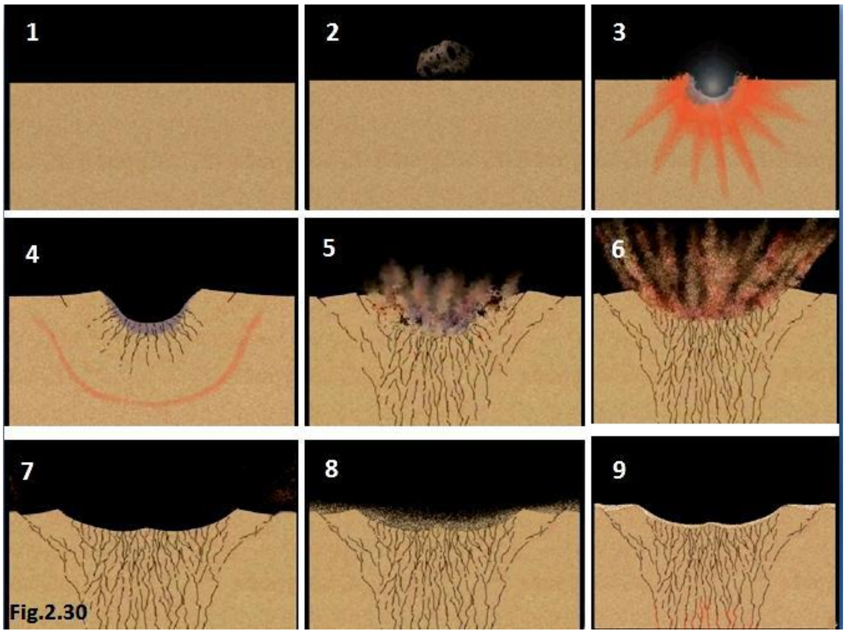
When this surrouding magma began to cool and crystallize, dense minerals such as olivine and pyroxene sank, while less dense plagioclase feldspar floated upward to form the anorthosite crust. Because the moon once had a surrouding magma, it is possible earth may have had one as well. (Fig.2.26).
Once formed, moon's crust was bombarded by debris from space for a period of several hundred million years. The craters produced during this period are visible today in the lunar highlands. (Fig. 2.27).



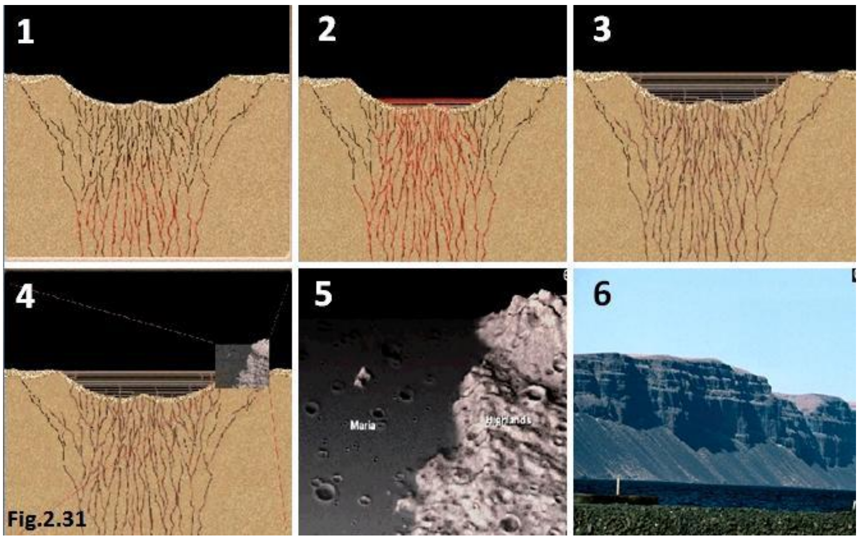
During this period of bombardment, crustal rocks were broken, melted and mixed together to c f ck c … **Lunar breccias.** (Fig. 2.28).
The moon was battered relentlessly until about 3.8 billion years ago. The impact made craters of all sizes including multi -ringed basins up to 2500 kilometers in diameter. (Fig.2.29).



The largest impacts produced huge craters and fracture the lunar crust sufficiently to allow magma to bleed out. (Fig.2.30).



These craters were flooded with layer upon layer of very fluid lavas resembling those of the Columbia Plateau in the Pacific Northwest. (Fig.2.31).



Lava intermittently flowed into these low areas for up to a billion years. The arrows point to the front of ancient lava flows on (Mare Imbrium). (Fig.2.32).
Eventually, the dark, flat, and comparatively craterless regions of the moon called **Maria** were formed.
Samples brought back by the **(Apollo 15)** (Fig.2.33) mission confirmed what geologists suspected, that the Maria lavas were composed of the rock basalt. Like similar basalt flows found in the Columbia Plateau region of the northwestern United States, the Maria lavas were very fluid and traveled hundreds of kilometers before solidifying

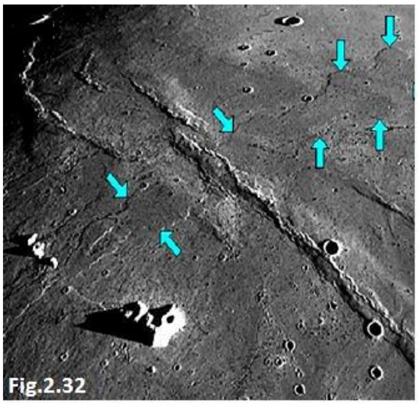


Fig.2.32

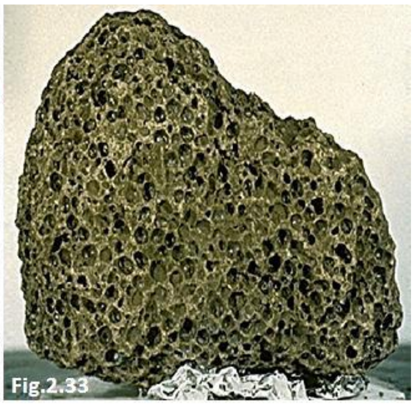


Fig.2.33

Rayed craters are the most recently formed prominent features on the moon Materials ejected from these "young" depressions blanket the surface of Maria and older ray less craters. (Fig.2.34).
All lunar terrains are mantled with a layer of gray, unconsolidated debris, called **regolith**, derived from a few billion years of meteoric bombardment.
(Fig.2.35).

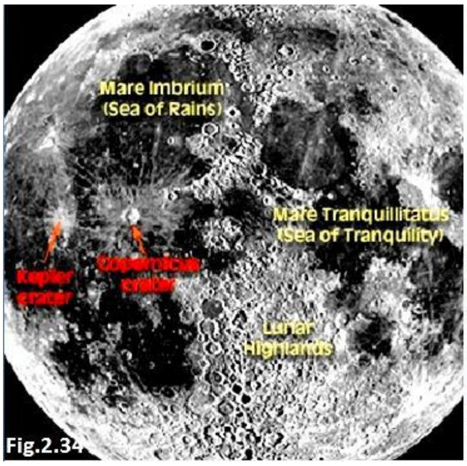
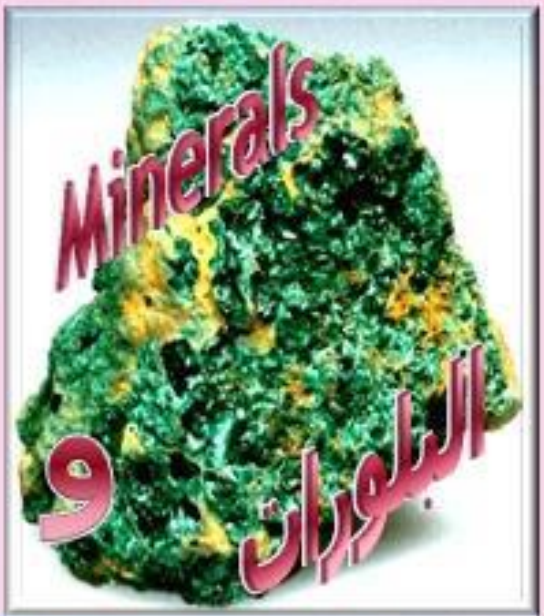


Fig.2.34


Fig.2.35

1- Write the planets of the solar system from nearest to farthest from the sun.
2- Indicate the planet that has more and less number of satellites.
3- What are the materials that make up the solar system? Number and explained in detail.
4- Compare among the planets group of internal and external components of the solar array.
5- Put true or false to the following sentences: - Pluto can swim in the water. - Mars is the farthest planet from Earth. - Saturn is the dwarf planets. - The temperature of the outer planets is less than the inner planets. - Watch the moon face and always one in our city.
6- If your weight on Earth 70 kg, what your weight on Mercury if you know that the gravitational force (3.7 m / S^2).
7- How much is your life on Mars? If you know that the time of rotation of Mars around itself reach (687 earthy days).
8- What are the constituent minerals and rocks of the Moon's crust? And what is called the high and low areas in the surface of the moon?
9- What is the most acceptable hypothesis in the emergence of the moon?
10- How our solar system formed?

Chapter Three
الفصل الثالث



Crystals	البلورات
-Introduction.	-المقدمة.
-Lattice.	-الشبيكة.
-Crystal.	-البلورة.
-Crystal properties.	-خصائص البلورات.
-Crystal systems.	-الأنظمة البلورية.

Minerals	المعادن
-Introduction.	-المقدمة.
-Mineral groups.	-مجموعات المعادن.
-Physical properties of minerals.	-الصفات الفيزيائية للمعادن.
-Economic use.	-الاستخدام الاقتصادي.

Crystals

3.1- Introduction:

Some of us may be surprised when they learn that the common metals such as copper, silver, aluminum and other ... As well as most of the solids are crystalline materials. Although we are accustomed to features of crystalline materials such as quartz and diamonds and salt, the faceted Clear and specific angles between the facets that may not seem to the eye while cutting metal familiar. However Body is crystalline metals, metal products, hiding in the susceptibility of metals as a result of roads and configuration. The judgment on the substance not is because of their outward appearance, but over the regularity of atoms and molecules of the arrangement League.

Crystallography dawned in 1913 with evidence of scientific based on X-ray and its potential

3.2-Lattice: Consists crystal typical of a repeat of a regular infinite in vacuum units constructivism identical, in the simplest crystals such as crystal copper or silver, for example, as well as in crystals of alkali metals, the unit reconstructive contain a single atom, and may contain the unit Constructivism in the general situation on several atoms or molecules until it reaches about a hundred atom in inorganic crystals, and to about ten thousand atom in the crystallization of proteins.

3.3- Crystal: It is a solid body, The arrangement of atoms in which the pattern of recurring.

3.4- Crystals properties: They are depending on:

1-Crystal faces: Are the surfaces that define the shape of the crystal which is mostly flat, and rarely to be convex or concave. Indicate these surfaces on a regular atomic arrangement engineering firm, which consists on the basis of the crystal material. (Fig.3.1).

2- Crystal angles:

a-Edge angle: It is an angle between two neighbor faces.

b-Interfacial angle: It is an angle between two faces; it can be measured by two perpendicular columns on neighbor and opposite faces.

c-Solid angle: It is an angle between three neighbor faces.

3- Crystal form:

They are similar surface of the crystal consists of each type of face or two faces and at least one related to the crystal axes.

The crystal can be form of one shape of faces named (simple form) or many shapes named (compound form).

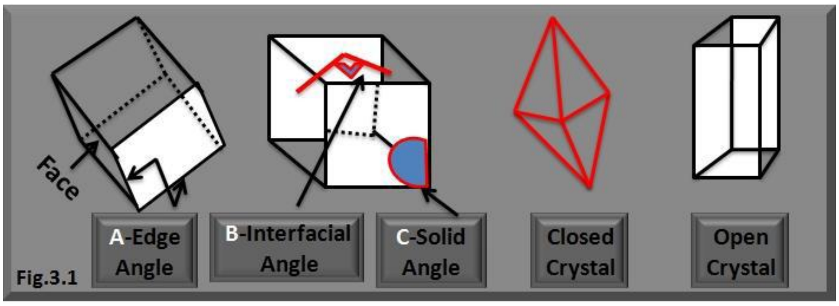


Fig.3.1

3.5- Crystal symmetry:

It is a phenomenon of the formation of a regular crystal form depending on the arrangement of atoms and ions of the constituent material in accordance with the coordination of certain natural, and show to the symmetry repetitive exchange aspects of the body as per their positions to take the crystal single-mode twice or more if they are administered in the crystal full cycle around the axis given.

3.6- Elements of symmetry:

Are signs of a fake attributed to the crystal symmetry, a point or line or level, single or combined, as follows:

1- Plane of symmetry.
2- Axis of symmetry.
3- Center of symmetry.
4- Inversion axis of symmetry.

1- Plane of symmetry:

It is the plane at which the crystal is divided into two equal halves, each half a mirror image of the other. (Fig.3.2).

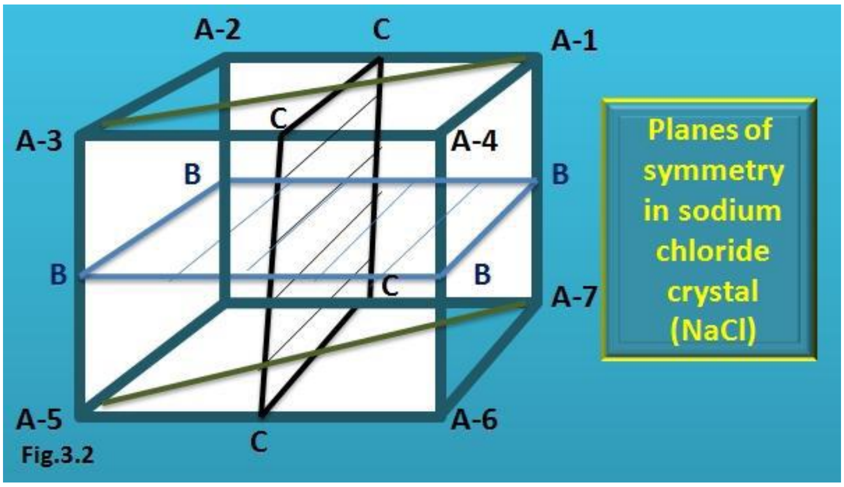


Fig.3.2

2- Axis of symmetry:

It is an imaginary line passess through crystal center. If the crystal is rotated around that line (360°), face, edge and any line of crystal repeat its self twice or more. (Fig.3.3).

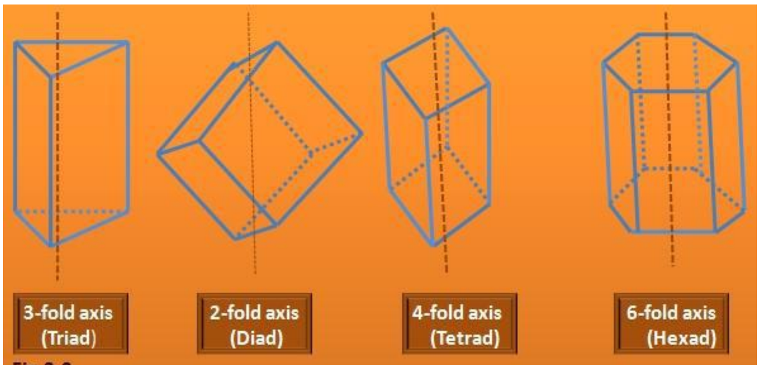


Fig.3.3

3- Center of symmetry:

It is a central imaginary point into crystal, That's where the distance of face, edge, and angle in certain side are equal to the other in opposite side from the center.

4- Inversion axis of symmetry:

This element collects between rotation symmetry and Inversion through the Center of crystal. If the crystal has double inversion at rotation axis, it needs crystal rotation for (180°) firstly, and then inversion every face, edge, or surface in crystal through symmetry center until the crystal takes its situation in vacancy. This axis is called (two-fold inversion) or (2). So for (3), (4) and (6).

3.7- Crystallographic axes:

Imaginary lines intersect within the crystal in its traditional downstream and up to different indications described for it place the crystal facets, each face more cuts at the center or at a distance from the center, which is normally three axes: a. b. c. (Fig.3.4).

Axis a: It is the line that extends vertically in a reading from the crystal examined.

Axis b: is the axis that runs parallel to the development of reading for those who examine the crystal.

Axis c: Are the vertical axes, which are more axes mostly uniform.

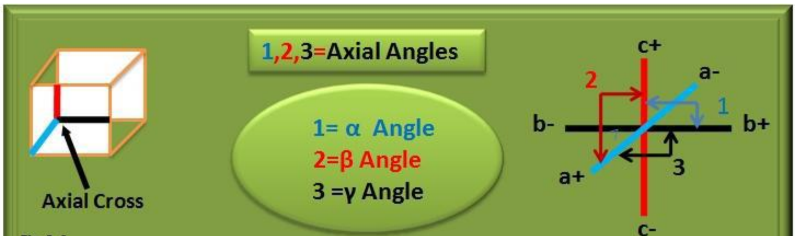


Fig.3.4.

3.8- Crystal Systems = (Crystallographic systems):

Denominations of the crystals were similar in terms of the lengths of its member's crystalline axes and angles between them, and each system crystalline symmetry elements of its own, and also distinctive crystalline axes.

3.9- System of the crystals:

The crystal systems are divided into two classes:

A- Depend on the axis lengths of crystal
x α β γ).

B- Depend on the elements of symmetry
grade in the crystal.

On the basis of **(A and B)** above, the crystal systems divided into seven systems:

1-Cubic system.
2-Tetragonal sys.
3-Hexagonal sys.
4-Trigonal sys.
5-Orthorhombic sys.
6-Monoclinic sys.
7-Triclinic system.

1- Cubic system:

A- Crystallographic axis: 1- Three axes.
2- Equal axes.
3- Perpendicular axes.

B- Elements of symmetry:
1- Axis of Symmetry=13 axis (3.Tetrad +
+ 4.Triad + 6.Diad).
1- Planes of symmetry= 9
3- Center of symmetry= present. (Fig.3.5).

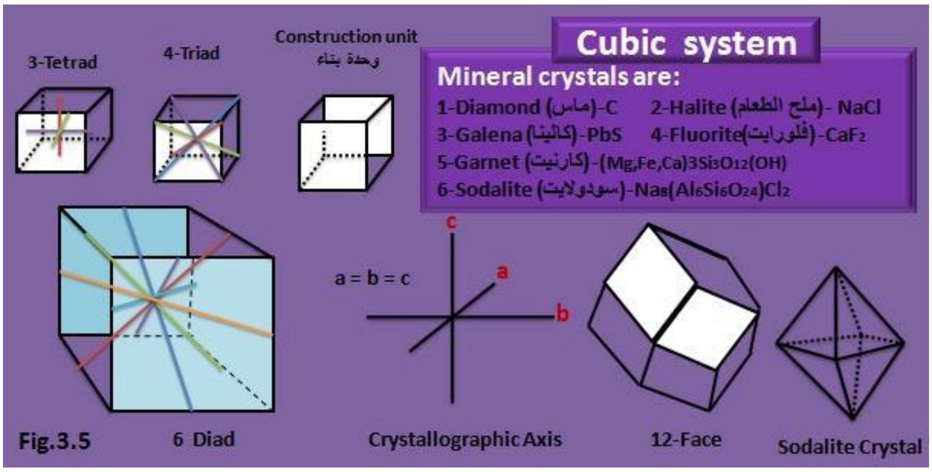


Fig.3.5

2- Tetragonal System:

A- Crystallographic Axes:
Three axes (two are equal, perpendicular and horizontal, while the third is longer or shorter and vertical on the two equal axes).

B- Elements Symmetry:
1- Axis of symmetry= 5 Axis (1.Tetrad + 4.
Diad).
2- Planes of symmetry= 5
3- Center of symmetry= present.
(Fig.3.6).
-

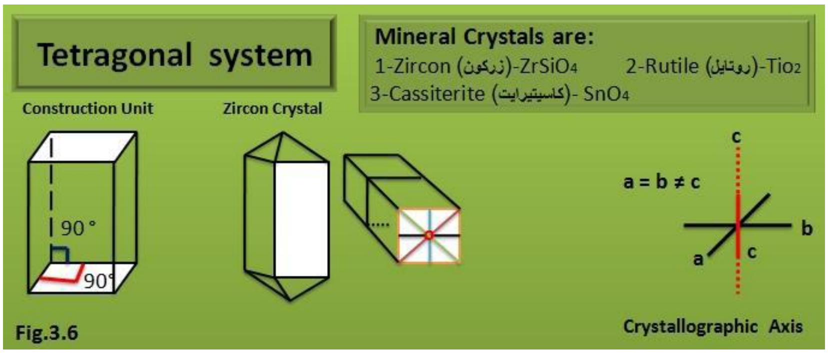


Fig.3.6

3- Hexagonal system:

A- Crystallographic axes:

Four axes (Three are equal; The angle between each two Axis is (120°). Fourth axis is longer or shorter and perpendicular on the plane of three equal axes).

B- Elements of symmetry:

1- Axes of symmetry= 7axes (1. Hexad + 6. Diad).
2- Plane of symmetry= 7
3- Center of symmetry= present. (Fig.3.7).

4- Trigonal system:

The Trigonal system is like hexagonal system except:
A- One axis of symmetry (1- Triad).
B- Non existence any horizontal planes of symmetry.

Mineral crystals (Trigonal System) are:
1- Calcite- $CaCO_3$
2-Corundum-Al_2O_3
3- Hematite-Fe_2O_3
4- Dolomite- $(CaMg)CO_3$

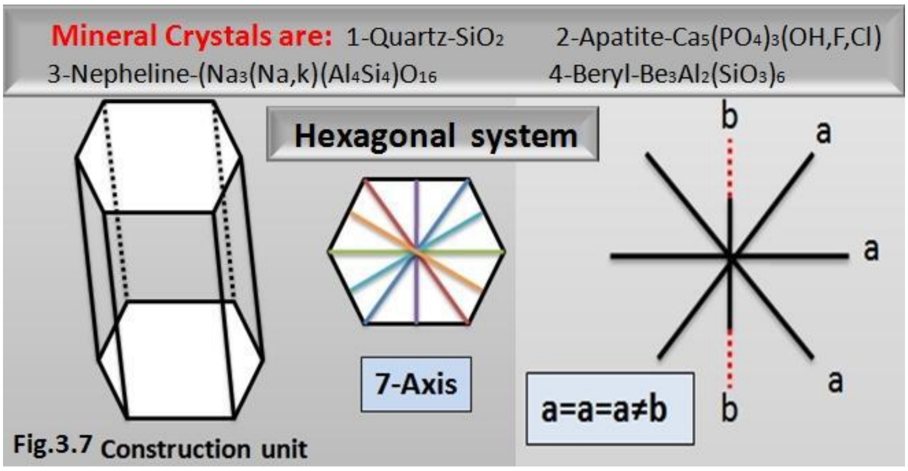


Fig.3.7

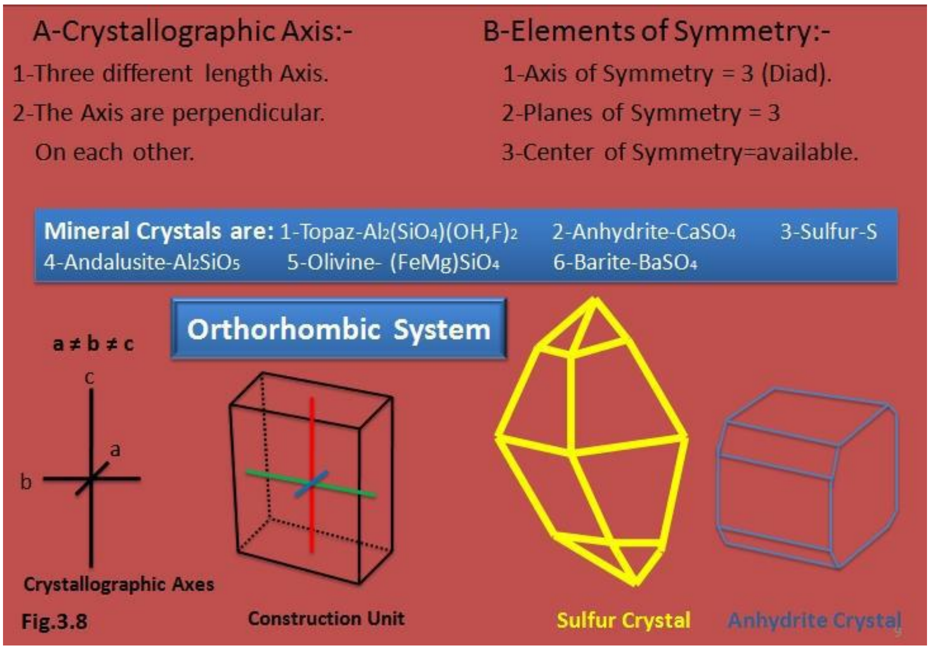
5- Orthorhombic system:

A- Crystallographic axes:

1- Three different length axes.
2- The axes are perpendicular on each other.

B- Elements of symmetry:

1- Axes of symmetry = 3 (Diad).
2- Planes of symmetry = 3
3- Center of symmetry = present.
(Fig.3.8).



6- Monoclinic system:

A- Crystallographic axes:

1- Three unequal axes.
2- Two axes intersects (A and C) at inclined β).
Beta angle sandwiched between a and b axes. Differ in the value of different metal crystals, which is less than 90 degrees in the lateral direction, and more than 90 degrees in the direction of the medial
3- Third axis (B) is perpendicular on the plane of (A and C).

B- Elements of Symmetry:

1- Axis of symmetry = 1 (Diad) conformable with (b) Axis.
2- Planes of Symmetry = 1 pass by (a and c axis).
3- Center of symmetry = present. (Fig.3.9).

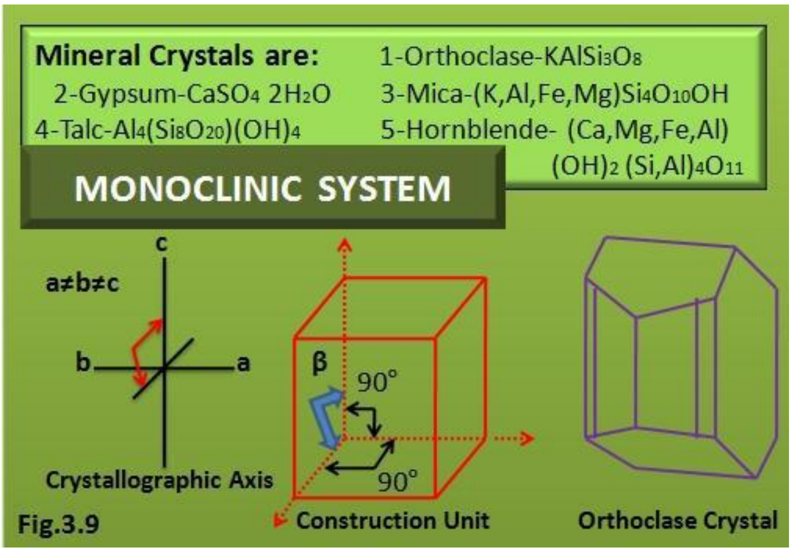


Fig.3.9

7- Triclinic system:

A- Crystallographic axes:

1- Three unequal axes.

2- Un-perpendicular axes.

B- Elements of Symmetry:

1- Axes of symmetry = absent.

2- Planes of symmetry = absent.

(Fig.3.10).

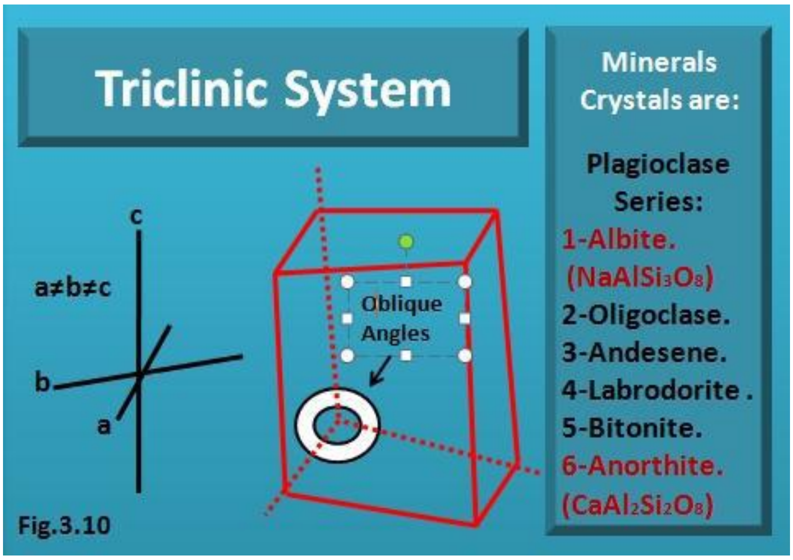


Fig.3.10

1- What is the meaning of crystal? Write the natural properties of crystals.
2- What is the crystal symmetry and elements of symmetry?
3- How many crystal systems in the earth crust minerals?
4- Match the correct words for the following

: A- Plagioclase Cubic system.

B- Beryl	Tetragonal sys.
C- Diamond	Hexagonal sys.
D- Hematite	Trigonal sys.
E- Zircon	Orthorhombic sys.
F- Quartz	Monoclinic sys.
G- Anhydrite	Triclinic system.

Minerals:

3.10- Introduction:

Mineral is inorganic substance which occurs naturally, and typically has a crystalline structure whose characteristics of hardness, luster, color, cleavage, fracture, and relative density can be used to identify it. Each mineral has a characteristic chemical composition.

Earth's crust is the source for a wide variety of useful and essential minerals.

Most people know that copper is used for electrical wiring and gold is used for jewelry.

But most people are not aware that the main ingredient in cosmetics is a powdered form of the mineral talc $Mg_3Si_4O_{10}(OH)_2$ or that the mineral quartz (SiO_2) is the main ingredient in glass. (Fig.3.11).

In addition to the economic importance of rock and minerals, events such as volcanic eruptions, mountains building, and earthquakes all involve these earth materials.(Fig.3.12). 1.

1-A rock can be defined simply as an aggregate of one or more minerals. Aggregate is mixture of minerals or rock can be sorted by the mechanical means.

2-Although most rocks are composed of more than one mineral, certain minerals are found in large, impure quantities. In these instances, they are considered to be a rock.

3-It is showing limestone outcrop (composed of the mineral calcite).

4-Nearly **4000** different minerals have been identified. No more than a few dozen are abundant.

Collectively, these few make up most of the rocks of earth's crust; they are classified as **rock- forming minerals**. 3.

By contrast:

Mineral:

A naturally occurring, inorganic solid with a definite chemical composition and a systematic internal structure.

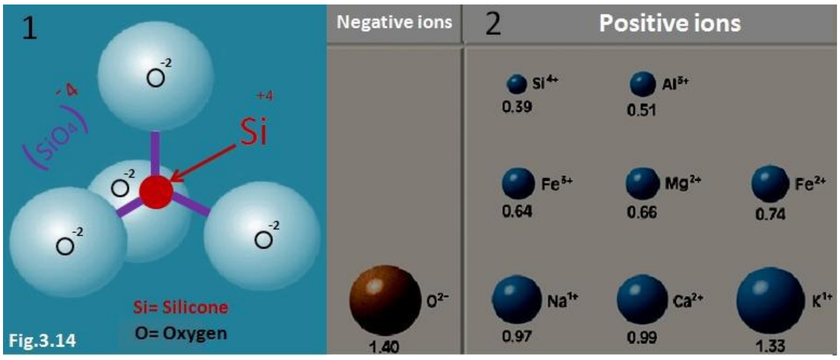
3.11- Mineral Groups:

1- Silicate group:

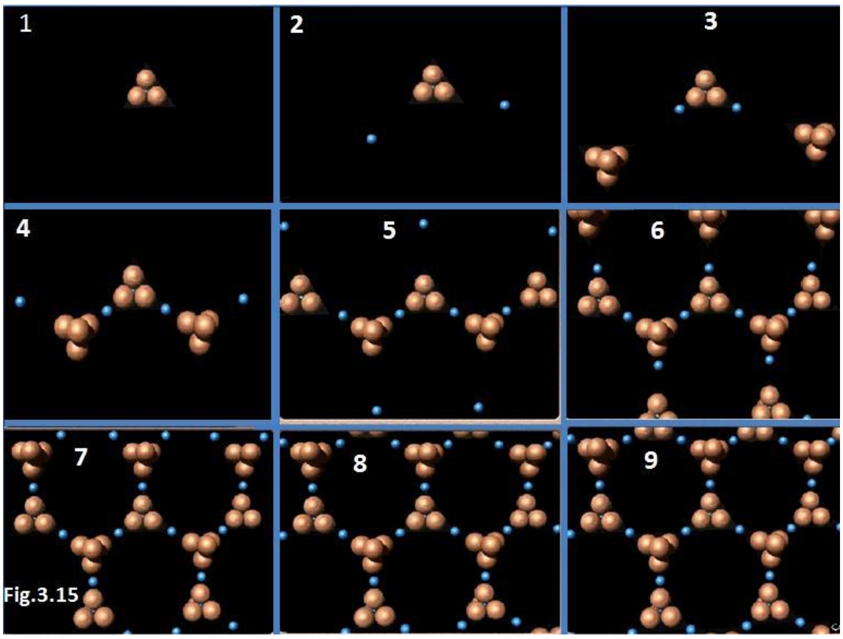
The most common group of rock forming minerals is the silicates. (Fig.3.13).

All silicates have the same fundamental building block, the silicon-oxygen tetrahedron.

The silicon- oxygen tetrahedron is not a compound. Rather, it is a complex ion with a charge of (– 4). (Fig.3.14.). 1. In nature, tetrahedral form neutral chemical compound (minerals) through the addition of positively charged ions. 2.



In this way, chemically stable structure is produced, consisting of individual tetrahedral linked together by positively charged ions.
(Fig. 3.15).



In addition, the tetrahedron may form a variety of structures by sharing the **oxygen atoms** between silicon atoms in adjacent tetrahedrons. (Fig.3.16).

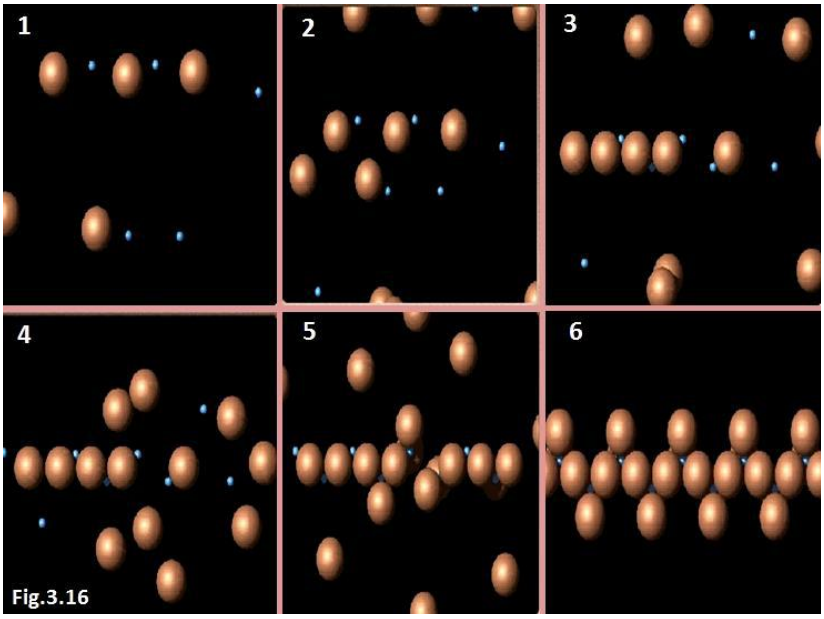


Fig.3.16

Notice that in this chain structure, each silicon atom is completely surrounded by four larger oxygen atoms. (Fig.3.17). 1.
Also notice that two of the four oxygen atoms are not shared atoms, whereas the other two are jointed to other silicon in this manner. (Fig.3.18.). 2 & 3.
It is the linkage across shared oxygen atoms that joint the tetrahedral into a chain structure. (Fig. 3.19). 4.

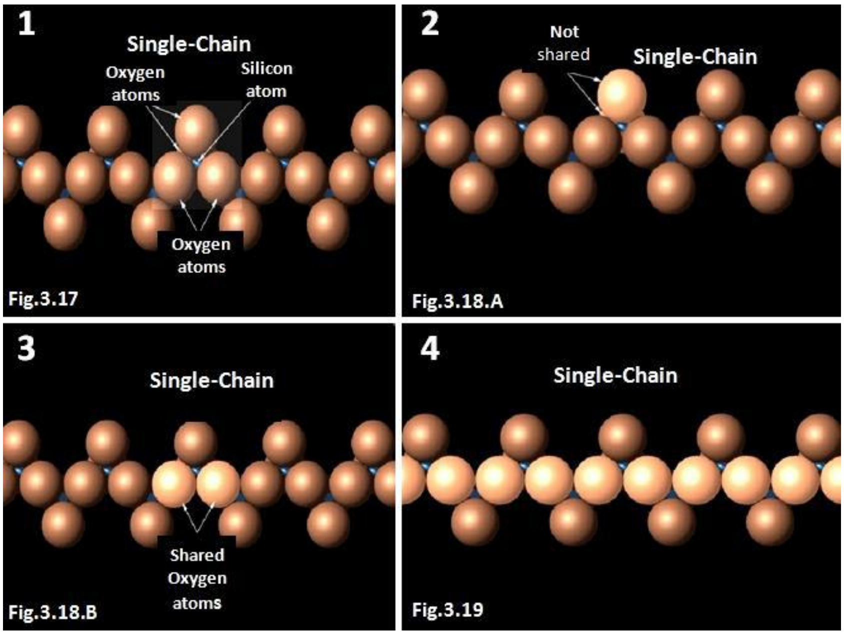


Fig.3.17 Fig.3.18.A Fig.3.18.B Fig.3.19

Other silicate structure exists. These include **double chains.** (Fig.3.20). 1. 2. 3. **Sheet structures** (Fig. 3.21). 1. 2. 3.

Complex **three-dimensional frameworks** (Fig.3.22)**.**

By now we may have noticed that the ratio of silicon atoms to oxygen atoms differs in each silicate structure. (Fig.3.23).

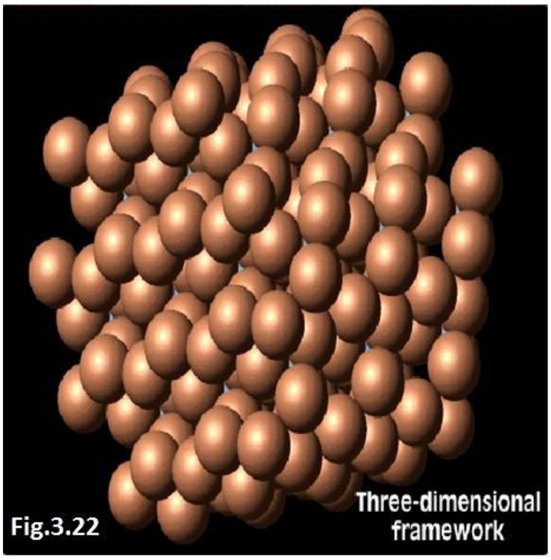


Fig.3.22

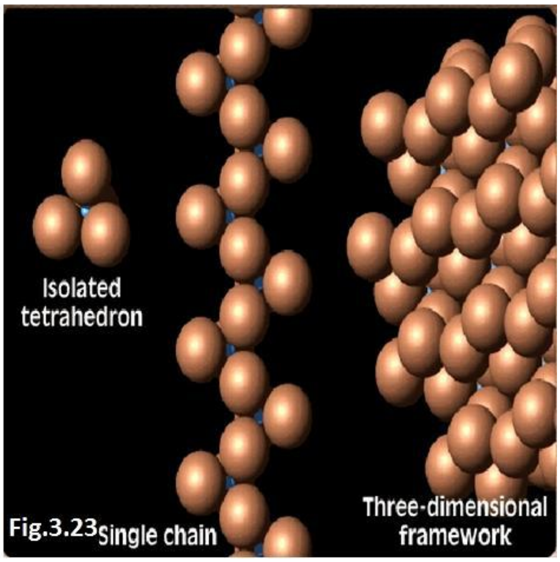


Fig.3.23

Minerals composed of isolated **tetrahedrons** contain 1 silicon atom for every 4 oxygen atoms like Olivine. (Fig.3.24).
Whereas in the **single chain,** the silicon-to oxygen ratio is 1 to 3 like Augite (An important member of the pyroxene group of silicate minerals. (Ca(Mg,Fe)Si_2O_6). (Fig.3.25).
While in the **three- dimensional** framework, the silicon to oxygen ratio is 1 to 2 like Quartz (Fig.3.26).
Whenever more oxygen atoms are shared, the percentage of silicone in the minerals increases. (Fig.3.27).

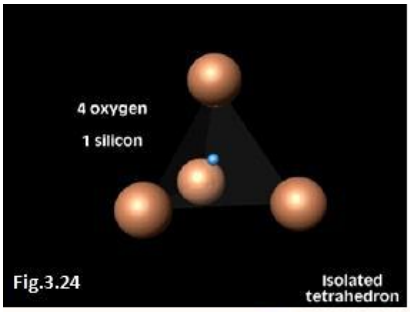


Fig.3.24

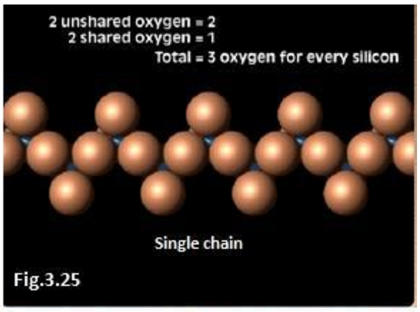


Fig.3.25

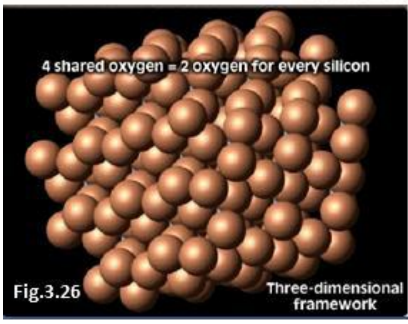


Fig.3.26

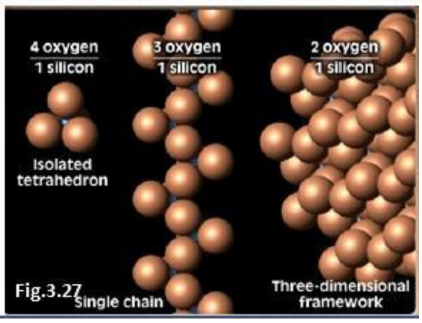


Fig.3.27

Silicate minerals are described as having "high" or "low" silicon content based on the ratio of silicon to oxygen. This difference in silicon content is important, as we will see when consider igneous rocks. (Fig.3.28).

Like the silicon- oxygen tetrahedron, most other silicate structures are not neutral chemical compounds. (Fig.3.29).1

They are all neutralized by the inclusion of positively charged metallic ions (Fig.3.29).2 that bind them together into a variety of crystalline configurations.

(Fig.3.30). (Fig.3.30).

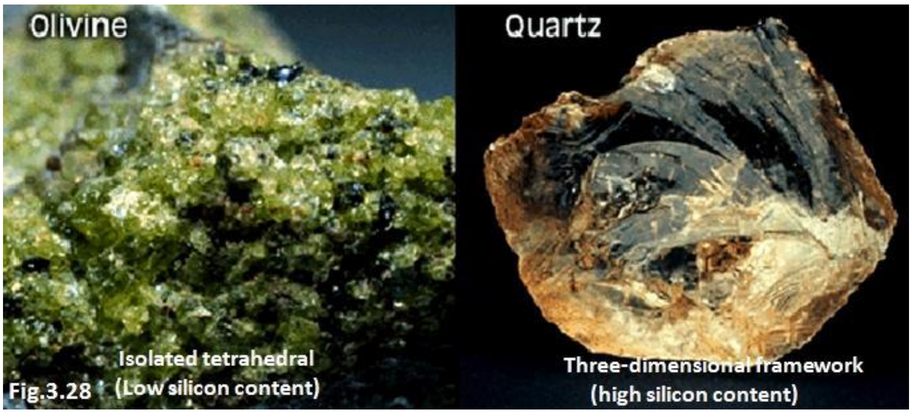


Fig.3.28

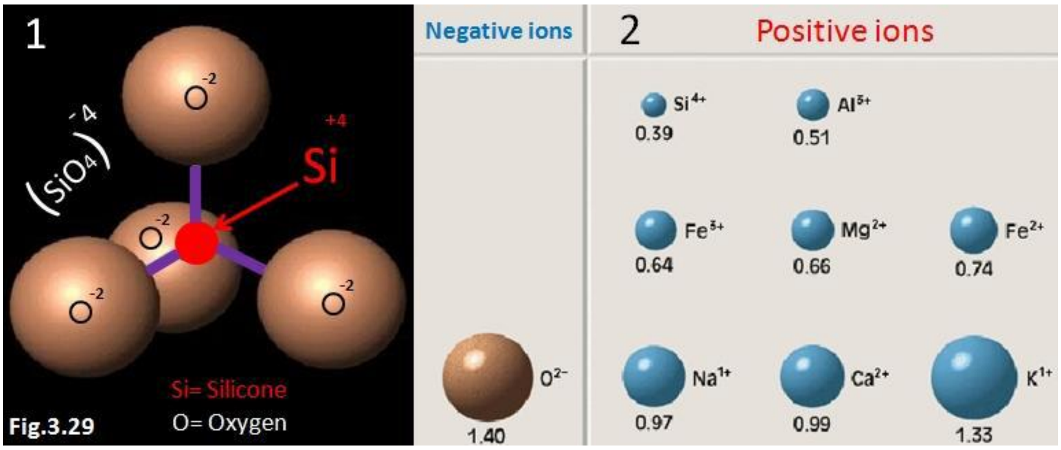


Fig.3.29

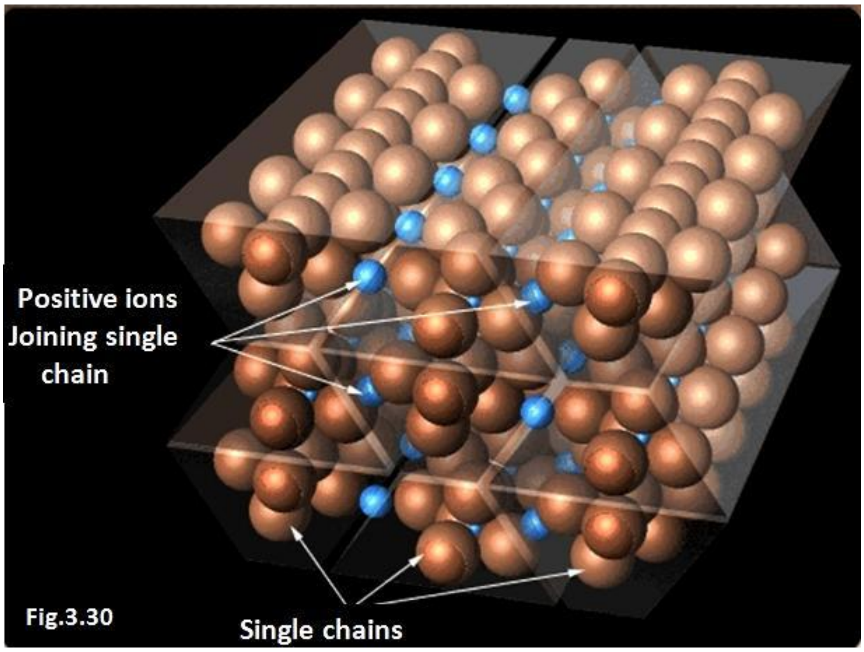


Fig.3.30

The major groups of silicate minerals and common examples are shown below:

Because the silicone-oxygen bonds are strong, silicate minerals tend to cleave or break between the silicon-oxygen structures rather than across them. (Fig.3.31).
For example, the micas have a sheet structure and thus tend to cleave into flat plates. (Fig.3.32).
Quartz, which has equally strong silicon-oxygen bonds in all directions, has no cleavage, but **fractures** instead. (Fig.3.33).
The silicates are generally divided into **two major groups** on the basis of their **chemical makeup**. (Fig.3.34).

Non ferromagnesian silicate (light).
The ferromagnesian silicates (dark) are minerals in which ions of iron (Iron = Ferro) and/or magnesium join their silicates structures (Fig.3.35).
Because of their iron content, ferromagnesian silicates are darker in color (Fig.3.35) and have higher specific gravity than the **non ferromagnesian silicates (light)** (Fig.3.36).

2- Carbonate group:

Other important rock forming minerals groups include the **carbonates.**
Calcite $CaCO_3$ (Fig.3.37) and dolomite (CaMg) CO_3 (Fig.3.37). They are commonly found in the **sedimentary rocks** limestone and dolostone (dolomite)

Fig.3.37

3- Sulphate and Halides groups:

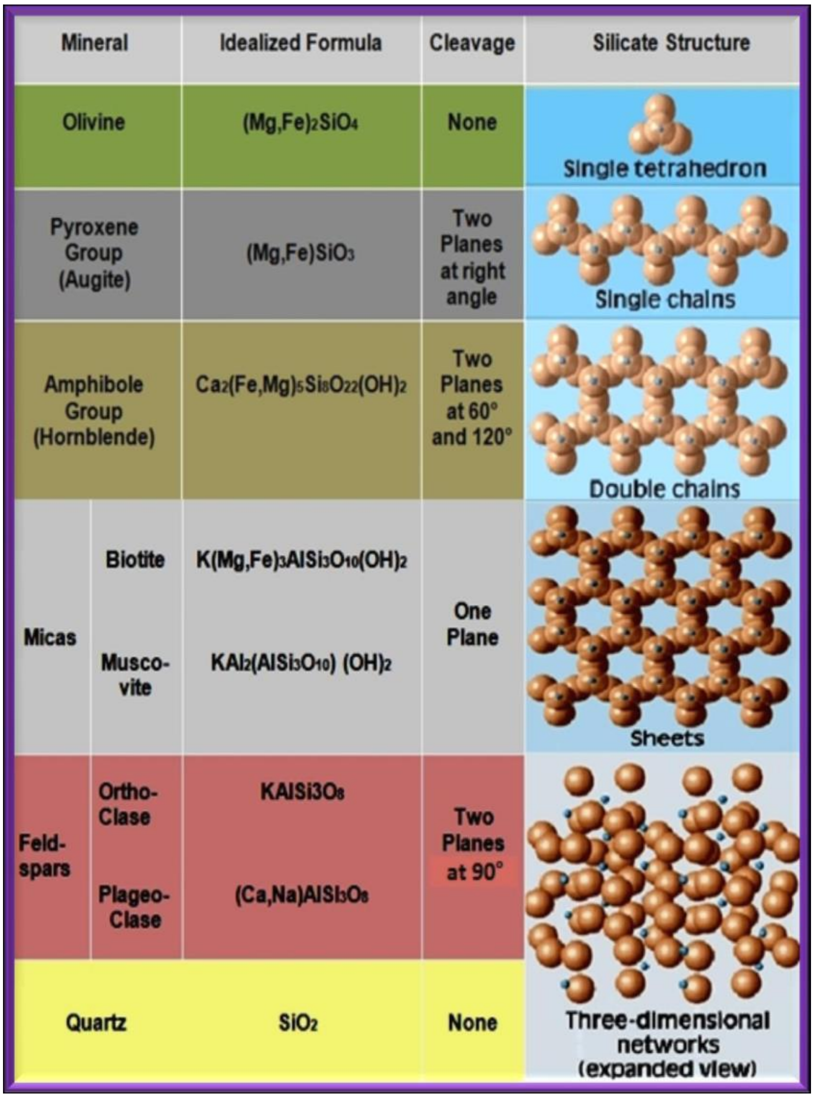
Three other non silicate minerals frequently found in sedimentary rocks are:

1-gypsum $CaSO_4.2H_2O$ (Fig.3.39). 1.

2-Halite (NaCl). 2.

3-**fluorite** (CaF_2)). 3.

Gypsum and halite are found in thick layers, which are the last vestiges of ancient seas that have long since evaporated.



Mineral		Idealized Formula	Cleavage	Silicate Structure
Olivine		$(Mg,Fe)_2SiO_4$	None	Single tetrahedron
Pyroxene Group (Augite)		$(Mg,Fe)SiO_3$	Two Planes at right angle	Single chains
Amphibole Group (Hornblende)		$Ca_2(Fe,Mg)_5Si_8O_{22}(OH)_2$	Two Planes at 60° and 120°	Double chains
Micas	Biotite	$K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$	One Plane	Sheets
	Musco-vite	$KAl_2(AlSi_3O_{10})(OH)_2$		
Feld-spars	Ortho-Clase	$KAlSi3O_8$	Two Planes at 90°	Three-dimensional networks (expanded view)
	Plageo-Clase	$(Ca,Na)AlSi_3O_8$		
Quartz		SiO_2	None	

4- Oxides group:

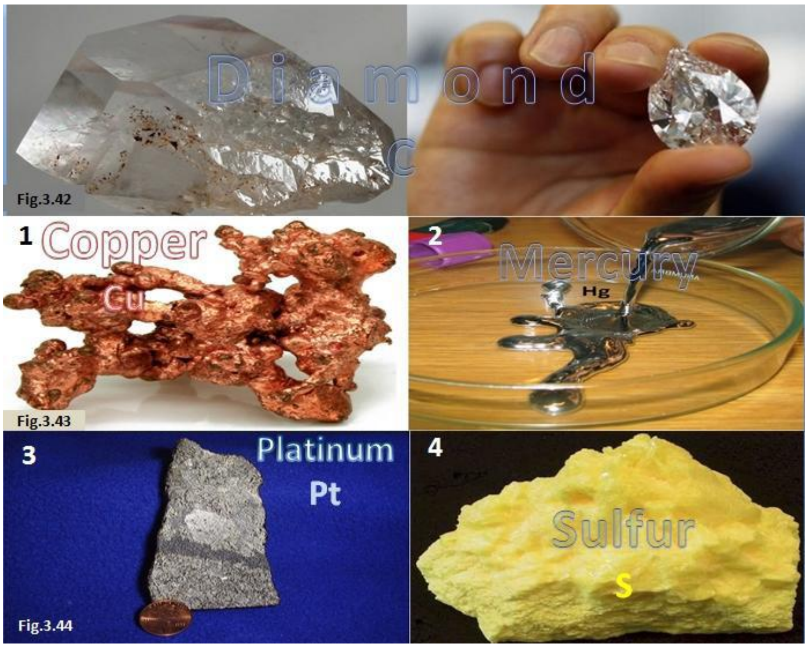
Although scarce when compared to the silicates, other mineral groups are important economically. These include the oxides like Magnetite Fe_3O_4.
(Fig.3.40).

5- Sulfides group:

Bornite Cu_5FeS_4 is the ore of the cupper. (Fig.3.41).

6- Native element:

Any element found in earth crust naturally, unattached in the form of Ore mineral Like native diamond C which is used as gemstone and abrasive (Fig.3.42) ..., cupper Cu, and mercury Hg (Fig.3.43.). 1 and 2. … A Platinum Pt and Sulfur (Fig.3.44). 3 and 4.



3.12- Physical properties of Minerals:

Every mineral has an orderly arrangement of atoms and a definite chemical composition which gives it a unique set of physical properties.

1- Crystal form:

It is the external expression of a mineral's orderly internal arrangement of atoms like Pyrite (FeS_2) of cubic system and quartz(SiO_2) of hexagonal crystals with pyramidal-shaped ends. (Fig.3.45).

2- Luster:

It is the appearance or quality of light reflects from the surface of mineral.

A- Pyrite (FeS_2) … Metallic luster. (Fig.3.46).1.
B- Fluoride (CaF_2) … non metallic luster. 2.
C- Chalk ($CaCO_3$-Very fine pure grains) …
Non metallic earthy luster. 3.
D- Quartz (SiO_2) … non metallic glassy
Luster. 4.
E- Bornite (Cu_5FeS_4-Ore of cupper) … sub
Metallic luster. 5.
F- Muscovite ($K_2Al_4(Si_3AlO_{10})_2(OH,F)_4$ …
Non metallic pearly luster. 6.

3- Color:

It is surely the most obvious characteristic of a mineral. (Fig.3.47).

Color is not always useful diagnostic property. For example, slight impurities in the mineral quartz (SiO_2) give it a variety of colors. (Fig.3.48).

4- Streak:

It is the color of a mineral in it's powdered from and is obtained by rubbing a mineral across a piece of unglazed porcelain called **streak plate**. (Fig.3.49). 1.
Although the color of a mineral may vary from sample to sample, the streak usually does not vary. 2.

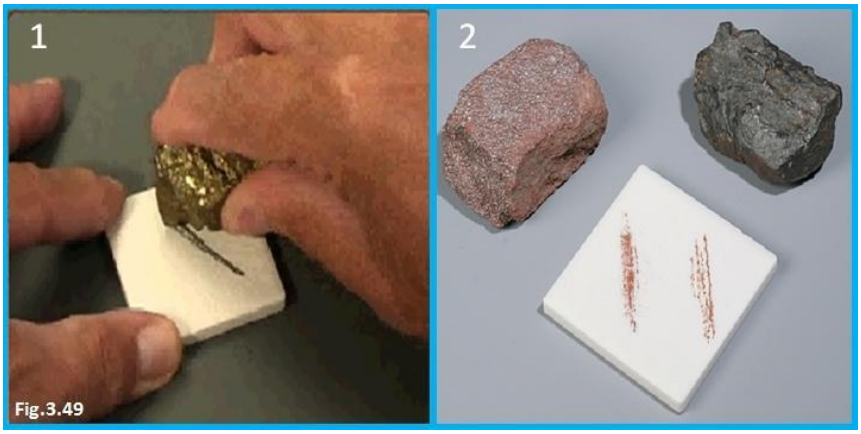
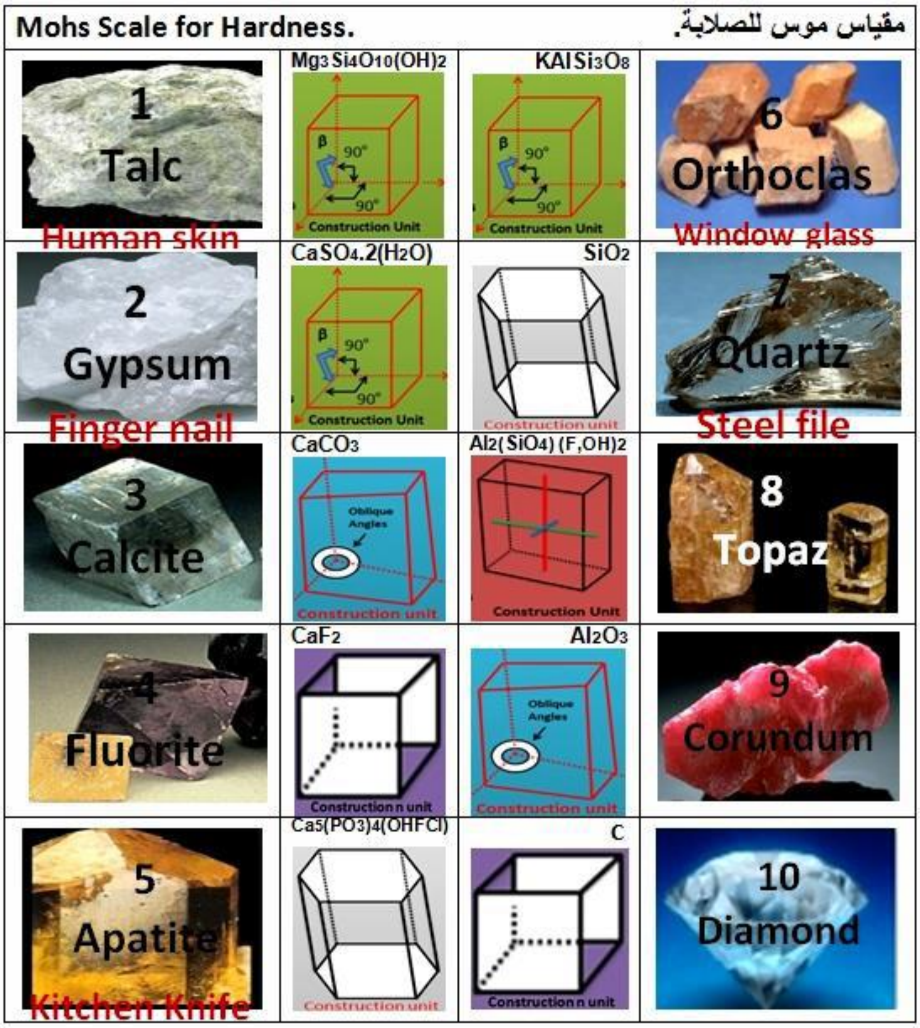


Fig.3.49

5- Hardness:

It is a measure of the resistance of a mineral to abrasion or scratching.

Mohs' scale (scientist) of hardness illustrated a relative scale for the softest and hardest minerals as below:



6- Cleavage:

It is the tendency of mineral to break along planes of weak bonding. (Fig.3.50).

The simplest type of cleavage is exhibited by the mica. (Fig.3.51). 1.

Because micas have weak chemical bonds in

The sample of muscovite below illustrates mineral that exhibit one plane of cleavage. (Fig.3.52).

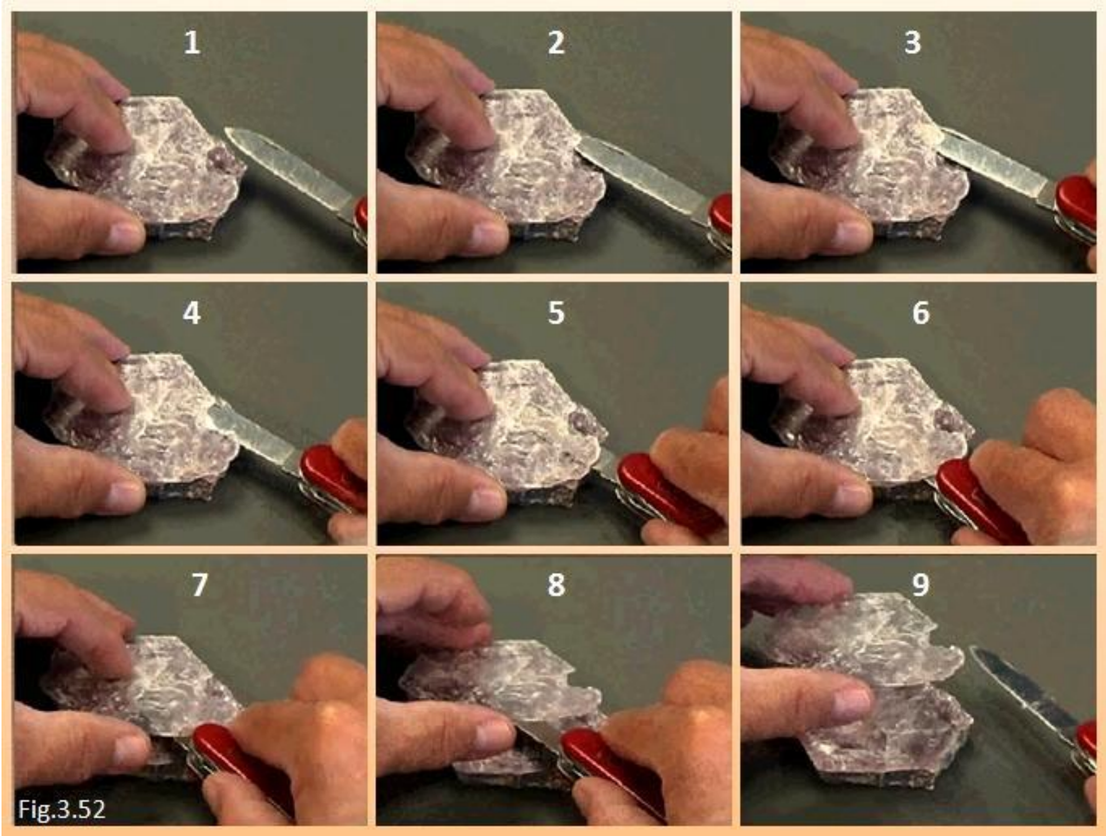


Fig.3.52

The mineral feldspar (The most important group of rock-forming silicate minerals), including the alkali feldspars $KAlSi_3O_8$ to $NaAlSi_3O_8$ (K-feldspar to albite) and the plagioclase feldspars $NaAlSi_3O_8$ to $CaAl_2Si_2O_8$ (albite to anorthite), has two cleavage directions.
(Fig.3.53).

When minerals break evenly in more than one direction, cleavage is described by the number of x F .3.54). 1…A which they meet like Halite mineral (NaCl). 2.

Calcite ($CaCO_3$) is a mineral whose cleavage angle is 75 degrees. (Fig.3.55). 1.
While hornblende includes hastingsite $Ca_2(Mg_4Al)[Si_7AlO_{22}]$ $(OH,F)_2$, tschermakite $Ca_2(Mg_3AL_2)[Si_6A_{l2}O_{22}]$ $(OH,F)_2$, edenite $NaCa2Mg_5[Si_7AlO_{22}](OH,F)_2$, and pargasite $NaCa_2(Mg_4Al)[Si_6Al2O_{22}](OH,F)_2$; has 2 cleavage angles, one at 60 degrees and one at 120 degrees. 2.

7- Fractures:

It is important not to confuse cleavage with crystal form. Remember, crystal form is the external expression of a mineral's orderly arrangement of atoms. Whereas, cleavage is the tendency of minerals to break along planes of weakness.
All minerals have crystal form, but some minerals lack cleavage.
Minerals that do not exhibit cleavage when broken are said **fracture**, like Malachite $Cu_2CO_3(OH)_2$ mineral. (Fig.3.56). 1.

Three kinds of fractures are:

a- Irregular fracture (Bornite Cu_5FeS). 2.

b- Conchoidal fracture (resemble broken glass). (Quartz SiO_2). 3.

c- Fibrous fracture. (Serpentine) $Mg_6[Si_4O_{10}](OH)_8$. 4.

7- Specific gravity:

It is a number representing the ratio of the weight of mineral to the weight of an equal volume of water at 4 centigrade.

For example: The specific gravity of quartz

Is (2.7) galena (7.5) and gold (20).

Most common minerals have a specific gravity of between **(2.5 – 3)**.

9- Other properties:

Other properties can be used to identify some minerals. (Fig.3.57).

For example: halite ($NaCl$) is ordinary table salt. It can be identified with your tongue. 1.

And talc $(Mg_3Si_4O_{10}(OH)_2$ feels soapy. 2.

Some varieties of magnetite (Mg_3O_4) are natural magnets. 3.

And certain minerals will effervesce (fizz) when hydrochloric acid is added Calcite $CaCO_3$. 4.

3.13-Eeconomic use.

Economic minerals include a wide range of minerals which are used in various fields, among them groups of native elements, oxides, sulfides, halides, carbonates, sulfates, phosphates and hydroxides in addition to silicates as shown below.

Group	Member	Formula	Economic use
Native elements العناصر الحرة	Gold	Au	Jewelry, Electronics المجوهرات، والالیكترونيات
	Cupper	Cu	Electronics الالیكترونيات
	Diamond	C	Abrasive Gemstone قشط، حجر كريم
	Sulfur	S	Sulfur drags, Chemical أدوية كبريتية، الكيميائيات
	Graphite	C	Pencil lead, Dry lubricant أقلام الرصاص، زيت التشحيم
	Silver	Ag	Jewelry, Photography المجوهرات، التصوير
	Platinum	Pt	Catalyst محفز
Oxides الاكاسيد	Hematite	Fe_2O_3	Ore of iron خام الحديد
	Magnetite	Fe_3O_4	Ore of iron خام الحديد
	Corundum	Al_2O_3	Gemstone, Abrasive حجر كريم، قشط
	Chromite	$FeCr_2O_4$	Ore of chromium خام الكروم
Sulfides الكبريتيدات	Galena	PbS	Ore of lead خام الرصاص
	Sphalerite	ZnS	Ore of zinc خام الزنك
	Pyrite	FeS	Foal's gold الذهب الكاذب
	Chalcopyrite	$CuFeS_2$	Ore of copper خام النحاس
	Bornite	Cu_5FeS_4	Ore of copper خام النحاس
	Cinnabar	HgS	Ore of mercury خام الزئبق
Halides الهاليدات	Halite	$NaCl$	Common salt ملح الطعام
	Fluorite	CaF_2	Use in steel making صناعة الفولاذ
	Sylvite	KCl	Fertilizer صناعة الأسمدة
Carbonate الكربونات	Calcite	$CaCO_3$	Portland cement الاسمنت البورتلاندي
	Dolomite	$CaMg(CO_3)_2$	Portland cement الاسمنت البورتلاندي
	Aragonite	$CaCO_3$	Portland cement الاسمنت البورتلاندي
Sulfates الكبريتات	Gypsum	$CaSO_4.2H_2O$	Plaster صناعة الجص
	Anhydrite	$cASO_4$	Plaster صناعة الجص
	Barite	$BaSO_4$	Drilling mud طين حفر الآبار
Phosphates الفوسفات	Apatite	$Ca_5(PO_4)_3(F,Cl,OH)$	Fertilizers صناعة الأسمدة
	Turquoise	$CuAl_6(PO_4)_4(OH)_3.4H_2O$	Gemstone حجر كريم
Hydroxide الهيدروكسيدات	Limonite	$FeO(OH).nH_2O$	Ore of iron, pigments خام الحديد، صناعة الأصباغ
	Bauxite	$Al(OH)_3.nH_2O$	Ore of aluminum خام الألمنيوم
Silicates السيليكات	Silicate minerals make up about 92 percentage of earth's crust		

1- Which of these mineral properties may be of mineral value in identifying the mineral quartz? a- luster. b- hardness. c- color. d- crystal form.
2- The ratio of silicone atoms to oxygen atoms in the same methods in each of the various silicate structures. a- true. b- false.
3- Which of these silicate minerals exhibits a sheet structure? a- quartz. b- muscovite. c- olivine. d- feldspar.
4- Which of these following is NOT a property used to identify minerals? a- hardness. b- streak. c- texture. d- crystal form.
5- The most common group of rock-forming minerals is the ------------------------. a- oxides. b- silicates. c- carbonates. d- sulfides.
6- When minerals break evenly in more than direction, cleavage is described by the number of planes exhibited and the angles at which they meet. a- true. b- false. 7- Most rocks are aggregates of minerals. a- true. b- false.

8- A cubic centimeter of quartz and gold Weight 2.7 and about 20 grams respectively. This indicates that ----------. a- Gold has a much higher specific gravity than quartz.

7- b- gold is much harder than quartz. c- gold is elastic than quartz. d- gold has a greater luster than quartz.
8- All ferromagnesian minerals contain one or both of these elements: a- iron, magnesium. b- magnesium, potassium. c- potassium, sodium. d- sodium, silicone. 10- The two major groups of silicate minerals are the ferromagnesian silicate and non ferromagnesian silicates. a- true. b- false.
11- All silicate minerals contain which of the following two elements? a- iron, magnesium. b- iron, silicone. c- silicone, oxygen. d- magnesium, silicone.
12- Which of these mineral properties may be of minimal value in identifying the mineral quartz? a- luster. b- hardness. c- color. d- crystal form.
13- All the minerals have a crystal form. a- true. b- false.
14- Which one of the following sets of two terms described how a mineral responds to mechanical impact? a- luster, hardness. b- hardness, cleavage. c- cleavage, fracture. d- fracture, crystal form.

15- The silicone - oxygen tetrahedron is a complex ion. a- true. b- false.

Chapter four: Rock cycle الفصل الرابع: دورة الصخور

-Kinds of rocks.

1-Igneous rocks.

-Introduction to igneous rocks.

-Texture of igneous rocks.

-Composition of igneous rocks.

-Naming of igneous rocks.

2-Sedimentary rocks.

-Introduction to igneous rocks.

-Types of sedimentary rocks.

-Sedimentary environment.

3-Metamorphic rocks.

-Introduction to metamorphic rocks.

-Agents of metamorphism.

-Texture and mineralogical changes.

-أنواع الصخور.

١-الصخور النارية.

-مقدمة الصخور النارية.

-نسيج الصخور النارية.

-تركيب الصخور النارية.

-تسمية الصخور النارية.

٢-الصخور الرسوبية.

-مقدمة الصخور الرسوبية.

-أنواع الصخور الرسوبية

-البيئات الرسوبية.

٣-الصخور المتحولة.

-مقدمة الصخور المتحولة.

-عوامل التحول.

-التغيرات النسيجية والمعدنية.

Rocks cycle:

The rock cycle is one means of viewing many of the interrelation in geology.
The rock cycle shows the origin of the three c ck … ff geologic processes transform one rock type into another.

Kinds of rocks:

There are three kinds of rocks are present in the earth crust. (Fig.4.1).

1- Igneous rocks.
2- Sedimentary rocks.
 9- Metamorphic rocks.

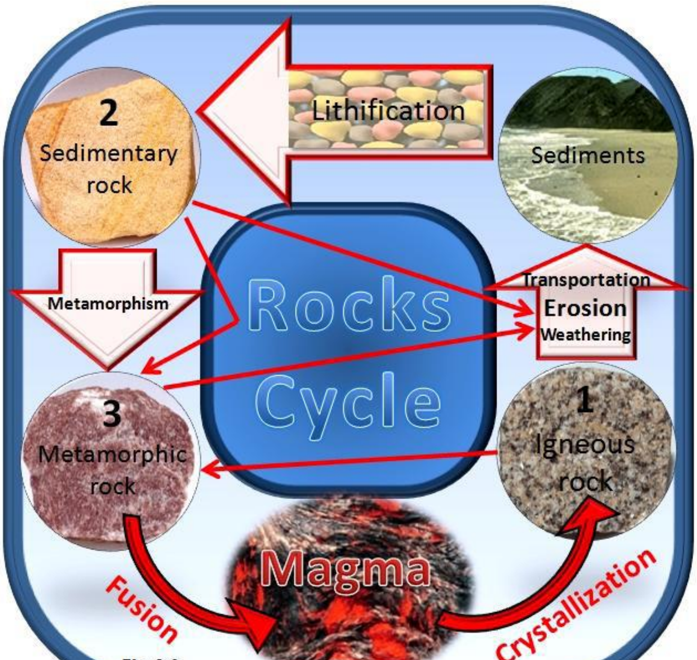


Fig.4.1

4.1- Igneous rocks:

1- **Igneous rocks** originated when molten material called **magma** cools and solidifies. (Fig.4.2).

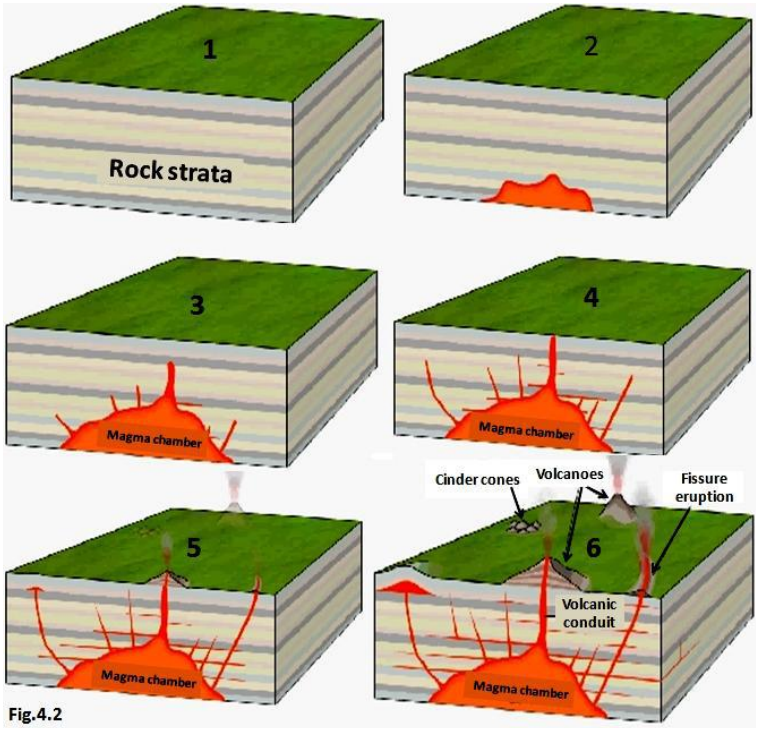
2- 

Fig.4.2

This process, called **crystallization**, may occur E ' f c . … O f c (Fig.4.3).

When igneous rocks are exposed at the surface, they will undergo **weathering**, a process which slowly disintegrated and decomposes rocks. (Fig.4.4).

The rock fragments are picking up and transported by **erosion agents** (Fig.4.5)., such as:
a- Running water. 1.
b- Glaciers. 2.
c- Winds. 3.
d- Waves. 4.

Eventually these particles and dissolved substance, called **sediments**, are deposited in the form of (Fig.4.6):
a- Delta deposits. 1.
b- Glacial moraine. 2.
c- Dunes deposits. 3.
d- Beach deposits. 4.

Next, the sediments undergo a process called **Lithification**, meaning "conversion to rock," either by:
1-Compaction. (Fig.4.7).
2-Cementation. (Fig.4.8). 1. 2. 3.
The result is **sedimentary rocks** such as **shale**, **sandstone**, and **conglomerate**. 4.

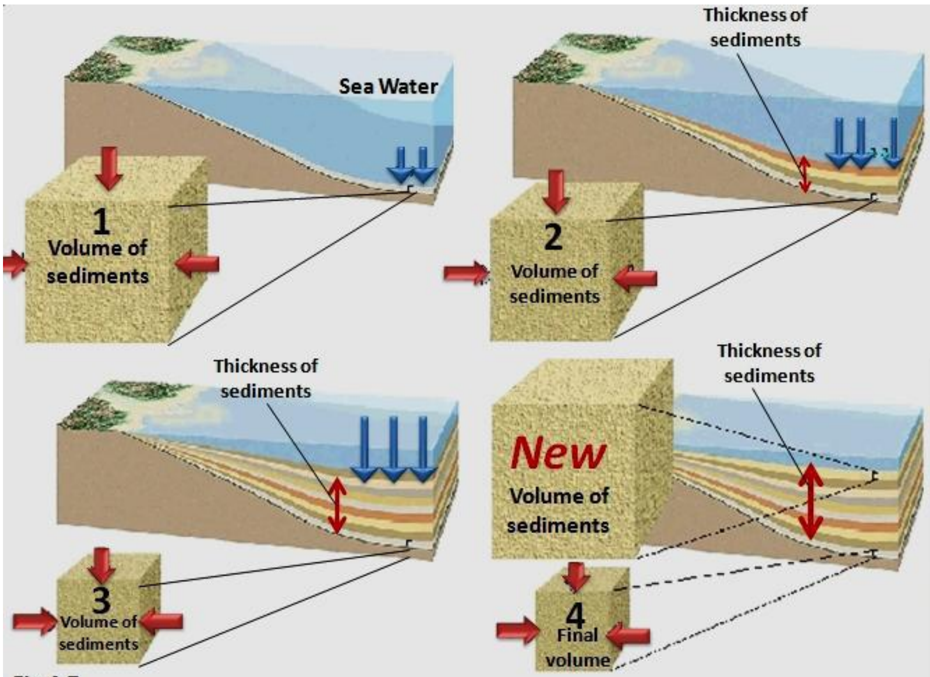


Fig.4.7

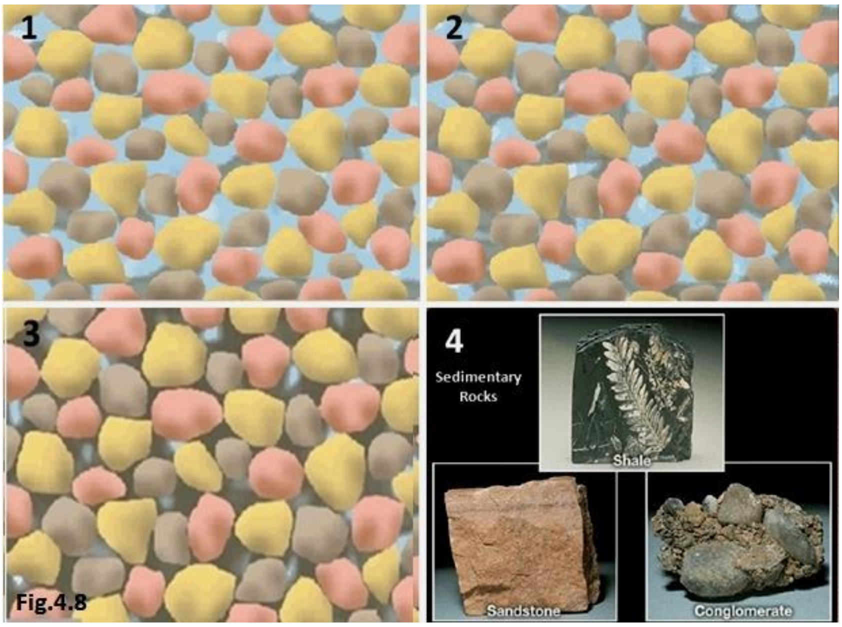
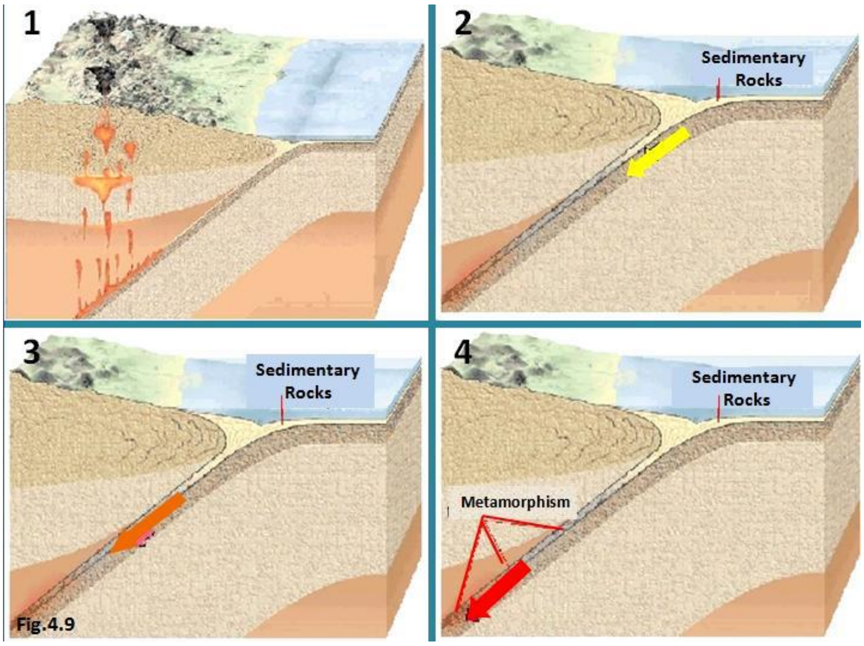


Fig.4.8

When sedimentary rocks are carried deep within earth, they will be subjected to great pressure and heat.
Any rocks subjected to strong compression forces and/or high temperatures change to metamorphic rocks.
When rocks in high temperature metamorphic environment are subjected to direct forces, they are easily folded.
Rocks that are transported to great depths may melt to **generate magma**.
(Fig.4.9).



As we saw, rocks are transformed from one type to another in a **never-ending cycle**. Earth materials do not always follow the paths shown in the rock cycle diagram. It is just as likely that **other paths** will be followed. (Fig.4.10).

4.2- Introduction to igneous rocks:

Recall from the discussion of the **rock cycle** that **igneous rocks** form when molten rock cools and **crystallizes**.

Molten rocks (**magma**) originated in the mantle and crust as a result of partial melting of solid rock.

Because the magma body is less dense than the surrounding rocks, it works its way toward the surface, occasionally producing a volcanic eruption. (Fig.4.11). 1.

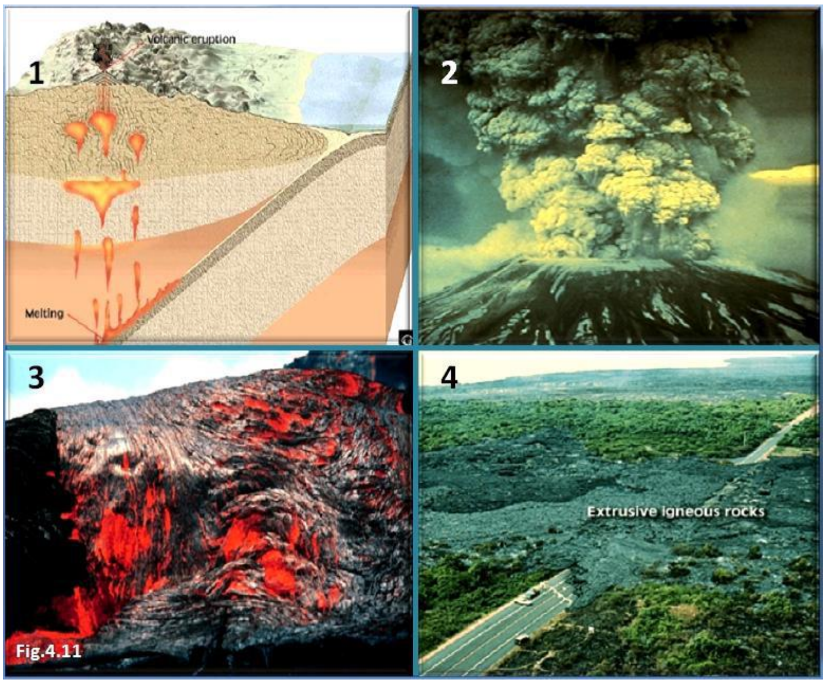
Volcanic eruptions may produce **pyroclastic debris** such as ash and cinders. 2.

Along with pyroclastic debris, volcanic eruption can produces extensive **lava flow**. 3.

Igneous rocks that form when lava solidifies are classified as **extrusive** or **volcanic igneous rocks**. 4.

Most magma never reaches the surface. Rather it crystallizes at depth to produce **intrusive** or **plutonic igneous rocks**. (Fig.4.12).

Although intrusive igneous rocks form at depth, uplifting and erosion often expose them at the surface. (Fig.4.13). 1 and 2.



Intrusive igneous rocks are exposed in many places including Yosemite National Park (California). (Fig.4.14). 1. Stone mountain. 2.
To summarize, igneous rocks form when lava cools quickly at the surface.
Or when magma crystallizes more slowly in a shallow **plutonic** like **sill**. 3.
Or at great depth over very long spans of time. 4.

4.3- Texture of igneous rocks:

The rate of cooling greatly affects both the size and arrangement of the crystals, a property called **texture**. (Fig.4.15). 1.
Rapid cooling produced **smaller crystals** and slower cooling allows time for **larger crystals** to form. 2.

Igneous rocks that form at the surface, or as small masses within the upper crust, possess a **fine-grained texture**.
Notice that the grains in fine-gained rocks are too small for individual minerals to be distinguished with the unaided eye. (Fig.4.16). 1.
Many fine-grained rocks contain voids leaved by gas bubbles that escaped as lava solidifies. These volcanic rocks usually form near the surface of lava flows and are said to a **vesicular texture**. 2.

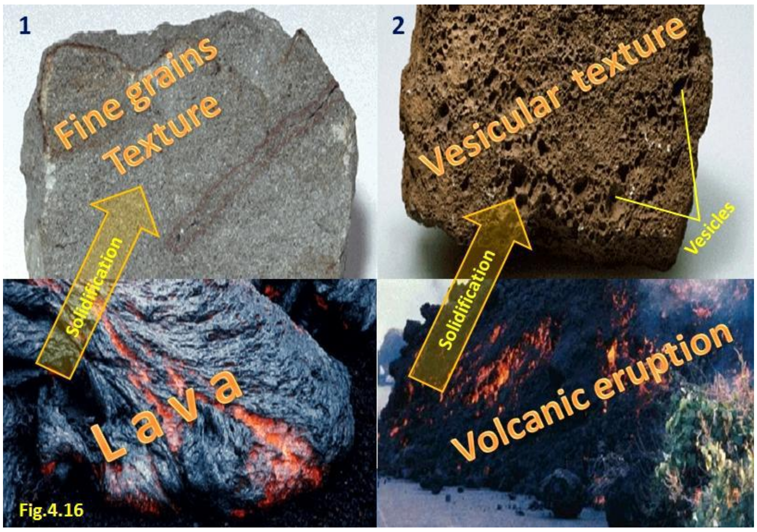


Fig.4.16

When large masses of magma solidify at depth, they form igneous rocks that exhibit a coarse-grained texture.
In contrast to fine-grained rocks, the individual minerals in coarse- grained rocks can be identified with the unaided eye. (Fig.4.17).

Rapid cooling of **lava** may generate a **glassy texture**. Glass results when the ions are unordered, that is, they have not formed an orderly crystalline structure.
Rocks with a glassy texture, like **obsidian**, also form when silica-rich lava is extruded as a viscous mass that solidifies as a glass. (Fig.4.18).

During some volcanic eruptions, silica-rich lava is ejected into the atmosphere where it is cooling quickly.
These events can generate a foamy mass of fine shards of intertwined glass called **pumice**. (Fig.4.19).

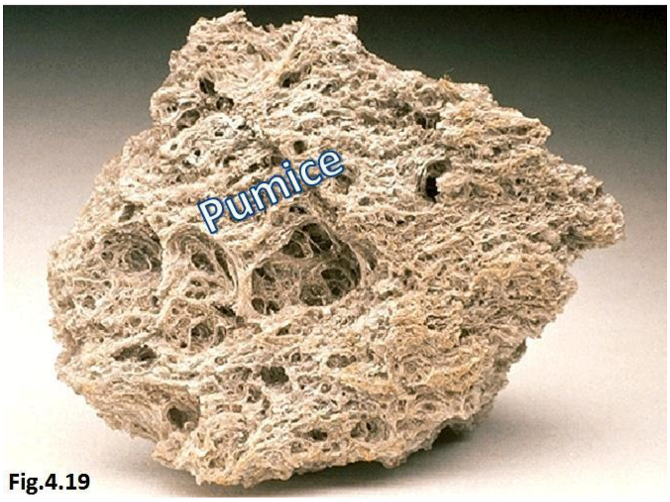


Fig.4.19

Some igneous rocks have large crystals embedded in a matrix of smaller crystals.
These rocks are said to have a **porphyritic texture**.
The large crystals in such a rock are referred as **phenocrysts**, with the matrix of smaller crystals called (**fine-grained**) **groundmass**. (Fig.4.20). 1.

Porphyritic rocks form when certain minerals begin to crystallize and grow quite large before others begin to form. 2.
Then the magma containing these large crystals migrates to a new environment where cooling takes place more rapidly. 3.
In this situation, the rock will have a **porphyritic** texture as shown in the sample below.
In other situation, the magma may migrate to a smaller intrusive body where cooling occurs more rapidly, but still slowly enough to produced visible crystals. 4.

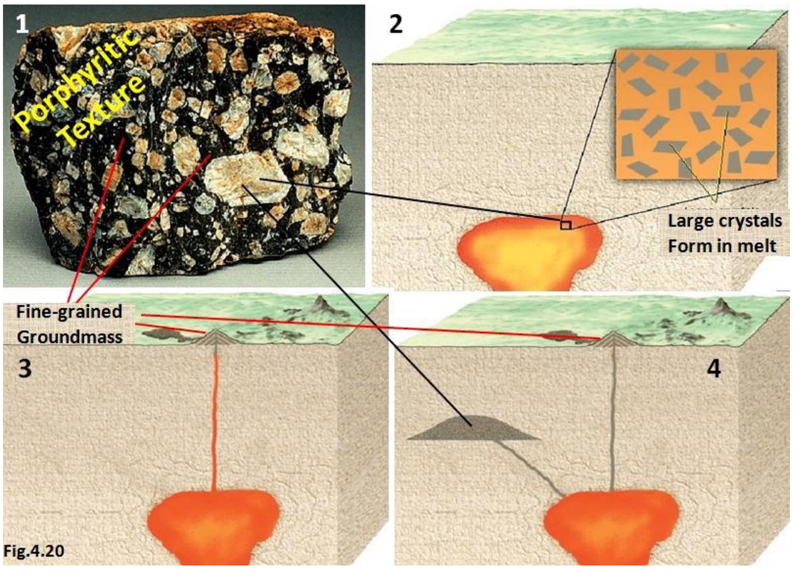


Fig.4.20

4.4- Compositions of igneous rocks:

Igneous rocks come in a **wide variety** of mineral composition. Igneous rocks are mainly composed of **silicate minerals**.
These silicate minerals are divided into two major groups based on their mineral makeup:

- The dark silicate.
- The light silicate.

The dark silicates are rich in iron and / or magnesium. **It is their iron content that gives the dark silicates their color**.
Igneous rocks can be composed mainly of **dark silicate minerals**. (Fig.4.21).

Dark Silicate	Light Silicate
Olivine $(Mg,Fe)SiO_4$	(Muscovite) $K2Al_4[Si_3AlO_{10}]_2(OH,F)_4$
Pyroxene group (Augite) $Ca(Mg,Fe)Si_2O_6$	Orthoclase ($KAlSi_3O_8$) Feldspar
Amphibole group (Hornblende) $(CaMgFeAl(OH)_2(SiAl)_4O_{11}$	Plagioclase $(NaCa)Al_2Si_2O_8$ Feldspar
Dark mica (biotite) $K_2(Mg,Fe)_6[Si_3AlO_{10}]_2(OH,F)_4$	Quartz SiO_2

By the contrast, the **light silicates** contain greater amounts of potassium, sodium and calcium rather than iron and magnesium.
Igneous rocks can be composed mainly of **light silicate minerals**.
(Fig.4.22).

Or, as is often the case, igneous rocks are composed of minerals from **both groups** in various combinations and.
(Fig.4.23).

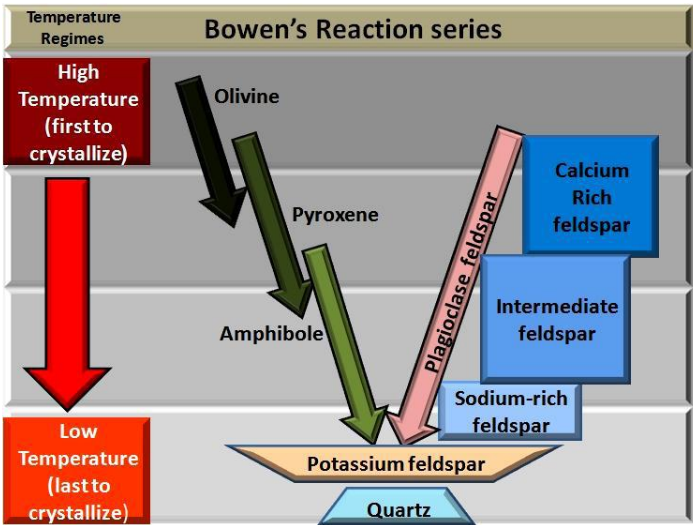
Near one end of the continuum are rocks composed mainly of the light-colored silicate.
These granitic rocks contain 70% percentage silica and are abundant in the continent crust. (Fig.4.24).

Basaltic rocks are rich in dark minerals and contain about 50 percentage silica.
Basalt makes up the **ocean floor** as well as lava flows and volcanic structures.
(Fig.4.25).

In addition to these major groups, igneous rocks with a wide variety of mineral composition also exist.
Why does such a large variety of igneous rocks exist?
The answer:
when the composition of magma appears to be relatively homogeneous around the globe.
N. L. Bowen was the first to demonstrate how a single magma body could generate a variety of igneous rocks.

Bowen demonstrates that minerals with a higher melting point, such as olivine, crystalline first, while minerals with a low melting point, such as potassium feldspar and quartz, crystallize much later.

As you might expect, minerals that form in the same temperature zone are found together in the same igneous rocks as shown below:



Igneous rocks that are composed of the earliest formed minerals, i.e., olivine and pyroxene, are said to have an **(ultramafic)** composition.
Igneous rocks composed mainly of pyroxene and calcium-rich plagioclase feldspar has a basaltic composition **(mafic)**.

While rocks composed of amphibole and plagioclase feldspar are said to have an **intermediate** or **andesitic composition**.
Igneous rocks formed from the last minerals to crystallize, namely quartz, potassium feldspar and sodium-rich plagioclase feldspar, are said to have a **granitic composition (felsic)**.

4.5- Naming igneous rocks:

Igneous rocks are named based on:

1- Texture.

2- Mineral composition.

Using the various igneous textures and mineral composition categories, we can develop the table that is used to name the basic igneous rocks.
For example, a fine-grained rock with a granitic composition is called **rhyolite**.

And coarse-grained rocks composed of quartz and potassium feldspar are called **granite**.
A porphyritic rock with a fine-grained groundmass (matrix) and andesitic composition is called **andesite porphyry** … f h as shown below:

Chemical Composition		Granitic (felsic)	Andesitic (intermediate)	Basaltic (mafic)	Ultramafic
Dominant Minerals		Quartz Potassium feldspar	Amphibols Intermediate Plagioclase feldspar	Pyroxine Calcium-rich Plagioclase feldspar	Olivine Pyroxine
Color		Light	Medium	Dark	Dark
TEXTURE	Coarse grained	*Granite*	*Diorite*	*Gabbro*	*Peridotite*
	Fine grained	*Rhyolite*	*Andesite*	*Basalt*	*Komatite (rare)*
	Porphyritic	"Porphyry" follows any of the above names Whenever there are appreciable phenocrysts			
	Glassy	*Obsidian* (compact glass) *Pumice* (frothy glass)			

1- Igneous rocks originate when hot, molten material called -----------------. a- sediments. b- volcano. c- earthquake. d- magma. 2- Igneous rocks rich in dark silicate minerals with about 50 percent silica are said to have a ----------------- composition. a- fine-grained. b- basaltic. c- rhyolitic. d- granitic. 3- Which one of the following is NOT a possible product of a volcanic eruption? a- ash. b- pyroclastic debris. c- cinder. d- marble. 4- An igneous rock with less than 15 percent dark minerals would have a ----------------- composition. a- basaltic (mafic). b- detriatal (lithic). c- andesitic (intermediate). d- granitic (felsic). 5- When the minerals in igneous rocks cannot be identified; the composition can be estimated based on the percentage of phenocrysts present in the rock. a- true. b- false. 6- Which one of the following greatly affects both the size and arrangement of mineral crystals in igneous rocks? a- Composition of the rock surrounding the magma. b- specific gravity of the magma or lava. c- rate of tectonic uplift. d- rate of cooling of the magma or lava.

7- Basalt makes up the ocean crust as well as lava flows and volcanic structure on land. a- true. b- false. 8- In a rock with porphyritic texture, the large crystals are referred to as -------------. a- groundmass. b- erratic. c- phenocrysts. d- orthoclase. 9- Rocks that contain voids leave by gases that escaped as lava solidifies are said to exhibit a ---------------------- texture. a- coarse-grained. b- vesicular. c- fine-grained. d- porphyritic. 10- Igneous rocks that form when lava solidifies are classified as extrusive or volcanic igneous rocks. a- true b- false 11- Which of these rocks is composed almost entirely of ferromagnesian minerals? a- granite b- basalt c- rhyolite d- peridotite 12- Igneous rocks that form from the last minerals to crystallize from magma will have a ---------------- composition consisting of quartz, potassium feldspar and sodium-rich plagioclase feldspar. a- andesitic (intermediate) b- basaltic (mafic) c- mafic (felsic) d- granitic (felsic)

2- Sedimentary Rocks:

4.2- Introduction to sedimentary rocks:

Recall from the **rock cycle** that **sedimentary rocks** form when the products of weathering are transported to a new location where they are deposited and eventually **lithified** into solid rock.

Weathering which begins the process can be either:

A- Mechanical weathering. 1.

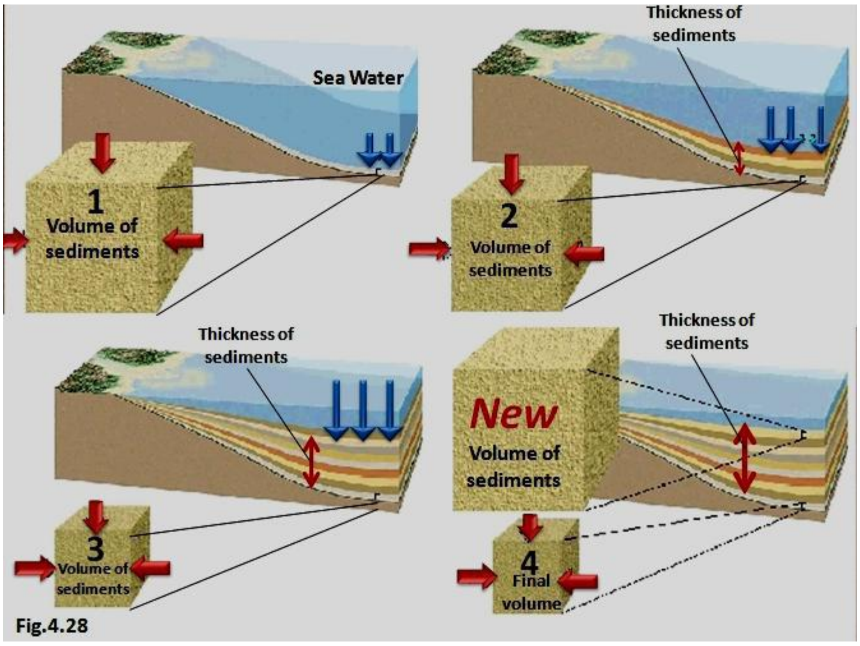
B- Chemical weathering. 2.

(Fig.4.26).

Erosion agents such as running water, wind, waves and ice remove the products of weathering and transport them to other locations.

Eventually, these solids particles and dissolved substance, called **sediments**, are deposited. (Fig.4.27)

Next, the sediments undergo **Lithification**, meaning "conversion to rock" by **compaction**. (Fig.4.28).



And/or by **cementation** as percolating water coats the sediments with mineral maters, and gradually cements the particles together. The result is sedimentary rocks such as **shale**, **sandstone** and **conglomerate**.

(Fig.4.29)

Some sedimentary rocks are not compacted or cemented but form as solid masses of intergrowth crystals.

Rock salt is one example.

(Fig.4.30).

4.3- Types of sedimentary rocks:

a-Detriatal sedimentary rocks.

b-Chemical sedimentary rocks.

c-Organic (biochemical) sedimentary rocks.

a- Detriatal sedimentary rocks.

The products of weathering include materials that originated and are transported as solid particles. (Fig.4.31). 1.

These particles are called **detritus** and the sedimentary rocks they form are called **detriatal sedimentary rocks**. 2.

Two minerals are especially common in Detritus rocks:

1- Clay.

2- Quartz.

The table below is showing the products of weathering:

Products of Weathering		
Original minerals	**Weathers To produce**	**Released Into solution**
Quartz	Quartz grains	Silica
Feldspar	Clay minerals	Silica K, Na, Ca
Amphibole (hornblende)	Clay minerals Limonite, Hematite	Silica Ca, Mg
Olivine	Limonite Hematite	Silica Mg

Geologist use particle size to distinguish among detriatal sedimentary rocks.

The common sediment name for all particles **larger than 2 millimeters is gravel**.

When gravel-sized particles predominate, the rock is called **conglomerate** if the particles are **rounded** and **breccias** if the pieces are **angular**.

The particles in **conglomerate** become **rounded** as they are transported, most frequency by streams. (Fig.4.32). 1.

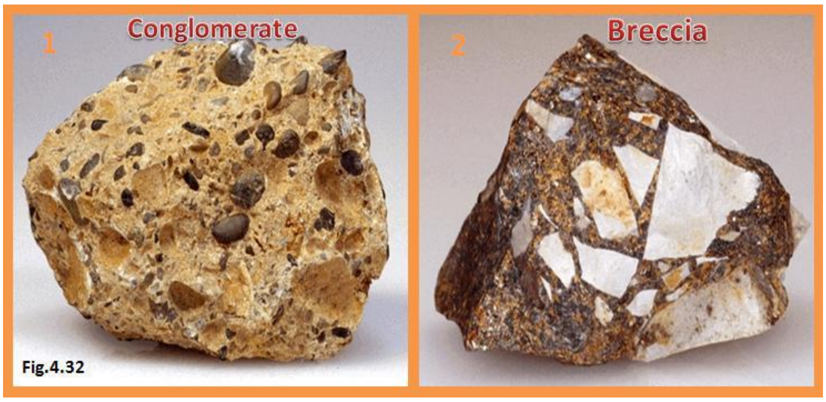
The **angular** pieces of brachia indicate the particles were not transported very far from their source prior to deposition. 2.

The common sediments name for particles between 1/16 mm and 2mm is **sand** and **sandstone**, And it is the name given to rocks when sand-sized grains dominate.

Because it is very durable, **quartz** is the predominant mineral in the most **sandstone**. (Fig.4.33). 1.

When substantial quantities of feldspar are present in sandstone, the rock is called **arkoses**. 2.

The presence of abundant feldspar suggests there was little chemical weathering of the sediments, something we might associate with a **dry climate**.



When the tiniest silt and clay- sized particles predominate, the common sediment name is **mud** and **shale** or **mudstone** is the name given the rock.
The table below is showing the particles size classification for Detritus rocks:

Particle Size Classification for Detrital Rocks			
Size range (millimeter)	Particle name	Common Sediment name	Detrital name
>256 64 – 256 4 – 64 2 - 4	Boulder Cobble Pebble Granule	Gravel	Conglomerate or Breccia
1/16 - 2	Sand	Sand	Sandstone
1/256 – 1/16 <1/256	Silt Clay	Mud	Shale or Mudstone

In a nontechnical context, the term "**Shale**" is used for all fine-grained sedimentary rocks. (Fig.4.34). 1.
Because shale crumbles easily, it forms gentler slopes of weathered debris.
By comparison, outcrops of more durable rocks like sandstone produced, steep cliffs.

b- Chemical sedimentary rocks:

Unlike detritus rocks which form from the solid products of weathering, the source of sediments for **chemical sedimentary rocks** is **materials dissolved in water**. (Fig.4.35). 1.

Three kinds of chemical sedimentary rocks:

1- When materials in solution precipitate, it forms chemical sediments, which become rocks such as limestone, chart and rock salt.2.
2- Precipitation of dissolved materials occurs by inorganic processes such as evaporation, temperature change and chemical activity.3.
3- Or by life-processes of water-dwelling organism. These materials are called **biochemical sediments**. 4.
Did you know shells are an example of (biochemical) sediments?

Limestone: the most abundant chemical sedimentary rock, is composed chiefly of the mineral **calcite**. (Fig.4.36). 1. Most limestone has a biochemical origin.

Example includes **coquina**, Which consists of shell fragments. 2.
Chalk: which is made of the hard parts of microscopic marine organisms. 3.
And limestone that originated as **coral reefs**. 4.

Travertine: is Limestone with an inorganic origin, which is often seen decorating caves. (Fig.4.37). 1.
Halite: Evaporates form when evaporation causes minerals to precipitate from water. Such minerals include halite (NaCl), the main component of rock salt. 2.
Chart: is the name used for a number of hard, compact rocks made of microcrystalline silica.
These rocks may have either inorganic or a biochemical origin. It usually is not possible to determine this by looking at a hand sample.3. 4. 5.

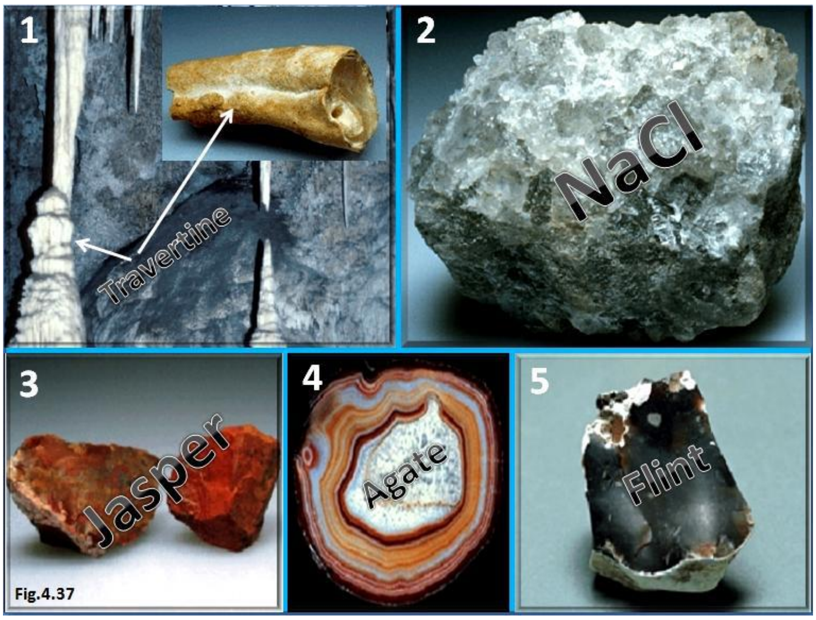


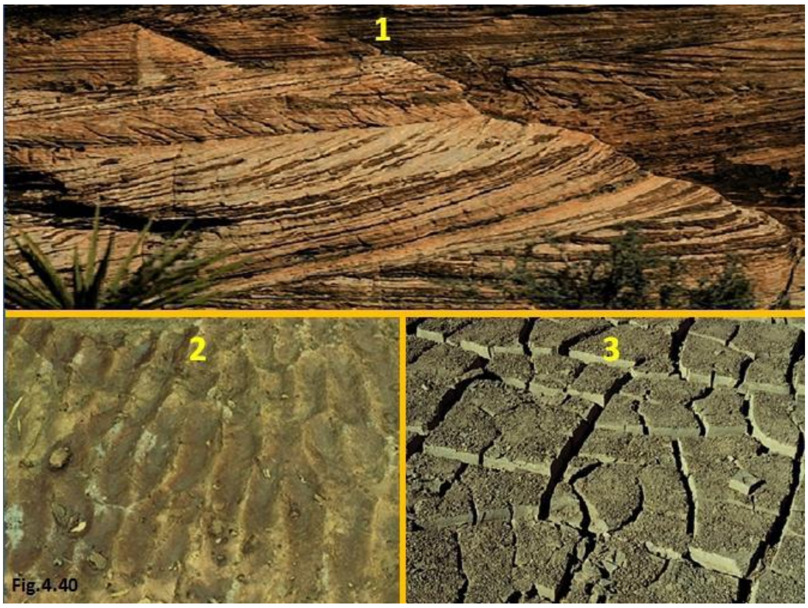
Fig.4.37

Gypsum: ($CaSO_4.2H_2O$), the main ingredient of rock gypsum. (Fig.4.38). 1.
Thick **evaporate deposits** may form when a large body of seawater isolated by reefs or sand barriers. 2

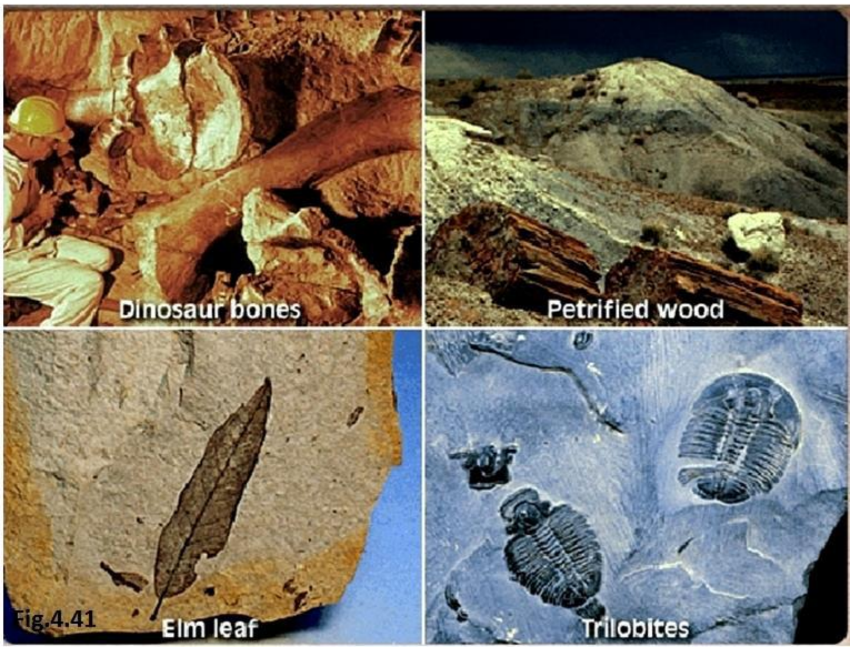
4.4- Sedimentary environments:

Sedimentary rocks form as layer upon layer of sediments accumulates. These **strata** are the single **most characteristic** of sedimentary rocks.
Each layer is unique. The variations among strata reflect the conditions under which each layer was deposited. (Fig.4.39).

Sedimentary rocks show a variety of structures that help us to interpret **past geologic conditions** like:
Cross-bedding: occurs in sand dunes and certain stream deposits. (Fig.4.40). 1.
Ripple – marks: are associated with currents of air and water or with the back and forth movement of waves. 2.
Mud-cracks: When they are preserved, they indicate alternating wet and dry conditions and are associated with such places as desert basins and shallow lakes. 3..



Fossils: They are preserved in sedimentary rocks, and important keys to **past environments**. (Fig.4.41).



The size of particles in sedimentary rocks provides useful information about **environments of depositions**. (Fig.4.42). 1 and 2.
Currents of water and air sort particles by size. **The stronger the current, the larger the particles size carried**. 3 and 4.
For example, in very **turbulent water** only large gravel-sized particles can settle out. 5.
Whereas fine particles settle in the waters of a **swamp**, **lake** or **lagoon**. 6.

The mineral composition of the rock can also contribute useful information about past environment.

For example, Evaporates can indicate an **arid** setting. (Fig.4.43). 1.
And certain limestone, like **coquina**, can indicate a warm, shallow marine environment. 2.

1- Which rock type is most likely associated with a high-energy environment such as a turbulent stream? a- conglomerate. b- shale. c- rock salt. d- chart.
2- Rock salt and rock gypsum are example of ------------- sedimentary rocks. a- detritus. b- biochemical. c- evaporate.
3- The percentage of abundant feldspar in a sedimentary rock suggested that advanced stages of chemical weathering have taken place. a- true. b- false.
4- When substantial quantities of feldspar are present in sandstone, the rock is called: a- agate. b- rock gypsum. c- arkoses. d- greywacke.
5- The sizes of particles in detritus sedimentary rocks often indicate the energy of transporting medium. a- true. b- false.
6- The most abundant chemical sedimentary rock is --------------. a- shale. b- conglomerate. c- chart. d- none of the above.

7- Angular pieces in detriatal sedimentary rocks indicate the particles were not transported very far from their source prior to deposition. a- true. b- false.

7- Compaction and cementation are examples of this process. a- lithification. b- crystallization. c- weathering. d- fusion. e- metamorphism.
8- Evaporates are examples of biochemical sedimentary rocks. a- true. b- false.

10- Compaction is a very important Lithification process for which sediments? a- mud. b- sand. c- gravel.

10- Which common mineral found in igneous rocks is most abundant in detritus sedimentary rocks? a- amphibole. b- biotitic. c- Plagioclase. d- quartz.
11- This detritus sedimentary rock consist primary of rounded gravel-size particles. a- breccias. b- coquina. c- shale. d- conglomerate.

13- Sedimentary rocks form when the products of ---------------- are transported to a new location where they are deposited and eventually ----------- into solid rock. a- melting; crystallized. b- deposition; eroded. c- crystallization; metamorphosed. d- tectonics, weathered. e- weathering, lithified.

15- Which sedimentary rock consists of materials that originated and were as solid particles? a- sandstone. b- rock salt. c- chart. d- travertine limestone.
16- Detritus sedimentary rocks are made primary of the products of mechanical weathering. a- true. b- false.
17- Geologist use -------------- to distinguish among detriatal sedimentary rocks. a- Particle size. b- method of formation. c- color. d- the location of source material. e- none of the above.
18- Precipitation of dissolved material by the life processes of water-dwelling organisms produces material called -------------- sediments a- biochemical. b- secondary. c- detritus. d- classic.
19- The common name for sediment consisting of particles between 1/16 mm and 2 mm is ---------. a- clay. b- silt. c- cobble. d- sand.
20- Agate, jasper and flint are all form of chart. a- true. b- false.

20- Which one of the following is NOT a sedimentary structure or feature that helps geologist interpret past geological conditions? a- vesicles. b- mud cracks. c- Particle sorting. d- ripple marks. e- cross-bedding.

3- Metamorphic Rocks:

4.3- Introduction to Metamorphic Rocks:

Recall from the discussion of the rock cycle that metamorphism involves the transformation of pre-existing rocks.

Metamorphic rocks can form from:

1- Igneous rocks. (Fig.4.44). 1.

2- Sedimentary rocks. 2.

3- Other metamorphic rocks. 3.

Fig.4.44

4.4- Agents of Metamorphism:

The agents of metamorphism are:

1- Heat.

2- Pressure (Stress).

3- Chemically active fluids.

These agents commonly acting together as shown below:

1- Heat:

Perhaps the most important agent of metamorphism is **heat,** because it provides the energy to drive chemical reactions. (Fig.4.45).

Rocks found near the surface of earth may be subjected to intense heat when they are faced by **magma**, a process called **contact metamorphism.**

Here the adjacent host rock is "**baked**" by the emplaced magma. (Fig.4.46).

Rocks may also be subjected to high temperature if they are carried deep within earth.

2- Pressure:

Pressure, like temperature, also increases with depth. (Fig.4.47).

Buried rocks are subjected to pressure, or stress exerted by the loads above it. (Fig.4.48).

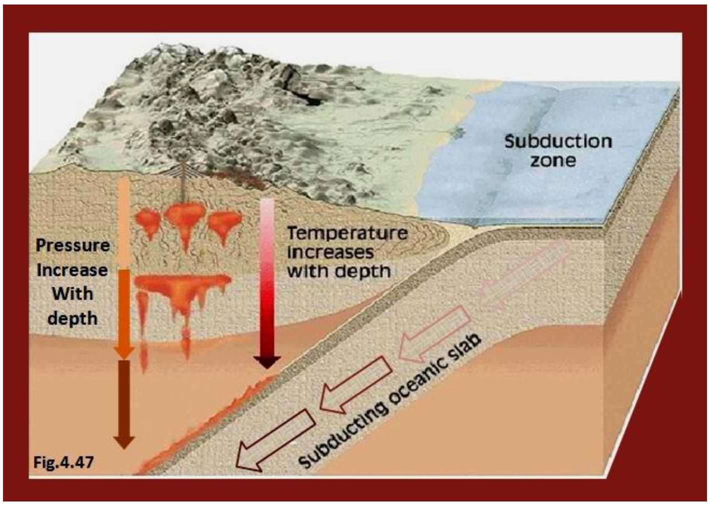


Fig.4.47

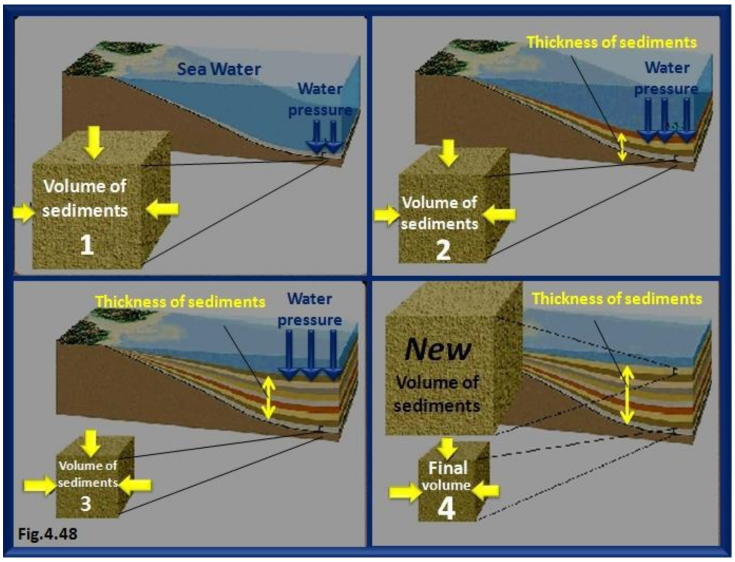


Fig.4.48

The **confining pressure** is applied equally in all directions and causes a reduction in volume, thereby generating a more compact (dense) rock. (Fig.4.49).

Rocks are also subjected to forces during mountain building that are unequal and in different directions, called **differential stress.** (Fig.4.50).

3- Chemically active fluids:

most commonly hot water containing ions in solution, also enhance the metamorphic process.
For example, along oceanic ridge, sea water circulates through hot basaltic rocks, transforming the existing iron-rich minerals into metamorphic minerals such as **serpentine** and **talc**. (Fig.4.51).

4.5- Textural and Mineralogical Changes:

The degree of metamorphism is reflected in the rock's texture and/or mineral composition.
When rocks are subjected to **low-grade metamorphism**, they become more compact and thus denser. (Fig.4.52).

During metamorphism, the crystals of some minerals, such as micas which have a sheet structure, and hornblende which has an elongated structure, will recrystallize with a preferred orientation.
The new orientation will be essentially **perpendicular to the direction of stress.** (Fig.4.54).

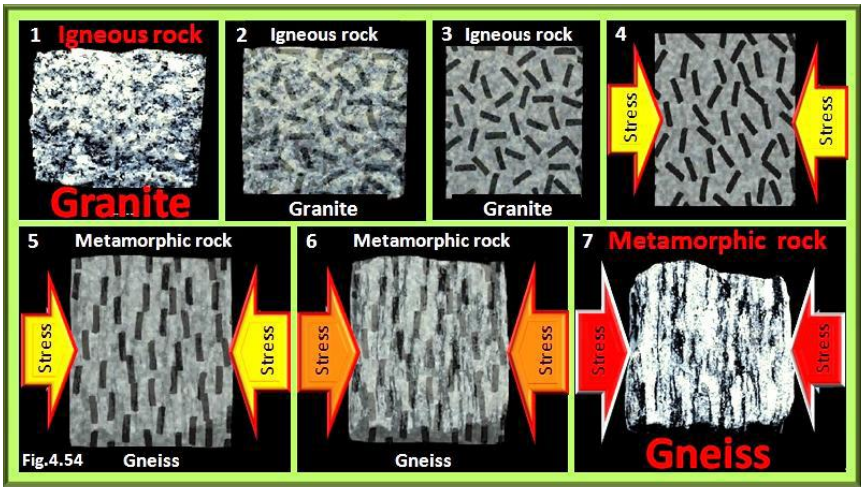


Fig.4.54

The resulting mineral alignment usually gives the rock **layered or banded** appearance termed **foliation**. (Fig.4.55).

Not all metamorphic rocks have a foliated texture. Metamorphic rocks composed of only one mineral that forms equidimensional crystals are generally **nonaffiliated**. (Fig.4.56).

In some environments, new minerals are formed during the metamorphic process.
For example, rocks adjacent to a large magma body would be altered by ion-rich hydrothermal solutions released during the later stages of crystallization. (Fig.4.57).

1- When a rock is buried it is subjected to greater confining pressure which tends to make the rock more --------------. a- active. b- elongated. c- fragile. d- dense.

2- Which one of the following metamorphic rocks is generally nonaffiliated? a- marble. b- mica schist. c- slate. d- gneiss.

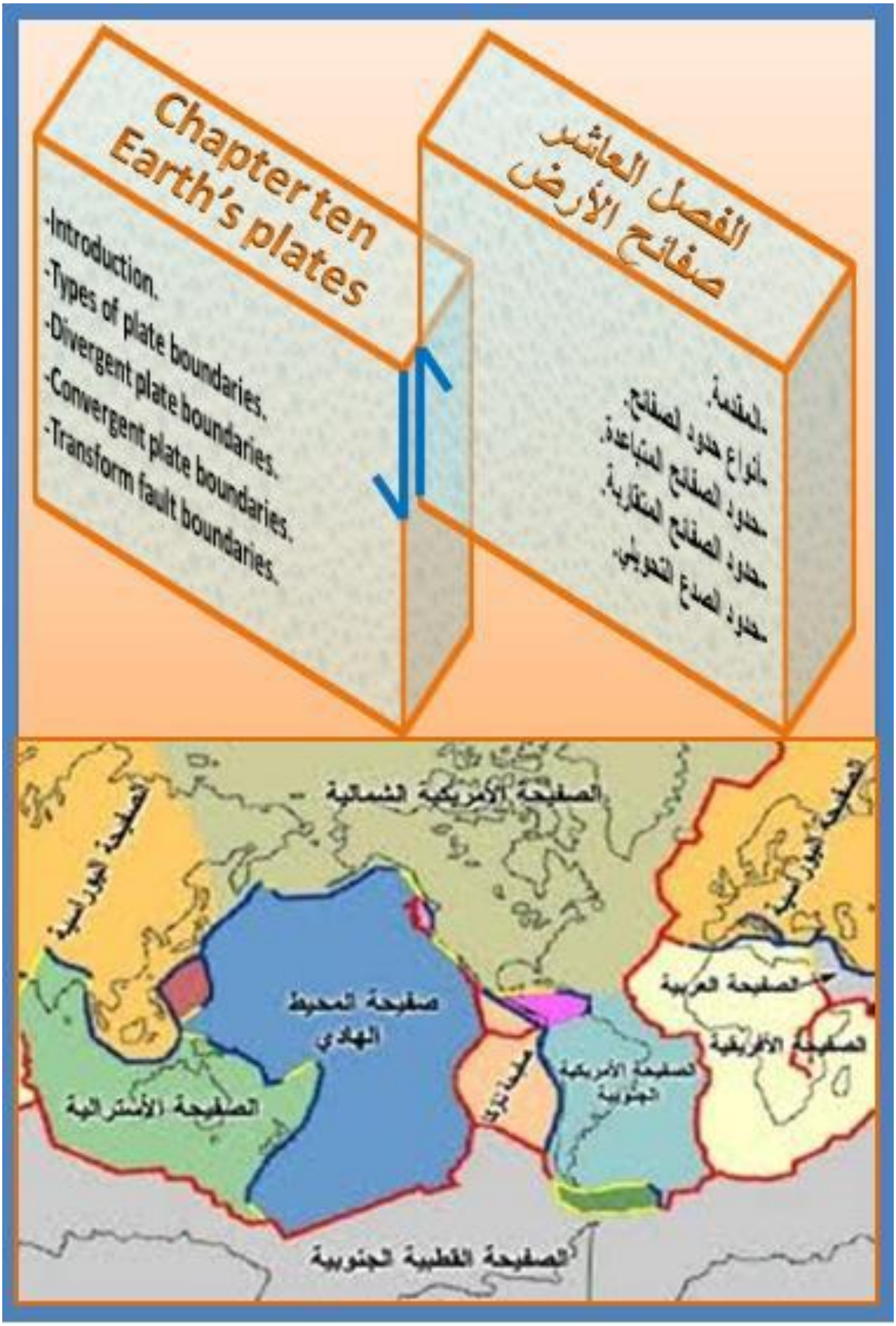
3- Nonaffiliated metamorphic rocks are usually composed of --------------------. a- elongated mineral grains. b- equidimensional mineral grains. c- a mixture of both above.
4- What is the major source of heat for contact metamorphism? a- deep burial. b- frictional heat created by moving faults. c- heat from the decomposition of minerals. d- heat from a nearby magma body.
5- Rocks subjected to intense heat when they are intruded by magma undergo process called ----------------. a- tectonic metamorphism. b- searing. c- contact metamorphism. d- thermal modification.
6- The "layered" or banded" appearance resulting from mineral alignment in a metamorphic rock is termed: a- Pseudo-crystallization. b- bedding. c- foliation. d- orientation.

7-Metamorphic rocks can form from other metamorphic rocks. a- true. b- false.

8-Which one of the following is NOT an agent of metamorphism? a- Pressure (stress). b- heat. c- crystallization. d- chemically active fluids.

9-Which one of the following is a foliated metamorphic rock? a- quartzite. b- anthracite coal. c- granite. d- gneiss.

10-The most common chemically active fluids involved in the metamorphic process are hot water containing ions in solution. a- true. b- false.


Chapter ten
Earth's plates
-Introduction.
-Types of plate boundaries.
-Divergent plate boundaries.
-Convergent plate boundaries.
-Transform fault boundaries.
الفصل العاشر
صفائح الأرض
-المقدمة.
-أنواع حدود الصفائح.
-حدود الصفائح المتباعدة.
-حدود الصفائح المتقاربة.
-حدود الصدع التحويلي.
الصفيحة الأمريكية الشمالية
صفيحة المحيط الهادي
الصفيحة العربية
الصفيحة الأفريقية
الصفيحة الأمريكية الجنوبية
الصفيحة الأسترالية
الصفيحة القطبية الجنوبية

10.1- Introduction:

Earth is a dynamic, ever changing planet!

If we could go back in time 200 million years, there would be no rocky mountains and valleys. Moreover, we would find landmasses with unfamiliar shapes and located in different positions from today's continents.

Earth scientists have shown that the landmass are not fixed, but slowly migrate across the globe. (Fig.10.1).

(Pangaea is meaning all the land).

Fig.10.1

Large landmass has split apart resulting in the formation of oceans, while the floor of the ocean has been recycled back into earth's interior.

Further, landmass that was separated by vast oceans have since collided and formed larger continents.

The movement of earth's outer layer continues today. Result of this movement includes earthquakes, volcanoes and building of earth's mountains.

The modern scientific theory which describes the movement of earth' outer layers is called **plate tectonics**.

According to the plate tectonics theory, the **uppermost mantle**, along with the overlying crust, behave as a strong, rigid layer known as the **lithosphere**. So

Lithosphere = Upper mantle + earth crust

(Fig.10.2).

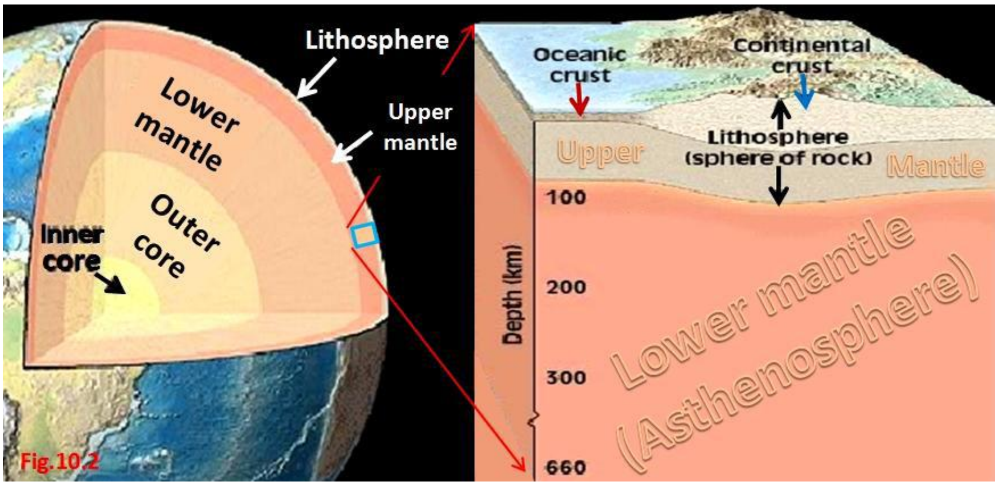


Fig.10.2

The **lithosphere** is **thinnest** in the oceans where its thickness may vary from as little as a few kilometers at the **oceanic ridge** to 100 kilometers in the deep-ocean basins. (Fig.10.3). 1.
By contrast, **continental lithosphere** is generally 100-150 kilometers thick but may be more than 250 kilometers thick below older portions of the continents. 2.
This rigid outer shell (lithosphere) overlies a hotter, weaker layer in the upper mantle known as the **asthenosphere.** 1 and 2.

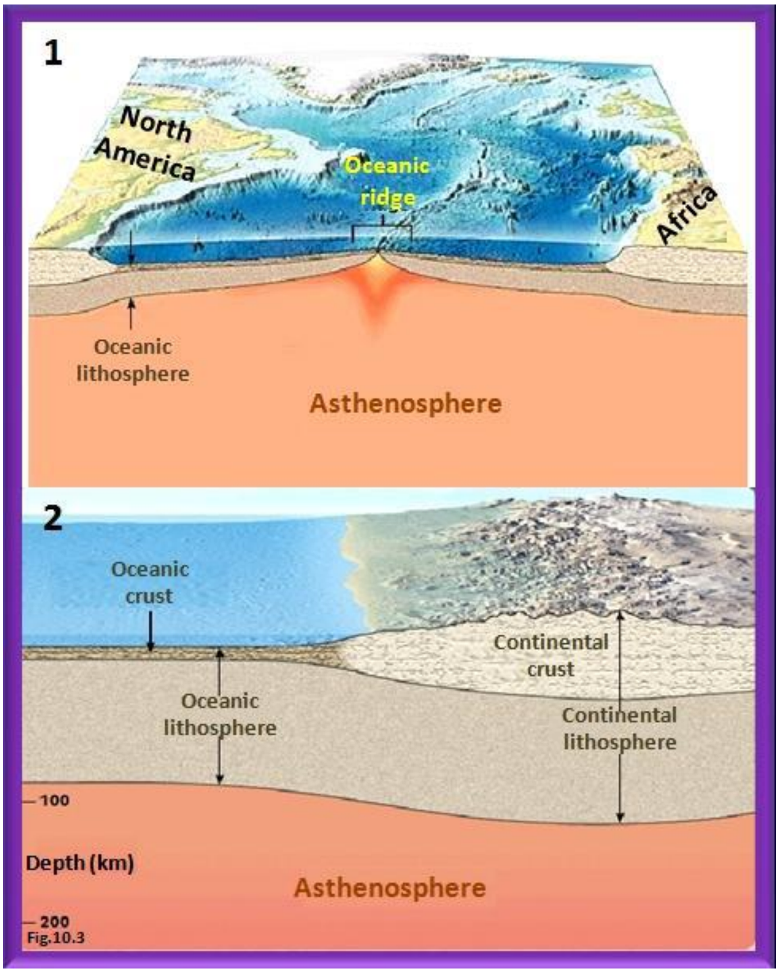


Fig.10.3

Scientists think that the weak rock within the asthenosphere allows earth's rigid outer shell to move. Further, the lithosphere is broken into numerous segments, called lithospheres plates, or simply **plates** into:

A-Seven major lithospheric plates are recognized. They are:
1-South American plate. 2-North American.
3-Pacific plate. 4-Austtralian-Indian.
5-Antaractic. 6-Eurasian
7-African plate. (Fig.10.4).
The largest is the **pacific plate**, which encompasses a significant portion of the pacific ocean basin.
Notice that most of the largest plates include an entire continent plus a large area of ocean floor.
B- Intermediate-size plates include:
1-Philippine plate. 2-Arabian.
3-Scotia. 4-Caribbian
5-Nazca. 6-Cocos
7-Juan de Fuca plate. (Fig.10.4).

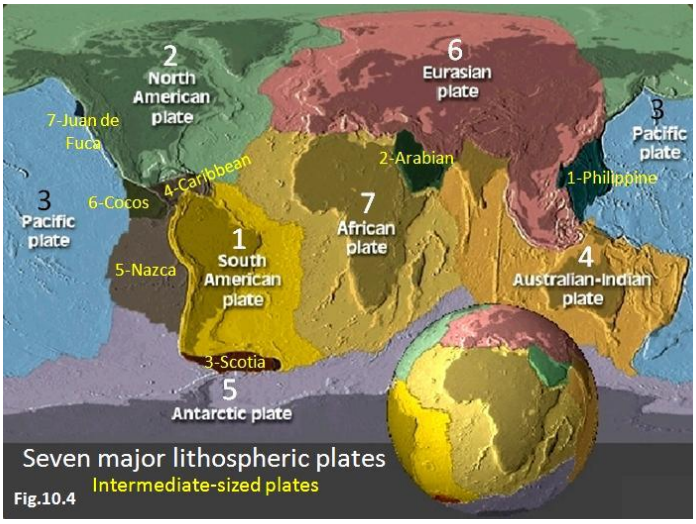


Fig.10.4

f planets. For example, most of our planet's earthquakes, volcanoes and mountain buildingEach plate is in constant motion relative to all other plates.
As the plates move, the distance between two locations on the same plate remains constant whereas the distance between sites on different planets gradually changes.
Most interactions occur at the margins (edges) o occur **along boundaries**.
Notice how the distribution of moderate to strong earthquakes is related to plate boundaries. (Fig.10.5). 1.
Volcanoes are also associated with **plate boundaries**. 2.

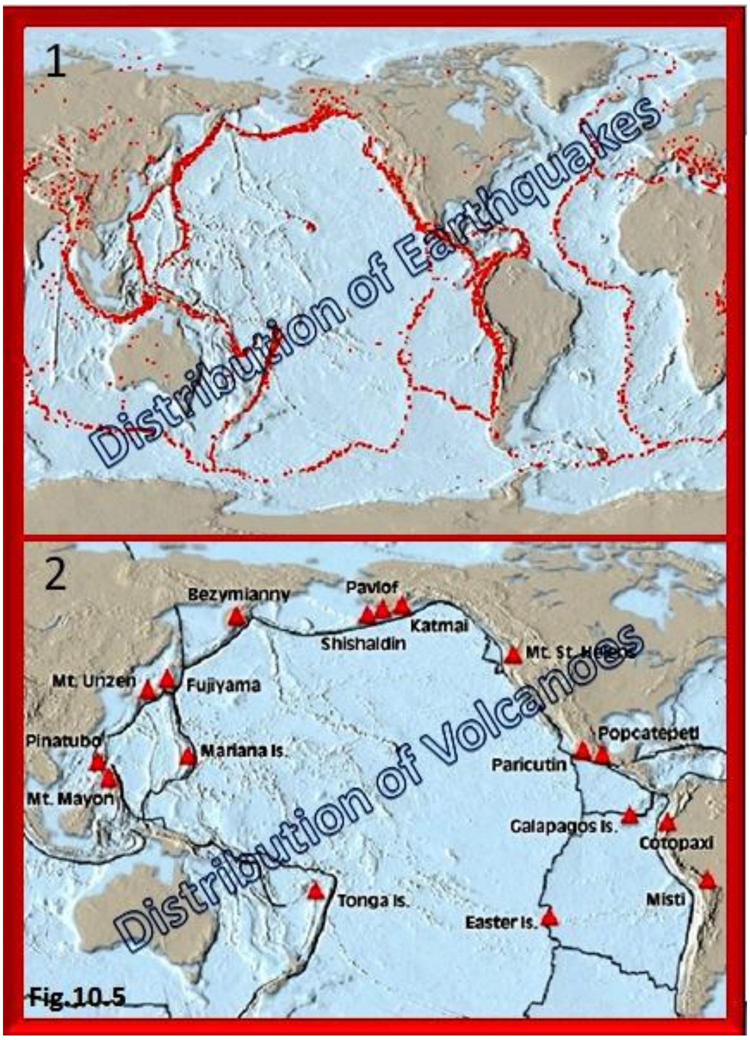


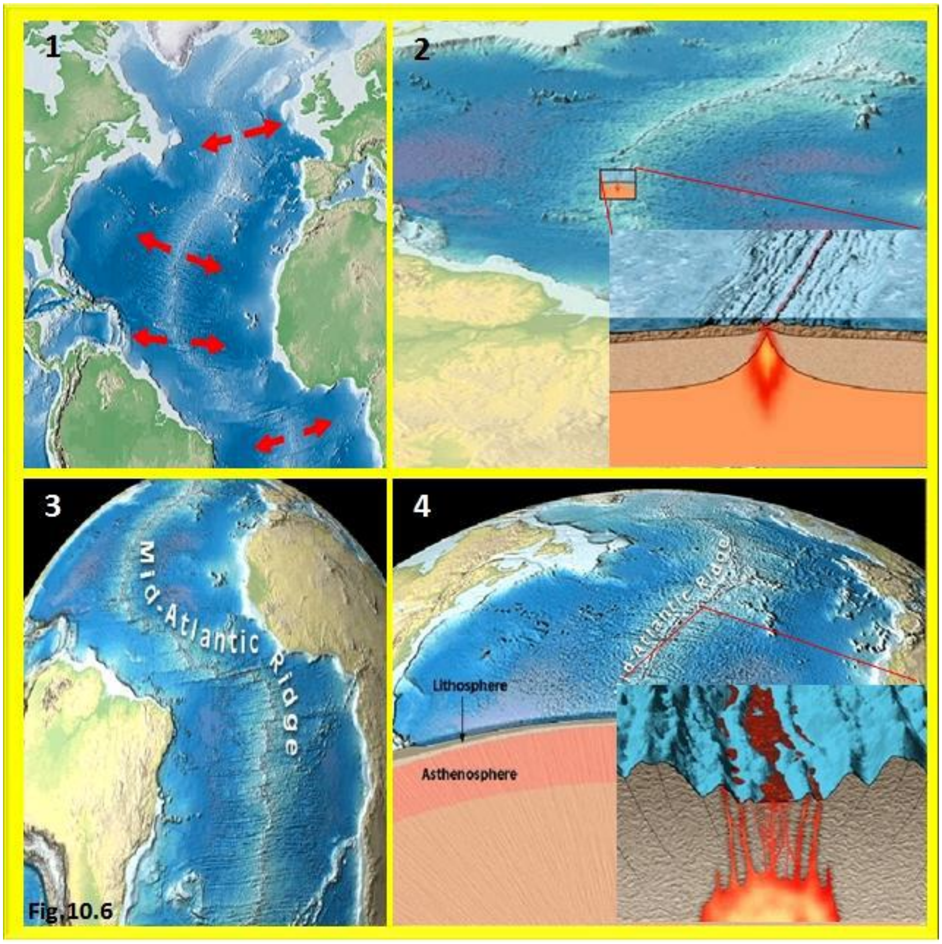
Fig.10.5

10.2- types of plate boundaries:

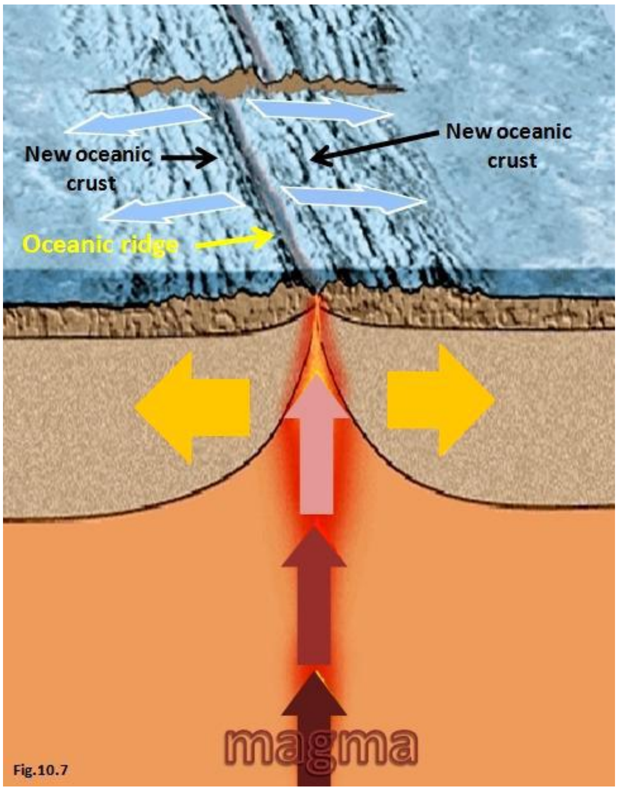
1- Divergent plate boundaries: Occur where two plates move apart from each other.
2- Convergent plate boundaries: Two plates move together toward each other.
3- Transform fault boundaries: Occur where two plates grind to each other.
Typically, all three types of boundaries can be found surrounding a plate.

1- Divergent boundaries:

At divergent plate boundaries, plates move apart. (Fig.10.6). 1.
Most divergent plate boundaries are located along crests of **oceanic ridges**. 2.
Let's examine the **Mid-Atlantic ridge** which extends along a north-south path down the center of the Atlantic ocean. 3.
Here as a plates move apart, the gap is filled with molten rock that oozes up from the hot mantle below. 4.



Gradually, this molten rock, called **magma**, Cools to make new slivers of sea floor. (Fig.10.7).



In a continuous manner, spreading and upwelling of magma add oceanic lithosphere to the edges of the diverging plates.
This mechanism has created the floor of the Atlantic ocean during the past 160 million years and is called **seafloor spreading**.
(Fig.10.8). 1 .. 6.
Average rates of seafloor spreading are about **5** centimeters per year.

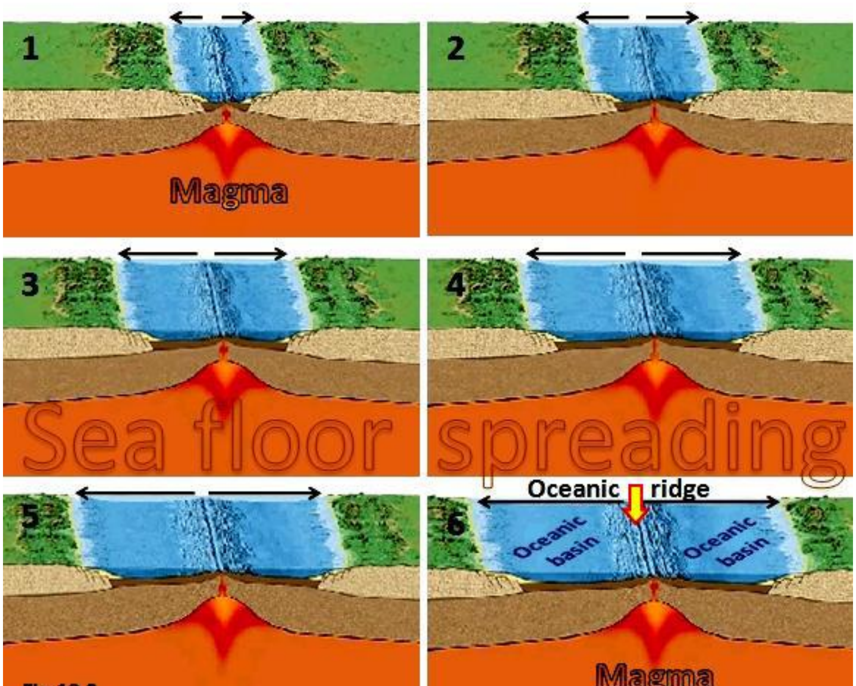


Fig.10.8

Some of the slowest spreading rates (2 centimeters per year) occur along the Mid-Atlantic Ridge; whereas rates exceeding 15 centimeters per year have been recorded along the East Pacific Ridge. (Fig.10.9).

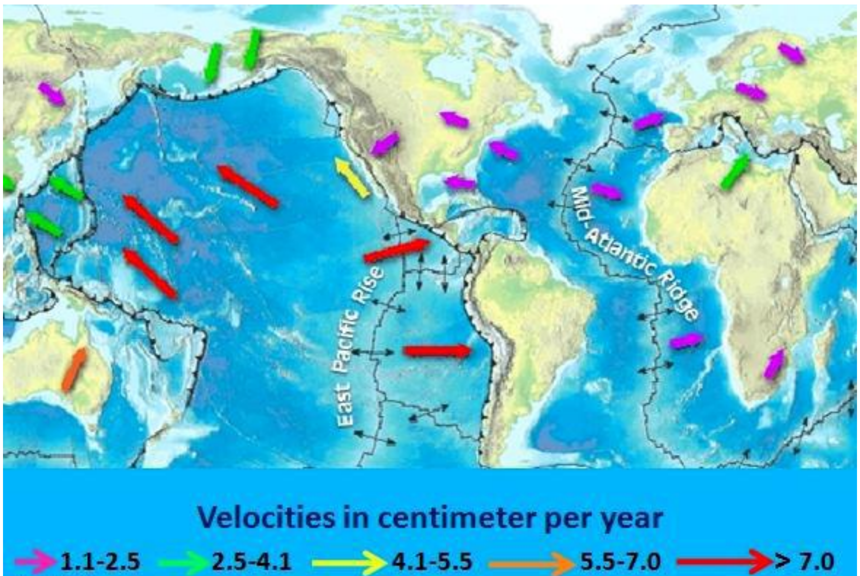
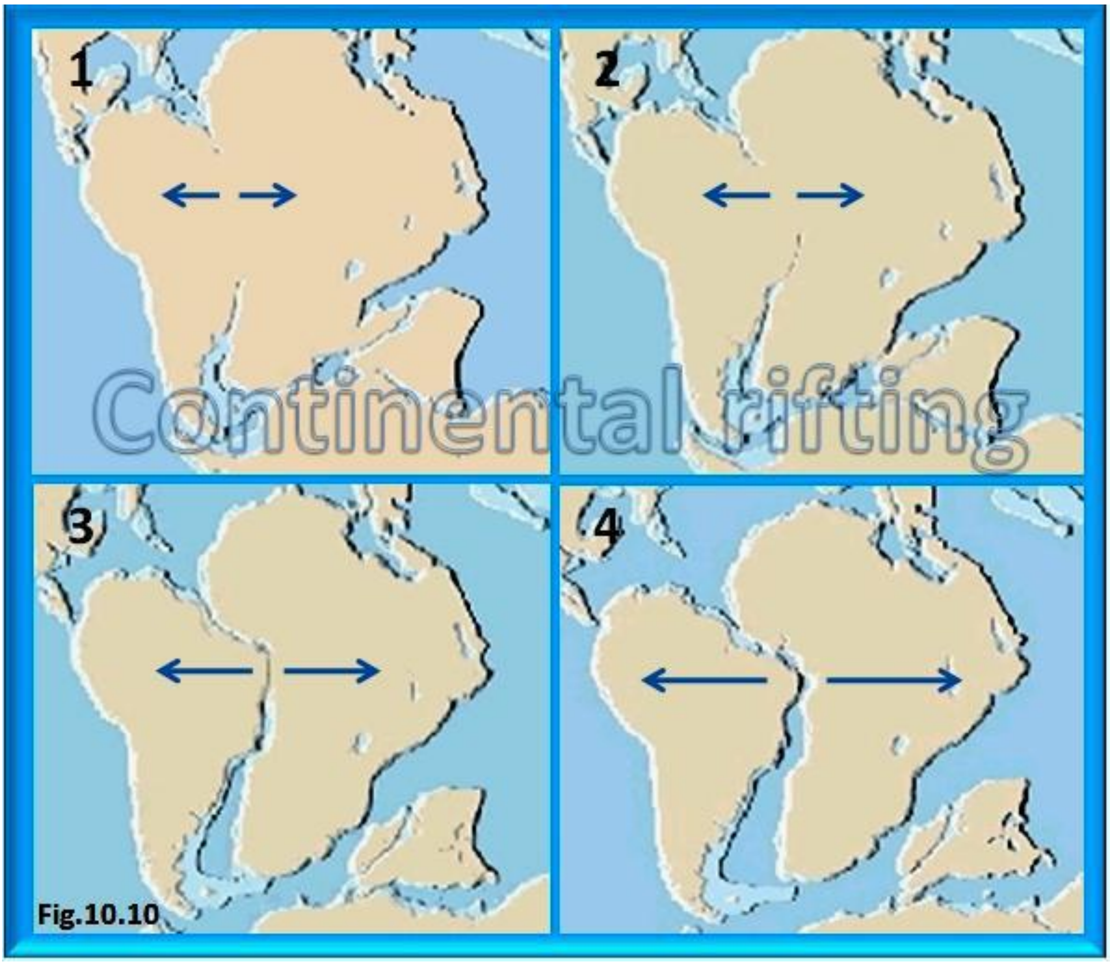


Fig.10.9

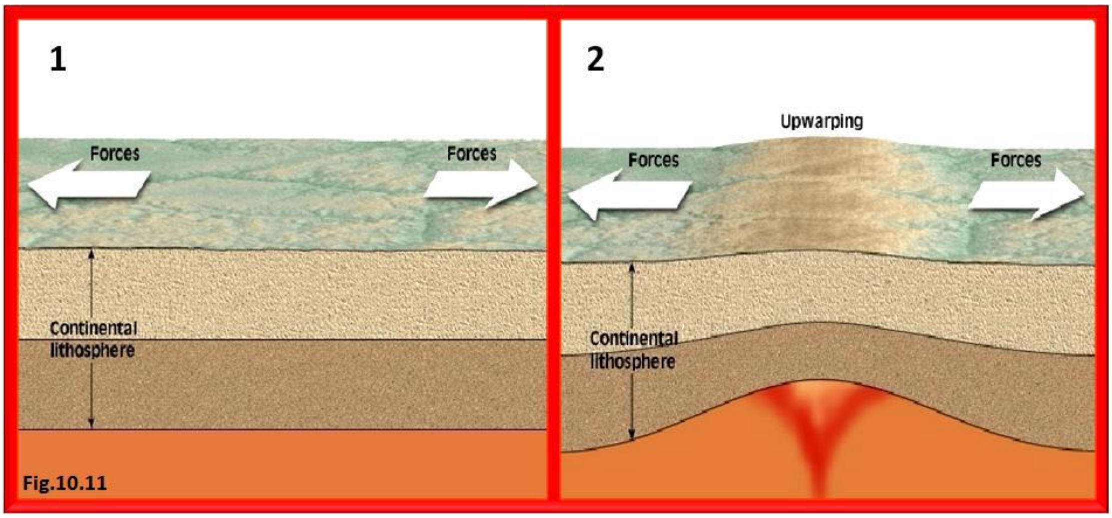
Although these rates of seafloor spreading seem slow on human time scale, they are rapid enough to have generated all Earth's ocean basins in the last 200 million years.

Spreading centers can also develop within a continent, in which case the landmass may split into two or more smaller continents.

This is known as **continental rifting**. F .10.10). 1 … 4.



Continental rifting takes place where forces pull two plates in opposite directions. (Fig.10.11). 1. As the lithosphere stretches, molten rock rises from below to up warp the crust. 2.



Eventually, the crust fractures to form a long trough called a **rift valley**. (Recall that rift valley is also found along the crests of some oceanic ridge). (Fig.10.12). 1.
Slowly, the rift valley lengthens and deepens. 2.

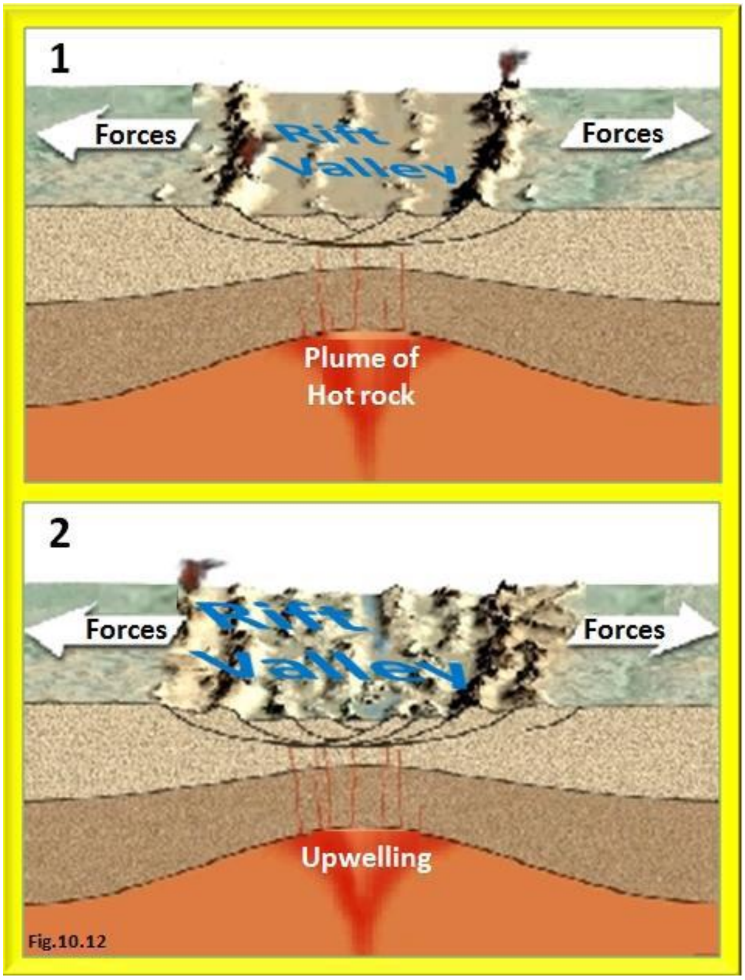


Fig.10.12

The East African **rift valleys** are Examples of such features. (Fig.10.13).

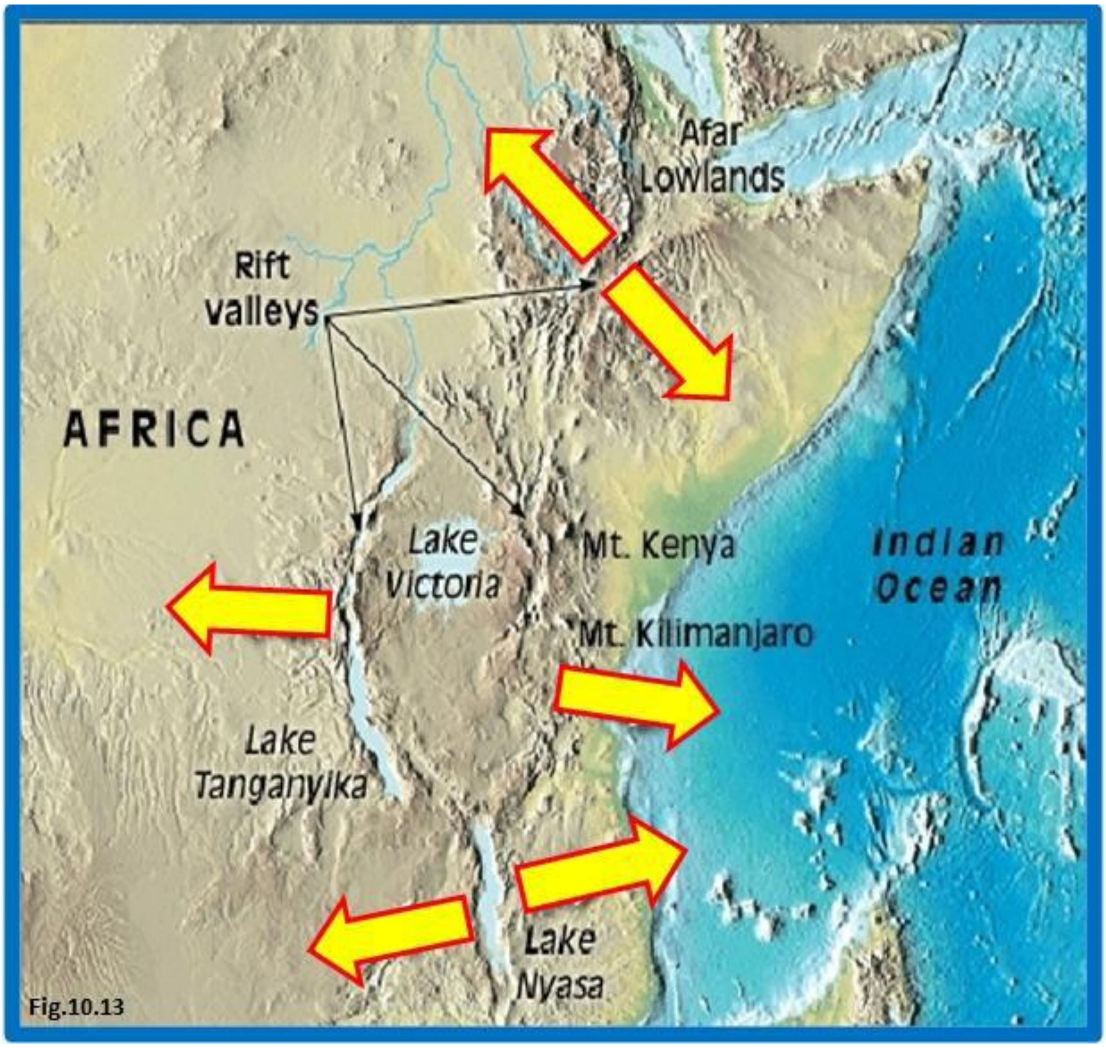


Fig.10.13

If spreading continues, it will extend to the plate margin and split the landmass into two, like South America and Africa did over 100 million years ago. (Fig.10.14).

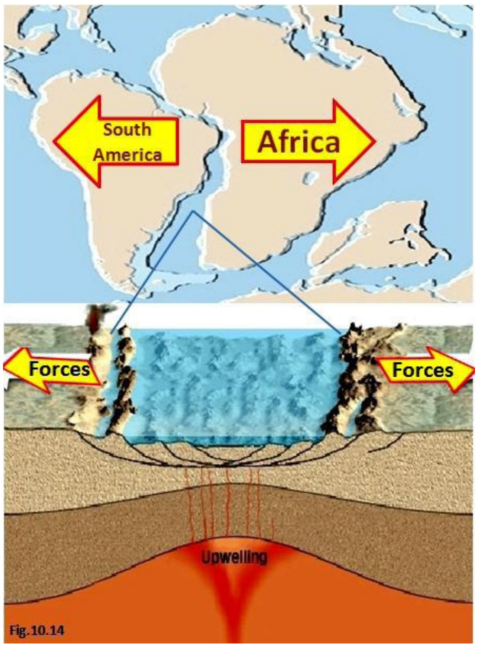


Fig.10.14

At this point the **rift valley** becomes a long, narrow sea with an outlet to the ocean, similar to the red sea. (Fig.10.15).

Fig.10.15

The red sea formed as the Arabian peninsula separated from North Africa.
Consequently, the Red sea provides Earth scientists with a view of how the Atlantic ocean may have looked in its infancy. (Fig.10.16).
Continued divergence brings us back "full-circle" to the development of a spreading center such as the present-day Mid-Atlantic Ridge.

Fig.10.16

2- Convergent boundaries:

Although **new lithosphere** is continually being produced at divergent plate boundaries, the surface of our planet is not growing larger.

To balance the amount of newly created lithosphere, older portions of oceanic lithosphere descend into the mantle along convergent plate boundaries.

Convergent plate margins occur where two plates are moving toward each other and the motion is accommodated by one plate sliding beneath the other. (Fig.10.17).

Convergent plate boundaries are also called **subduction zones**, because they are sites where lithosphere is descending (Being subducted) into the asthenosphere. (Fig.10.17).

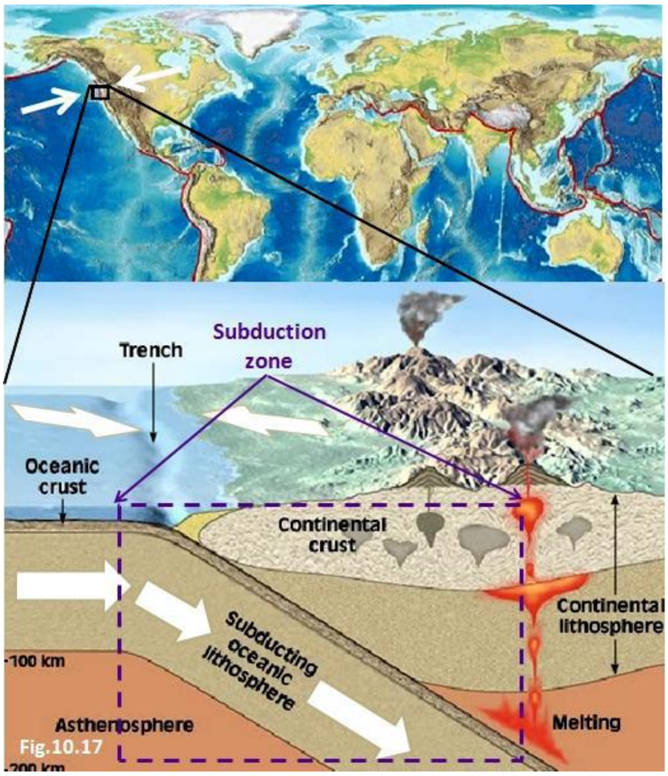


Fig.10.17

-Deep-oceanic trenches:

develop between two converging plates and indicate where the subducting plate begins its descent beneath the overriding plate.

Subduction occurs because the density of the subduction lithospheric plate is greater than that of the underlying asthenosphere.

Older oceanic lithosphere is cooler and denser than the underlying asthenosphere.

By contrast continental lithosphere is less dense and therefore more buoyant, which prevents it from being subducted to any great depth.

As a consequence, the subducted plate is almost always **oceanic**. (Fig.10.18).

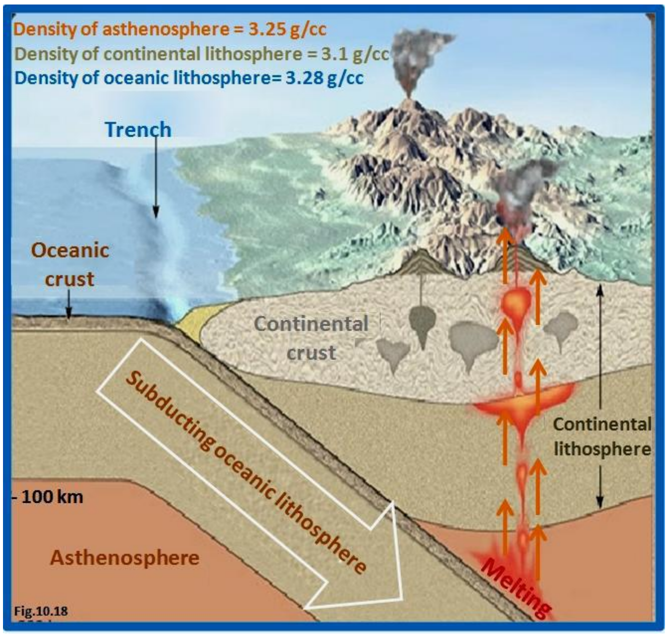


Fig.10.18

Some plates of oceanic lithosphere descend into the asthenosphere at angles of only a few degrees, whereas others plunge nearly vertically (90 degrees). (Fig.19.19). 1 and 2.

The angle at which oceanic lithosphere descends into the asthenosphere, depends on its density. When a plate of lithosphere is **less** than 10 million years old it is typically less dense than the underlying asthenosphere and subduction is nearly horizontal. 3.

As oceanic lithosphere ages (gets further from the spreading center), it cools. This causes it to thicken and increase in density. Once the age of oceanic lithosphere **exceeds** 10 million years, it is denser than the asthenosphere and will sink given the opportunity. 4.

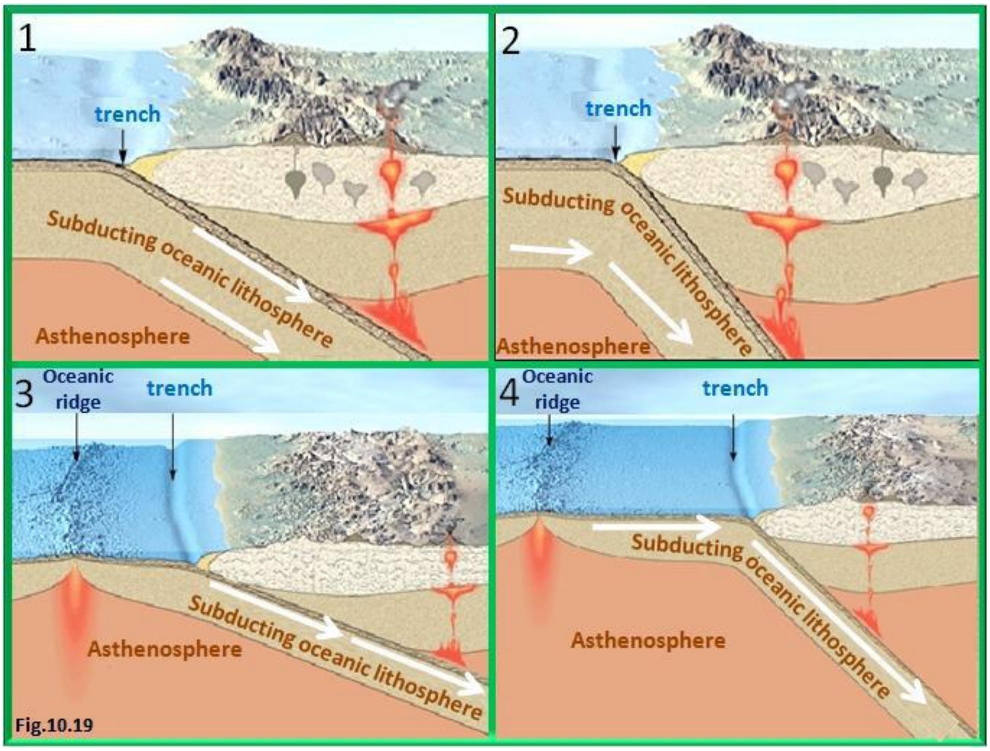


Fig.10.19

In parts of the Western Pacific some oceanic lithosphere is older than 160 million years. This is the thickest and densest in today's oceans.

The subduction plates in this region typically descend into the mantle at angles approaching 90 degrees. (Fig.10.20).

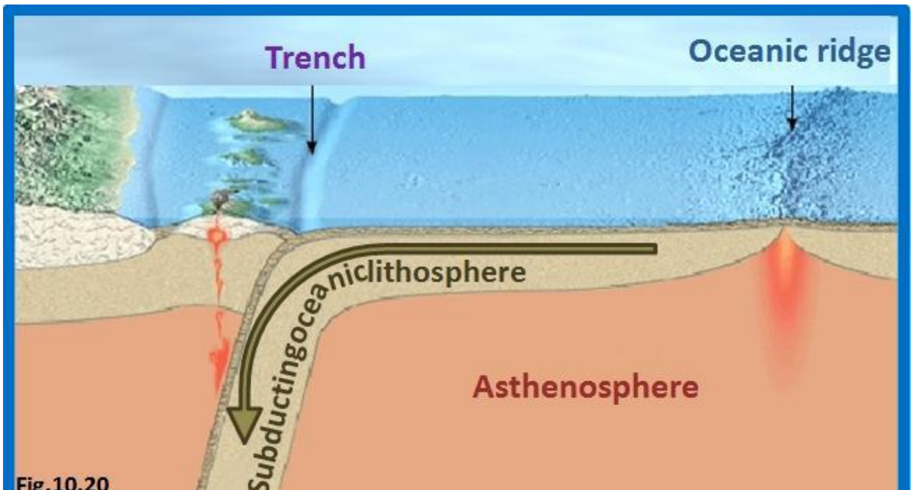


Fig.10.20

It is important to realize that a subducting plate does not follow a fixed path into the mantle. Rather, it sinks vertically as it descends, causing the **trench**. (Fig.10.21).

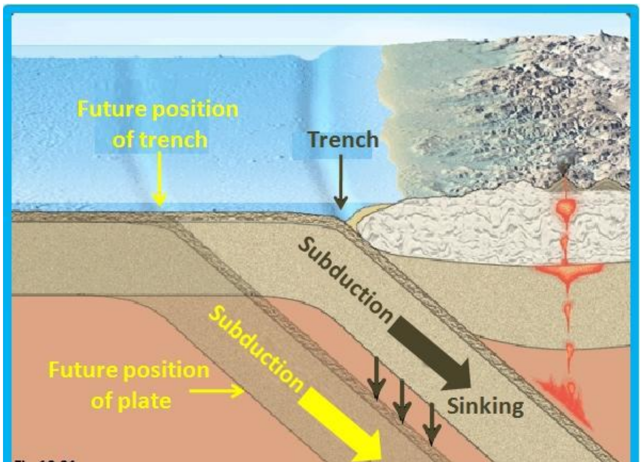


Fig.10.21

When the subduction plate sinks, it creates a flow in the asthenosphere that "pulls" the overriding plate toward the **retreating trench**. (Imagine what would happen if you were sitting in a lifeboat near the titanic as it is sank!) (Fig.10.22) 1.

Although all convergent plate boundaries have many similar characteristics, they are highly variable features.

Nevertheless, they can be placed into one of three broad groups based on the type of crustal material involved.

Convergent plate boundaries form:

A-Continental lithosphere overrides oceanic. 2.

B-Plate of oceanic lithosphere is subducted beneath another. 3.

C-Two plate of continental lithosphere converge and eventually collide.

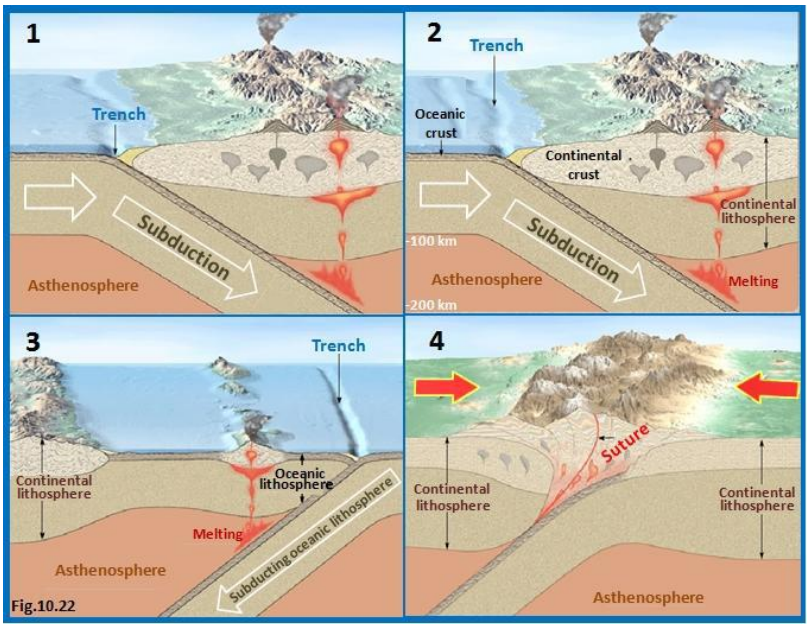


Fig.10.22

The spreading, Collision, Subduction zone and trench of Tectonic plates is showing below: (Fig.10.23).

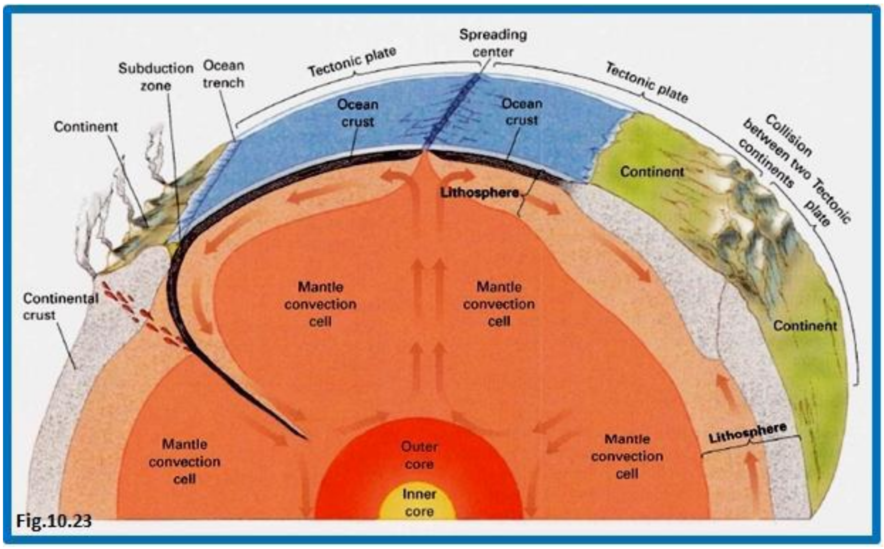


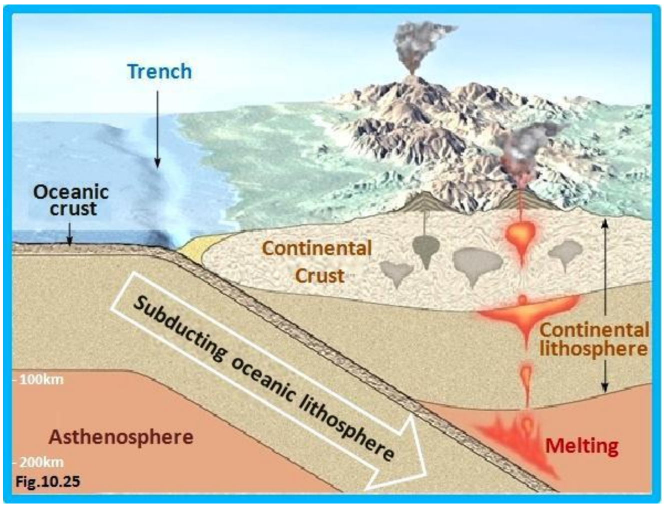
Fig.10.23

A- Continental lithosphere overrides Oceanic:

Let's take a look at what happens when an oceanic plate converges with continental lithosphere. (Fig.10.24).

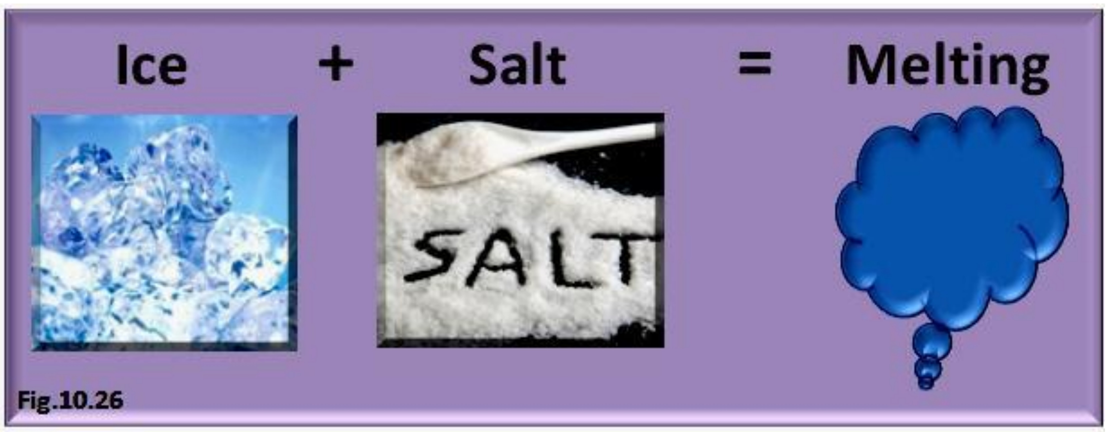
Whenever a plate capped with continental crust converges with a plate of oceanic lithosphere, the buoyant continental plate remains "floating" while the denser oceanic plats descends into the mantle.

When the descending oceanic plate reaches a depth of roughly 100 killiometers, melting is triggered within the hot asthenosphere that lies above it. (Fig.10.25).



But how the subduction of cool plate of oceanic lithosphere causes mantle rock to melt?

The answer lies in the fact that water acts like salt does to melt ice. That is, "wet" rock, in a high temperature environment, melts at a lower temperature than "dry" rock. (Fig.10.26).



Sediments and oceanic crust contain a large amount of water which is carried to great depths by a subduction plate.

When the plate plunges downward, water is "squeezed" from pore spaces as **confining pressure** increases. At greater depths, heat and pressure drive water from hydrated (water-rich) minerals such as amphiboles. (Fig.10.27). 1.

At a depth of roughly 100 kilometers, the asthenosphere is sufficiently hot that introduction of water typically leads to **partial melting**. 2.

The semi-molten rock generated by this process contains as little as **10 percent melt**, which is mixed with unmelted mantle rock. Being less dense than the surrounding mantle, this hot mobile mixture gradually rises toward the surface as tear-drop shaped structures. 3.

When this partially molten material reaches the base of the crust, it is thought to "pond" beneath the somewhat less dense continental rocks. Here fluid **basaltic magma** separates from the unmelted components and continues its ascent. 4.

Depending on the environment, Mantle-derived, basaltic magma may rise through the crust to feed volcanic eruption at the surface.

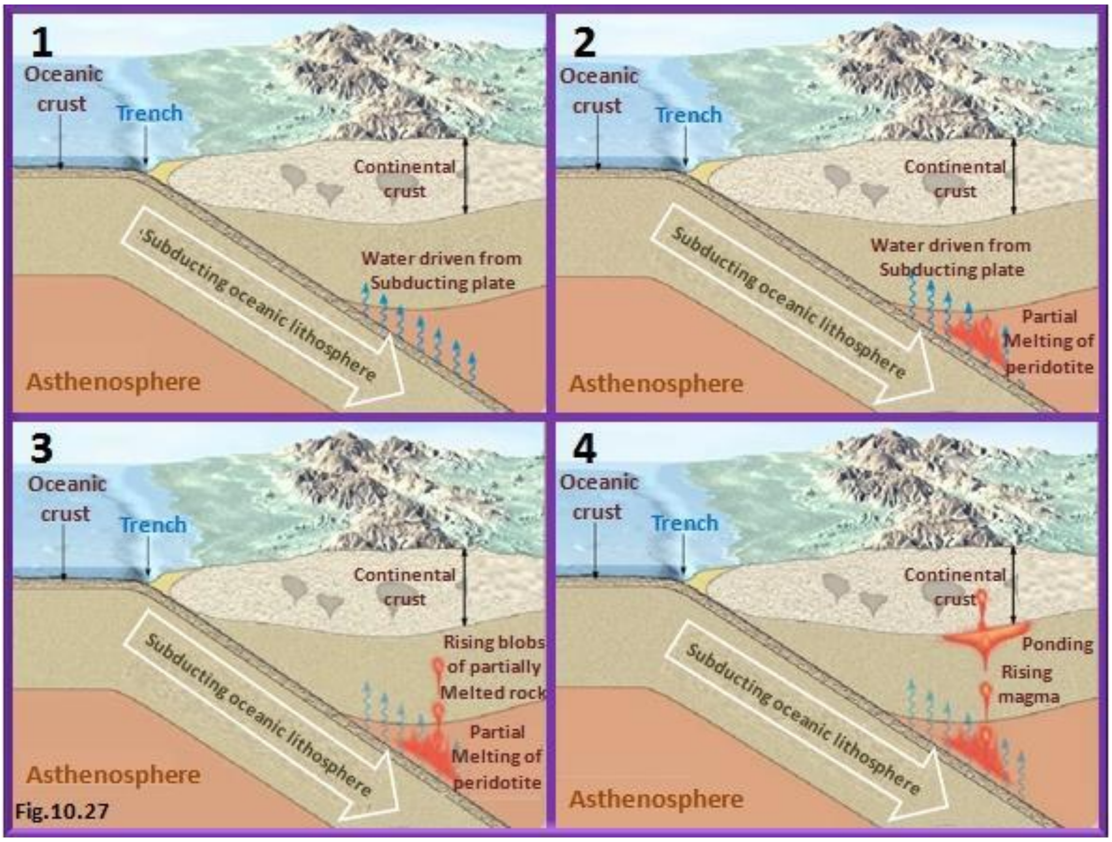


Fig.10.27

In a continental setting, basaltic magma typically melts and assimilates some of the crustal rocks through which it ascends.

The result is the formation of the **silica-rich magmas** having an **andesitic** composition, or less often, a **rhyolitic** composition. (Fig.10.28). 1

On occasions when andesitic magmas reach the surface, they often erupt explosively, generating large columns of volcanic ash, pumice and gases

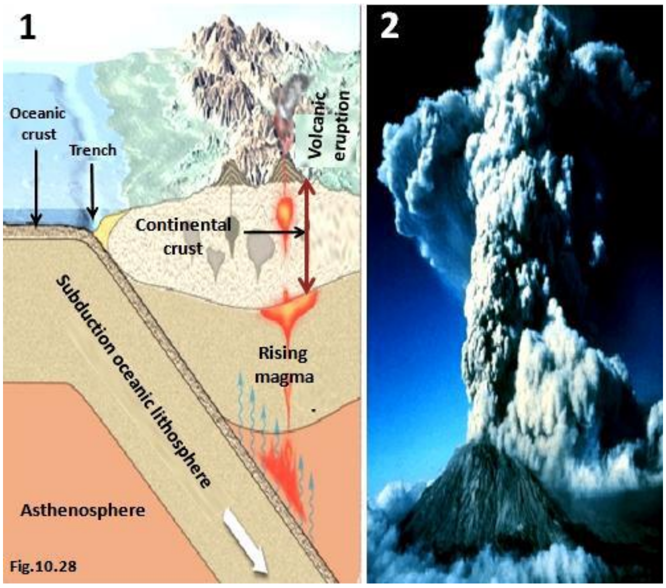


Fig.10.28

The volcanoes of the towering Andes are the products of magma generated by the subduction of the oceanic Nazca plate beneath the South American continent.
This chain of volcanic peaks, termed a **continental volcanic arc**, identifies the region of intrusive and extrusive igneous activity associated with an oceanic-continental convergent boundary. (Fig.10.29).

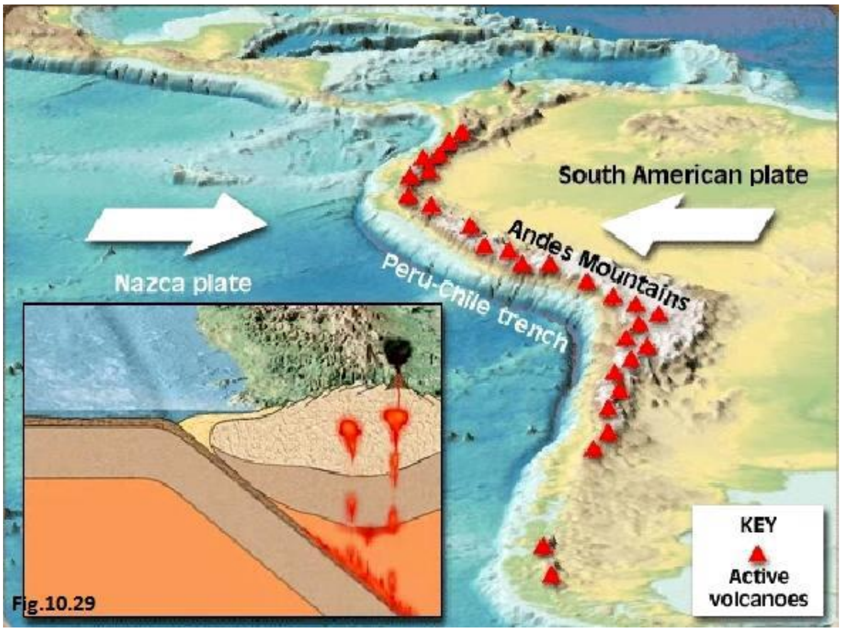


Fig.10.29

B- Plate of oceanic lithosphere is subducted beneath another:

Now let's look at what happens when two plates composed of oceanic lithosphere converge. In this setting, one oceanic plate descends beneath the other, often initiating volcanic activity at the surface.
Here, volcanoes grow up from the ocean floor, rather than on a continent. Should the volcanoes continue to grow, they will eventually reach the surface to form a **volcanic island arc**, or simply, an **island arc**. (Fig.10.30).

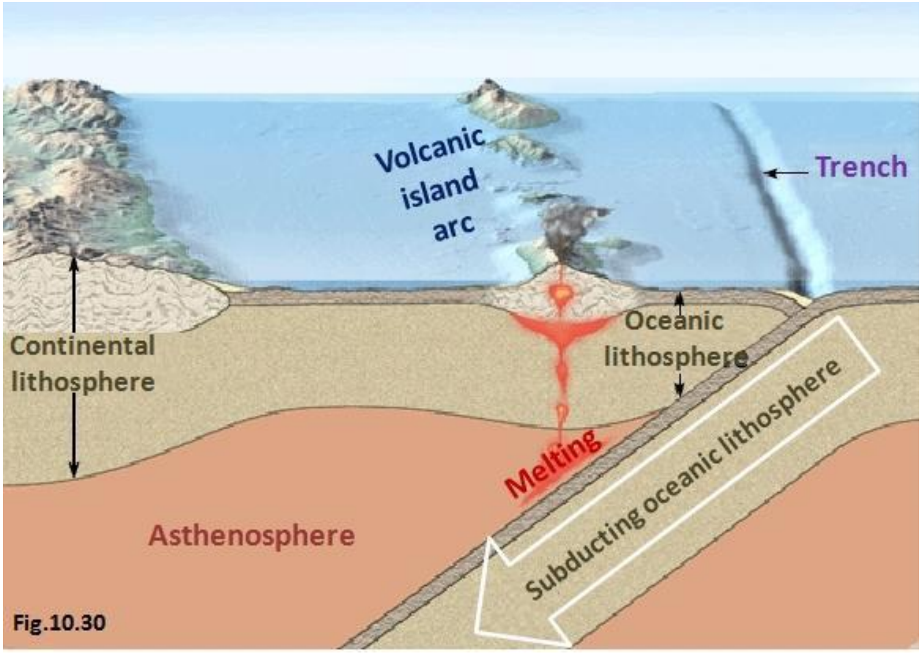


Fig.10.30

The image below shows a volcanic island arc that is part of Indonesia. (Fig.10.31). 1.
Most volcanic island arcs located in the Western Pacific, where they form parallel to a deep-oceanic trench. 2.

Fig.10.31

C- Two plate of continental lithosphere converge and eventually collide:

The third type of convergent plate boundary exists where two lithospheric plates, each carrying continental crust, collide.

If the subduction plate also contains continental lithosphere, continued subduction eventually brings the two continents together.

F .10.32). 1 … 4.

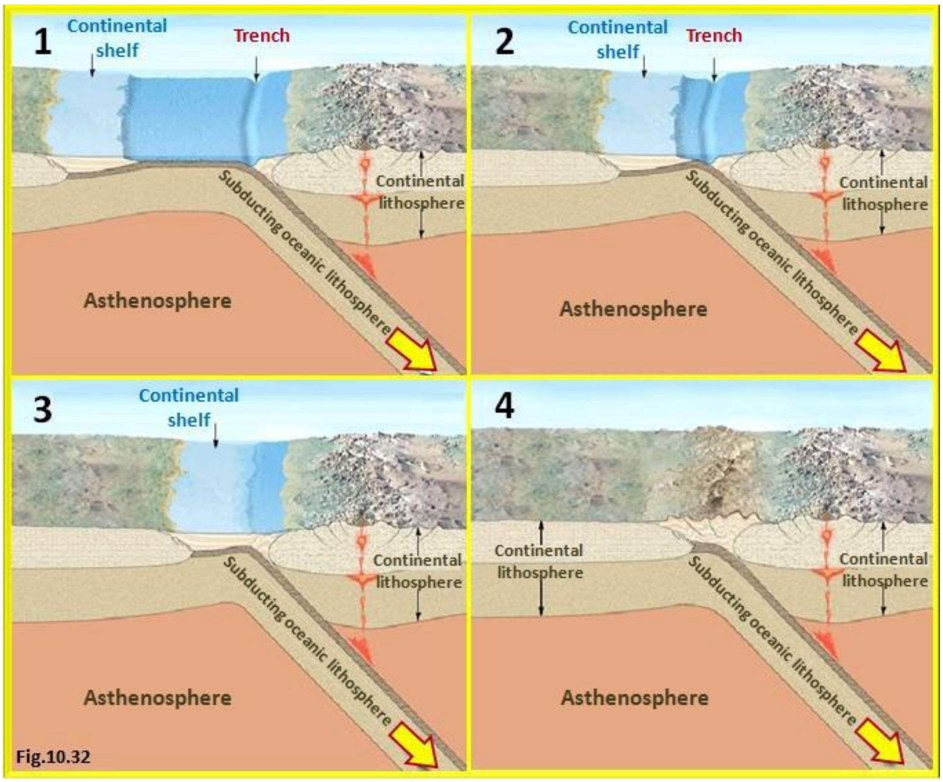


Fig.10.32

Because continental crust is too buoyant to undergo appreciable subduction, a collision between the continental plates results. (Fig.10.33).

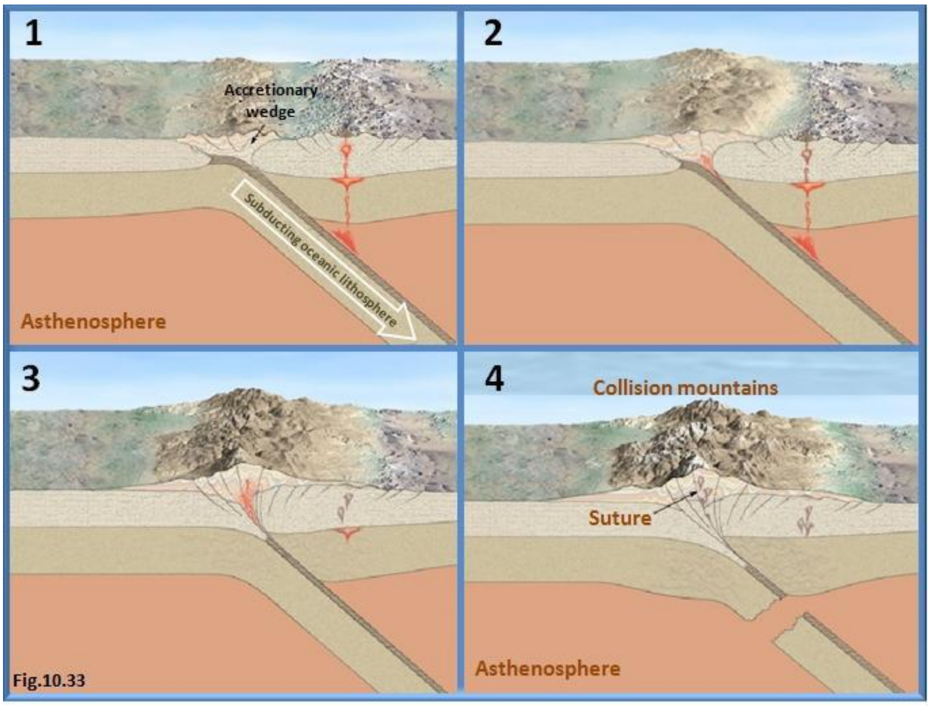


Fig.10.33

Such a collision occurred when India "rammed" into Asia and produce the Himalayas-the most spectacular mountain range on Earth and the Tibetan Plateau. (Fig.10.34). 1 and 2.
Other examples are the Urals, Caucasus, Pyrenees, Caledonians, Appalachians and Alps

Fig.10.34

3- Transform fault boundaries:

The third type of plate boundary is called a **transform fault**. It found where plates slide horizontally past one another without generating new lithosphere as occurs along divergent plate boundaries and without the destruction of lithosphere as occurs along convergent zones. (Fig.10.35). 1.

Most transform faults join two segments of the oceanic ridge system. 2.

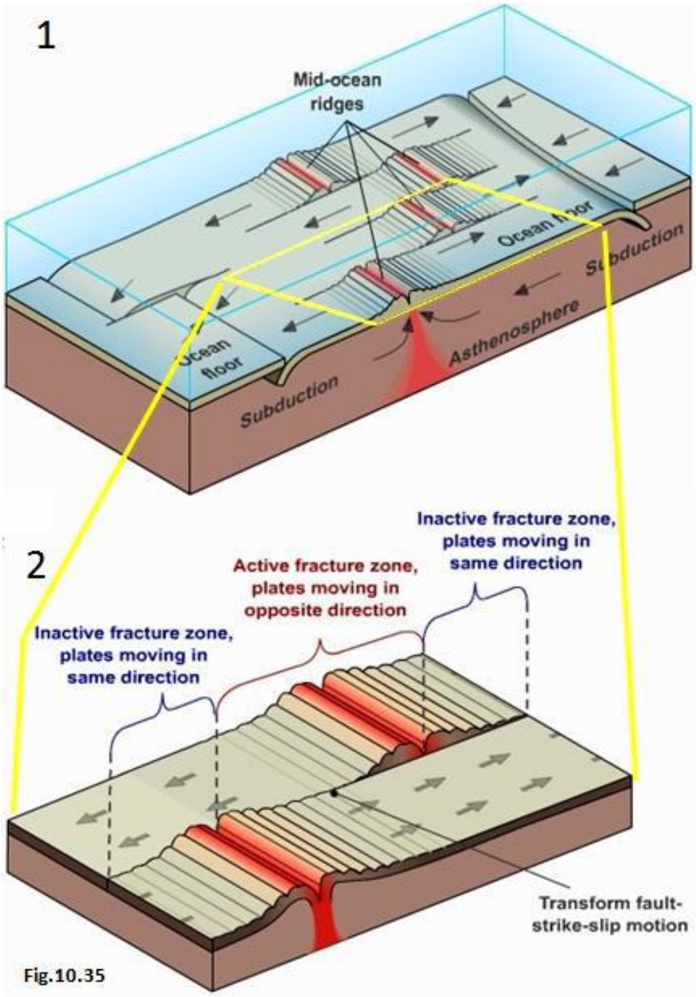


Fig.10.35

Transform faults join the globe's active belts (convergent and spreading centers) into a continuous network. (Fig.10.36).

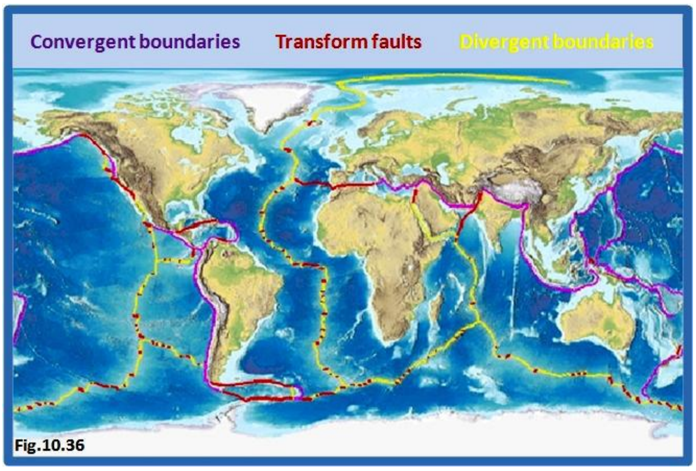


Fig.10.36

The adjacent plates of oceanic crust grind past one another, sporadically generating earthquakes. (Fig.10.37).

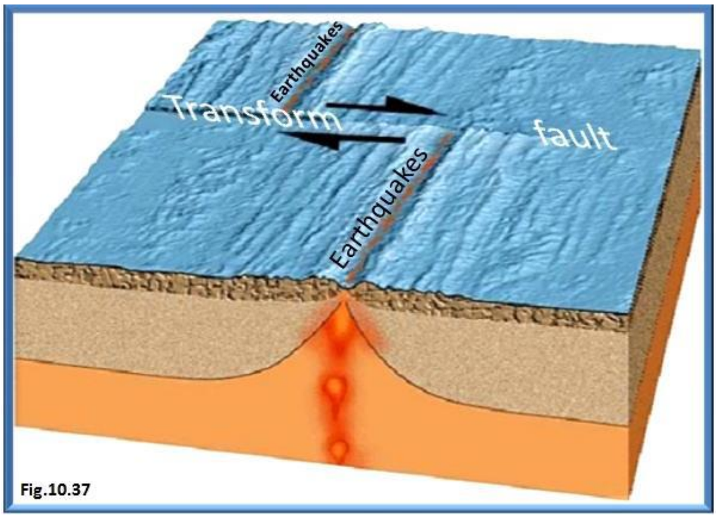


Fig.10.37

Although most transform faults are associated with oceanic ridge, some like the Andreas Fault in California, cut through continental crust. (Fig.10.38). 1.
Such situations provide geologists an opportunity to study transform faults first hand. 2.
Along the San Andreas Fault, the Pacific plate is moving toward the northwest, past the North American plate.

Fig.10.38

1- Earth's rigid outer layer overlies a zone of weaker and hotter material known as the : a- cry sphere. b- lithosphere. c- asthenosphere. d- mesosphere.

2- Great earthquakes can be generated at transform fault boundaries. a- true. b- false. 3- Most volcanic island arcs located in the ------------------. a- western pacific. b- Gulf of Mexico. c- Caribbean Sea. d- South Atlantic.

4- At divergent plate boundaries, two plates ------------------------.

a- move together. b- grind each other. c- join to produce a large plate. d- move a part. 5- Whenever a plate of oceanic lithosphere convergence with a plate of continental lithosphere -----------------------------.

a- the continental lithosphere descends into the asthenosphere. b- the continental lithosphere gets pushed toward the ridge. c- the oceanic lithosphere descends into the asthenosphere. d- the oceanic lithosphere gets pushed toward the ridge.

6- Transform faults occur where plates slide past one another and generate new lithosphere. a- true. b- false.

7- At transform faults boundaries, two plates ------------------------. a- move together. b- grind each other. c- join to produce a large plate. d- move a part.

8- The theory of plate tectonics holds that the outer rigid layer of Earth is broken into about a dozen major segments called shields. a- true. b- false.

9- According to the theory of plate tectonic, plates interact mainly --------------. a- along plate boundaries. b- near the center of each plate where stress is greatest. c- on the underside of each plate.

10- As plates move apart, the gap between them is filled with molten rock called ----------. a- granite. b- silica. c- magma. d- amphibolites.

11- At convergent plate boundaries -----------. a- new lithosphere is forming. b- old lithosphere is being destroyed. c- neither a or b. d- both a and b.

12- Volcano associated with continental volcanic arcs generally -------------. a- are located on island like Hawaii. b- emit mainly lava flow. c- erupt explosively. d- erupt on the average of every 1000 years.

13- Subduction occurs because: a- forces created at spreading centers are causing plates to move together. b- the sediments that cap the oceanic crust act as a lubricant to aid subduction. c- the subduction lithosphere has a greater density than the underlying asthenosphere. d- the lithosphere is warm and weak.

14- Most of the largest plates --------------. a- consist primary of oceanic crust. b- are dominated by continental crust. c- contain large amounts of both oceanic and continental crust.

15- The region where oceanic lithosphere descends into the asthenosphere is called --------------. a- an accretionary wedge. b- a hot spot. c- a mantle plume. d- a subduction zone.

16- Older oceanic lithosphere is cooler, thicker and denser than young oceanic lithosphere. a- true. b- false.

17- Along the San Andreas Fault, the Pacific plate is moving toward the northwest, relative to the North American plate. a- true. b- false.

18- What is the main factor that triggers the formation of magma when a cold plate of oceanic lithosphere is subducted? a- the subducted plate supplies water to the hot mantle rock thereby lowering its melting temperature. b- friction between the subducting plate and the mantle rock generates enough heat to trigger melting. c- the subducting plate carries sediments deep into Earth where it melts. d- the subducting plate displaces hot mantle rock which rises to form magma.

19- The mechanism that has generated the floors of the world's ocean is called ---------. a- ocean floor convergence. b- ocean floor construction. c- seafloor construction. d- seafloor spreading

20- Which one of these mountain belts was NOT formed by a continental collision? a- Himalayas. b- Andes. c- Appalachians. d- Urals.

21- Earth's rigid outer layer is called: a- cry sphere. b- lithosphere. c- asthenosphere. d- mesosphere.

22- Collision mountain belts form because continental crust is too buoyant to undergo subduction, and results in collision between continental fragments. a- true. b- false.

23- New oceanic crust is created at divergent boundaries at rate of about: a- 5 centimeters per century. b- 5 centimeters per year. c- 5 meters per year. d- 5 kilometers per year.

24- The lithosphere is thickest under the oceans and thinner beneath the continents. a- true. b- false.

25- When an oceanic plate and a continental plate converge, a -------------- is formed along a subduction zone. a- asthenospheric rise. b- oceanic trench. c- oceanic ridge. d- transform fault. e- rift.

26- Convergent plate margins occur where two plates are moving toward one another and the movement is accommodated by: a- earth getting larger. b- one plate sliding horizontally the other. c- new material being added at transform fault boundaries. d- one plate descending beneath the other.

27- Most divergent boundaries are located: a- in mountain regions such as the Alps and Himalayas. b- in deep-ocean trenches. c- along oceanic ridge. d- in the center of large continents.

28- Which of these plates is the larger? a- Nazca. b- Pacific. c- Australian-Indian. d- Africa.

29- At convergent plate boundaries, two plates -------------. a- move together. b- grind each other. c- reverse direction. d- move apart.

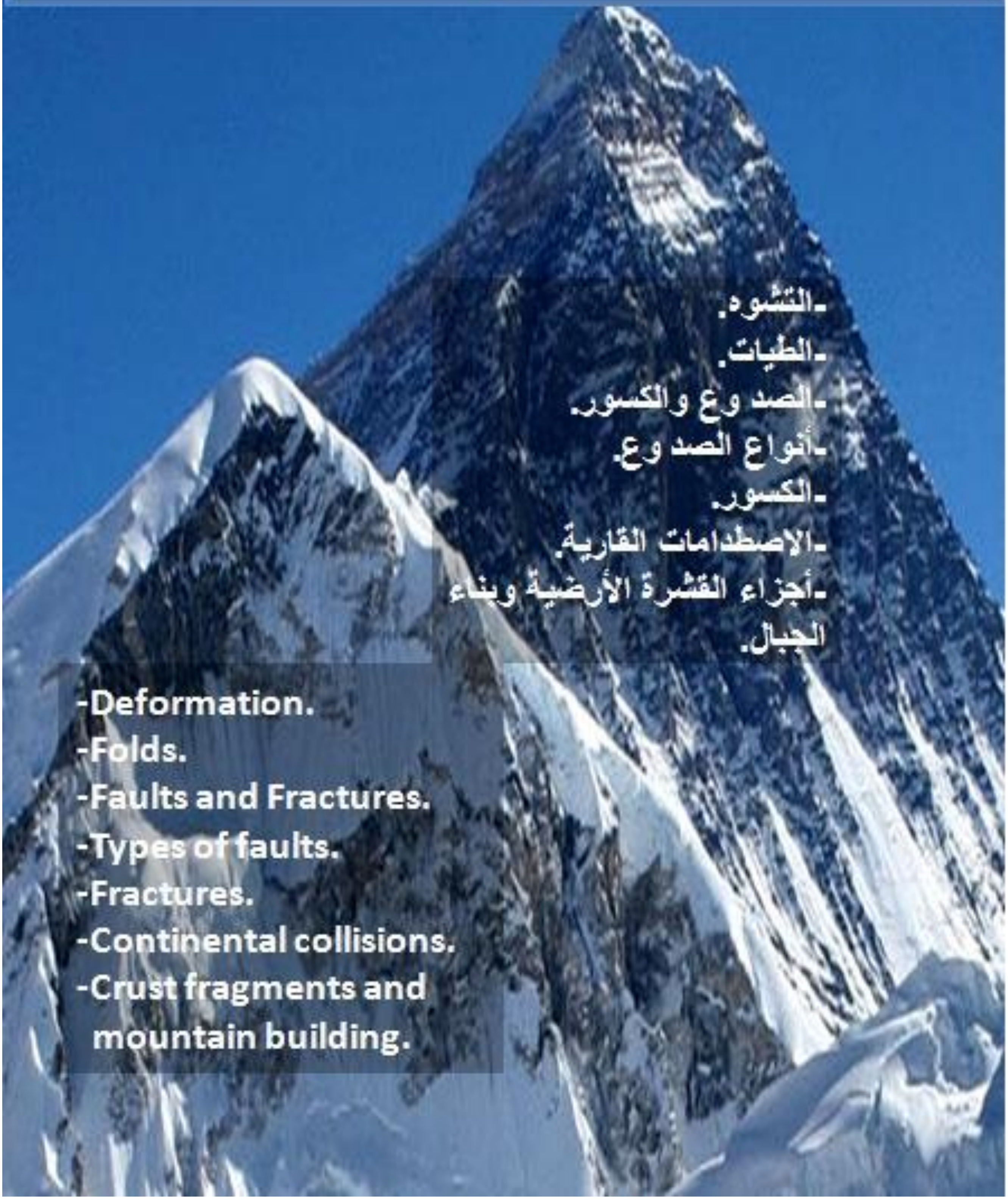
30- When two oceanic plates converge, and one plate descends to form a trench, material from the melting plate often forms a -------- at the surface. a- continental rift. b- volcanic island arc. c- oceanic ridge. d- mountain range.

31- Which of these water bodies was once a rift valley? a- Lake Michigan. b- Red Sea. c- Caspian Sea. d- Black Sea.

32- What layer of earth allows the plates to move? a- cry sphere. b- lithosphere. c- asthenosphere. d- mesosphere.

Chapter eleven الفصل الحادي عشر

Mountain building بناء الجبال



-التشوه.
-الطيات.
-الصدوع والكسور.
-أنواع الصدوع.
-الكسور.
-الاصطدامات القارية.
-أجزاء القشرة الأرضية وبناء الجبال.

- Deformation.
- Folds.
- Faults and Fractures.
- Types of faults.
- Fractures.
- Continental collisions.
- Crust fragments and mountain building.

11.1- Deformation:

Earth is a dynamic planet. Tectonic forces deformed rock to produce our planet's spectacular mountain belts.

When rocks are subjected to forces (stresses) greater than their own strength, they begin to deform usually by **folding** and **faulting**. (Fig.11.1).

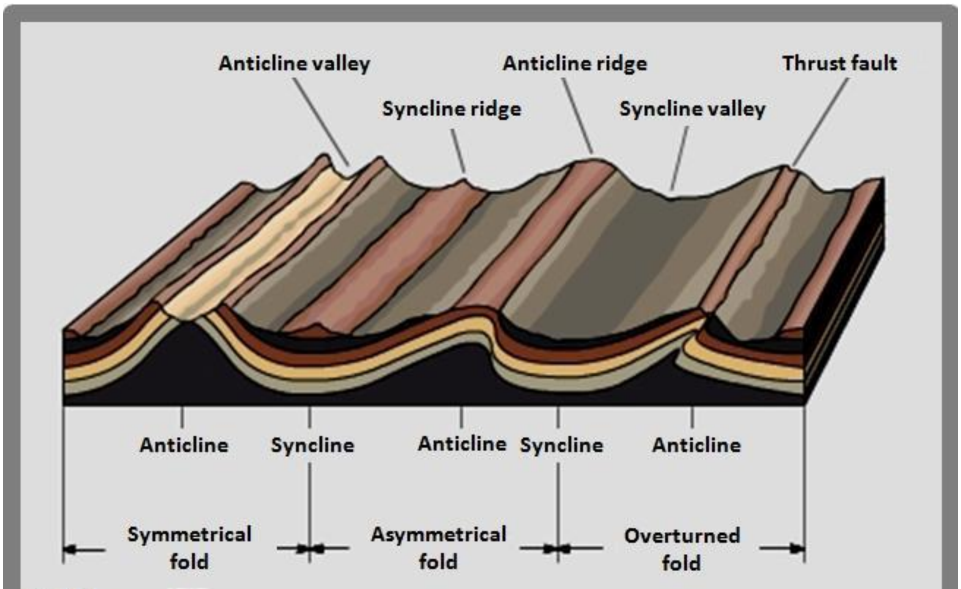


Fig.11.1

Some of the geologic structures associated with crustal deformation include folds, faults and joints or fractures. (Fig.11.2).

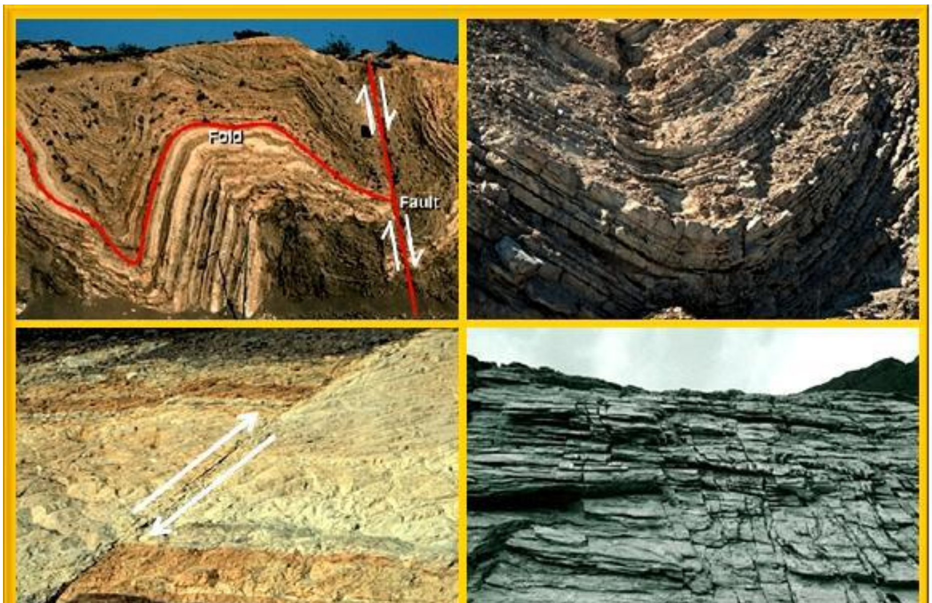
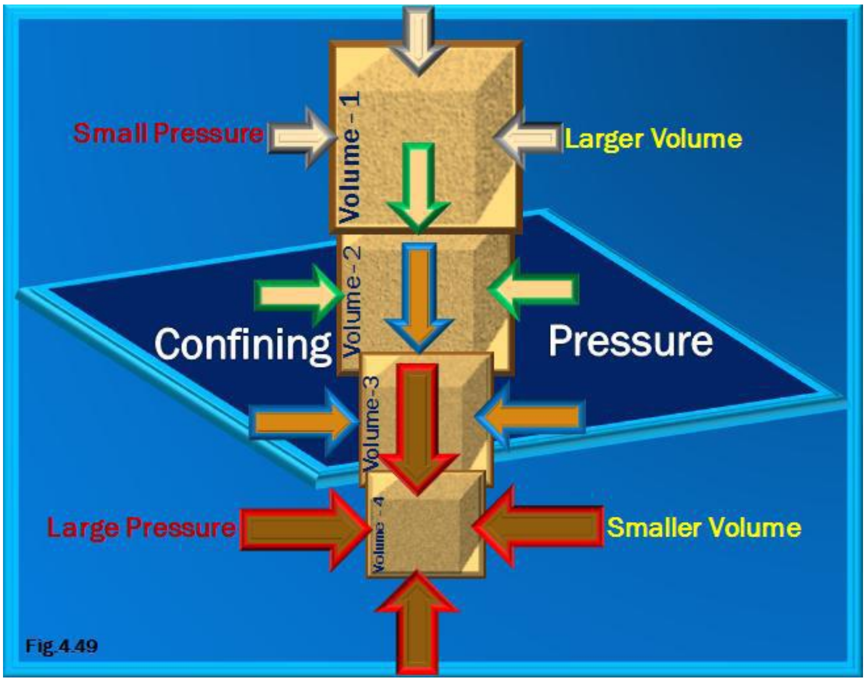


Fig.11.2

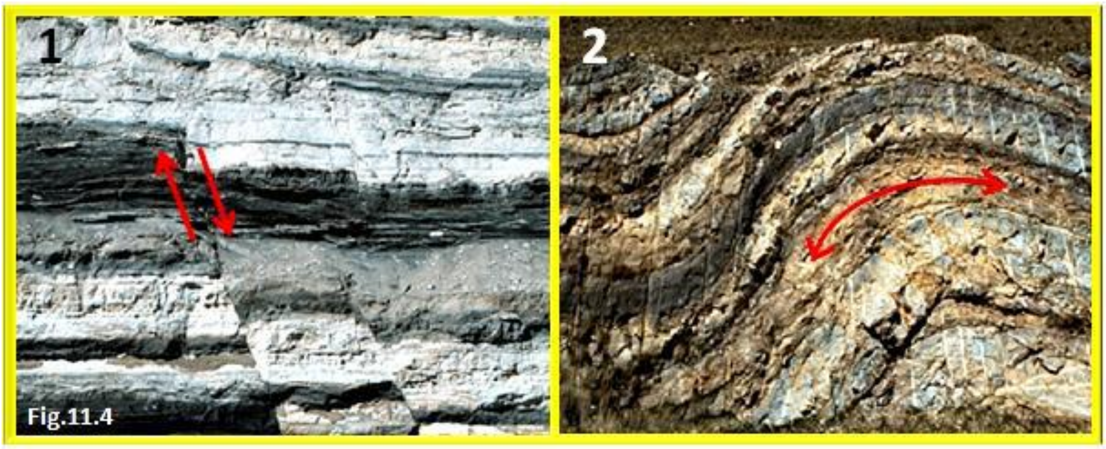
-Confining pressure:

Among the stresses that deform rock is confining pressure, which, like air pressure, is uniform in all direction.

Confining pressure is often the result of the load of overlying rocks and causes a reduction in the volume. (Fig.11.3).



In the upper crust where the confining pressure and temperature are relatively low, rocks are **brittle** and will usually fracture when deformed. (Fig.11.4). 1.
At great depth where confining pressure and temperature are high, rocks become **ductile** and deformed by folding. This deformation occurs at considerable depth. 2.



-Differential stresses:
Like those produced along plate margins, produces most crustal deformations.
F .11.5). 1 … 4.

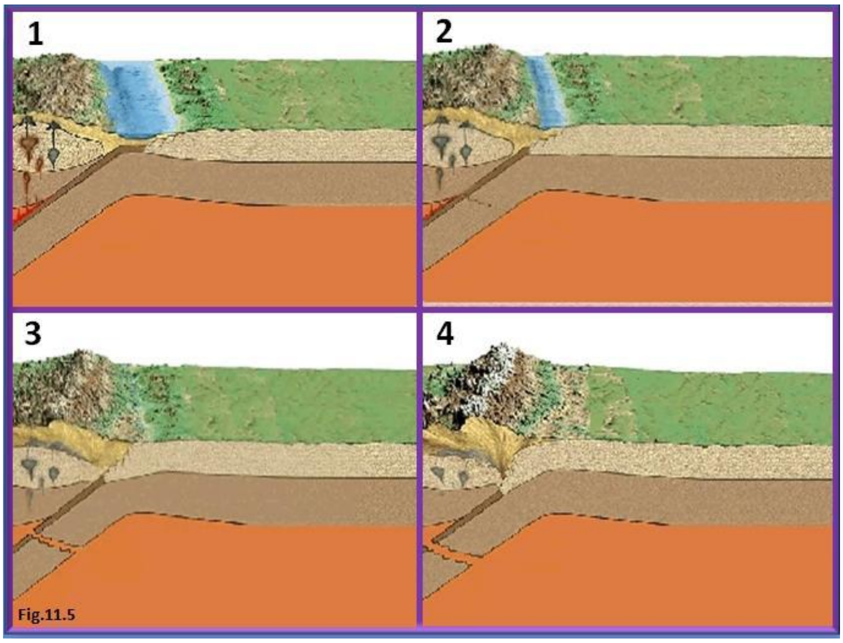


Fig.11.5

When differential stresses act to shorten a rock body, they are known as **compression stresses**. (Fig.11.6). 1.
Conversely, when stresses act in opposing direction, they tend to elongate, or pull apart, a rock unit and are known as **tensional stresses**. 2.
In addition, differential stresses can cause rock to **shear**. 3.
The features of deformation generate features at many different scales.
At one extreme are Earth's major mountain belts and at the other are localized stresses that create small features in bedrock. 4.
These features, which include folds, faults, and fractures or joints, are called **rock structures**

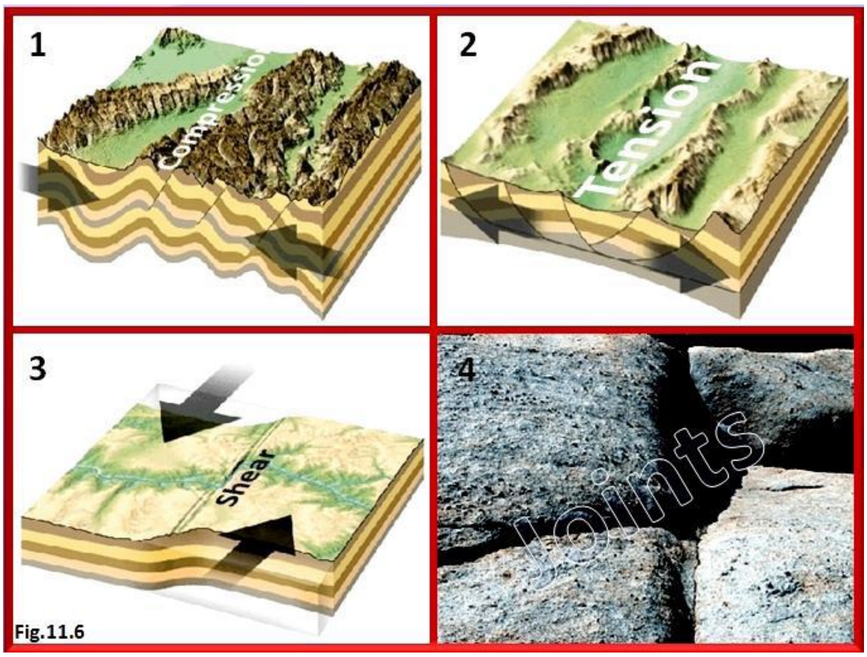


Fig.11.6

11.2- Folds:

During mountain building, flat-laying sedimentary rocks are often bent into a series of wavelike undulation called **folds**.
The two sides of a fold are called **limbs**.

A line drawn along the points of maximum curvature is termed the **axis** (**hinge line**) of the fold, and the **axial plane** is an imaginary surface that divides a fold as symmetrically as possible. (Fig.11.7).

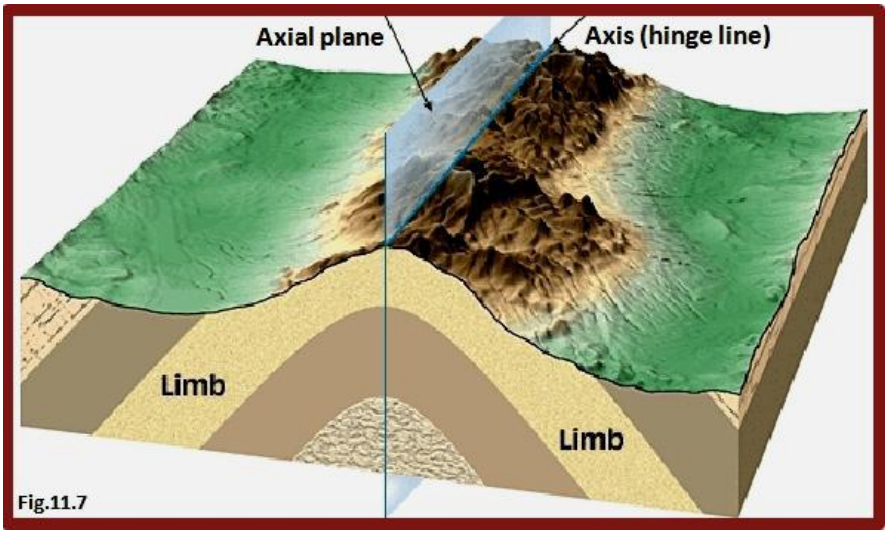


Fig.11.7

The two most common types of folds are called anticline and syncline.

Anticline, which is commonly formed by up folding, or arching, of rock layers and often in associated with syncline. (Fig.11.8).

Depending on their orientation, these basic folds are described :

A-Symmetrical: when the limbs on either side of the axial plane diverge at the same angle. 1.

B-Asymmetrical when the limbs on either side of the axial plane diverge not at the same angle. 2.

An asymmetrical fold is said to be **overturned** if one limb is tilted beyond the vertical. 3.

If an overturned fold "lies on its side" so that the axial plane is horizontal, it is called a **recumbent** fold. 4.

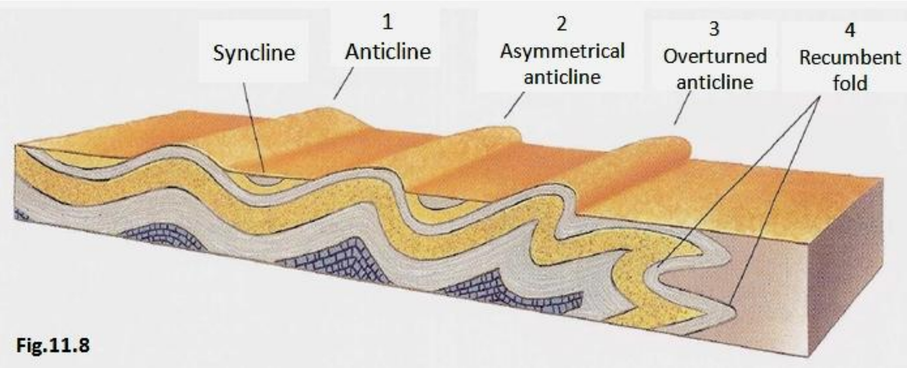


Fig.11.8

Folds do not continue forever, rather ends die out much like wrinkles in a table cloth.

These ends are said **plunge** because their axis penetrates into the ground. (Fig.11.9). 1.

View of plunging folds as they may appear after extensive erosion. 2.

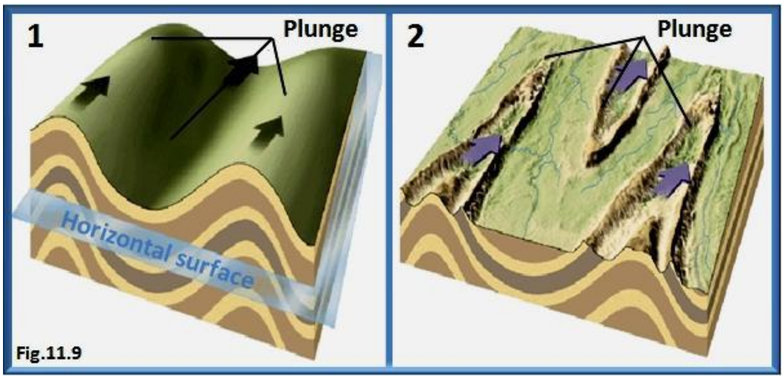


Fig.11.9

Although most folds are caused by compression stresses, some are the consequence of vertical displacements along faults.
Monocline is such structures.
(Fig.11.10).

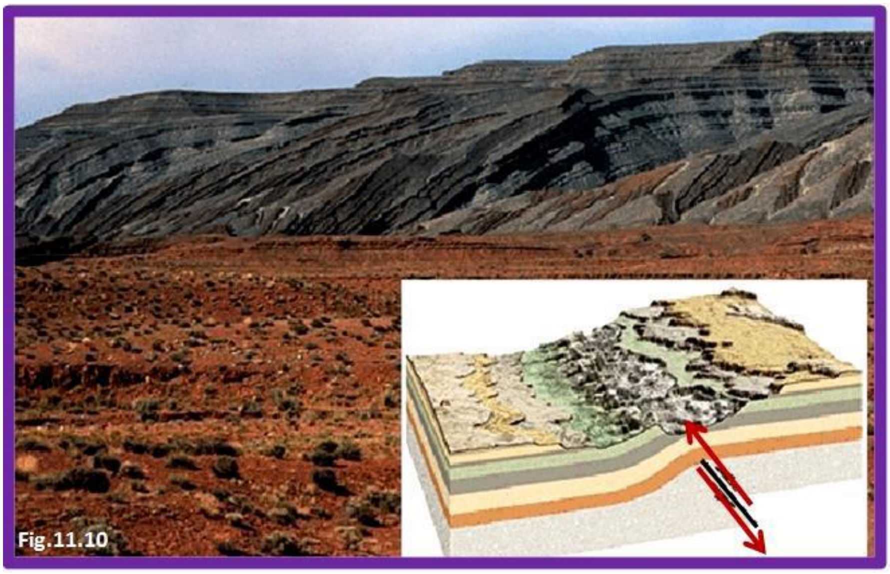


Fig.11.10

Broad **up** warps can also generate nearly circular structures called **domes**. (Fig.11.11). 1.
Nearly circular **down** warped structures are called **basins**. 2.

-

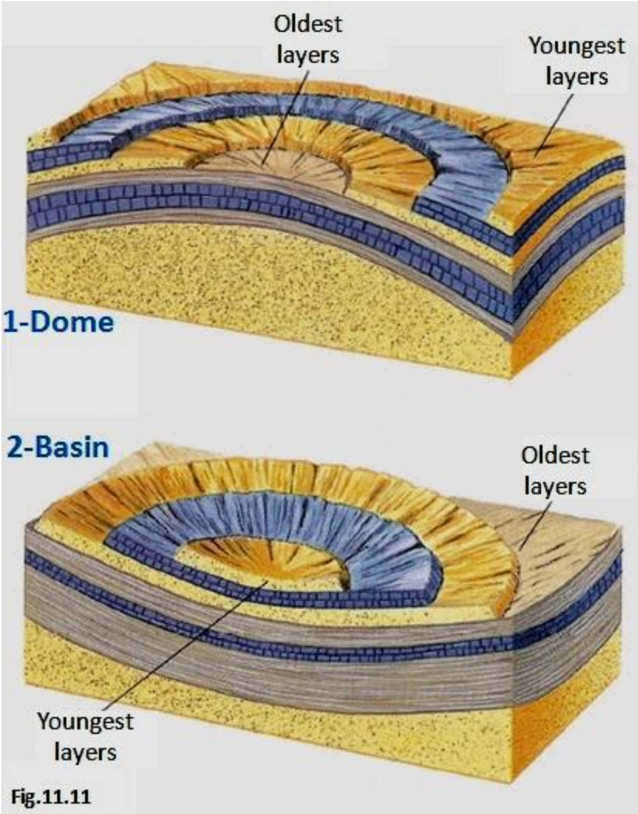


Fig.11.11

11.3- Faults and Fractures:

Faults are fractures along which displacement has taken place. (Fig.11.12). 1.
Faults in which the movement is primarily parallel to the dip of the fault surface are called **dip-slip fault**. 2.

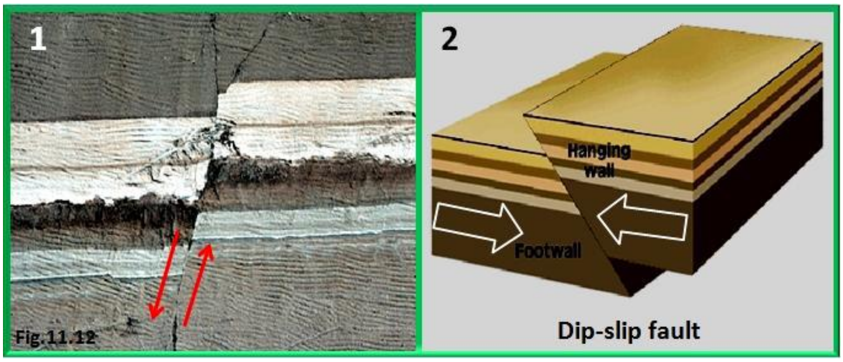
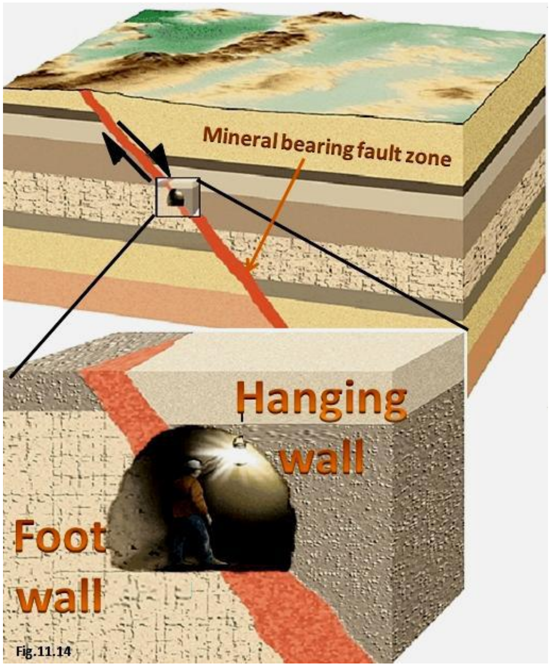


Fig.11.12
Dip-slip fault

Vertical displacements along dip-slip faults may produce long, low cliffs called **fault scarps**. (Fig.11.13).

To describe the displacement along a dip-slip fault, we use nomenclature that arose from miners who excavated shafts along fault zones. (Fig.11.14).
The rock surface above the mineralized fault zone is called the **hanging wall** and the rock surface below the mineralized fault zone is called the **footwall**

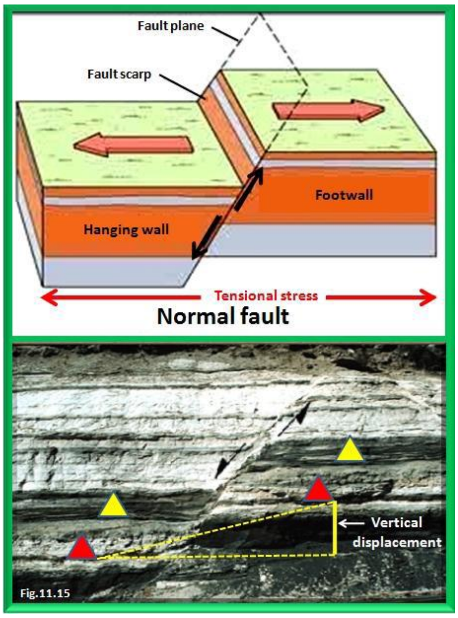


11.4- Types of faults:

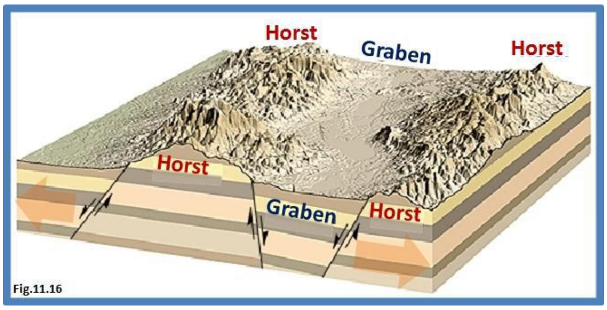
Faults are classified into:

A- Normal faults:

Normal faults indicate the existence of tensional stresses that tend to pull the crust apart.
When the hanging wall block moves down relative to the footwall block, called normal fault. (Fig.11.15). Most normal faults are small, having displacements of only a meter or so.



Normal faulting may also result in a central block called a **graben** which is bounded by uplifted structures called **horsts**.
(Fig.11.16).



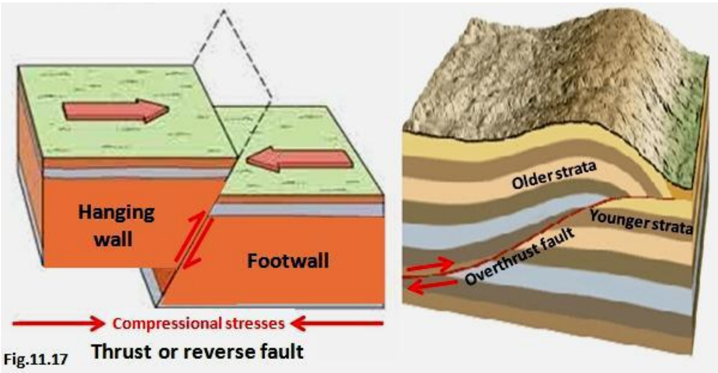
B- Thrust and reverse faults:

When the hanging wall block moves up relative to the footwall block called thrust fault. It occurs in compression environment. The result of this large-scale movement is that older strata overlying younger rock.

Thrust fault ……. Dip < 45°

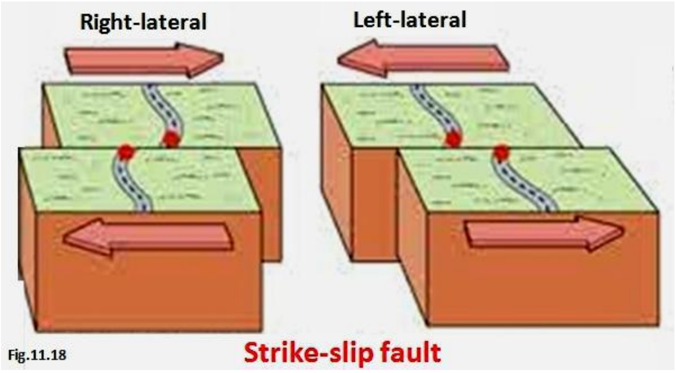
Reverse fault ….. Dip > 45°

(Fig.11.17).

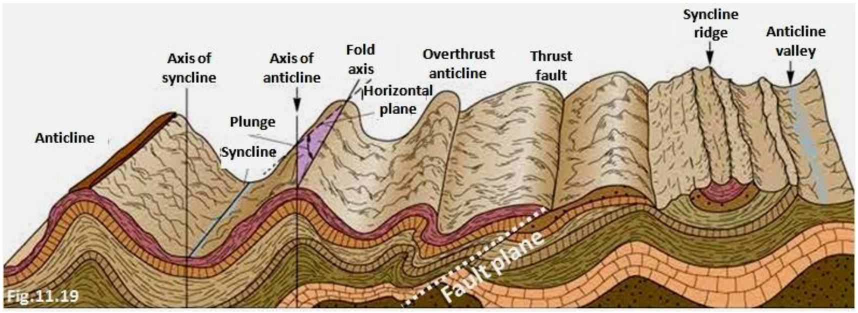


C- Strike-slip fault:

fault extends parallel to the extending of faulting layers. (Fig.11.18).



Commonly, the mountain belts contains anticline, syncline, overturned anticline, thrust fault, moreover syncline ridge and anticline valley. (Fig.11.19).



11.5- Fractures:

Fractures along which no appreciable displacement has occurred are called **joints**.
(Fig.11.20). 1.

Columnar joints form when igneous rocks cool and develop shrinkage fractures that produced elongated joints column. 2.

Most joints are the result of brittle failure of rocks, when rocks in the outermost crust are deformed. (Fig.11.21).

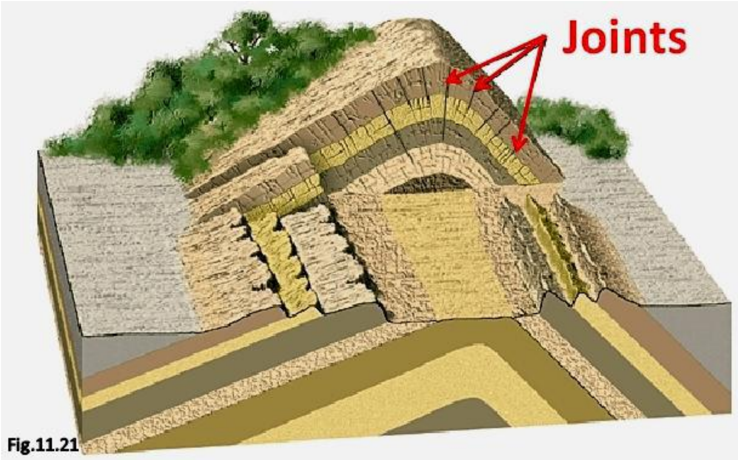


Fig.11.21

11.6- Continental collisions:

Mountains are often spectacular features that rise several hundred meters or more above their surroundings.
Mountain ranges form where two plates of oceanic lithosphere converge and one is subjected beneath the other.
The result is a chain of volcanic strutures called **volcanic island arc**. (Fig.11.22).

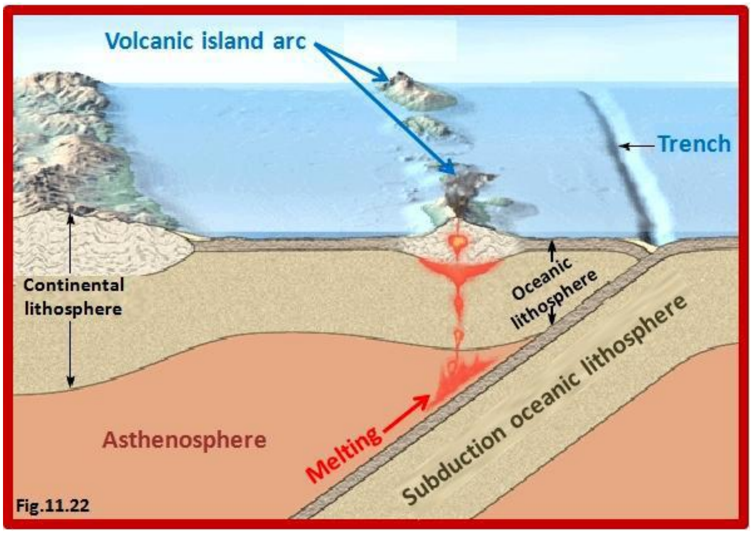


Fig.11.22

However, most major mountain belts show evidence of enormous compressional forces that have folded, faulted and generally deformed large sections of earth's crust.
Most prominent of this group are the relatively young mountain belts of the American Cordillera, which runs along the western margin of the Americas and the Alpine-Himallia chain that extends from the mediterranean through Iran to northen India and into Indochina. Also included the older more deeply eroded mountain belts such as the Appalachians, Caledonians and Urals. (Fig.11.23).

Fig.11.23

Most of these major mountain belts were formed during the collision of two or more buoyant crustal blocks.

Collision mountain ranges develop when continued subduction beneath a continental margin carries another continental block to the trench. (Fig.11.24). 1 … 4.

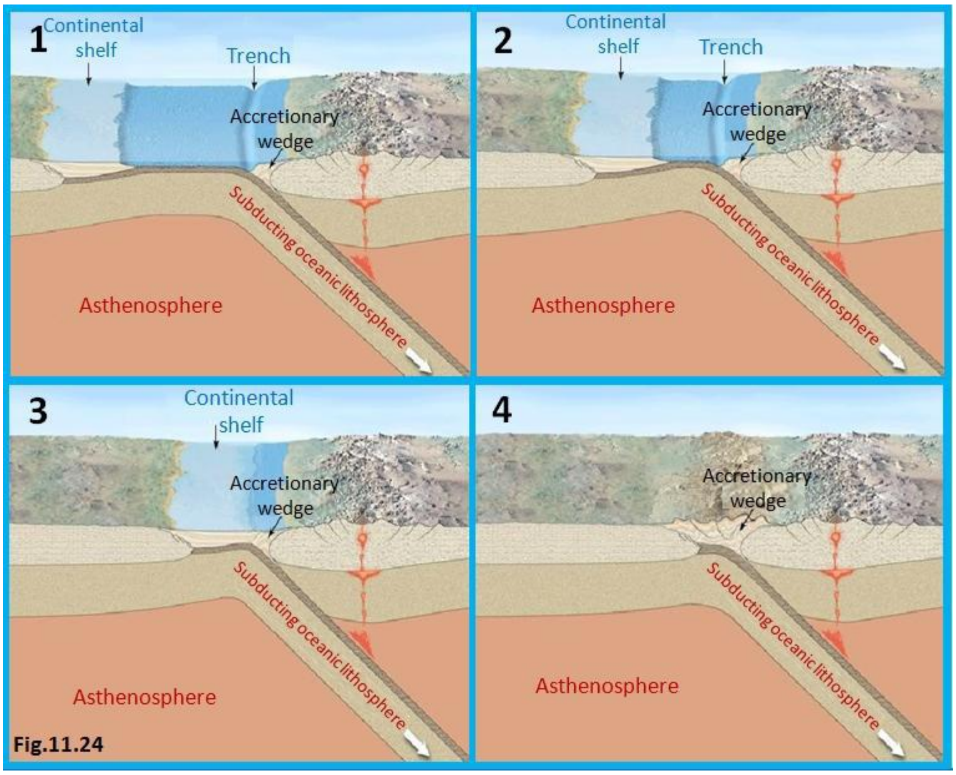


Fig.11.24

Because continental crust is too buoyant to undergo appreciable subduction, a collision between the continental fragments results. (Fig.11.25).

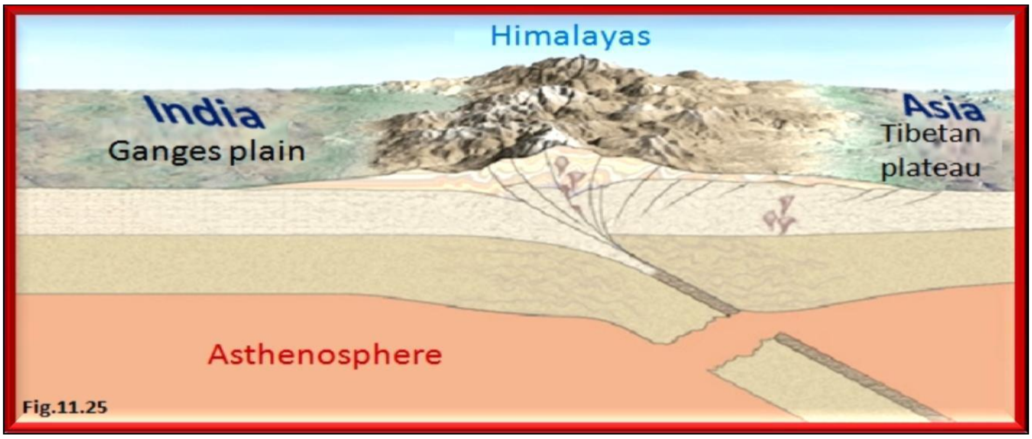


Fig.11.25

Such a collision occurred when the sub continental of India "rammed" into Asia and produced the Himalaya-the most spectacular mountain range on Earth.
The formation of the Himalayas began about 150 million years ago when India separated from the supercontinent of **Pangaea** and began to slowly drift northward. (Fig.11.26).
About 45 million years ago, India reached the trench that was located along the southern margin of Asia.

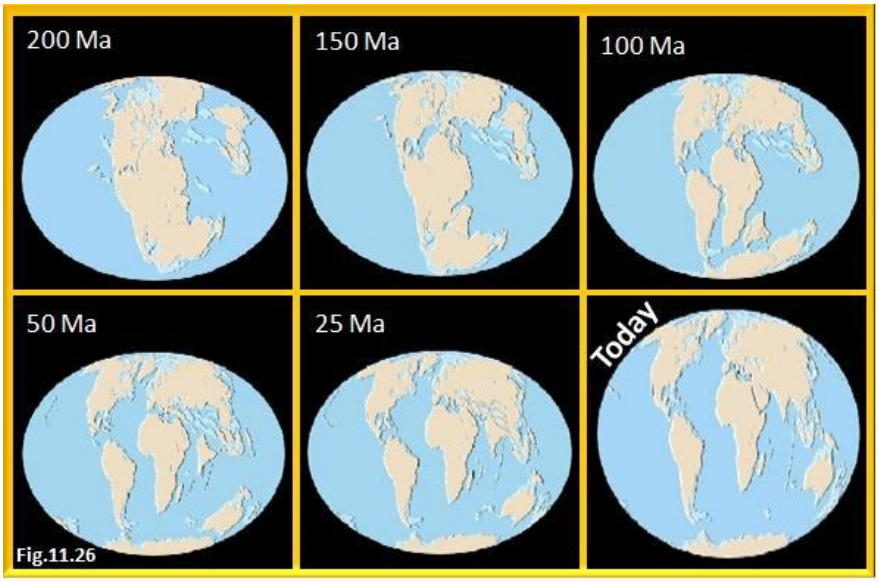


Fig.11.26

The continued northward migration of India deformed and elevated the margins of these continental blocks.

Gradually, these lithospheric plates were shortened and thickened producing the spectacular Himalaya Mountains and the Tibetan Plateau. (Fig.11.27).

It is estimated that India has penetrated at least 2000 kilometers into Asia and is still Moving northward at a rate of few centimeters per year

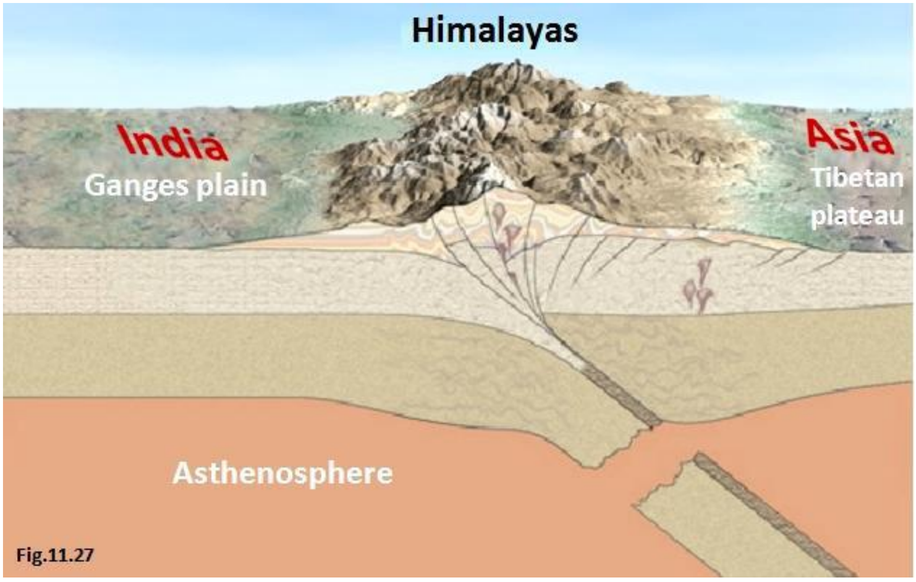


Fig.11.27

11.7- Crustal fragments and mountain building:

Small crustal fragments have also collided with one another, or with continental margin to generate mountainous topography.

Modern day examples of such crustal fragments include the island of **Madagascar**, (Fig.11.28) 1. And island arcs like **Japan**, the Marianas, and the Aleutian islands. 2.

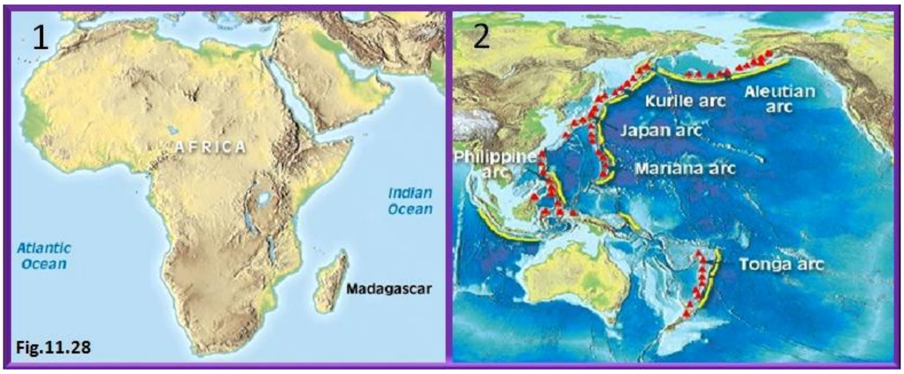


Fig.11.28

Numerous submerged crustal fragments having various origins. (Fig11.29).

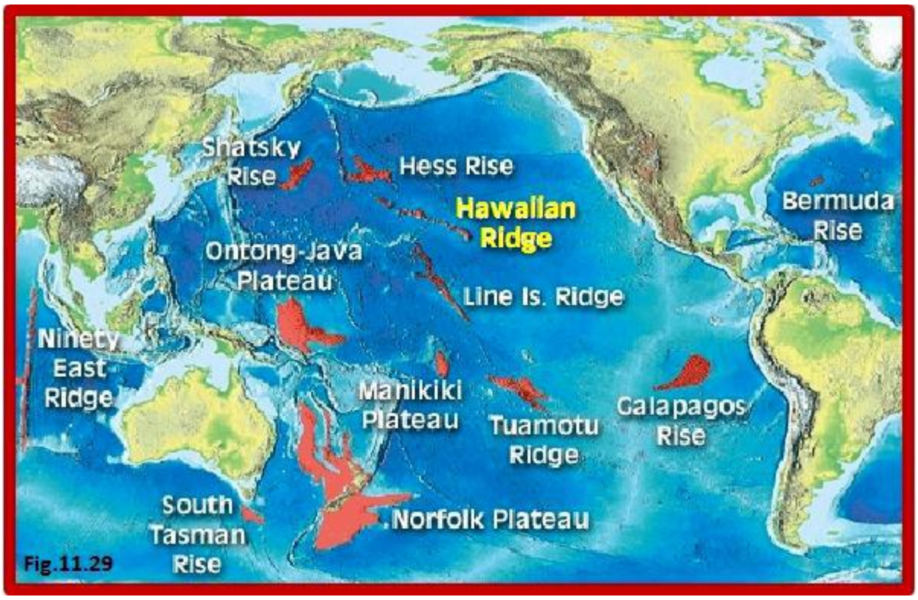


Fig.11.29

For example, an islands arc may be carried to a trench where it is "peeled" from the subducting plate and thrust upon the adjacent continental block, thereby generating a mountainous terrain. This newly accreted material may later be displaced farther inland by the addition of other crustal fragments. (Fig.11.30). 1 and 2.

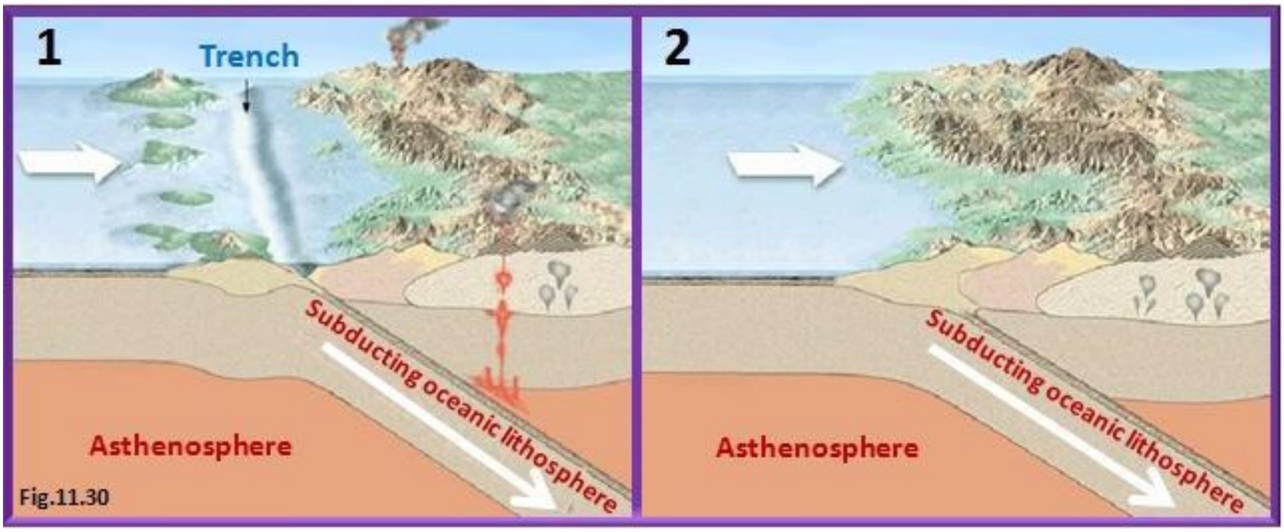


Fig.11.30

The mountain belts of Alaska and British Columbia appear to have formed principally from the accretion of small crustal fragments upon the North American continent. (Fig.11.31). 1 … 4.

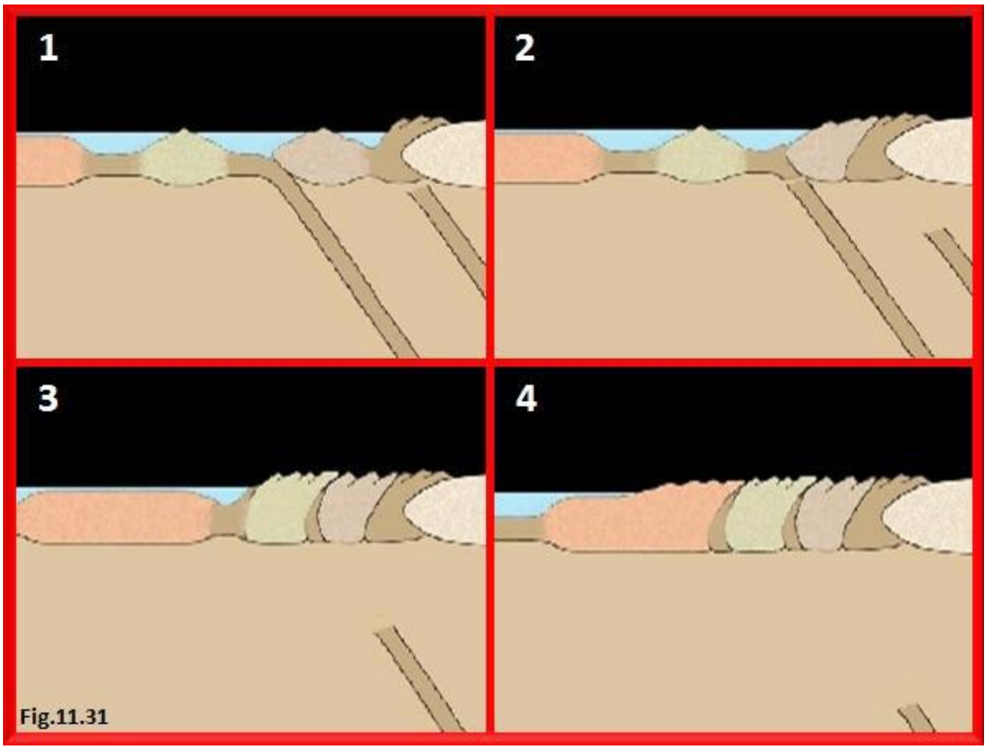


Fig.11.31

Geologists refer to these accreted crustal blocks as **terrains**. Simply, the term terrene designates any crustal fragment that has a geologic history distinct from that of adjoining terrenes. (Fig.11.32).

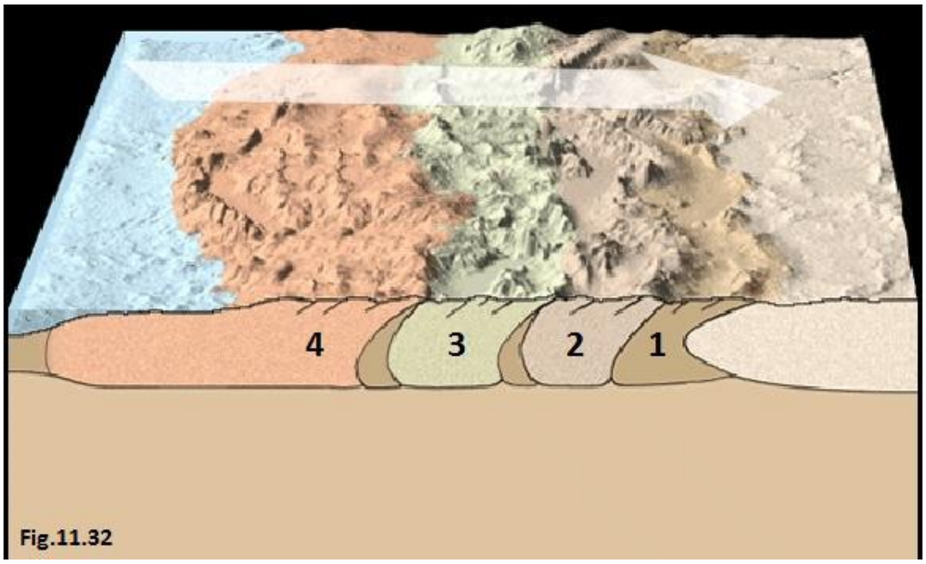
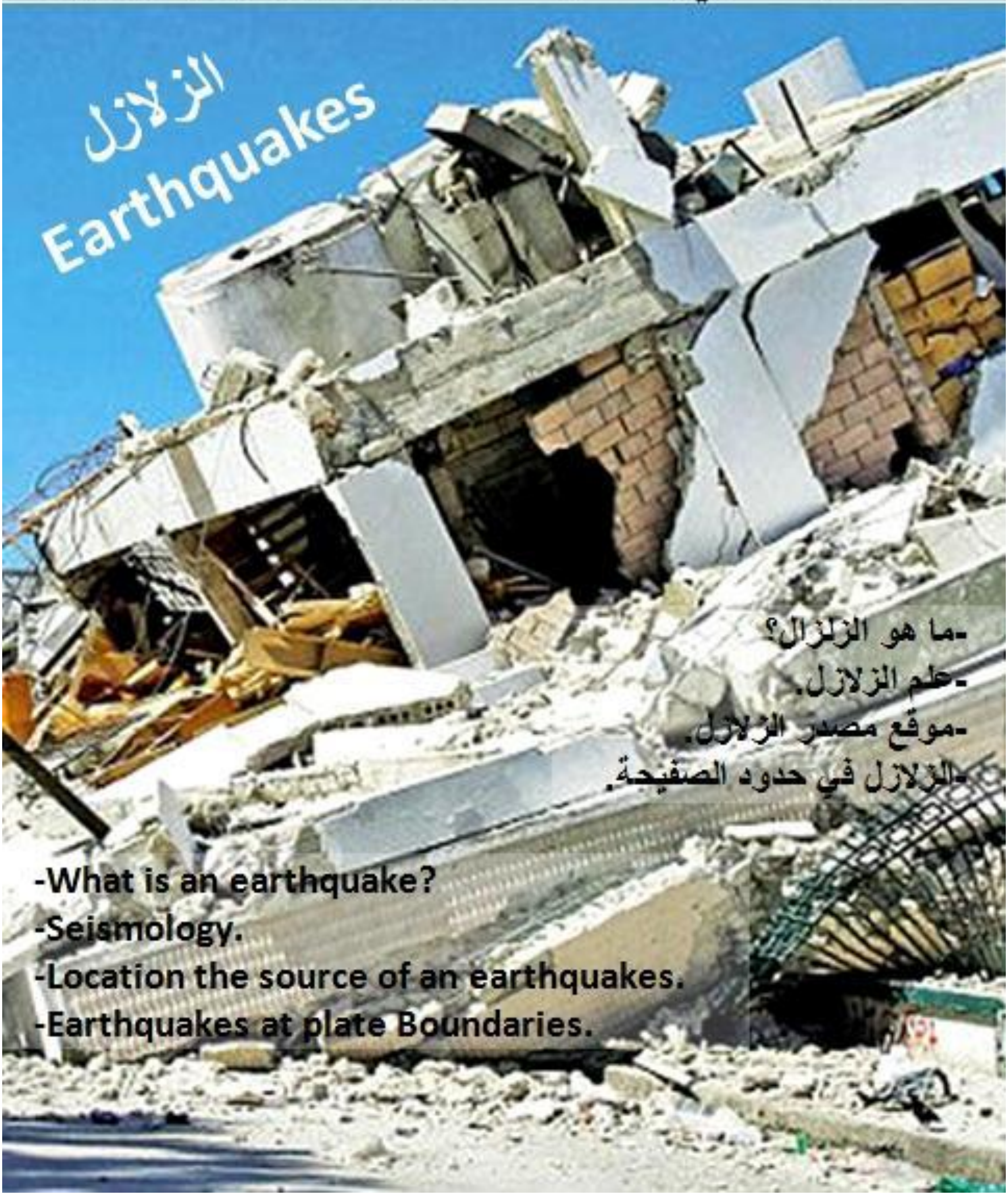


Fig.11.32

1- Nearly circular down warped structures are called -------------. a- basins. b- troughs. c- syncline. d- valley folds.
2- Normal faulting may produce a down-faulted central block called a -------------. a- horst. b- trough. c- graben. d- syncline.
3- An overturned fold that "lies on its side" so that the axial plane is horizontal is called a ------------- fold. a- horizontal. b- disturbed. c- recumbent. d- deformed.
4- Displacement along dip-slip faults may produce long, low cliff, called ---------------. a- escarpments. b- ridges. c- embankments. d- fault scarps.
5- Near Earth's surface crustal rocks tend to deform by ---------------- deformation. a- ductile. b- seismic. c- shear. d- brittle.
6- Compressional stress ---------------- a rock body. a- elongated. b- shorten.
7- Which of these faults may displace older strata over younger strata? a- strike-slip faults. b- normal faults. c- reverse faults. d- thrust faults.
8- Fractures along which no appreciable displacement has occurred are called -------. a- thrust fault. b- joints. c- rifts. d- shear zone.
9- Transform faults are example of ------------. a- strike-slip faults. b- normal faults. c- reverse faults. d- thrust faults.
10- Tensional stresses ----------------- a rock body. a- elongated. b- shorten.
11- This fold commonly formed by uplifting or arching of rock layers. a- syncline. b- up cline. c- anticline. d- recline.
12- At great depths, crustal rock tends to deform by -------------- deformation. a- ductile. b- seismic. c- shear. d- brittle.
13- At dip-slip fault, in which the hanging wall block moves down relative to the footwall block, is called a -------------- fault. a- transform. b- strike-slip. c- normal. d- reverse. e- none of the above.

14- Faults are fractures along which displacement has taken place. a- true. b- false.

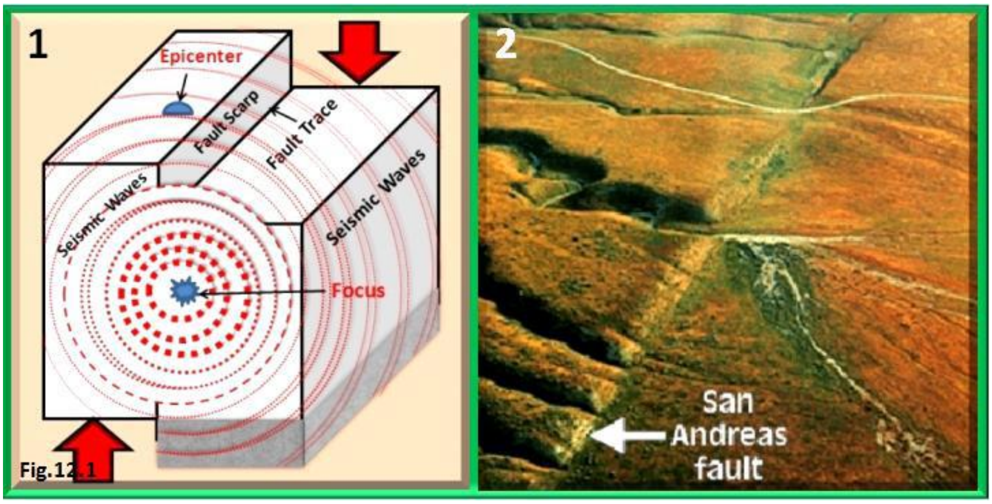
Chapter twelve الفصل الثاني عشر



12.1- What is an earthquake?

Roughly 1000 damaging earthquakes occur each year.

Earthquake is the vibration of earth, produced by the rapid release of energy.
This energy radiation in all directions from its source, the **focus**, in the form of waves. (Fig.12.1). 1.
We know that most earthquakes result from movements along large fractures called **faults**. 2.



The actual mechanism of earthquakes generation was discovered by H .F. **Reid** during a study following the 1906 San Francisco earthquake. (Fig.12.2). 1.
This great earthquake was accompanied by displacements of several meters along the northern portion of the San Andreas fault.
The San Andreas fault zone separates two great sections of earth's crust, the North America plate and the Pacific plate.
Field investigations determined that during this single earthquake, the Pacific plate slid as much as 4.7 meters in a northward direction past the north American plate. 2.

The mechanism for earthquake generation which Reid deduced from these facts is termed **elastic rebound**. (Fig.12.3).

Geologists were aware that earthquakes occurred along large faults, but the actual mechanism that generated earthquakes eluded them. (Fig.12.4). 1.

By studying the great 1906 San Francisco earthquake. **Reid** concluded that tectonic forces over tens or hundreds of years slowly deform the crustal rock on both sides of the fault. 2.
Under these conditions, the rocks are bending and strong elastic energy much like a wooden stick would if bent.
Eventually the frictional resistance holding the rocks together is overcome.3.
The vibrations of we know as an earthquake occur as the rock elastically "snaps back" to its original shape. 4.
In summary, **Reid's discovery** that earthquake waves are generated as rocks snap back to their original shape is termed **elastic rebound**.

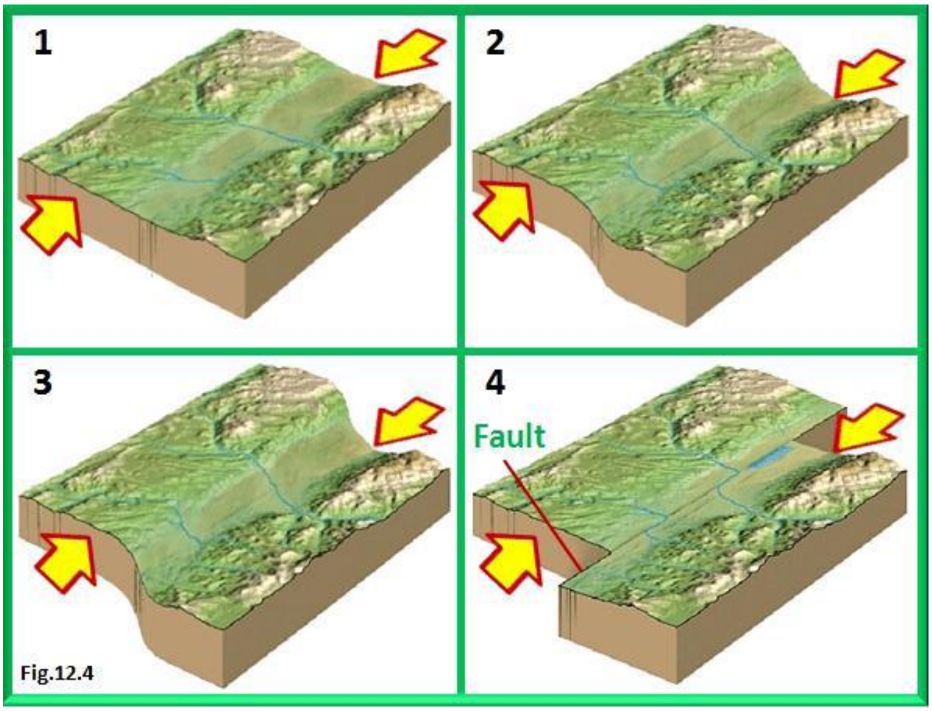


Fig.12.4

12.2-Seismology:

The study of earthquakes waves, **seismology**, dates back to the Chinese almost 2000 years ago.
In principle at least, modern seismographs, instruments that record seismic waves, are not unlike those used by the early Chinese.
Seismographs have a mass freely suspended from a support that is attached to the ground.
When the vibrations from a distant earthquake reach the instrument, the inertia of the mass keeps it relatively stationary, while the ground and support move.
The movement of the ground in relation to the stationary mass is recorded on a rotating drum or other device. (Fig.12.5).

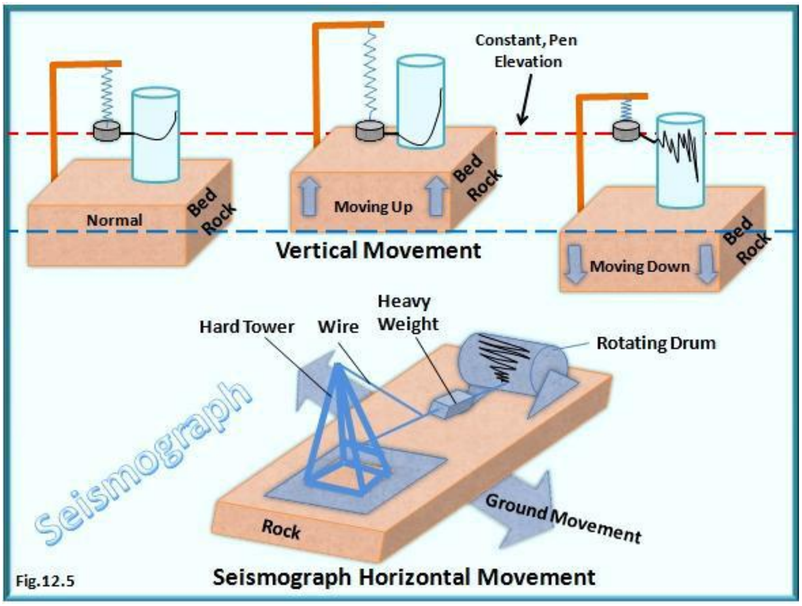


Fig.12.5

The records obtained from seismographs, called seismograms, provide a great deal of information about the behavior of seismic waves.

Simply stated, seismic waves are elastic energy that radiate in all directions from the **focus**.

The propagation (Transmission) of this energy can be compared to the ripples generated when a stone is dropped in static water pond.

(Fig.12.6). 1.

Seismograms reveal that **two main** groups of seismic waves are generated by the slippage of a rock mass. 2.

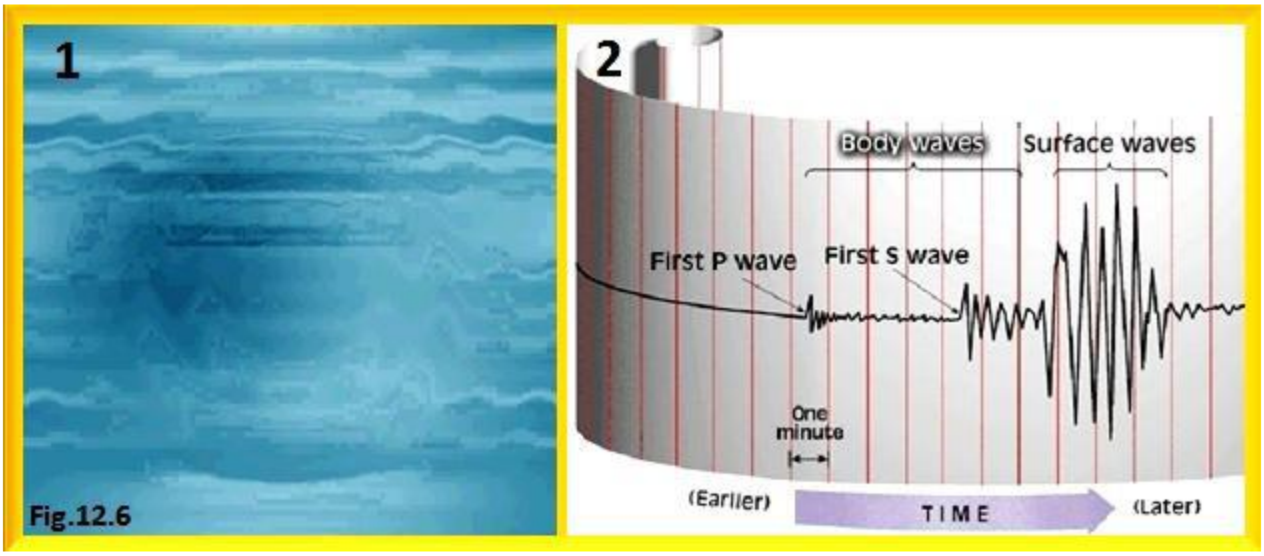


Fig.12.6

A- Surface waves:

One of these wave types along the outer part of Earth, called surface waves. (Fig.12.7). 1.

B- Body waves:

Others wave travels through earth's interior and are called body waves. 2.

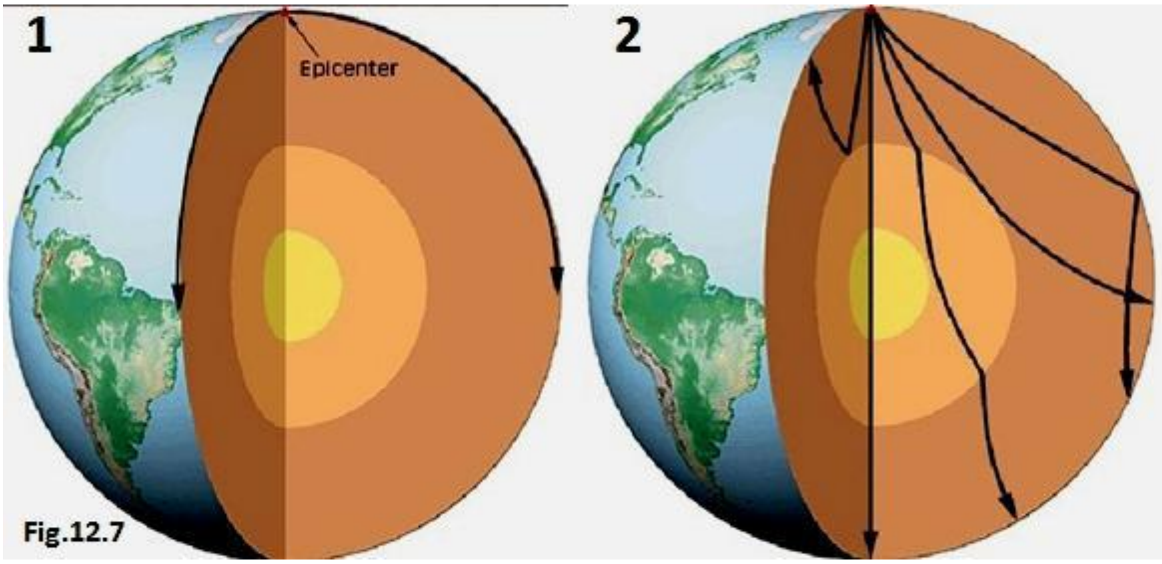


Fig.12.7

A-Surface waves:
The motion of surface waves is more complex and includes a side-to-side as well as an up- and-down motion that is particularly damaging to structures. (Fig.12.8). 1 and 2.

B- Body waves:
They are divided into two types called:

1-Primary or **P** waves: P waves push (compress) and pull (expand) rocks in the direction the waves is travelling. 3.

2-Secondary or **S** waves: S waves, on the other hand, "shake" the particles at right angles their direction of travel. 4

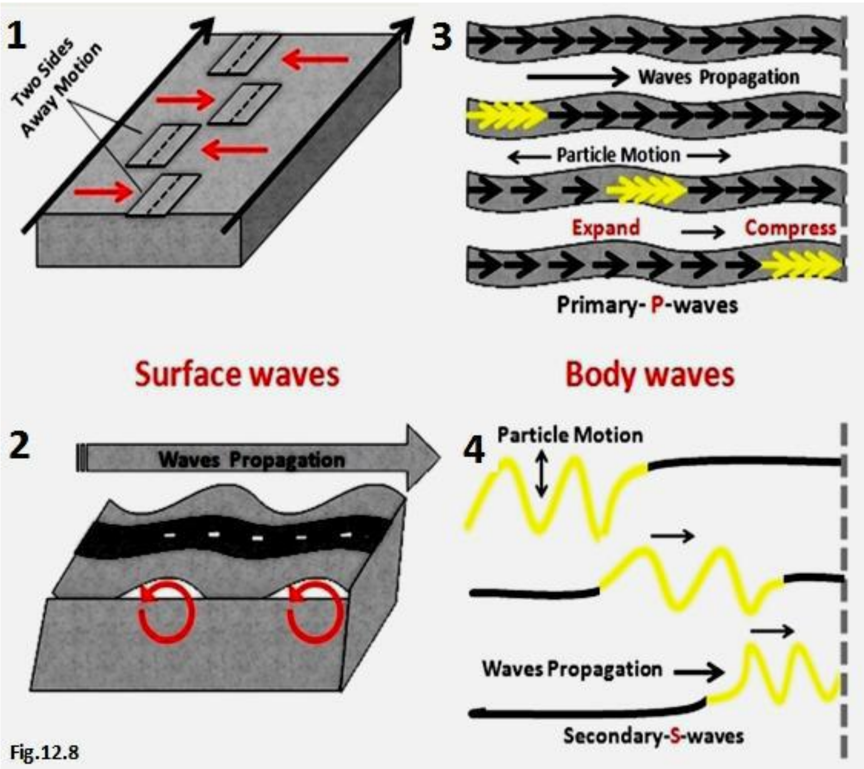


Fig.12.8

By observing a seismogram, some of the differences among these seismic waves become apparent. In addition to these differences, P waves will travel through solids, liquids and gases, whereas S waves will travel only through solids.

Seismic waves are useful in determining the location of earthquakes.

More importantly, seismic waves provide a tool for probing Earth's interior. (Fig.12.9).

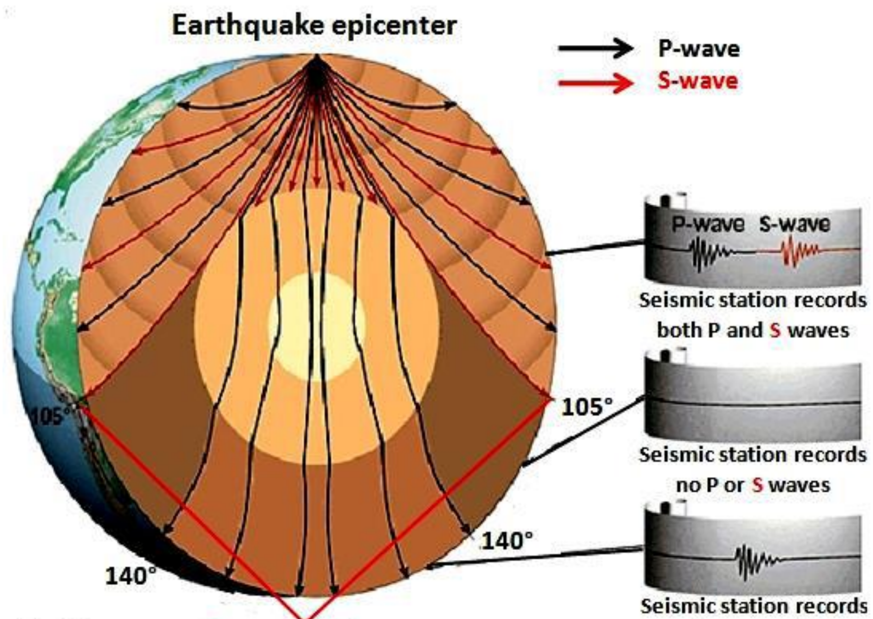


Fig.12.9

12.3- Location the source of an Earthquake:

When a location of an earthquake is determined on a map, seismologists plot the, **epicenter** which is point on Earth's surface directly above the **focus**. (Fig.12.10).

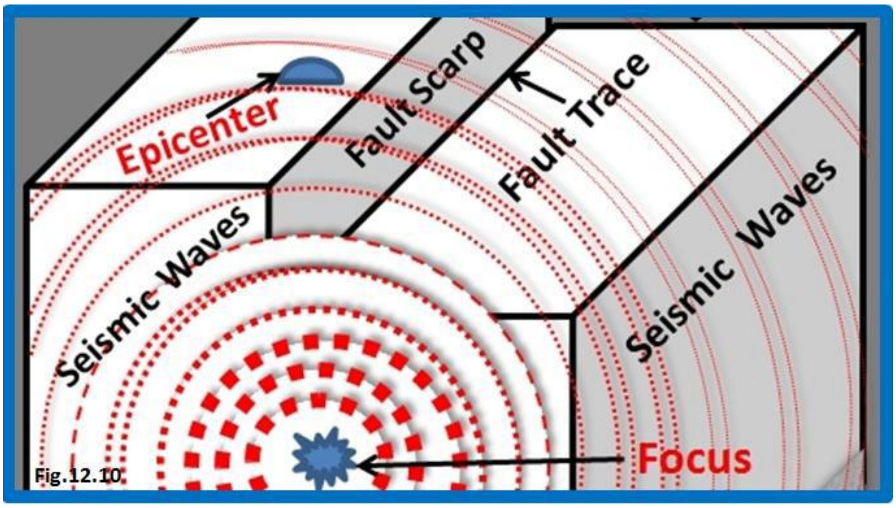


Fig.12.10

The difference in the velocities of **P** and **S** waves provides a method for **locating the epicenter of an earthquake**. (Fig.12.11).

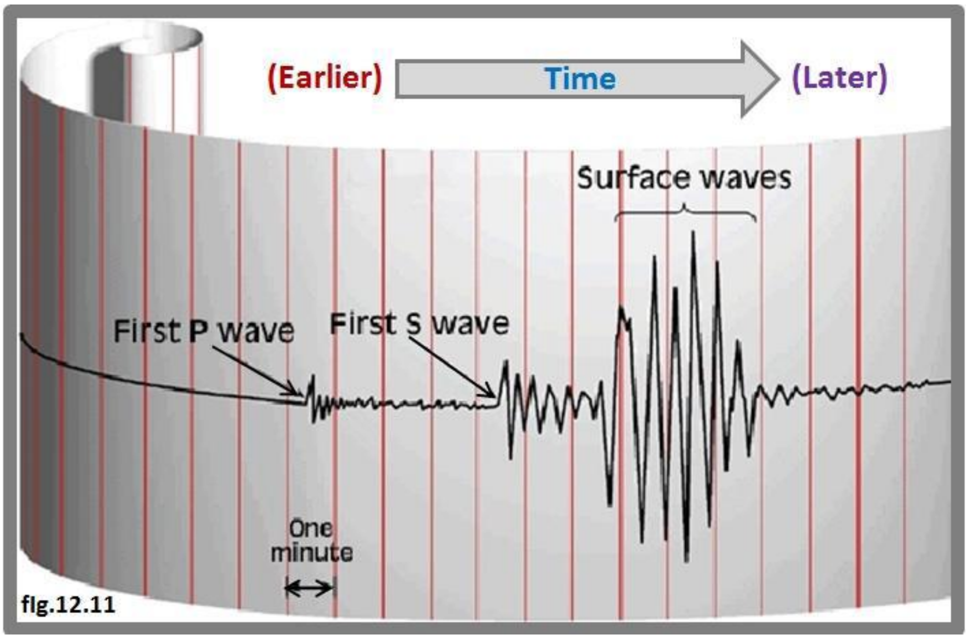


fig.12.11

To determine the distance between a recording station and an earthquake epicenter, seismologists use a travel-time graph. Time is the difference between the arrival of **P** and S waves.
The difference between the arrival time **P** and **S** wave is between **680-780** km/minute. (Fig.12.12).

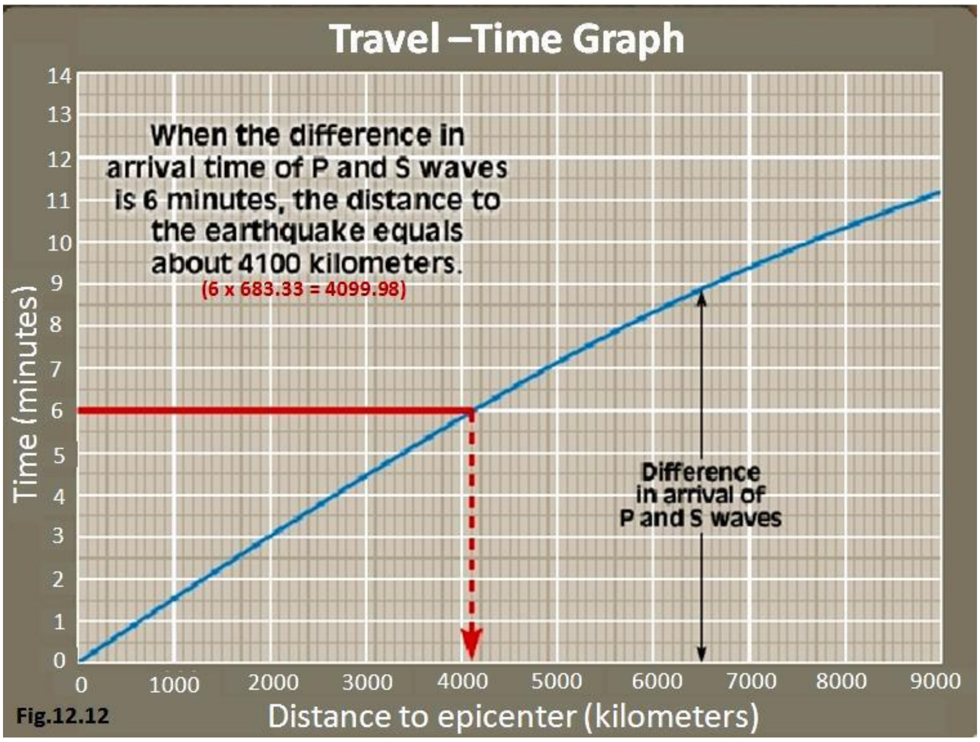


Fig.12.12

Using seismogram from three recording stations and a travel-time graph, we can establish the location of the earthquake **epicenter**. (Fig.12.13).

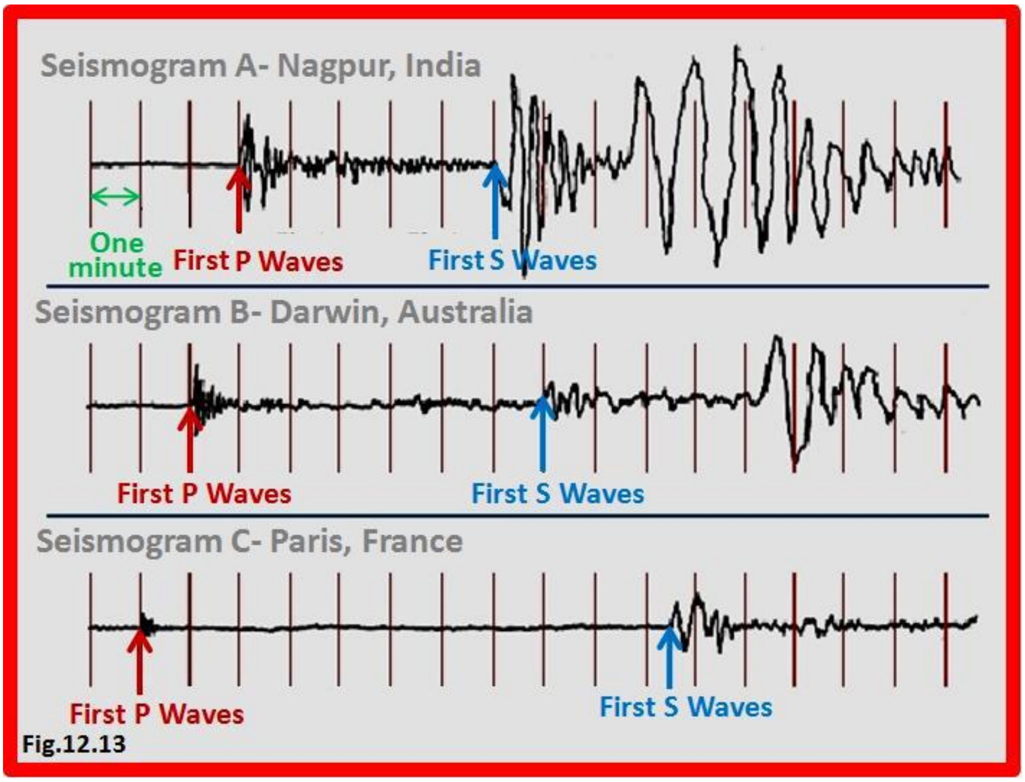


Fig.12.13

How far is the epicenter from a recording station located in Nagpur, India, Darwin, Australia and Paris, France?

Nagpur, India: 5 x 683.33 ≈ 3400 km

Darwin, Australia: 7 x 683.33 ≈ 4800 km

Paris, France: 10.5 x 683.33 ≈ 7200 km

From information above we conclude that this earthquakes occurred somewhere along a circle centered around Nagpur, Darwin and Paris with a radius of 3400, 4800 and 7200 kilometers respectively. (Fig.12.14).

With this final circle of data we conclude that the earthquake occurred in northern China.

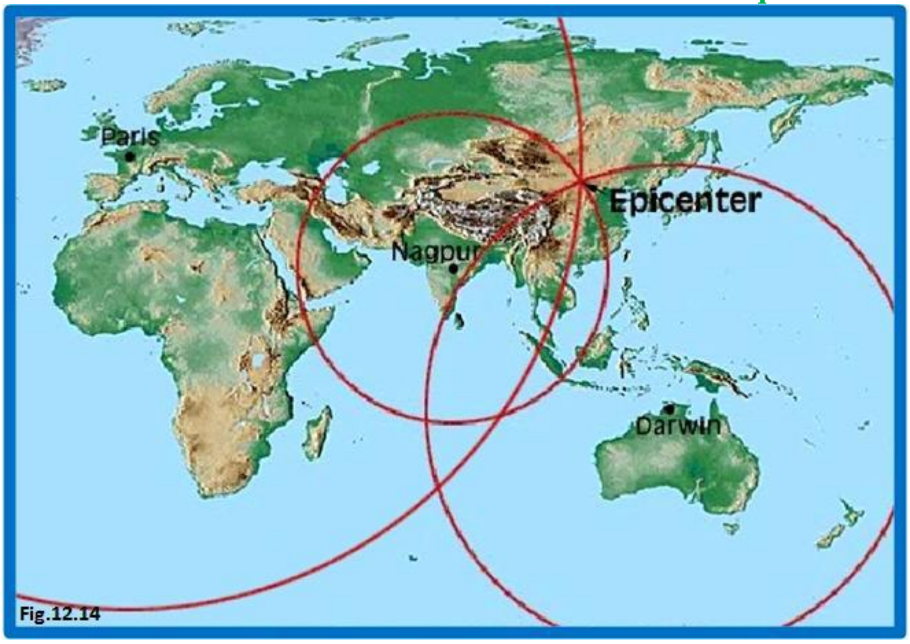


Fig.12.14

12.4- Earthquakes at Plate Boundaries:

Why are most earthquakes generated along plate (margins)?

Based on our understanding of the mechanism that generates earthquakes, one would predict that earthquakes should only occur in Earth's cool, rigid outermost layer.

Here, rock is deformed, it bends, due to strong elastic energy-like a stretched rubber band.
Once the rock is strained beyond its breaking point, it ruptures, releasing the stored energy as the vibration (seismic waves) of an earthquake. F .12.15). 1 … 4.

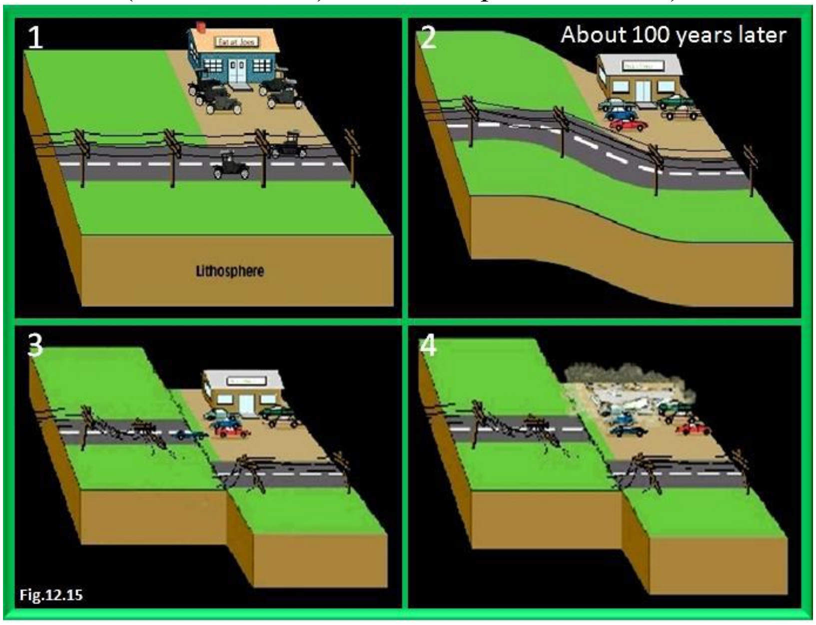


Fig.12.15

The hot, mobile rocks of the asthenosphere are not capable of storing elastic energy and, therefore, should not be capable of generating an earthquake. (Fig.12.16).
Nevertheless, earthquakes having depths nearly 700 kilometers are known.
Most deep-focus earthquakes are closely associated with volcanic arcs and oceanic trenches, where dense slabs of lithosphere plunge into the mantle.
The unique connection between deep-focus earthquakes and oceanic trenches was discovered through studies conducted in the **Tonga Island**

How do scientists explain this zone of earthquakes that extends from the Tonga trench down to a depth of nearly 700 kilometers?
In the plate tectonics model, oceanic trenches are produced where cold, dense slabs of oceanic lithosphere plunge into the asthenosphere.
Shallow-focus earthquakes are produced as the descending plate is bent and where it interacts with the . F .12.16). 1 … 6.

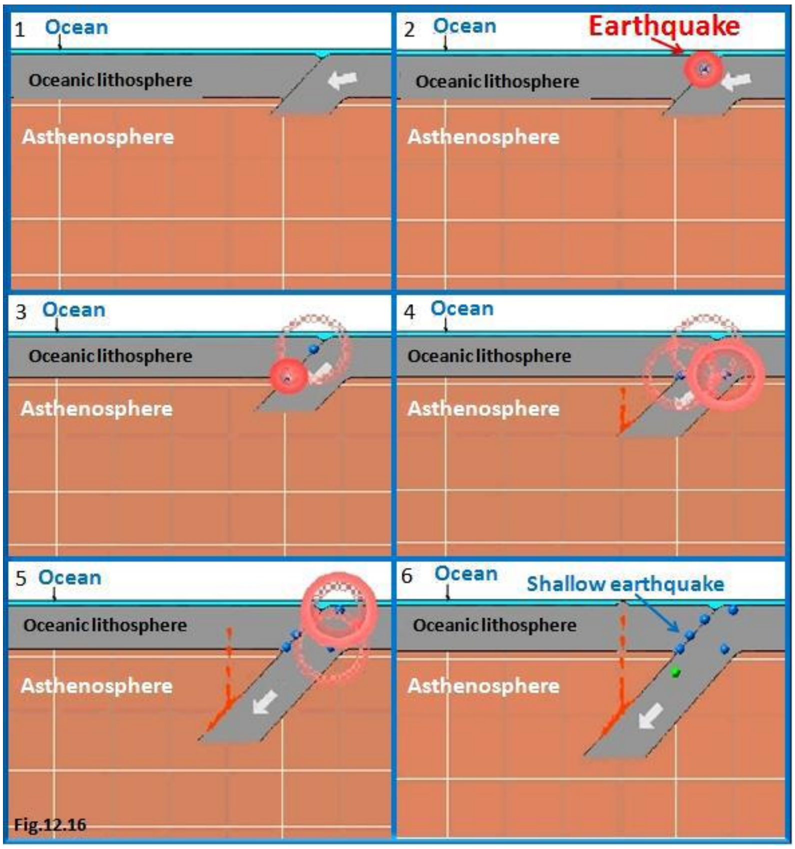


Fig.12.16

When the cold, rigid plate descends farther into the asthenosphere, forces acting on it generate earthquakes at even greater depths. F .12.17). 1 …3

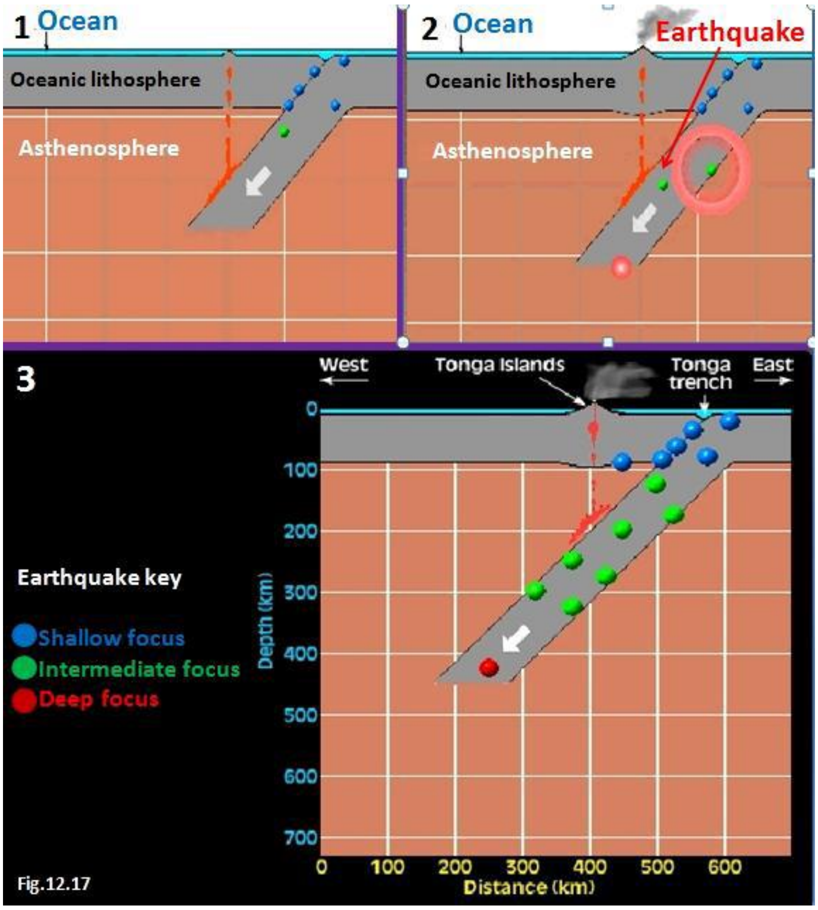


Fig.12.17

Because the earthquakes occur within the rigid, subducting plate rather than within the hot asthenosphere, they provide a method of tracking the plate's descent.

Earthquakes are almost never record at depths greater than 700 kilometers. By the time, the downward plunging slab reaches this depth; it is too hot and thus too "soft" for earthquake to occur. (Fig.12.18).

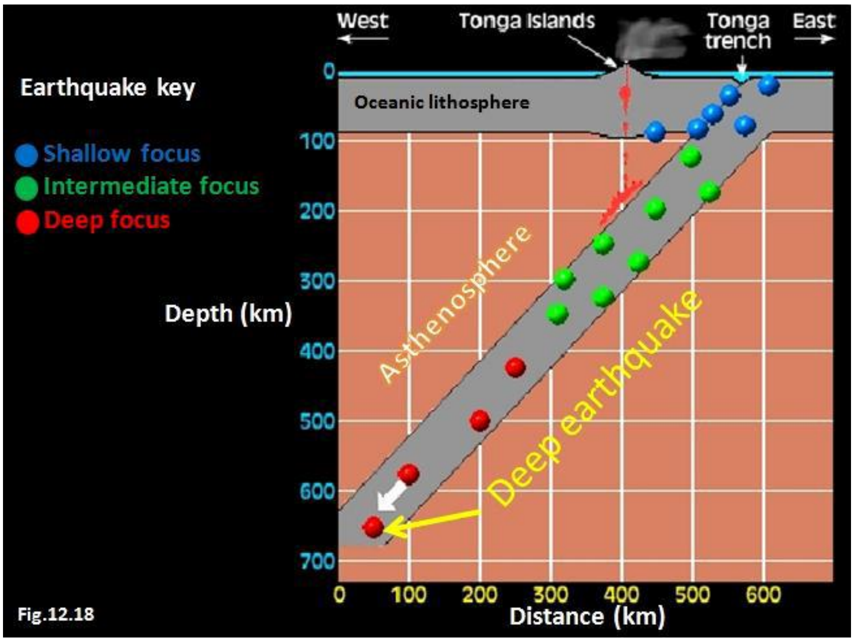


Fig.12.18

Additional evidence supporting the plate tectonics model comes from the observation that only shallow-focus earthquakes occur along divergent and transform fault boundaries.

Since oceanic trenches are only places where cold slabs of oceanic crust plunge to great depths, these should be the only sites of deep-focus earthquakes.

Indeed, the absence of deep-focus earthquakes along oceanic ridges and transform faults supports the theory of plate tectonics. (Fig.12.19).

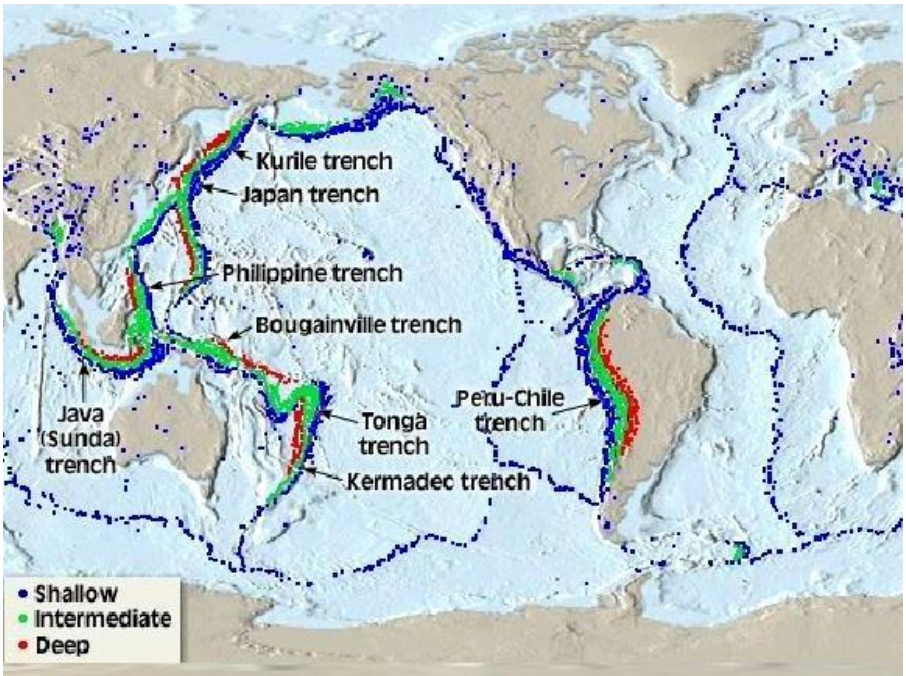


Fig.12.19

1- Which seismic waves travel the faster? a- P waves b- S waves c- surface waves d- sonic waves
2- Earthquakes are thought to be generated within the ---------------. a- hot, mobile asthenosphere b- hot, mobile outer core c- cold, rigid lithosphere
3- Most earthquakes occur in a region known as the ----------------. a- Tropic of cancer b- circum-pacific belt c- Transatlantic zone d- Oceanic ridge system
4- -------------- have the shorter periods. a- Surface waves b- P waves c- Tertiary waves d- S waves
5- The location at the surface directly above the source of an earthquakes is called the ------------------. a- epicenter b- seismic center c- focus d- inertia
6- Earthquakes occur in the lithosphere because it is able to store elastic energy like a stretched rubber band. a- true b- false

7- -------------- have the greatest amplitude. a- Surface waves b- P waves c- Tertiary waves d- S waves

7- An earthquake is the vibration of Earth produced by the rapid release of energy. a- true b- false

9- There is a close association between the distribution of earthquakes and ---------------. a- deep-ocean basins b- plate boundaries c- the interior of large plates d- the interior of continents

10- From a single earthquake recording, scientists can tell -------------. a- how many aftershocks below the surface b- the direction the recorder is from the surface point of the earthquake c- the depth of earthquake below the surface d- the distance the recorder is from the earthquake

11- Which one of the following is NOT a type of seismic waves? a- P waves b- Tertiary waves c- surface waves d- S waves

12- The absence of deep-focus earthquakes along oceanic ridges and transform faults supports the theory of plate tectonics. a- true b- false

13- The mechanism for earthquake generation deduced by H. F. Reid in the early 1900 is termed -------------. a- elastic rebound b- plastic rebound c- ductile generation d- plastic flow

14- Only shallow-focus earthquakes are detected in this setting. a- the asthenosphere b- oceanic ridge c- subduction zones d- convergent plate boundaries

15- Of the two types of body waves, the S waves travel faster. a- true b- false

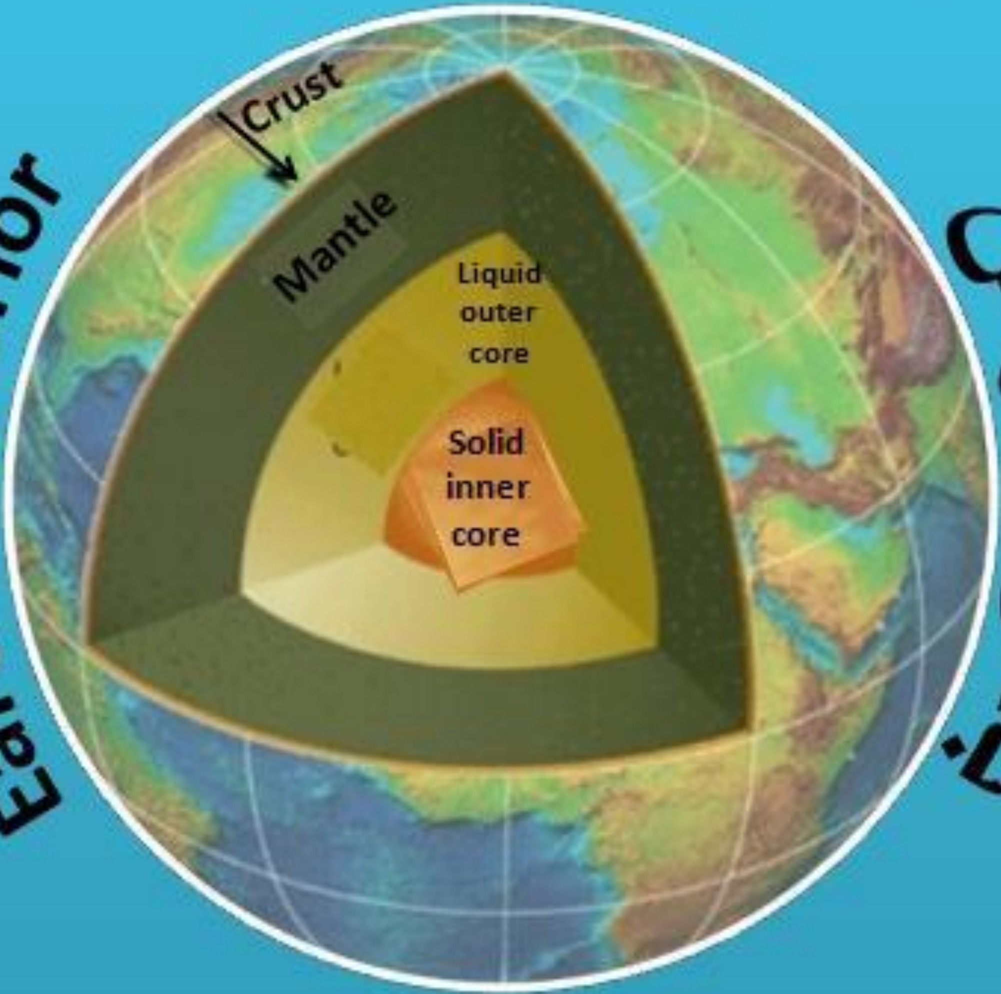
16- --------------, the study of earthquakes, dates back to the Chinese almost 2000 years ago. a- Refractometry b- Tension physics c- waves modification d- Seismology

Chapter thirteen

الفصل الثالث عشر

Earth's interior

باطن الأرض



-Earth's layered structures. -بنيات طبقات الأرض.
-Inner core. -اللب الداخلي.
-Outer core. -اللب الخارجي.
-Mantle. -الوشاح.
-Crust. -القشرة.
-Asthenosphere. -غلاف الانسياب.
-Lithosphere. -الغلاف الصخري.

13.1- Earth's layered structures:

Did you know?

The temperature increases towards earth's center where it may exceed 6700 C°.

Heat from earth's interior is the major source of energy for the movement of earth's outer shell.

Did you know?

You might suspect that the internal structure of earth has been sampled directly. However, humans have never penetrated beneath the crust!

The internal structure of earth is determined by using indirect observations. Every time there is an earthquake, waves of energy (called seismic waves) penetrate earth's interior.

Seismic waves change their speed and are bent and reflected as they move through zones having different properties. An extensive series of monitoring stations around the word detects and records this energy.

The data are analyzed and used to work out the structure of earth' interior.

Scientists have determined that earth' interior is divided into four major layers.

A- Inner core.

B- Outer core.

C- Mantle.

D- Crust.

A- Inner core:

At earth's center is the inner core. It is solid, iron-rich sphere having a diameter of 2432 kilometers. (Fig.13.1). 1.

B- Outer core:

Surrounding the inner core is the outer core, a fluid, metallic layer some 2270 kilometers thick. 2.

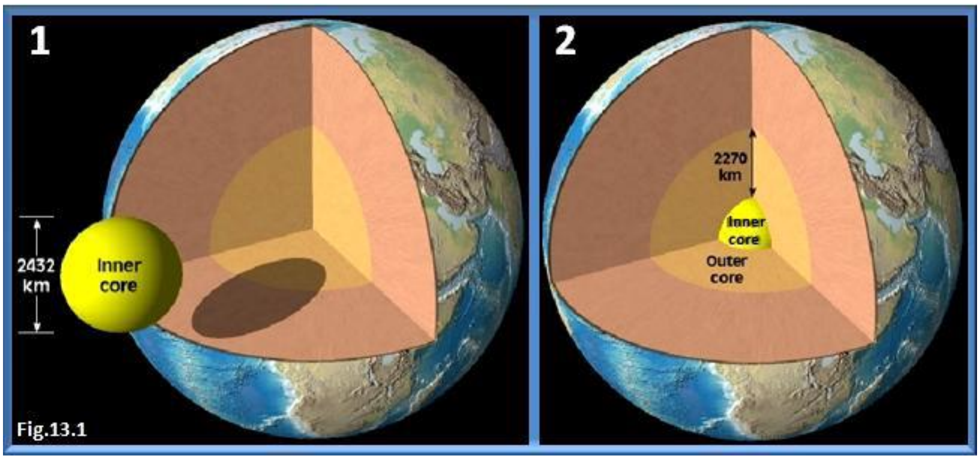
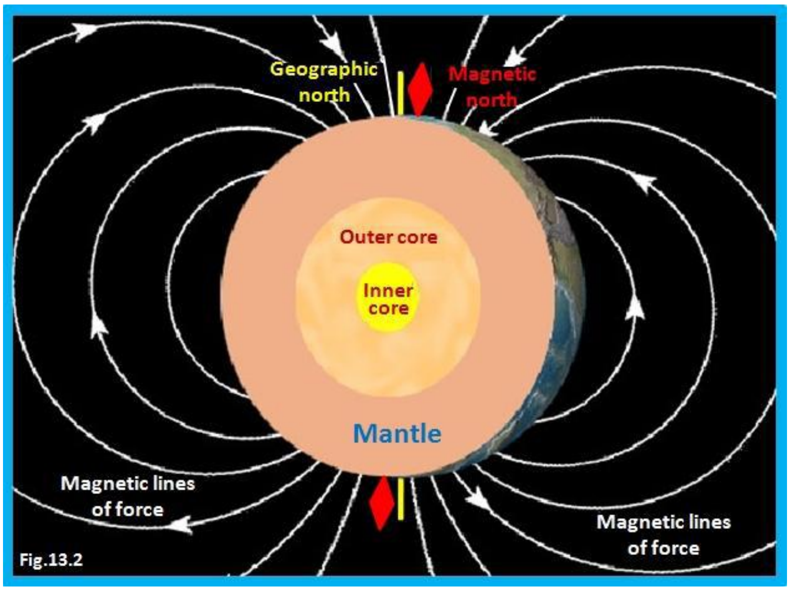
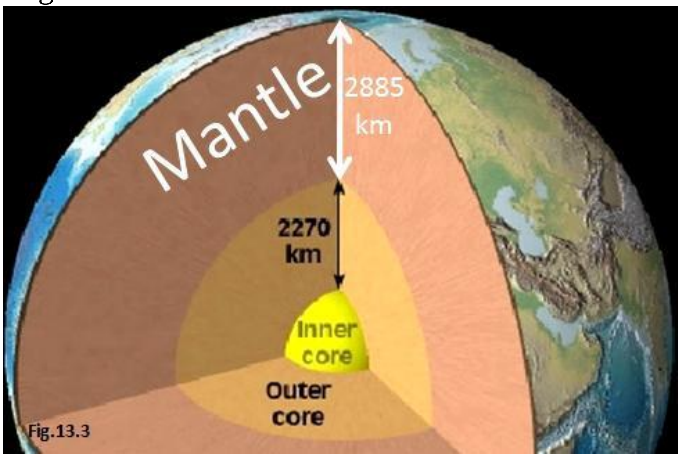


Fig.13.1

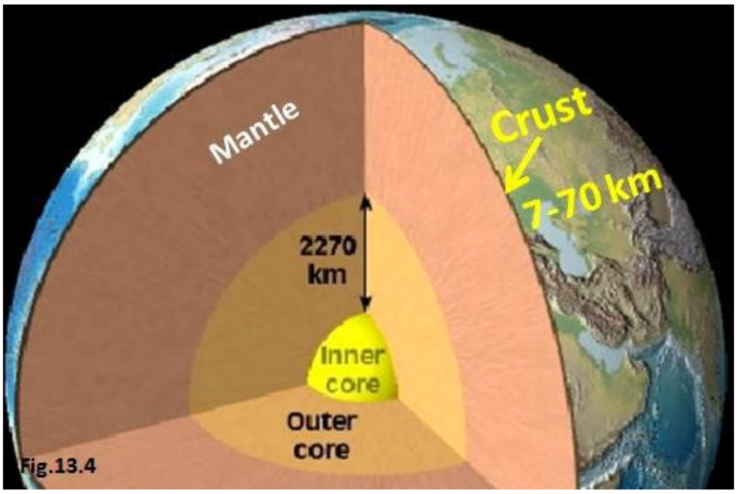
Earth's magnetic field is thought to be generated by vigorous churning of the iron-rich material in the hot, fluid outer core. (Fig.13.2).



C- Mantle: Beyond the outer core is the mantle, a solid, rocky layer having a thickness of about 2885 kilometers. Over 82 percentage of earth's volume is contained within the mantle. (Fig.3.13). The rock that makes up the mantle is composed of silicate minerals that are rich in iron and magnesium.



D- Crust: The outermost layer is the crust, a very thin outer skin that ranges from about 7 to more than 70 kilometers. (Fig.13.4).



Earth's crust is divided into:

1- Continental crust: In most regions, the continental crust is about 35 kilometer thickness, but it may exceed 70 kilometers in areas of prominent mountains.

The continental crust consists of many types of rocks. One of the most common in the upper crust is the igneous rock **granite**.

2- Oceanic crust: Compared with continental crust, oceanic crust is quite thin, average only 7 kilometers in thickness.

In addition, the oceanic crust is very uniform in composition, being mainly composed of the dark igneous **basalt**.

On average, continental rocks are less dense (weigh less in equal amount) than oceanic rocks, which partially explains the lower position of the ocean floor compared to the continents. (Fig.13.5).

Did you know?

Continental crust "**float**" higher than oceanic crust, for the same reason an empty ship floats higher than a loaded one.

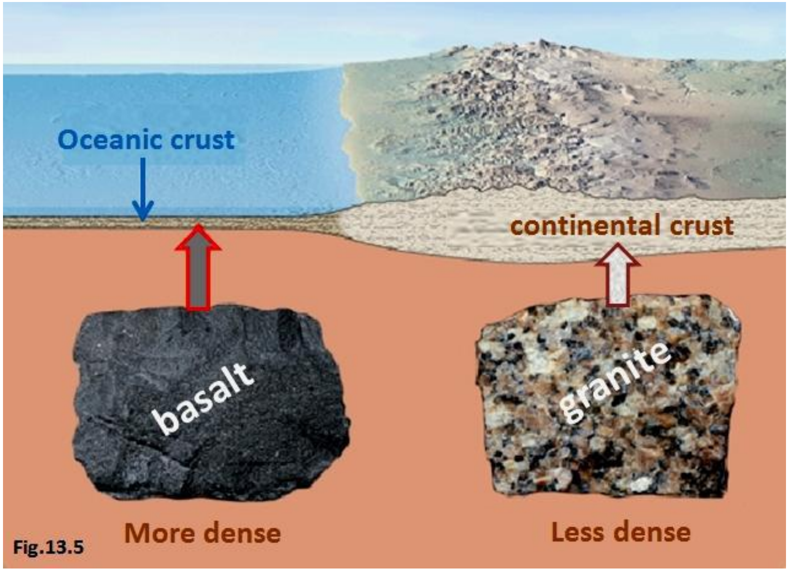


Fig.13.5

In addition to earth's four major layers, scientists have identified two other divisions of earth's interior:

E- Asthenosphere.

F- Lithosphere.

(Fig.13.6).

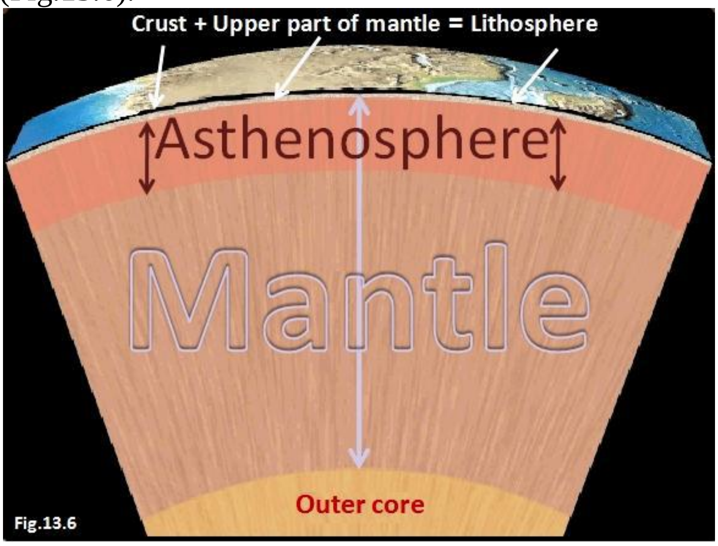


Fig.13.6

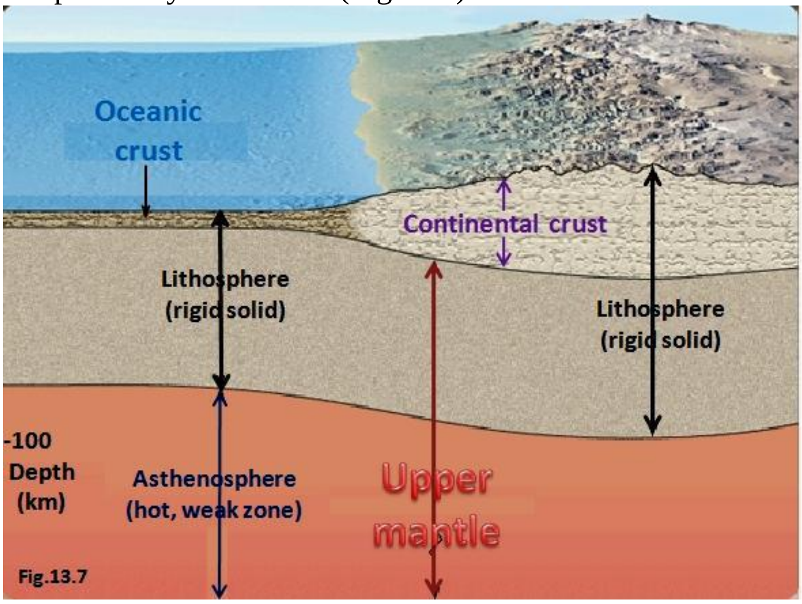
E-asthenosphere:

It located within the upper mantle, between the depths 100-660 kilometers and is composed of hot, rocky material that is capable of very slow movement.

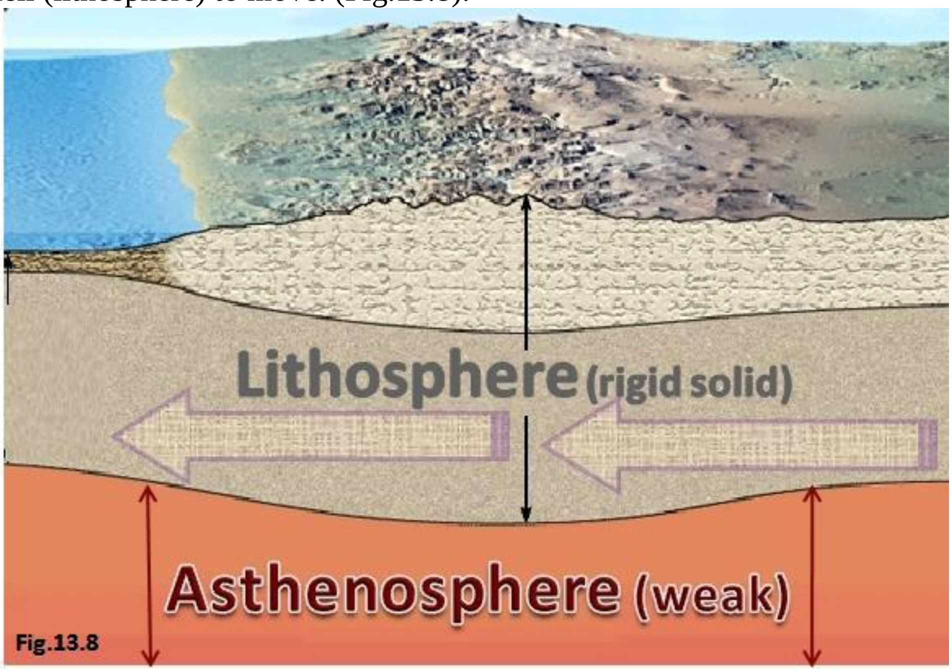
F-Lithosphere:

Situated above the asthenosphere, called the lithosphere. It includes the uppermost mantle and overlying crust and behaves as a strong, rigid layer.

In contrast to the hot, weak zone below, the lithosphere is strong because it composed of comparatively cool rocks. (Fig.13.7).



Geologists have discovered that the weak rocks within the asthenosphere allow earth's rigid outer shell (lithosphere) to move. (Fig.13.8).



1- Which of earth's major divisions is thought to be solid, metallic sphere? a- crust b- mantle c- outer core d- inner core
2- What name is given to earth's solid, rigid outermost layer? a- bathysphere b- lithosphere c- mesosphere d- asthenosphere
3- Which of earth's major divisions make up over 82 percent of our planet's volume? a- crust b- mantle c- outer core d- inner core

4- This region consists of a variety of rock types including the common igneous rock granite. a- continental crust b- oceanic crust c- mantle d- core

4- This layer average only about 7 kilometers thickness. a- continental crust b- oceanic crust c- mantle d- core

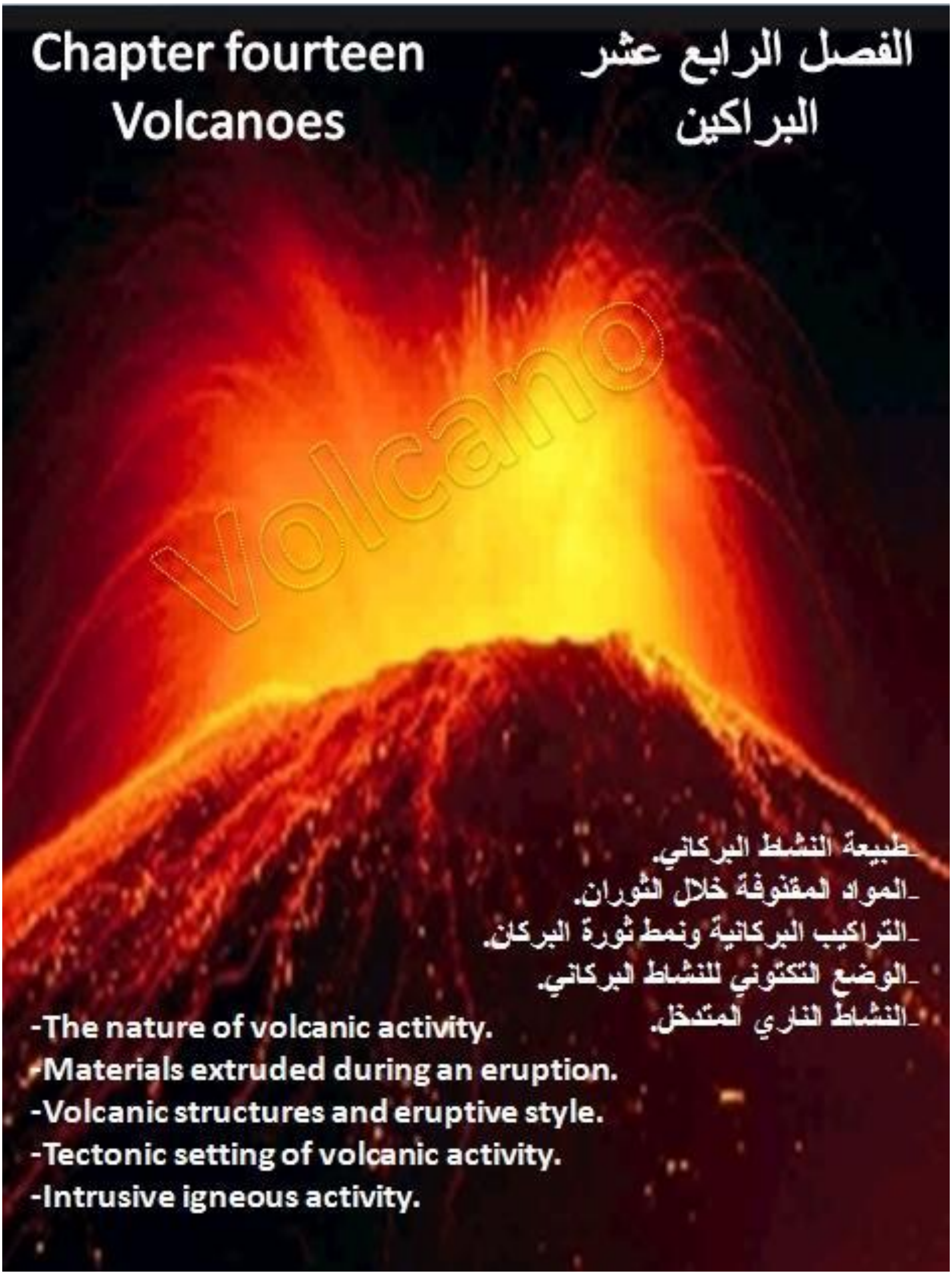
6- This thick shell of rock is composed mostly of silicate minerals that are rich in iron and magnesium. a- continental crust b- mantle c- outer core d- inner core

7-Name the hot, weak layer found in the upper mantle. a- bathysphere b- lithosphere c- mesosphere d- asthenosphere

8- This region is composed primary of the igneous rock basalt. a- continental crust b- oceanic crust c- mantle d- core

9- What layer is composed of the crust plus the uppermost mantle? a- bathysphere b- oceanic crust c- mantle d- lithosphere

10- What layer permits movement of earth's rigid outer shell (plates)? a- bathysphere b- lithosphere c- mantle d- asthenosphere


Chapter fourteen
Volcanoes
الفصل الرابع عشر
البراكين
Volcano
-طبيعة النشاط البركاني.
-المواد المقذوفة خلال الثوران.
-التراكيب البركانية ونمط ثورة البركان.
-الوضع التكتوني للنشاط البركاني.
-النشاط الناري المتدخل.
-The nature of volcanic activity.
-Materials extruded during an eruption.
-Volcanic structures and eruptive style.
-Tectonic setting of volcanic activity.
-Intrusive igneous activity.

14.1- The nature of volcanic activity:

Volcanic activity is commonly perceived as a process that produced a picturesque, cone-shaped structure which periodically erupts in a violent manner. Although some eruptions may be cataclysmic, many are relatively quiescent. (Fig.14.1).

Fig.14.1

The primary factors that determine the nature of volcanic eruption include:

A- The magma's composition.
B- The magma's temperature.
C- The amount of dissolved gases it
Contains.

These factors affect the magma's **viscosity**.
The more viscous a material, the greater its resistance to flow.
(Fig.14.2).

Fig.14.2

When the temperatures of lava are high, it is more fluid. As the temperature drops, the lava becomes more viscous.

Magma that produced **basaltic** rock contain about 50% silica and tend to be quite fluid. Thus, hot basaltic lavas tend to be quite fluid and have been known to travel distances of 150 kilometers before congealing.

By contrast, rhyolitic magmas (those that crystallized to form **rhyolite** and magma) contain over 70% silica and are very viscous.
(Table.14.1.)

Table.14.1					
Composition	Silica content	Viscosity	Gas content	Tendency to form pyroclastic	Volcanic landform
Basaltic magma	Least (≈50%)	Least	Least (1.2%)	Least	Shield Volcanoes Basalt Plateaus Cinder Cones
Andesitic magma	Intermediate (≈60%)	Intermediate	Intermediate (3.4%)	Intermediate	Composite Cones
Rhyolitic magma	Most (≈70%)	Greatest	Greatest (4.6%)Least	Greatest	Volcanic domes Pyroclastic Flows

Rhyolitic lavas are very viscous and tend to form comparatively short, thick flows.
Gases in fluid basaltic magmas migrate upward and escape from the vent with relative ease.
The gases often propel incandescent lava hundreds of meters into the air.
At the other extreme, highly viscous magmas impede the upward migration of expanding gases.
The gases collect as bubbles that increase in pressure until they explosively eject the semi molten rock from a volcano.
Thus, the viscosity of magma, plus the quantity of dissolved gases and the ease with which they escape, determine the nature of a volcanic eruption. (Fig.14.3).

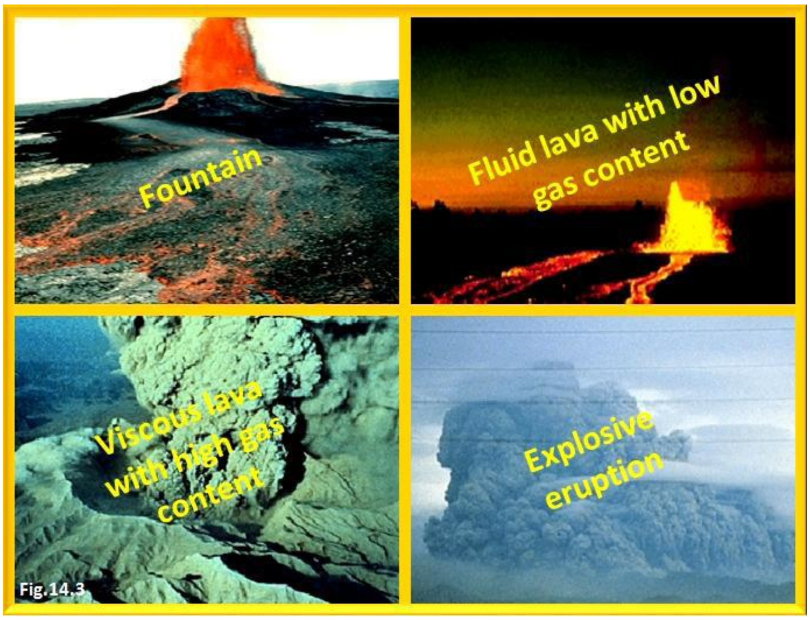


Fig.14.3

14.2- Materials extruded during an eruption:
Depending on the chemical composition of the magma, volcanic eruptions extrude various quantities of **lava gases**, and **pyroclastic materials**. (Fig.14.4).
Due to the low silica content, basaltic magma extruded mainly lavas that are very fluid and flow in thin, broad sheets or **stream-like ribbons**. 2.
When fluid basaltic lavas congeal, they often form a smooth skin that a wrinkle as the still-molten subsurface continues to advance. These flows are called **pahoehoe**. 3.
Another common type of basaltic lava, called **aa**, has a rough jagged surface. **Active aa flows** are relatively cool and thick, and advance more slowly than **pahoehoe** flows. 4.

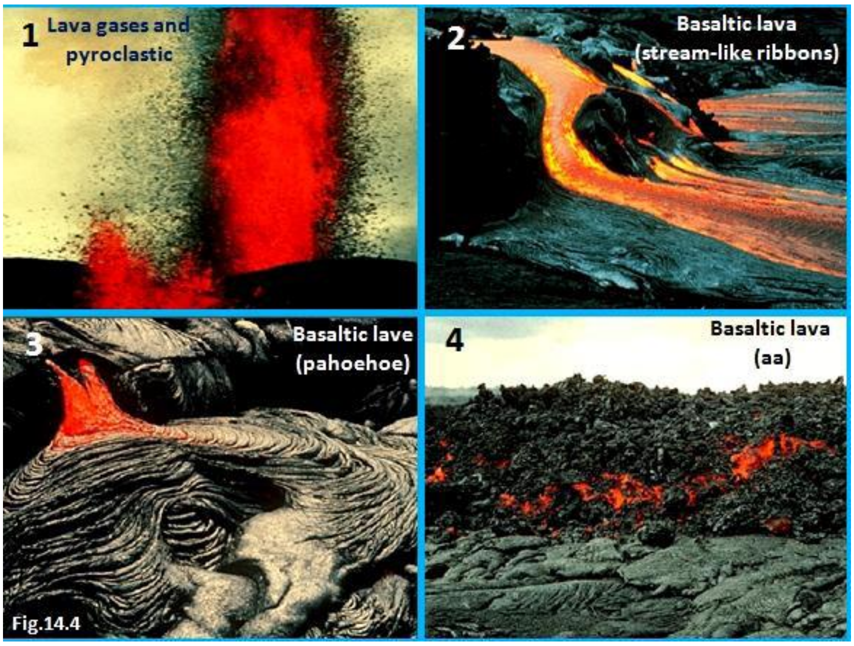


Fig.14.4

Depending on chemical composition, the **gaseous portion** of most magma is believed to make up 1 – 6% of the total weight.
(Table.14.1, gas content).
Analyses of samples taken during Hawaiian eruptions indicate that the **gases** are about:
70% water vapor.
15% carbon dioxide.
5% nitrogen.
5% sulfur dioxide.
Less amounts of chloride, hydrogen and argon.
Pyroclastic are formed when pulverized rock, blobs of lava, and glass fragments are ejected from the vent.
Magma high in silica tends to eject large quantities of pyroclastic materials. (tendency to form pyroclastic.
(Table.14.1).
Fine ash and dust particles (< 2mm in diameter) are produced when the extruded lava contains so many gas bubbles that it resembles the froth flowing from a newly opened bottle of champagne.
Fine debris can be blasted high into the atmosphere where it can produced brilliant sunsets and may temporarily lower earth's average temperature. (Fig.14.5). 1.
Sometimes the froth-like lava is ejected in large pieces. 2.
Pyroclastic materials ranging in size from small beads up to walnuts (2 – 64 mm in diameter) are termed **lapilli**. (These eject is also referred to as cinders). 3.
Particles larger than lapilli (greater than 64 mm) are called **blocks** when they are made of hardened lava and bombs when they are ejected as incandescent lava. 4.

14.3- Volcanic structures and eruptive style:

The eruptive history of each volcano is unique; consequently, all volcanoes are somewhat different in form and size.

Never the less, volcanologists have recognized that volcanoes exhibiting somewhat similar eruptive styles can be grouped together.

A- Shield volcano:

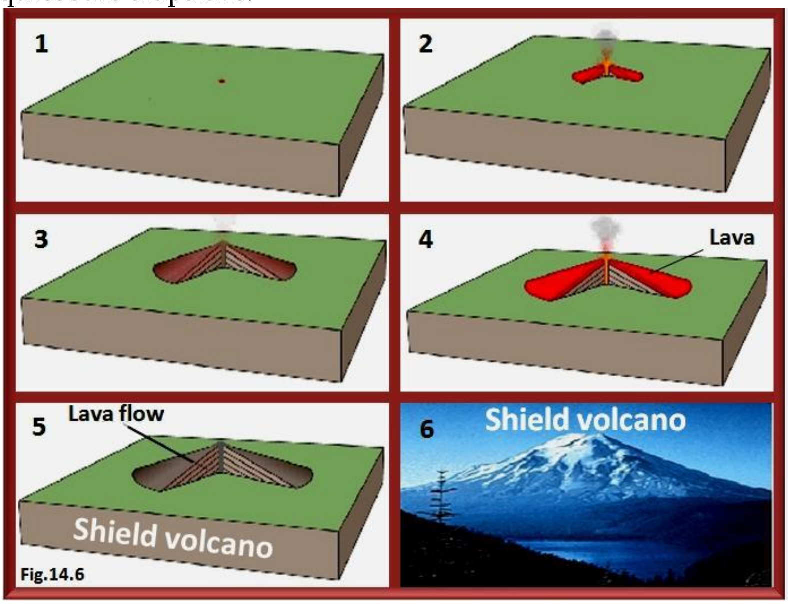
When fluid lava is extruded, the volcano takes the shape of a broad, domed structure called **shield volcano.** (Fig.14.6). 1 … 5.

Shield volcanoes are built primary of fluid basaltic lava flows and contain only a small percentage of pyroclastic.

Typically, shield volcanoes have a slope of only a few degrees. 6.

In addition, shield volcanoes can be some of the largest volcanoes on earth, as exemplified by the volcanoes of the Hawaiian Islands.

Because shield volcanoes are associated with very fluid magma, these volcanoes generally exhibit quiescent eruptions.



B- Cinder cones:

As the name suggests, cinder cones are built from ejected lava fragments.
F .14.7). 1 … 4.
Because loose pyroclastic material has **high angle of repose** (between 30 and 40 degrees), and Cinder cones have very steep slopes. 5.
Cinder cone is relatively small, usually less than 300 meters high, and sometimes form near or on the flanks of larger volcanoes. 6.

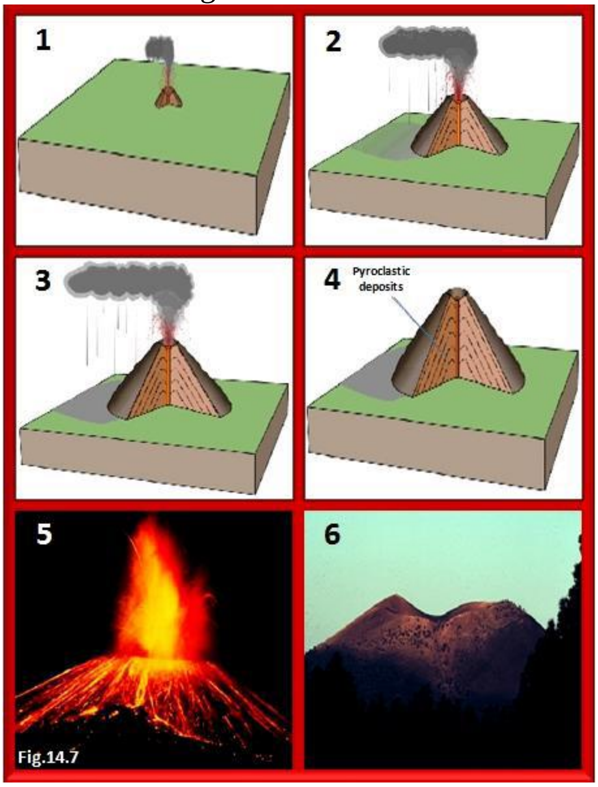


Fig.14.7

C- Composite cones (stratovolcanoes):

Earth' most picturesque volcanoes are called composite cones or stratovolcanoes.
A composite cone is a large, nearly symmetrical structure composed of interbedded lavas and pyroclastic deposits, emitted mainly from a central vent.
A composite cone may extrude viscous lava for a long period and then the eruptive style changes and the volcano violently ejects pyroclastic materials. (Fig.14.8). 1 … 4.
Composite cones represent one of the most violent types of volcanic activity. 5.
Occasionally, composite cones produced dangerous **pyroclastic flows**.
These fiery clouds, called nuee ardentes, consist of turbulent stream clouds and ash flows that down volcanic slopes at speeds that reach 200 kilometers per hour.
In addition, composite cones often generate a type of mudflow known as a **lahar**. 6.

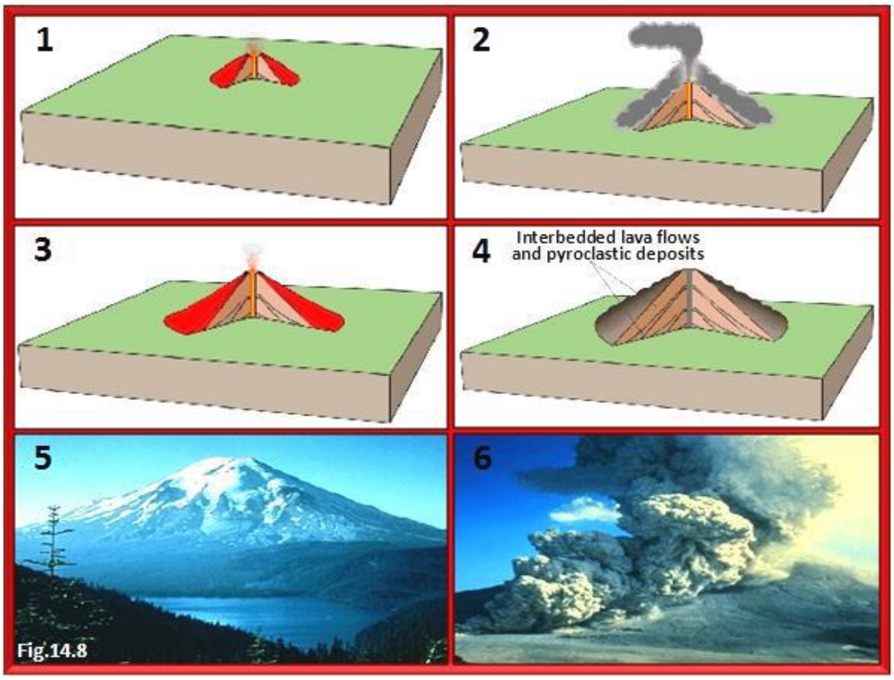


Fig.14.8

14.4-Tectonic setting of volcanic activity:

you can interpret volcanic activity in four tectonic setting by using your information: (Fig.14.9). 1 … 4.

A-Continental rift volcanism. 1.
B-Continental volcanic arc. 2
C-Hot-spot volcanism. 3.
D-Volcanic-island arc. 4.

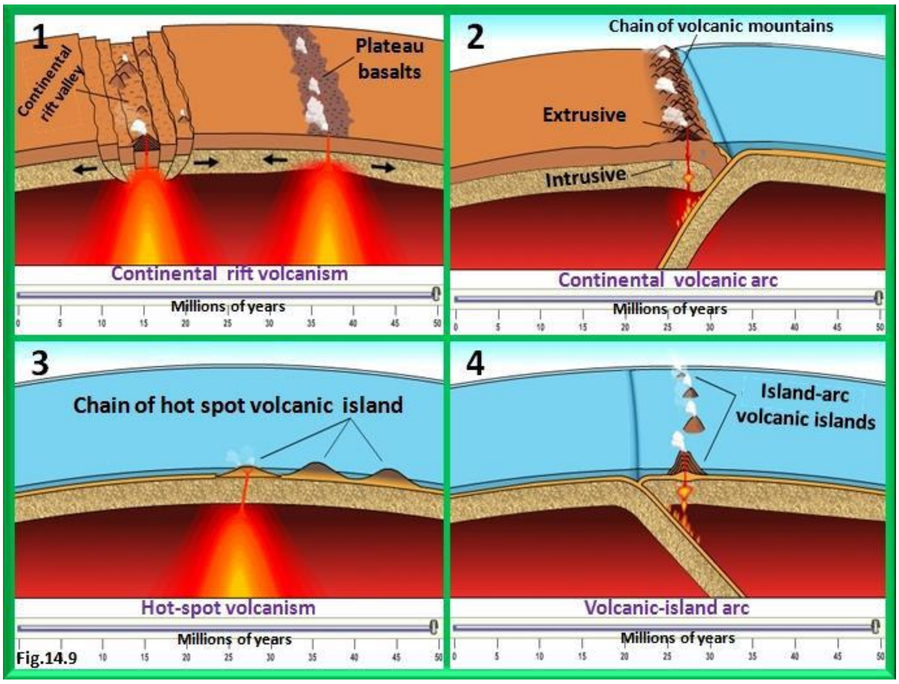
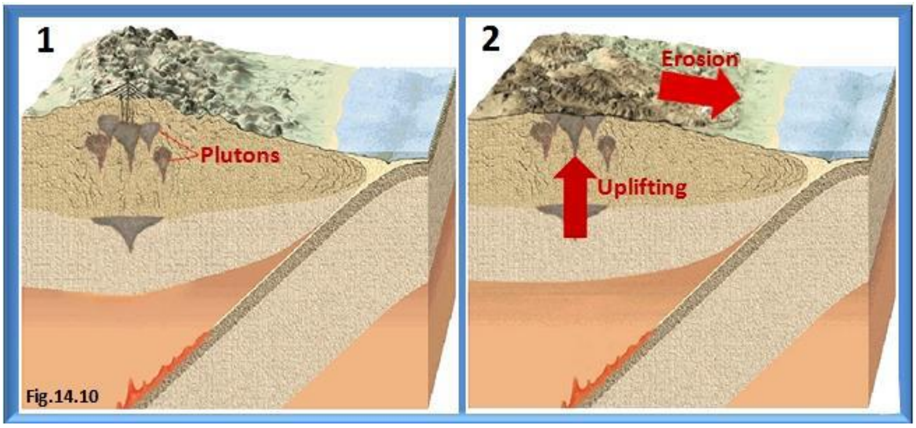


Fig.14.9

14.5- Intrusive igneous activity:

Although volcanic eruptions can be violent natural events and are therefore worthy of study.
Most magma is emplaced at depth.
The structures that result from the emplacement of magma at depth are called **plutons**. (Fig.14.10). 1.
Since all plutons form out of our view, they can only be studied first hand after uplifting and erosion have exposed them. 2.



Plutons are generally classified according to their shape as either:
A-Tabular (sheet like).
B-Massive.
(Fig.14.11). 1 and 2.

And by their orientation with respect to the host rock. They are said to be :
A-Discordant: If they cut existing rock.
B-Concordant: If they form parallel to existing
Sedimentary beds. (Fig.14.12). 1 and 2.
-Dikes: (Dykes) are sheet like plutons produced when magma is injected in fractures that cut across rock layers. (Fig.14.13). 1.
-Sills: are tabular structures formed when magma is injected along sedimentary bedding surfaces. 2.
-Laccoliths: form like sills, but form viscous magma, which collects as lens-shaped masses that arched the overlying strata. 3.
-Batholiths: are the largest intrusive igneous features. 4.
Batholiths can form the cores of mountains such as the Sierra Nevada. **(S.W of USA).**

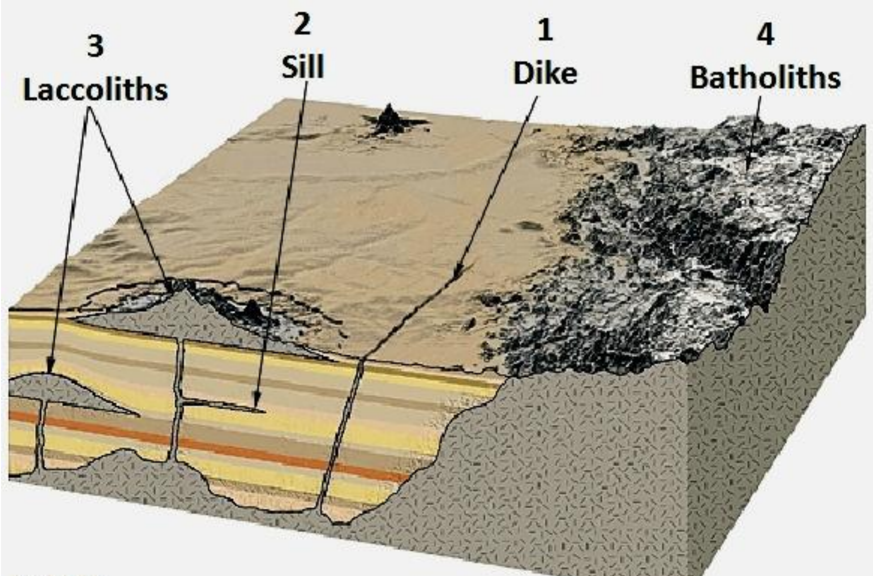


Fig.14.13

1- Exemplified by the Hawaiian, Islands, this type of volcano tends to be the largest on earth. a- cinder b- shield c- composite
2- This type of magma, with a silica content of about 70%, has the greatest tendency to form pyroclastic. a- rhyolitic b- andesitic c- magmatic d- basaltic
3- Which one of the following is NOT a primary factor of magma that directly determines the nature of the volcanic eruption? a- temperature b- amount of dissolved gases c- composition d- volume
4- This type of magma, with about 60% silica content, tends to form composite cones. a- rhyolitic b- andesitic c- magmatic d- basaltic
5- Magmas that produced --------- rock contain about 50% silica and tend to be quite -------. a- basaltic; fluid b- rhyolitic; viscous c- rhyolitic; fluid d- basaltic; viscous

6- Intrusive igneous bodies are classified according to their shape and orientation with respect to the host rock. a- true b- false

7------------ Cones, such as sunset Crater, Arizona tend to have very steep slope. a- cinder b- shield c- composite

8- A volcano that takes the shape of a broad, domed structure is called a ---------- volcano. a- cinder b- shield c- composite

References:

-Anderson, R. S., Anderson, S. P., 2011. Geomorphology. The Mechanics and Chemistry of Landscapes. Cambridge University Press. 673 P.

-Arts, T. G., education. P., Tarbuck. E. J., Lutgens. F.K., Tasa. D., 2009. Geode: Earth Science. Copyright 2009 by Pearson Education and its licensors.

-Blake, S., Burton, K., Harries, N., Parkinson, I., Rogers, N., Widdowson, M., 2008. An Introduction to Our Dynamic Planet. Edited by Nick Rogers. Cambridge University Press. 390 P.

-Borrero, F., Hess, F. S., Kunze, J. H. G., Leslie, S. A., Manga, S. L. M., Sharo,L., Snow,t., Geographic, D. Z. N., 2008. Earth Science. Geology, the Environment, and the Universe. National Geography. The McGraw-Hill Companies, Inc. 1054 P.

-Christopherson., 2009. Geosystems. An introduction to Physical Geology. Seventh edition. Pearson International Edition. Printed in U. S. of America. 687 P.

-Marshak, S., 2009. Essentials of Geology. International Student Edition. Printed in USA. Third edition.518.p.

-Fossen, H., 2010. Structural Geology. Cambridge University Press. 546 p.

-JR, G. T. M., 2004. Living in the Environment. Thirteenth Edition. Printed in Canada. 757 P.

-Owen, C., Pirie, D., Draper, G., 2006. Earth Lab. Exploring the Earth Science. Second edition. Printed in China. 564 P.

-Pluijm, B. A. V. D., Marshak, S., 2004. Earth Structure. An Introduction to Structural Geology and Tectonics. Second Edition. W. W. Norton and Company New York. London. 673 P.

- Boehm, R. G., 1997. World Geography. National geographic society. Printed in U. S. of America. 786 P.

-Thompson, G. R., Turk, j., 2007. Earth Science and Environment. Fourth Edition. Thomson Learning Academic Resources Center 1-800-423-0563. Printed in Canada. 715 P.

-Thorp, J. H., Thoms, M. G., Delong, M. D., 2008. The Riverine Ecosystem Synthesis. Toward Conceptual Cohesiveness in River Science. Printed in U. S. of America. 208 p.

-Yeats, R. S., Sieh, K., Allen, C. R., 1997. The Geology of Earthquakes. New York, Oxford. Oxford University Press. 568 P.

web sites:

www.pdfsb.net

http://volcanoes.usgs.gov/

http://www.geography4kids.com/files/earth_volcano.html

http://imnh.isu.edu/digitalatlas/hydr/concepts/surfhyd/srfwtr.htm

http://water.usgs.gov/edu/mearthsw.html

http://www.sandatlas.org/rock-types/

http://geology.com/rocks/

http://csep10.phys.utk.edu/astr161/lect/earth/atmosphere.html

http://www.enchantedlearning.com/subjects/astronomy/planets/earth/Atmosphere.shtml

http://www.britannica.com/EBchecked/topic/176199/earthquake

http://www.ga.gov.au/scientific-topics/hazards/earthquake/basics/what

http://water.epa.gov/learn/resources/groundwater.cfm

http://www.kalkaskacounty.net/planningeduc0020.asp

http://www.preservearticles.com/201101072821/causes-of-groundwater-pollution.html

http://earth.rice.edu/mtpe/hydro/hydrosphere/hydrosphere_what.html http://www.britannica.com/EBchecked/topic/279025/hydrosphere

www.stmarysmedia.co.uk/jb19/project/Wind.htm

المصادر العربية:

-ثامر خزعل العامري : 2222 .جيولوجيا العصر الرباعي. نشر وطبع وتوزيع مديرية دار الكتب
والطباعة والنشر .وزارة التعليم العالي والبحث العلمي .بغداد 111 .ص.
-زكي عبد الجبار محمود : 2222 .بصرية المعادن .وزارة التعليم العالي والبحث العلمي . جامعة
الموصل .نشر وطبع وتوزيع :دار الكتب للطباعة والنشر-الموصل 111 .ص.
-طارق صالح عباوي وعامر داود ناصر وصالح خضر خلف : 2222 .علم المتحجرات الدقيقة.
وزارة التعليم العالي والبحث العلمي .جامعة الموصل .كلية العلوم .الطبعة الثانية .نشر وطبع وتوزيع
دار الكتب للطباعة والنشر .الموصل 113 .ص.
-عبد الهادي يحيى الصائغ وفاروق صنع الله العمري : 4111 .الجيولوجيا العامة .الطبعة الثالثة.
وزارة التعليم العالي والبحث العلمي .جامعة الموصل .نشر وطبع وتوزيع دار الكتب للطباعة والنشر .الموصل 131 .ص.
-علم الأرض(الجيولوجيا).للصف الثالث الثانوي-الفصل الدراسي الأول-قسم العلوم الطبيعية:
. 2244شركة العبيكان للأبحاث والتطوير .وزارة التربية والتعليم .المملكة العربية السعودية . الجزء
الأول الصفائح الأرضية 13 .ص .الجزء الثاني .البراكين 11 .ص.
-علم الأرض(الجيولوجيا).للصف الثاني الثانوي-الفصل الدراسي الأول-قسم العلوم الطبيعية.
: 2244شركة العبيكان للأبحاث والتطوير .وزارة التربية والتعليم .المملكة العربية السعودية . الجزء
الأول .المعادن والصخور 31 .ص .الجزء الثاني .البراكين 31 .ص.

-**فاروق صنع اله و رمزي خضر الناصر : 2222 .**علم الطبقات .وزارة التعليم العالي والبحث العلمي .جامعة الموصل 131 .ص.
-**فاروق صنع اله العمري وعامر داود ناصر ورمزي خضر الناصر : 2222 .**مبادئ علم المتحجرات .وزارة التعليم العالي والبحث العلمي .جامعة الموصل .كلية العلوم .قسم علم الأرض.
الدار الجامعية للطباعة والنشر 133 .ص.
-**مجيد عبود جاسم(ترجمة : 4193 .)**الجيولوجيا الفيزيائية .مطبعة جامعة البصرة 331 .ص.
-**مجيد عبود جاسم(ترجمة الجزء الثاني : 4193 .)**الجيولوجيا الفيزيائية .طبع على نفقة جامعة البصرة131. - ص331 .
-**مختار رسمي راشد(تعريب : 4111 .)**ما هي الجيولوجيا؟ مطابع الهيئة المصرية العامة للكتاب.
131ص.

Dictionaries:

-Allaby, M., 2008. Earth Sciences. Third Edition. Edited by Michael Allaby. Oxford University Press. 663 p.

المعاجم العربية:

-**مجمع اللغة العربية : 4192 .**معجم الجيولوجيا .طبع بالهيئة العامة لشئون المطابع الأميرية. القاهرة .جمهورية مصر العربية 131 .ص.
-**منير البعلبكي : 4171 .**المورد .الطبعة الثالثة عشر .بيروت .لبنان 1111 .ص.
-**معجم مصطلحات جيولوجيا النفط : 4191 .**شركة النفط الوطنية العراقية.
- .**مطبعة جامعة أكسفورد** English – English – Arabic Dictionary **2244 .**معجم انكليزي–
انكليزي – عرب Oxford University Press.2011 .قاموس أكسفورد الحديث Oxford .
Word Powerطبعة موسعة 311 .ص