Historical Geology

Geology Department

For 3rd year Students

Dr. Ahmed Selima

CHAPTER ONE

Introduction

- Less than 100 years ago, the earth was only 6000 years old.
- Kelvin proposed an age based on the rate of heat loss from the earth's interior. He didn't take account the heat continually generated within the earth by the radioactivity.

- Radioactivity provided a tool for dating rocks directly. Such techniques indicate the earth has existed for 4.6 billion years ago.

Origin of the universe

All matter of the universe was once concentrated in a single mass.

Expansion of this mass called the "Big Pang."

<u>**Origin of the earth**</u>

The earth is setting in space.

<u>Sun</u>:

It has 99.9% of the total mass.

the orbits of all planets of all lie very nearly in the same plane.

the distance between the sun and the earth is about 150 million Km.

The planets are: -

1- Mercury
2- Venus
3- Earth
4- Mars
5- Jupiter
6- Saturn
7- Uranus
8- Neptune

<u>Galaxy</u>:

The Milky way is caused by huge clouds of gas and dust.

Earth Chronology

Our understanding of the earth's events almost entirely has been based on the studies of the crustal rocks that are exposed today or near the earth's surface.

Certain rocks have survived with little changes for millions, even billions of years.

A- Sedimentary rocks:

* sequential nature and it includes fossils.
* 15% of earth history.

B- Igneous and Metamorphic rocks:

* radioactive elements incorporated into the earth rocks as they were formed.
* 85% of earth history.

Organizing the rock record

1- Field study of Rocks

   the geologic history of an area begins with field study of actual rocks than can be seen at the earth's surface.

2- All rocks whether igneous, metamorphic or sedimentary are recognizable and mappable units called formation.

Stratigraphic principle

1- original horizontality
2- Superposition
3- Original lateral continuity
4- Cross cutting relationship

CHAPTER TWO

Age of the earth

1- **Direct Evidence**

The oldest rock, granites, has age of about 4 billion years.

Dating of meteorites and rocks from the surface of the moon around 4.6 billion years.

2- **Indirect Evidence**

It is based on the present-occurrence of the various nuclides of the Lead the occur in minerals of the earth crust.

Radioactive Decay

Radioactive comes from 2 sources

1- Long lived nuclides

2- Short lived nuclides (cosmic ray)

A nuclide is defined as any species of atom that exists for a measurable period of time.

Chronologic tools are Fossils and radioactive decay

we can see fossils with naked eye starting from Phanerozoic eon.

igneous and metamorphic rocks have 20 minerals, we use 8 of them as a chronological tool.

Decay produces β, α, or e^- in order to give a stable element.

1- **Primary nuclides long lived nuclides:**

It persisted since the earth first formed, about 20 nuclides have been detected, only 4 are widespread, and generally useful as chronologic tools.

parent radionuclide → Daughter radionuclide

a) Potassium 40 → Argon 40
b) Rubidium 87 → Strontium 87
c) Uranium 235 → Lead 207
d) Uranium 238 → Lead 206

2- **Short lived nuclides**:

The production of the upper atmosphere in earth is by the cosmic rays. The cosmic rays include 8 nuclides that have been recorded, only Carbon 14 widely useful as chronologic tool.

Neutrons are ejected from nuclei of the upper atmosphere in collisions with cosmic rays (A). Captured by nitrogen nuclei (N-14), neutrons transform these nuclei into carbon-14.

The half-life of Carbon 14 is 5600 years.

A small amount of radioactive C-14 that ultimately enters animals and plants provides an extreme useful for dating the last 50000 years of earth history.

Methods for dating ancient rocks:

4 widespread primary nuclides

a) Potassium 40 → Argon 40
b) Rubidium 87 → Strontium 87
c) Uranium 235 → Lead 207
d) Uranium 238 → Lead 206

Age of earth

Direct method

Meteorites and rock recorded from the moon have not been subjected to the process of recycling that affected the rocks on earth's crust.

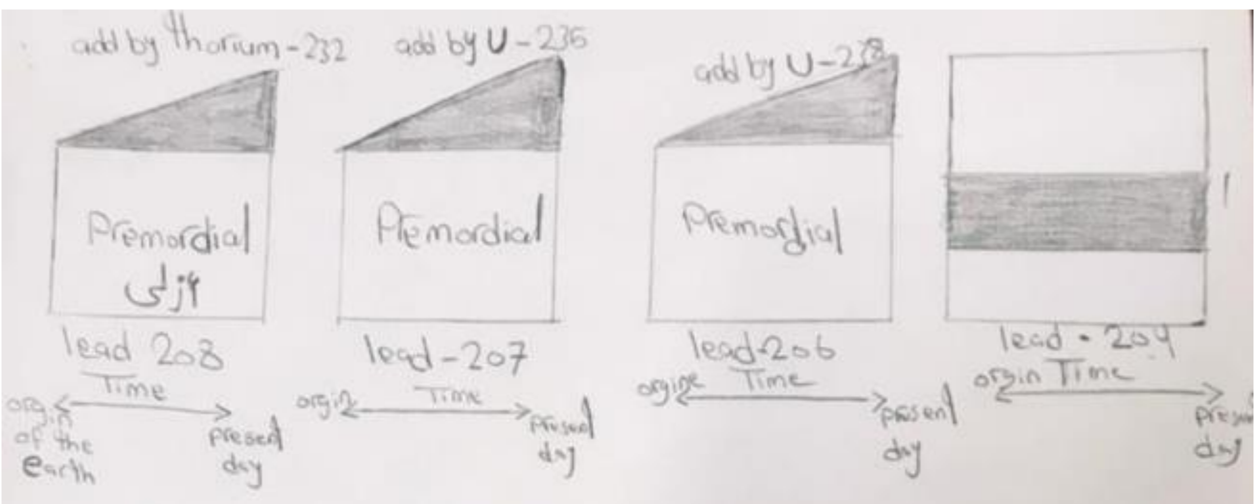
This method suggested that earth has about 4.6 billion years.

Indirect method

It is based on the present - day abundance of the various nuclides of lead that occur in minerals of the earth's crust.

Natural Lead include 4 stable nuclides

Lead 204, Lead 206, Leaf 207, and Lead 208 are produced by the radioactive decay of Uranium and Thorium.



The fourth Lead is not produced by radioactive decay.

If there were some means of determining the original relative abundance of the four lead isotopes at the time of the earth was formed then we could simply calculate the time required for the additional Lead- 206, Lead-207 and lead-208 to have been produced by radioactive decay. Certain meteorites Containing neither uranium nor other radioactive elements that delay into Lead are thought to provide a reasonable approximation of the earth's original abundance of lead. years.

The earth & age can be calculated that about 4.6 billion years.

CHAPTER THREE

The Precambrian Earth

The oldest rock formed about 4. billion years ago, 541 My ago.

This accounts for 85% of earth history (4.6 My).

Complex igneous and metamorphic rocks (Basement).

Precambrian Rocks and geography:

All Continents stable areas or Cratons

Craton: long-stable region of a continent, whose Precambrian rocks are either on the surface or under relatively thin Cover of younger Sedimentary rocks.

Shield: Each Craton includes a large area where Precambrian rocks-chiefly metamorphic and granitic

are exposed without a Cover of younger Strata 28% earth surface.

Mobile belt: portion of the Continent that are undeformed Craton. It is an elongated region of the earth's crust.

characterized by tectonic instability, subsiding at times to extraordinary thick Sequences of sediments and rising at other times to become mountain chains, chiefly of phanerozoic age.

Most Precambrian exposures consist of igneous and metamorphic basement rocks. But Some consist of Sedimentary rocks have been deformed or metamorphosed only slightly or not at all. (Tens of thousands of meters)// millions of years of-Precambrian Time.

Precambrian Chronology

Because Precambrian sedimentary sequences lack fossils, it has not yet been possible to fit them into Common time classification applicable worldwide... but can be classified to local Criteria.

Archean Eon below and younger Proterozoic above.

Precambrian 85% makes up 50% percent of the earth's sedimentary rock volume and is exposed on 20% of the land surface.

From the radiometric-age determination of Igneous, and metamorphic rocks each Precambrian shield region can be divided into Subregions based on rock ages. Structural province termed orogenic fronts [abrupt metamorphic or fault boundary.

Greenstone Belts: Archean Sedimentary rocks occur in thick sequences that also contain metamorphosed volcanic rocks found and surround by dome like masses of Archean granite.

The greenstone belt Sequences include abundant of pillow lava (under water) and Volcanic clastic rocks (breccia, S.S, and tuffs)

Sedimentary rocks in greenstone belt Sequences are greywacke generally graded (Graded bedding) due to turbidity current (turbidites) deeper water.

Evolving Precambrian Environments

Late Precambrian Continents were intensively eroded.

<u>Banded Iron Formations (BIF):</u> a thick sequences of iron rich Sedimentary cherts that abundant only in Early Precambrian

recks, reflect Condition of in the ocean before free oxygen was present in the atmosphere.

Most BIF are more than 2 billion years old, after 2 billion.

it became scarce. layers of BIF range from less than 1 mm to several centimeters and can be traced for distances up to 300 km, constitutes about one-third of the rock.

The precipitation was probably supplied by primitive single- Celled phytoplankton (planktonic plants).

<u>Stromatolites:</u> are mound like accumulation of $CaCo_3$ produced by algae, abundant in Late Precambrian deposits shallow marine.

When high tide or storms brings in load of fine grained $Caco_3$

particles, a thin layer of them is trapped by filaments.

<u>Tillites</u>: about 30% of the earth's land surface was Covered by Continental glaciers in recent geologic history, and much of this ice remains today in Greenland and Antarctica.

Debris flows (Sometimes called mud flows).

water saturated mud and rock that moves quickly down slope under the influence of gravity (after heavy rain in arid regions).

Precambrian glaciation occurred first in the early Proterozoic around 2.2 to 2.3 billion years ago. The second in late Proterozoic around 700 My ago.

<u>Evolution of the ocean and atmosphere</u>

We suppose that the ocean and atmosphere are mere residue of light, volatile materials left over from the original acceleration of the Solid earth. scientists believe that the earth's gaseous atmosphere is not merely a residue of initial solar gases but is instead an accumulation of volatile materials released by the volcanic heating and outgassing of elements originally combined into the minerals of the solid earth.

such volcanic degassing over the long Course of the earth history, is the most probable source of our ocean and atmosphere.

Local heating and melting of the earth's Solid and upper mantle (= volcanoes) all of which release large materials of volatile elements at the earth's surface

Volcanic gases: (water vapor + CO_2 + H_2 + N_2 + ammonia NH_3 methane CH_4 + 2 and others)

The ocean through Earth history

ocean have been present Since early Precambrian time, but the volume and precise Composition of these early ocean are uncertain.

Fluids from the earth's interior:

original acceleration from the solid earth, but instead were added somewhat later by volcanic outgassing from the materials of the solid crust and mantle over Long Course of the earth history, is the most probable Source of oceans (= water) and atmosphere (gases).

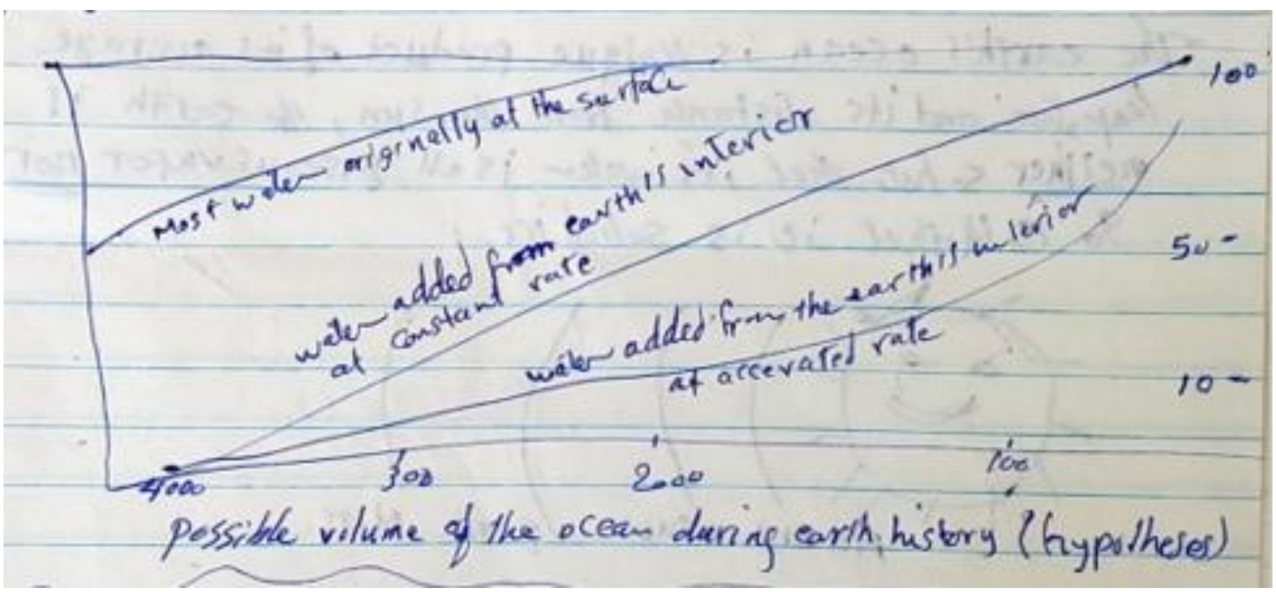
large quantities of BIF Chert (massive, non-crystalline quartz" in the early Precambrian suggests that the early oceans must have contained vastly more iron than they do today.

In the middle and late Precambrian Carbonate rocks became abundant

(Ca Mg (CO3)2) almost of dolomite instead of

Calcite.

So Precambrian oceans may have Contained more magnesium than modern oceans.



Changing atmosphere: The earth, Venus and Mars

The present atmosphere of Venus and Mars are dominated by (Cos), as most probable was the early atmosphere of the earth.

The earth, Venus and Mars:

Venus and Mars the atmosphere of both Co_2 than N_2 originated from volcanic outgassing on Venus and Mars the volcanic Co_2 has accumulated as gas where on the earth it has been steadily removed from the atmosphere, Leaving N2 as dominant gas.

Why does Earth have a hydrosphere unlike Mars and Venus?

Venus so Hot …

$H2o \xrightarrow{\Delta} H2\uparrow + O2$ by intense solar radiation.

Mars: it's mass about $\frac{1}{100}$ the mass of the earth, so it has less quantity of water vapor.

The small amount of water vapor form frost rather than accumulation as an ocean.

The earth's ocean is unique product of its average temperature and its distance from the sun, the earth is neither so hot that its water is all gaseous nor so cold that it's solid ice.

Carbon Dioxide and the ocean: the carbon dioxide steadily removed.

1- dissolved in ocean water.
2- Co_2 as solid in sedimentary rocks, 77% as Co_3
3- 23% as ancient animals, plants (black shale)
4- Photosynthesis

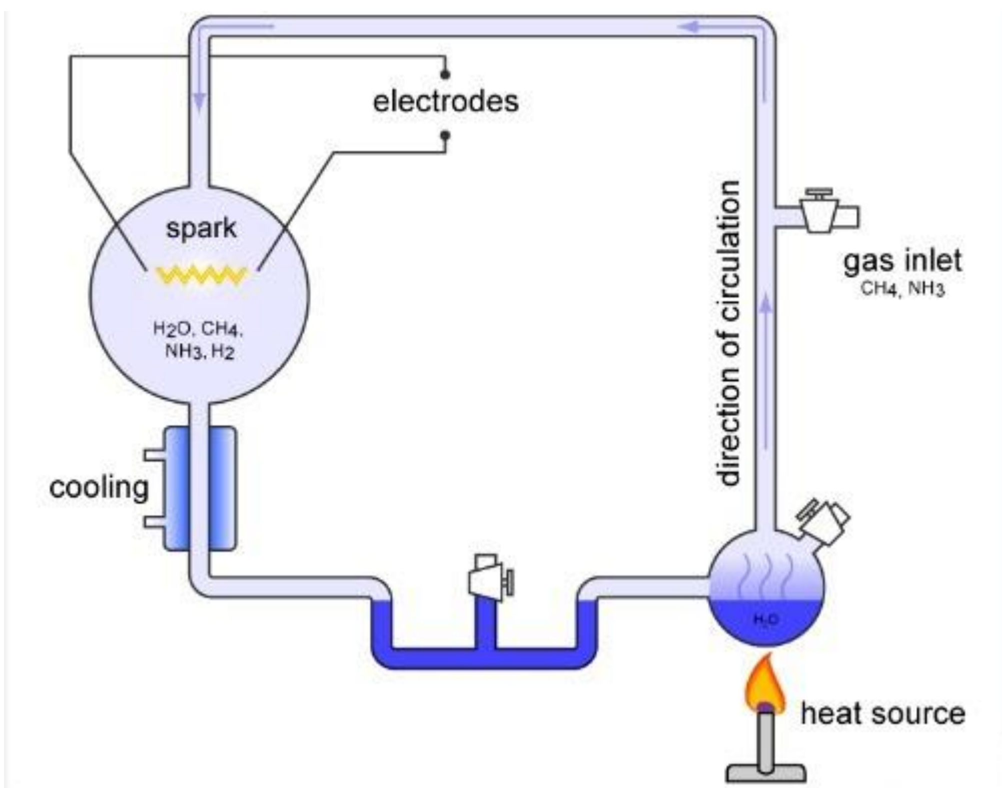
CHAPTER FOUR

The Expansion of Life

Earliest life: - ancient organisms are found in Sedimentary recks of almost all ages. Including some formed over 3 billion years ago.

Organisms body consists of

water+ carbon+ fats + proteins+ DNA +Nitrogen+ Hydrogen.



The Miller–Urey experiment is a famous chemistry experiment that simulated the conditions thought at the time (1952) to be present in the atmosphere of the early, prebiotic Earth, in order to test the hypothesis of the chemical origin of life under those conditions. The experiment used water (H2O), methane (CH4), ammonia (NH3), hydrogen (H2), and an electric arc (the latter simulating hypothesized lightning).

simple present-day life: -

some organisms Called autotrophs, Heterotrophs.

simplest modem organisms are microscopic bacteria and blue-green algae which Collectively known as prokaryotes which lack a chromosome bearing nucleus.

All other organisms from single-celled plants and animals are made up of cells having such a nucleus.

Nucleus-bearing organisms are Called eucaryotes, other basic structural features such as genetic systems and metabolic process and wall.

Fossil evidence of early life:

The only direct evidence of early life is that provided by the study of fossils remains of past organisms that were preserved in ancient sedimentary rocks.

The First clues of Precambrian Life Come from Stromatolites and fossil prokaryotes.

1- **Gunflint chert fossils**: exposed in Minnesota, they occur in 1.9 billion years old rock.
2- **Fig tree fossil**: alder prokaryotes over 3.2 billion years from south Africa.
3- **Bitter springs formation fossils**: under 1.5 billion years Australia.

Early Eucaryotes:

They are relatively Complex animals and plants found in late Precambrian rocks (megaphytes and metazoans), were discovered in 1947 in Australia in Sand stones of the Ediacaran Hills. Age about 650 to 700 My ago.

The period between Precambrian and Cambrian, 541My and 570 My, is called Ediacaran period.

CHAPTER FIVE

The Phanerozoic record

This phase began with the expansion of shell bearing animals about 570 million years ago.

The Phanerozoic era represents only the most recent 15 percent of the earth's history.

Phanerozoic made up fully one half of all sedimentary rocks on earth, covering about 80 percent of the land areas of the earth normally range in thickness from a few hundred to a few thousand meters and less buried as deeply in the crust as have Precambrian rocks, so it is better preserved.

The rock cycle

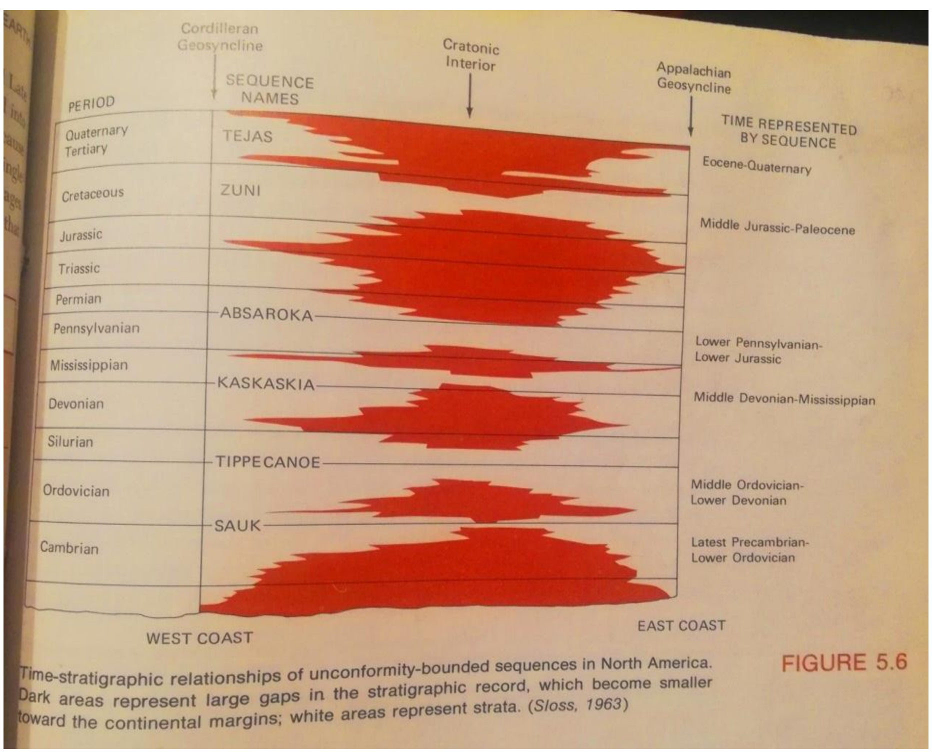
This concept helps explain the decreasing abundance of sedimentary rocks with geologic time for most older rocks have been destroyed and recycled by tectonic activity erosion i.e., a new arrangement of old material that has been around since the earth began. At any given time in the geological past some portions of the earth's surface were undergoing erosion and some portions were undergoing sedimentation producing new sedimentary records Half of the total sedimentary rock mass is Precambrian in age and half is Phanerozoic in age. The mass half age of all crustal rocks is thus about 600 million years.

<u>Unconformity bounded units</u>:

Intervals of continent –wide rock erosion permit the definition of still another type of unit called a sequence.

The greatest unconformity of all lies at the base of Cambrian above the underlying Precambrian rocks.

Uplift at this time was so elongated and erosion so intense that most of the late Precambrian record was removed.



Time-stratigraphic relationships of unconformity-bounded sequences in North America. Dark areas represent large gaps in the stratigraphic record, which become smaller toward the continental margins; white areas represent strata. (*Sloss, 1963*)

Paleoecology:

Interpreting the interactions of ancient sedimentary environments and their contained animal and plants fossils

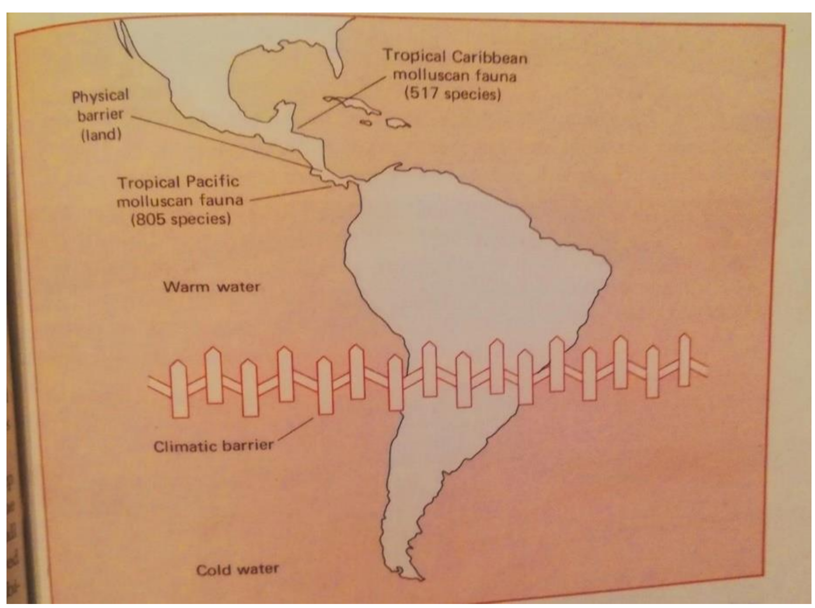
Biogeographic provinces:

Almost no species of animals or plants occur in all parts of the world. Most are confined to large regions called Biogeographic provinces which are surrounded by barriers. land areas are barriers to the dispersal of marine organisms and open water is a barrier for most land dwellings.

organisms and deep ocean basins pose as great a barrier as a land mass.

Inhospitable climates constitute a barrier to both terrestrial and marine animals and plants.

So, the barrier may be physical or climatic.



CHAPTER SIX

Plate Tectonics

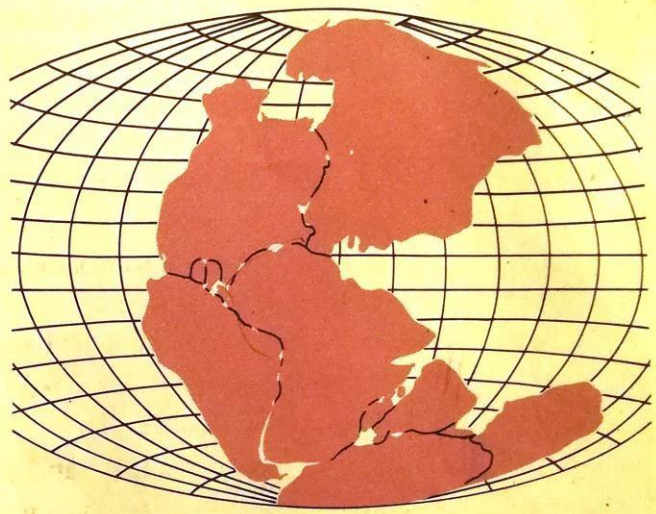
The earth's present outer skin is divided into 7 huge plates that move as coherent units, plus about 20 much smaller plates sandwiched between them.

The rigid lithosphere that incorporates these moving plates includes approximately the outer 100 kilometers of the earth motions of these lithosphere plates produce earthquakes, volcanoes and certain geographic features of the modern earth.

Discovery of plates motions

A- **Continental drift**

Among the first of these was one proposed in 1912 by Alfred Wegener. He was impressed by the jigsaw –puzzle like fit of shapes of some of the continents. The most obvious such fit is that between west coast of Africa and the east coast of north and south America, he suggested that the continents were originally jointed in a single large land mass that subsequently broke apart to create the separate continents we see today.



A reconstruction of the probable relationships of the continents in Triassic time before they drifted into their present configurations. (*Dietz and Holden, 1970*)

B- **Ocean-floor Topography**

Before 1920 the only method for determining ocean, floor topography or depths was to laboriously a heavy weight attached to thousands of feet of steel wire over the side of a ship, but there were so scattered and provided little evidence for ocean bottom irregularities.

In the 1920's the first echo-sounders were developed, and the oceans are traversed by a worldwide mountain chain, the oceanic ridge-rise system-rifts along the ridge crests suggest a pulling-apart of the ocean floor.

C-**Ocean floor Magnetism**

The rocks of the ocean floor are almost exclusively basalt containing a large and relatively constant amount of magnetite, which makes them strongly Magnetic when lava cools to form basalt. the magnetic crystals become magnetized in the direction of the earth's magnetic field. Lava forming at different times has different directions of magnetization, reflecting the earth's magnetic field at that time the lava cools.

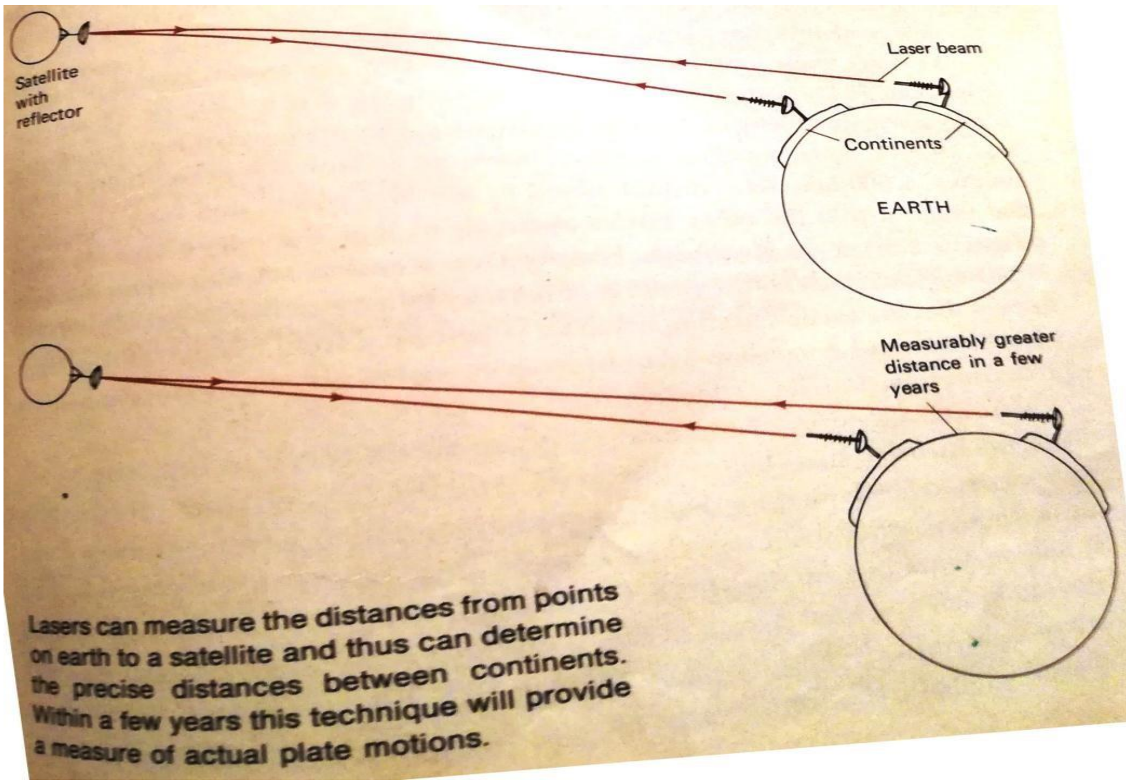
Confirmation of plate motions

1- **Earthquakes and plate boundaries**

The boundaries of huge crustal plates where new volcanic rocks are created along spreading centers and destroyed as they plunge downward in subduction zones.

2-**Laser beam measurements**

Reflected from the moon will soon provide the first precise measurements of plate motions.



3-**<u>The journey of the green turtle</u>**

The green turtle lives its life on the coast of Brazil. Each year between it leaves home and swims 2000 kilometers on December and March

Ascension Island ‘'area 90 square kilometers -12 kilometer across” in the middle of the Atlantic Ocean.

Here the turtle nests and then returns with it's young to Brazil.

The journey each way takes about two months. Many geologists now suspect that the turtle's nesting behavior is inherited from much earlier time when Brazil and Accension island ''or more correctly it's mid oceanic –ridge predecessors ''were a lot closer together.

CHAPTER SEVEN

Cambrian To Devonian Time

We began our survey of Phanerozoic history by considering the first one–third of Phanerozoic time – a span of 200 million years that includes the Cambrian – Ordovician –Silurian and Devonian periods. The earth's continents were covered by shallow seas and sediments bear fossils.

Early Paleozoic Lands and seas:

Cambrian rocks provide the first clear record of Continents-wide advance and retreat of the sea i.e., Epicontinental seas.

In most regions the Lower Cambrian contact with the underlying Precambrian rocks is easily recognizable. Unconformity or by means of the first appearance of Cambrian fossils. At time, the lands stood high and the marine waters spilled only onto the edges of the continental shelves. At other times, large portions as the continents subsided below. Sea level and were almost to totally covered by shallow seas.

Early Paleozoic Continents and Mountain belts:

When the Paleozoic Era began several separate continental masses lay scattered about on the earth's surface.

Throughout the Paleozoic, these continents slowly drifted together and joined, one by one. So that at the end of the Paleozoic, some 300 million years later they formed a single huge continent which we call Pangaea.

After the Triassic period Pangaea gradually broke apart.

Its fragments were rearranged during the latter part of the Mesozoic and the Cenozoic Eras.

In post Triassic time Pangaea was disassembled as a new system.

Were a new oceanic crust formed from upwelling mantle material.

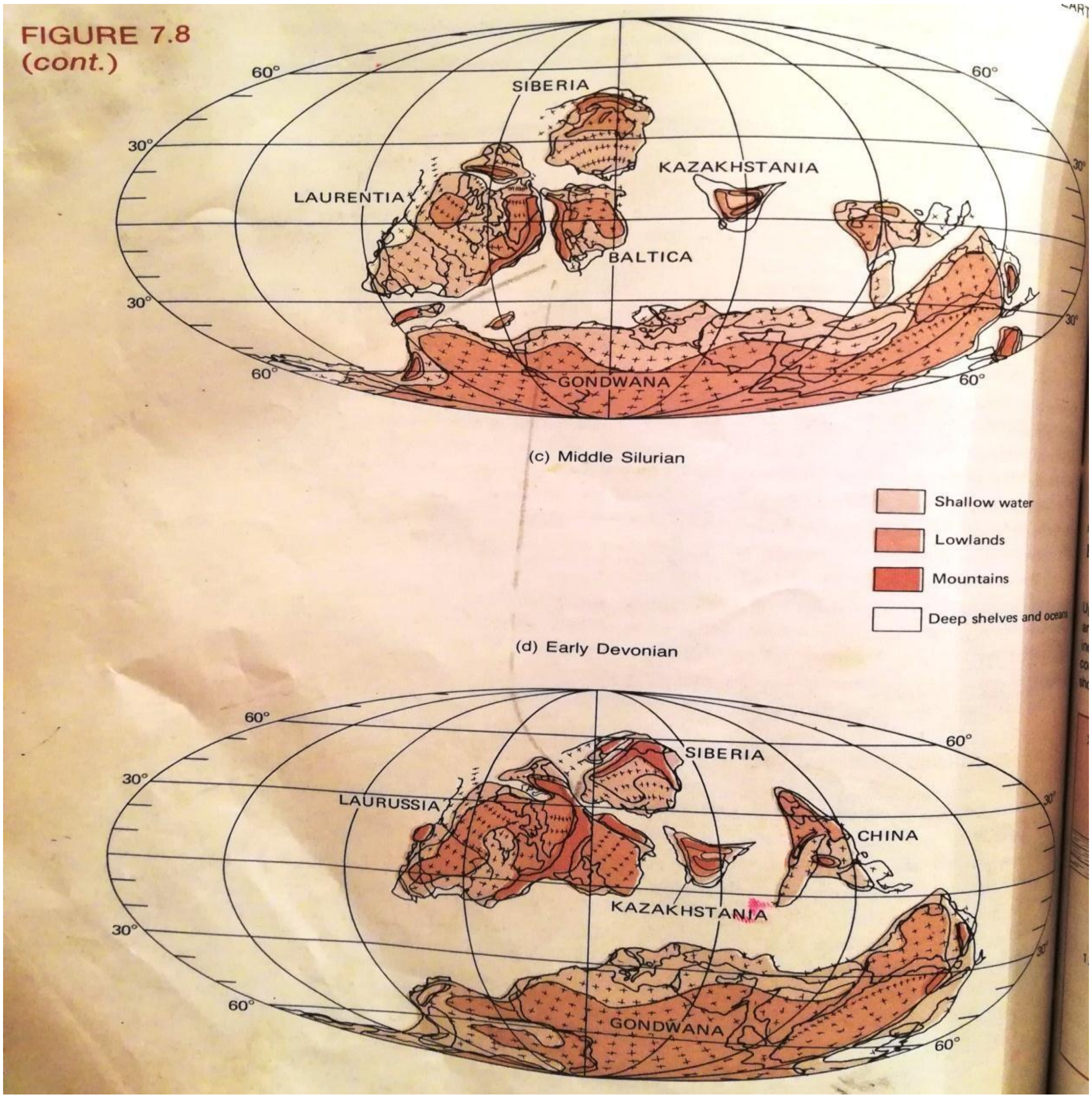
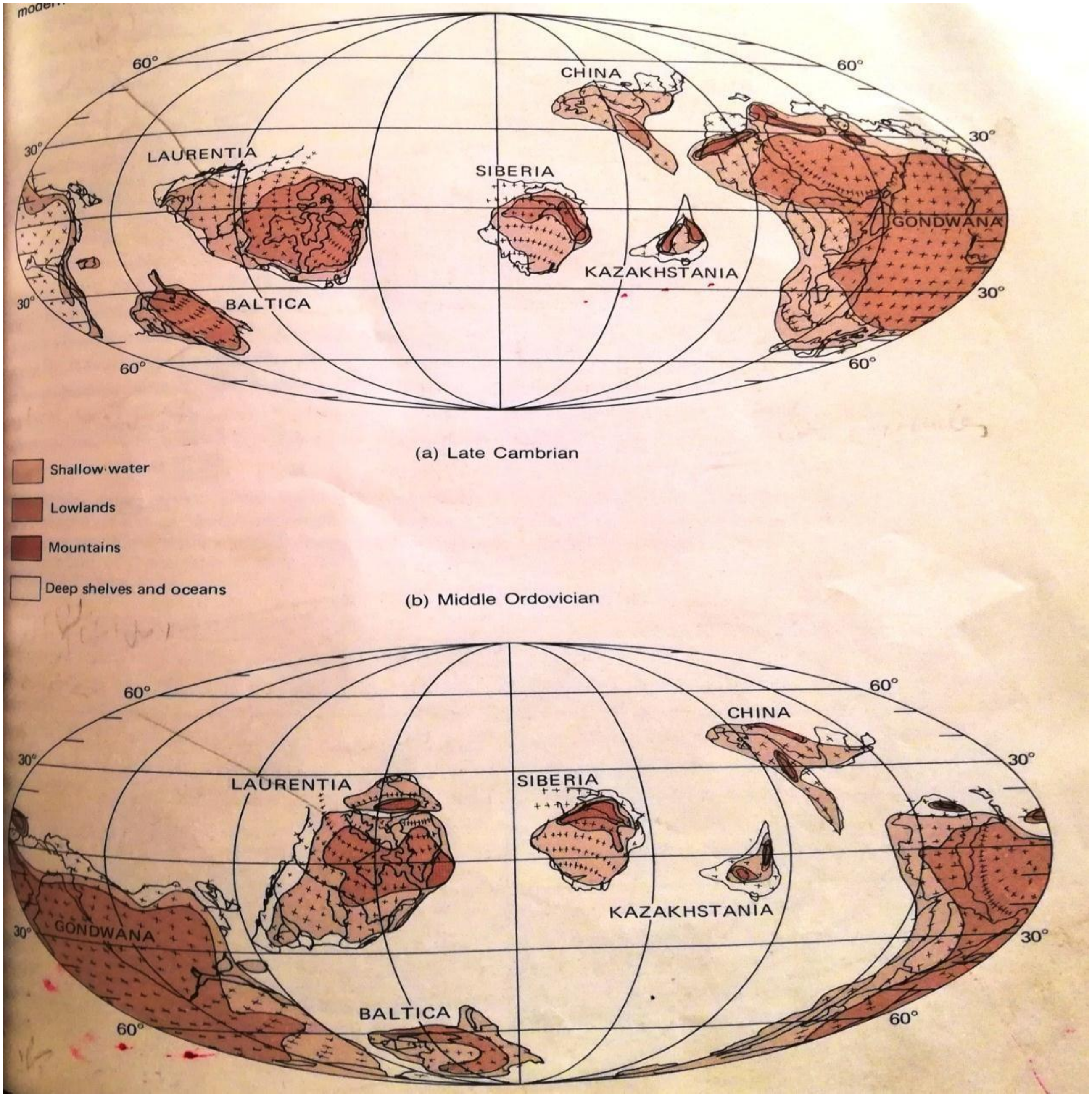


FIGURE 7.8
(cont.)
SIBERIA
KAZAKHSTANIA
LAURENTIA
BALTICA
GONDWANA
60°
30°
(c) Middle Silurian
Shallow water
Lowlands
Mountains
Deep shelves and oceans
(d) Early Devonian
SIBERIA
LAURUSSIA
CHINA
KAZAKHSTANIA
GONDWANA



(a) Late Cambrian

(b) Middle Ordovician

Cambrian continents lay at low latitudes in the Ordovician and Silurian, the Continent of Gondwana [A huge Paleozoic southern hemisphere continent that consisted of present day Africa, Antarctica, India, South America and Australia] Swept across the south pole, while Siberia, Kazakhstani and China rearranged themselves at low latitudes. Simultaneously ancestral North America –labeled Laurentia – and ancestral of Northern Europe and Russia – labeled Baltica – rotated counter clockwise and drew close together in the Devonian they collided beginning the assembly of Pangaea.

The Expansion of Marine Life:

Many marine animals secrete shells of calcium carbonate which may become fossilized .

The eight 8 principal phyla of the present-day shell-bearing marine animals originated in the early Paleozoic time and have been abundant since Devonian time.

These Phyla are [Sarcodina, Porifera, Coelenterate, Bryozoa, Brachiopod, Mollusca, Arthropoda, and Echinodermata]

South Valley University
Qena Faculty of science
Geology department

Practical course: ***Historical Geology***, 3rd year Geology

Time Table

Week	Hours	Content
1.	2	Introduction of ***Historical Geology,*** with some notes about the Time scale.
2.	2	*Macro- Fossils* The geologic history of ***Bivalv*es**.
3.	2	
4.	2	The geologic history of ***Gastropods***.
5.	2	The geologic history of ***Ammonites & Belemnites***.
6.	2	The geologic history of ***Brachiopods***.
7.	2	The geologic history of ***Echinoderms***.
8.	2	The geologic history of ***Coelenterates*** & ***Porifera***.
9.	2	*Micro- Fossils* The geologic history of ***Forams***.
10.	2	
11.	2	
12.	2	Discussion of some reports in Historical Geology made by students.

Some examples for what we study.
Week (1):

A- Macro- Fossils

Geologic history of Bivalves

Bivalves are first recorded in rock of Middle Cambrian in Spain. These fossils were uncommon until Silurian; many genera appeared in the end of Paleozoic.
A high percentage of forms died out at the close of Permian, and many new genera appeared in the Triassic.
A great diversity of forms appeared during Mesozoic, and the class reached its acme during Tertiary. It is still occurs abundantly in seas today.

1. Classification:
   Phylum: Mollusca
   Class: Bivalvia
   Subclass: Ostreina
   Family: Ostreidae
   Genus: *Ostrea*
   Ostrea sp.

   Stratigraphic Range: The genus *Ostrea* appeared in Cretaceous (140 My) and still occurs in seas today, except in Polar Regions. It has a wide geographic distribution.

2. Classification:
   Phylum: Mollusca
   Class: Bivalvia
   Subclass: Spondylidae
   Genus: *Spodylus*
   Spodylus sp.

   Stratigraphic Range: The genus *Spodylus* appeared in Cretaceous (140 My) and still wide spread in seas today.

3. Classification:
   Phylum: Mollusca
   Class: Bivalvia
   Subclass: Ostreina
   Family: Graphaeidae
   Genus: *Exogyra*
   Exogyra sp.

   Stratigraphic Range: The genus *Exogyra* appeared in Lower Cretaceous (140 My) and became extinct in the Upper Cretaceous.

Week (2)

4. Classification: Phylum: Mollusca
   Class: Bivalvia
   Subclass: Veneroida
   Family: Veneridae
   Genus: *Venus*
   Venus sp.

   Stratigraphic Range: The genus *Venus* first appeared in Oligocene (35 My) and still occurs in seas today.

5. Classification: Phylum: Mollusca
   Class: Bivalvia
   Subclass: Pteroida
   Family: Pectinidae
   Genus: *Pecten*
   Pecten sp.

   Stratigraphic Range: The genus *Pecten* first appeared in upper Eocene (40 My) and, still occurs in the sea through the world.

6. Classification: Phylum: Mollusca
   Class: Gastropoda
   Subclass: Archaeogastropoda
   Family: Patellidae
   Genus: *Patella*
   Patella sp.

   Stratigraphic Range: The genus *Patella* appeared in Eocene sediments and through the world, and still occurs in the sea today.

7. Classification: Phylum: Mollusca
   Class: Gastropoda
   Subclass: Archaeogastropoda
   Family: Turbinidae
   Genus: *Turbo*
   Turbo sp.

   Stratigraphic Range: The genus *Turbo* first appeared in upper Cretaceous (80 My) and still occurs in the sea today.

Week (3)

8. Classification:

Phylum: Mollusca
Class: Gastropoda
Subclass: Archaeogastropoda
Family: Trochidae
Genus: *Trochus*
Trochus sp.

Stratigraphic Range: The earliest known examples of *Trochus* derived from fossil bearing deposits of the Miocene (20 My) and it still occurs in numerous forms in the sea today.

9. Classification:

Phylum: Mollusca
Class: Gastropoda
Subclass: Mesogastropoda
Family: Naticidae
Genus: *Natica*
Natica sp.

Stratigraphic Range: The genus *Natica* dates from the Cretaceous and still occurs in the sea today.

10. Classification:

Phylum: Mollusca
Class: Gastropoda
Subclass: Mesogastropoda
Family: Strombidae
Genus: *Strombus*
Strombus sp.

Stratigraphic Range: The genus *Strombus* first appeared in the Eocene rocks (40 My) and it still occurs in the sea today, it has a broad geographical distribution.

Week (4)

11. Classification:	Phylum:	Mollusca
	Class:	Gastropoda
	Subclass:	Mesogastropoda
	Family:	Turritellidae
	Genus:	*Turritella*
		Turritella sp.

Stratigraphic Range: The genus *Turritella* first appeared in the upper Cretaceous rocks (80 My) and still occurs in the sea today, the greatest evolutionary development of this genus took place during the Eocene. Therefore, it is an excellent guide fossil for the whole Tertiary.

12. Classification:	Phylum:	Mollusca
	Class:	Gastropoda
	Subclass:	Neogastropoda
	Family:	Conidae
	Genus:	*Conus*
		Conus sp.

Stratigraphic Range: The genus *Conus* is known from the upper Cretaceous (80 My) and it still occurs in the sea today.

13. Classification:	Phylum:	Mollusca
	Class:	Gastropoda
	Subclass:	Neogastropoda
	Family:	Muricidae
	Genus:	*Murex*
		Murex sp.

Stratigraphic Range: The genus *Murex* appeared in the Miocene (20 My) and it still occurs in the sea today.

Week (5)

Geologic history of Ammonites and Belemnites

Ammonites first appeared in Devonian, and reached maximum diversity in Mesozoic era. They extinct at the close of Cretaceous.
Belemnites first appeared in rocks of the Upper Carboniferous. They were most abundant and diverse in the Jurassic and Cretaceous.

14. Classification: Phylum: Mollusca
Class: Cephalopoda
Subclass: Ammonoidea
Genus: *Hildoceras*
Hildoceras sp.

Stratigraphic Range: The genus *Hildoceras* is restricted to the lower Jurassic period.

15. Classification: Phylum: Mollusca
Class: Cephalopoda
Subclass: Ammonoidea
Genus: *Amaltheus*
Amaltheus sp.

Stratigraphic Range: The genus *Amaltheus* is restricted to the lower Jurassic period. It had a wide geographic distribution, which made it a very useful guide fossil.

16. Classification: Phylum: Mollusca
Class: Cephalopoda
Subclass: Ammonoidea
Superfamly: Hoplitoidea
Family: Engonoceratidae
Genus: *Neolobites*
Neolobites sp.

Stratigraphic Range: The genus *Neolobites* is typical for Cenomanian.

17. Classification: Phylum: Mollusca
Class: Cephalopoda
Subclass: Ammonoidea
Family: Dactylioceratidae
Genus: *Dactylioceras*
Dactylioceras sp.

Stratigraphic Range:
The genus *Dactylioceras* is typical of the end of Lower Jurassic (170 My), its wide geographic distribution makes it an excellent guide fossil for the Lower Jurassic.

18. Classification: Phylum: Mollusca
Class: Cephalopoda
Subclass: Coleoidea
Family: Belemnitidae
Genus: *Belemnites*
Belemnites sp.

Stratigraphic Range: *Belemnites* is often widespread in rocks of the Mesozoic era, it is most abundant in Jurassic and Cretaceous.

Week (6)

Geologic history of Brachiopods

The earliest Brachiopods discovered in sedimentary strata of the lower Cambrian, belonging to the Articulates. The greatest period of Brachiopod development was the Paleozoic era, they survive today in a very small number of genera.

19. Classification:
Phylum: Brachiopoda
Class: Articulata
Subclass: Trebratulida
Family: Trebratulidae
Genus: *Trebratula*
Trebratula sp.

Stratigraphic Range: The genus *Trebratula* found in sediments of the European Miocene and Pliocene. These animals increased rapidly in the Mesozoic, but they reduced to a few genera during the Cenozoic.

20. Classification:
Phylum: Brachiopoda
Class: Articulata
Subclass: Spiriferida
Family: Spiriferidae
Genus: *Spirifer*
Spirifer sp.

Stratigraphic Range: The genus *Spirifer* occurs worldwide, its stratigraphic distribution ranges from Devonian to Permian. It is consider a guide fossil for the Carboniferous.

21. Classification:
Phylum: Brachiopoda
Class: Articulata
Subclass: Rhynchonellida
Family: Rhynchonellidae
Genus: *Rhynchonella*
Rhynchonella sp.

Stratigraphic Range: The genus *Rhynchonella* is characteristic of the Jurassic.

22. Classification:
Phylum: Brachiopoda
Class: Articulata
Subclass: Spiriferida
Family: Atrypidae
Genus: *Atrypa*
Atrypa reticularis

Stratigraphic Range: The genus *Atrypa* found from the lower Silurian to the upper Devonian, in some places reached to the Carboniferous.

Week (7)

Geologic history of Echinoderms

Echinoderms ranges from middle Ordovician to Recent, they possess some form of calcareous skeleton. We have a very good fossil record for the evolution of this group. The echinoderms are a large and successful, entirely marine group, most workers divide the living echinoderms into four classes; Crinoidea, Stelleroidea, Echinoidea and Holothuroidea. The crinoids (feather stars) are the only surviving group whose members are primarily sessile.

23. Classification:	Phylum:	Echinodermata
	Class:	Echinoidea
	Subclass:	Irregularia
	Order:	Spatangoida
	Genus:	*Micraster*
		Micraster sp.

Stratigraphic Range: The genus *Micraster* ranges from Cenomanian (upper Cretaceous) to Danian (lower Paleocene).

Week (8):

Geologic history of Porifera

Porifera discovered in sedimentary strata of Paleozoic era, ranges from Paleozoic to Recent. They are guide fossils for Mesozoic and Tertiary especially in Europe.

24. Classification:

Phylum: Porifera
Class: Demosponga
Genus: *Siphonia*

Stratigraphic Range: The genus *Siphonia* ranges from middle Cretaceous to the Tertiary and restricted to Europe.

25. Classification:

Phylum: Porifera
Class: Calcarea
Genus: *Raphidonema*

Stratigraphic Range: The genus *Raphidonema* ranges from the Triassic to the Cretaceous and restricted to Europe.

Week (9)

Coelentrata

26. Classification:	Phylum:	Coelentrata
	Class:	Anthozoa
	Subclass:	Tabulata
	Genus:	*Syringopora*

Stratigraphic Range: The Tabulate Corals appeared in the Middle Ordovician were diverse in Silurian and Devonian. Their number decreased in late Paleozoic, and extinct at the close of Paleozoic era.

27. Classification:	Phylum:	Coelentrata
	Class:	Anthozoa
	Subclass:	Zoantharia (Hexacorallia)

Stratigraphic Range: Hexacorals appeared in the Middle Triassic period, assumed important value in the Jurassic, and remain diverse today.

28. Classification:	Phylum:	Coelentrata
	Class:	Anthozoa
	Subclass:	Tetracorallia
	Genus:	*Zaphrentites*
		Zaphrentites sp.

Stratigraphic Range: The genus *Zaphrentites* restricted to the Carboniferous.

Week (10)

B- Micro- Fossils

29. Classification:	Family:	Textularidae
	Genus:	*Textularia*

Stratigraphic Range: The genus *Textularia* ranges from Cretaceous to Recent.

30. Classification:	Family:	Globorotalidae
	Genus:	*Morozovella velascoensis*

Stratigraphic Range: *Morozovella velascoensis* is a marker planktonic zone for the Late Paleocene.

31. Classification:	Family:	Globorotalidae
	Genus:	*Morozovella pusilla pusilla*

Stratigraphic Range: *Morozovella pusilla pusilla* is a marker planktonic form for Selandian- Thanetian boundary.

Week (11)

32. Classification: Family: Globotruncanidae
Genus: *Rosita contusa*

Stratigraphic Range: This species ranges from upper Santonian to Maastrichtian.

33. Classification: Family:
Genus: *Praemurica inconstans*

Stratigraphic Range: *Praemurica inconstans* is a marker planktonic form for Danian- Selandian boundary.

34. Classification: Family: Globotruncanidae
Genus: *Globotruncana arca*

Stratigraphic Range: This species ranges from Santonian to Maastrichtian.