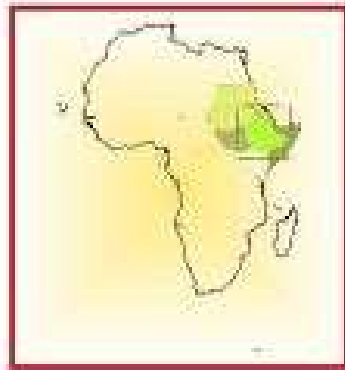


Geography of Ethiopia and The Horn



Course name: Geography of Ethiopia and The Horn

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Chapter Two:

THE GEOLOGY OF ETHIOPIA AND THE HORN

2.1 Introduction

- **Geology** is an earth science that studies about;
 - the **evolution of the earth**,
 - the **materials** of which it is made of, and
 - the **processes** acting upon them.
- ✓ It is concerned with events;
 - ✓ that took place in the remote past
 - ✓ when no witness and
 - ✓ with features far beneath the earth's surface
 - ✓ where no one can see.

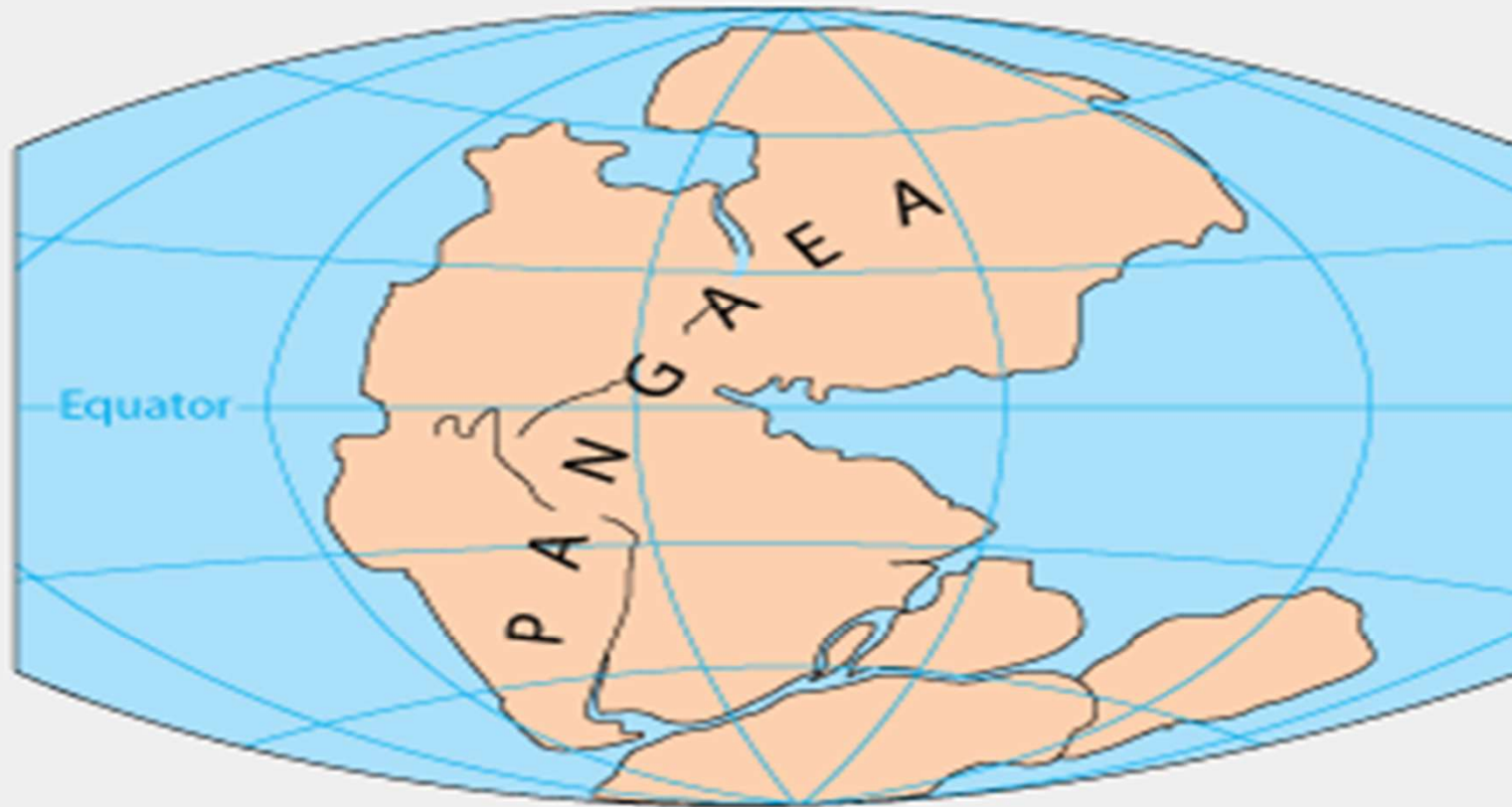
- A geological understanding can be obtained by;
 - inference, using clues from;
 - what can be seen and
 - what can be measured.
- There are many such clues such as;
 - By direct observation of the **rocks** and landforms which can be observed and studied at the Earth's surface, and

Intro.....

- By **indirect methods** such as
 - ✓ geophysics (e.g. studying **earthquake waves** which can penetrate deep beneath the Earth's surface),
 - ✓ geochemistry (analysis of the **detailed composition of rocks** which can give clues as to their origin) and
 - ✓ geochronology (methods for **finding the ages of rocks**, from the **radioactive elements** they contain).

Intro...

- The earth's continents were together in a single huge continent called **Pangaea**.



PERMIAN
250 million years ago

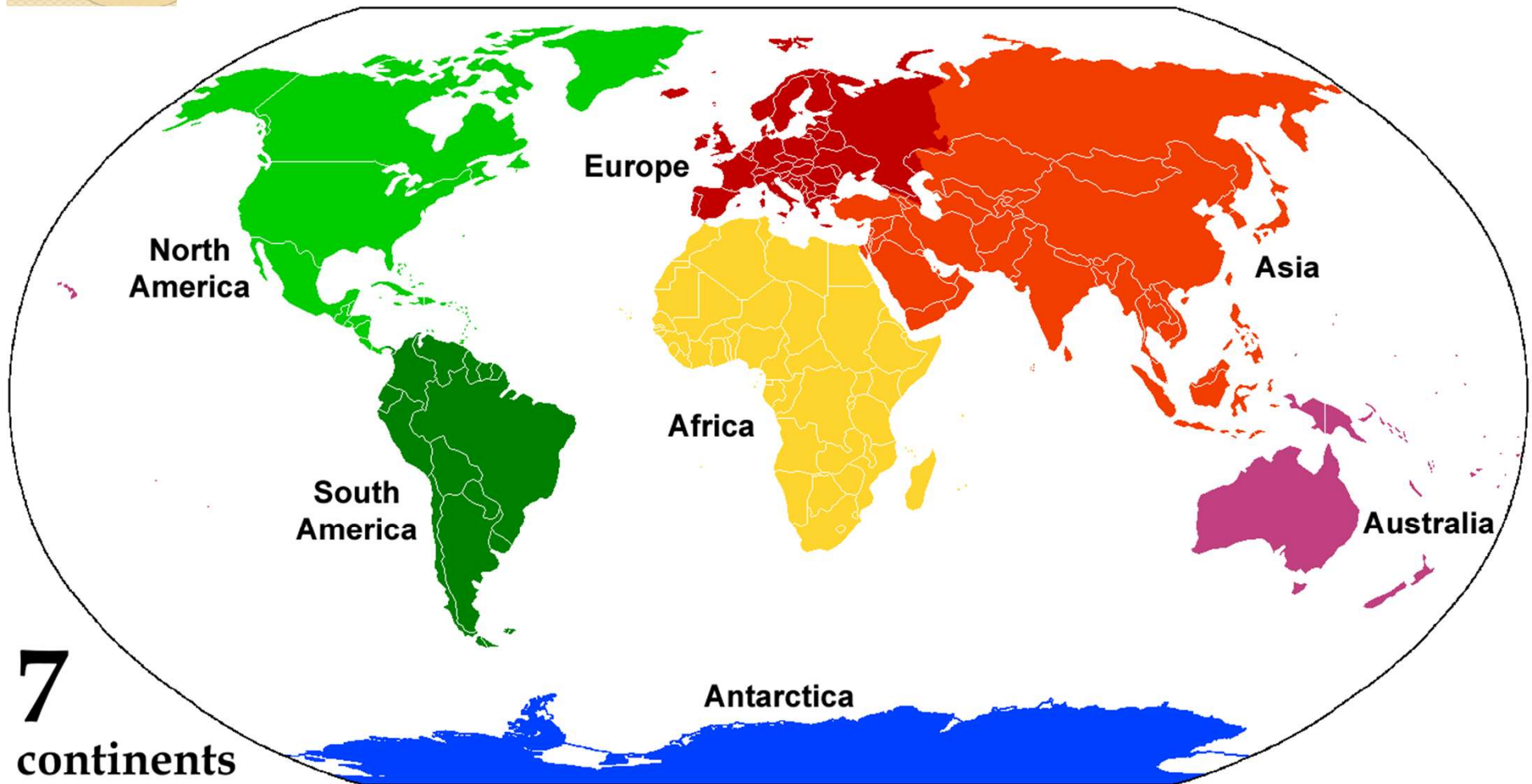
Intro...

- ✓ The large super continent was then split into
 - ✓ **Gondwanaland** and
 - ✓ **Laurasia**;



Intro...

- ✓ later into smaller fragments over the last million years. These then drifted apart to form the present arrangement of continents.

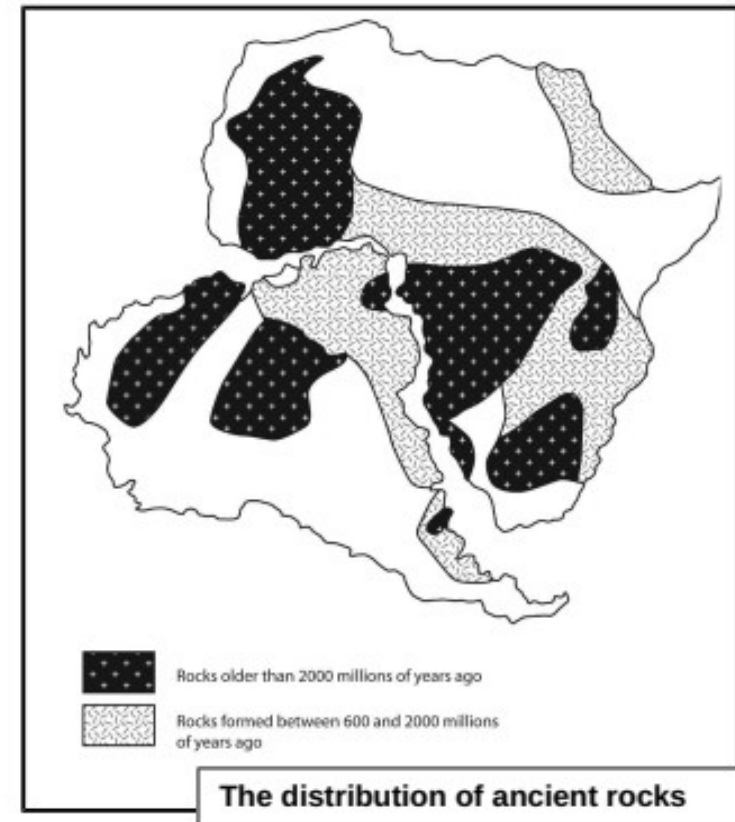


Intro.....

✓ Australian Climatologist Alfred Wegener
proposed the *hypothesis* that the
continents were assembled together as a
supercontinent, called the Continental
drift Theory.

❖ His principal observations, which can be considered as evidence were:

a) **Fit of the continents:** The opposing coastlines of continents often fit together.



Intro.....

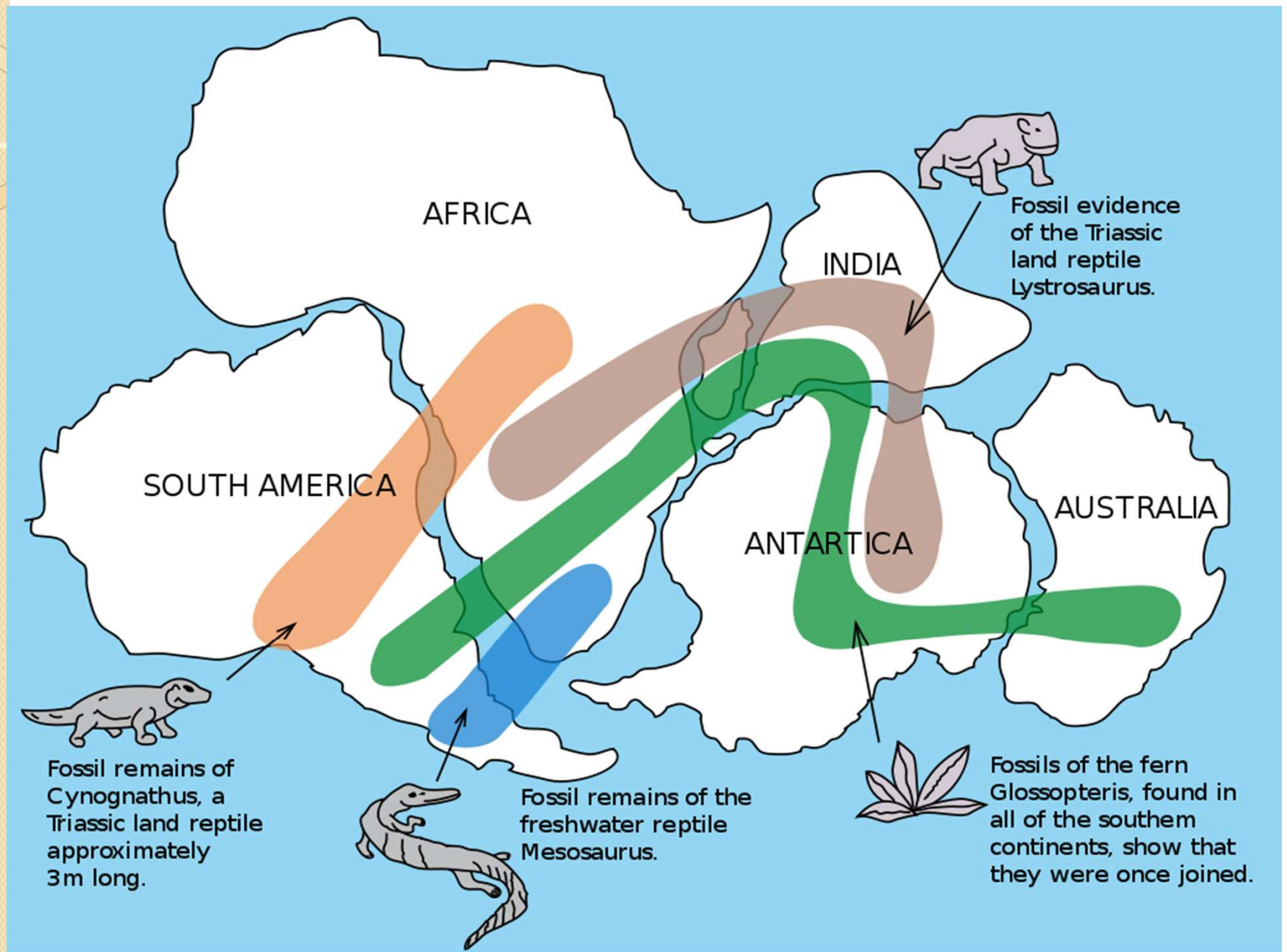
b) Match of mountain belts, rock types: If the continents are reassembled as **Pangaea**,

- ✓ mountains in West Africa,
- ✓ North America,
- ✓ Greenland, and
- ✓ Western Europe match up.

Intro....

c) **Distribution of fossils:** The distribution of plants and animal fossils on separate continents forms definite linked patterns if continents reassembled.

d) **Paleoclimates:** rocks formed 200 million years ago in India, Australia, South America, and southern Africa all exhibited evidence of continental glaciations.



2.2. The Geologic Processes: Endogenic and Exogenic Forces

- Geology studies how Earth's materials,
 - structures,
 - processes and
 - organisms **have** changed over time.
- ✓ These processes are divided into two major groups:
internal and external processes
 - ✓ **The internal processes (endogenic) include;**
 - ✓ volcanic activity,
 - ✓ all the tectonic processes (folding, faulting, orogenesis (mountain building), and
 - ✓ epeirogenesis (slow rising and sinking of the landmass)

The Geologic Processes.....

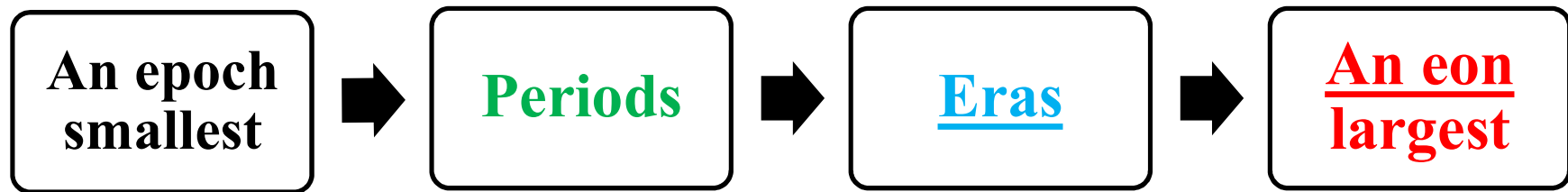
- ✓ The processes result in building of;
 - ✓ structural and volcanic features like;
 - ✓ plateaus,
 - ✓ rift valleys,
 - ✓ Block Mountains,
 - ✓ volcanic mountains, etc.
- ✓ The external (exogenic or geomorphic) processes include;
 - ✓ weathering, mass transfer,
 - ✓ erosion and deposition.

The Geologic Processes....

- ✓ They act upon the volcanic and structural landforms by;
 - ✓ **modifying,**
 - ✓ **roughening and**
 - ✓ **lowering them down.**
- ✓ The landmass of Ethiopia is the result of the combined effect of these two processes; **Internal (endogenic)** and **External (exogenic)**.

2.3. The Geological Time Scale and Age Dating Techniques

- To describe the **geology** and **history of life** on Earth, scientists have developed **the geological time scale**, which is divided into four units.



- **Each eon is divided into Eras.** Each **Era** is again divided into **periods**. Periods into **An epoch**

2.3. Geological...

- ✓ The **Eras** are given names that indicate the kind of **life** that existed in them, i.e.,
 - ❖ The **Paleozoic Era** (ancient life) is the age of invertebrates,
 - ❖ The **Mesozoic Era** (the middle life) is the age of reptiles
 - ❖ The **Cenozoic Era** (recent life) is the age of mammals.
- ✓ These geological time divisions **differ** from each other;
 - a) **By the relative position of land and sea,**
 - b) **By the kind of climate and**
 - c) **important animal and plant life that developed and existed at that Era/period.**
- ✓ **Geological time is difficult to measure precisely.**

2.3. Geological...

- The Earth was formed $\approx$ 4.5 billion years ago
- **the earliest forms of life** were thought to have originated about **3.5 billion years ago**.
- ✓ The **span of time before life appeared** was termed the **Precambrian Era**.

2.3. Geological...

- ✓ The division of time units in the geological time scale is based on the occurrence of geological events (e.g. mass extinctions).
- ✓ However, the geological time categories do not usually consist of a uniform length of time.
- ✓ The geological time scale, illustrated below is built largely on the basis of life and evolution

Table 2.1: The Geological time scale

Era	Period	Began (million years)	End	Major events (Million years ago)
4. Cenozoic	Quaternary	1.6	present	Major glaciers in North America and Europe (1.5)
	Tertiary	70	1.6	Rocky Mountains (65), individual continents take shape.
3. Mesozoic	Cretaceous	146	70	Dinosaurs extinct (65), western interior seaway and marine reptiles (144 – 65)
	Jurassic	208	146	Pangaea (one land mass) begins to break up (200)
	Triassic	225	208	First mammals and dinosaurs

2.3. Geological...

2. Paleozoic	permian	290	225	Greatest extinction on Earth (245)
	Pennsylvanian	322	290	Greatest extinction on Earth (245)
	Mississippian	362	322	Coal-forming forests
	Devonian	408	362	First land animals and first forests (408)
	Silurian	439	408	Life invades land
	Ordovician	510	439	First fish appeared
	Cambria	600	510	Great diversity of marine invertebrates
1. Precambrian	Proterozoic	2,500	600	Marine fossil invertebrates (600)
	Archean	4,500	2,500	Earliest fossils recorded (3,500), earliest rock formation (4,000)

Age Dating Techniques

There are two techniques of knowing the age of rocks:

A. Relative Dating

- ✓ It uses geological evidence to assign comparative ages of fossils.
- ✓ There are two ways to know the relative age of a rock:
 - a) By looking at any fossils the rock may contain some evidence. If any of the fossils are unique to **one of the geologic time periods**, then the rock was formed during that particular time period.

Age Dating ...Cont.

b) using layers of rocks "What is on top of the **older rocks?**" layers of rocks in a cliff or hillside, younger rocks are on top of older rocks.

- ✓ These two methods only give the relative age of rocks ; i.e., which one is younger and which one is older.

Layers of Sedimentary Rocks



Age Dating ...Cont.

B. Absolute Dating: known as Radiometric techniques.

- ✓ This technique developed with discovery of radioactivity in 1896.
- ✓ Radioactive elements like **uranium** (U) & **thorium** (Th) decay to form different elements/isotopes of the same element.
- ✓ Every radioactive element has its own half-life.

Age Dating ...Cont.

Two of the major techniques used are;

A. **Carbon-14 Technique**: Upon the organism's death, carbon-14 begins to disintegrate at a known rate, and no further replacement of carbon from atmospheric carbon dioxide can take place.

✓ Carbon-14 has **half-life of 5730 years**.

B. **Potassium-Argon Technique**: is widely used for dating rocks. This is b/c potassium-40 is abundant in **micas**, **feldspars**, and **hornblendes**.

2.4. Geological Processes and the Resulting Landforms of Ethiopia and the Horn

2.4.1. The Precambrian Era Geologic Processes (4.5 billion - 600 million yrs).

- It covers 5/6th of the earth's history.
 - ✓ our knowledge of the events in this era is **limited** b/c of
 - ✓ Its remoteness in time and
 - ✓ the absence of well-preserved fossils,.
 - ✓ However, general description of main geologic processes can be made.

2.4.1 Precambrian

- ✓ The major geologic event of the Precambrian Era was Orogenesis (Mountain building).
 - ✓ As a result, the land was subjected to intense folding.
 - ✓ This was accompanied by intrusive igneous activity.
 - ✓ The result was the formation of huge mountain ranges
- ✓ In between the orogenic periods and after the last orogenesis, there were long periods of denudation, which reduced these mountains to near-level (peneplained) rock surfaces.

2.4.1 Precambrian

- ✓ This “levelled” surface was later (in the *Mesozoic* and *Cenozoic* Eras) covered by younger rock formations
- ✓ Therefore, in most parts of Ethiopia rocks belong to this Eras found beneath all others, forming the basement rocks.

2.4. 1 The precambrian...

- ✓ These rocks had been subjected to pressure and heat;
 - ✓ from overlying **weight**,
 - ✓ **earth movements** (folding, orogenesis) and
 - ✓ to **intrusive igneous** activity;
- ✓ As the result the original rocks (both *sedimentary* and *igneous*) were **altered** into **metamorphic rocks** of varying stages of metamorphism.

2.4.1 Precambrian

- ✓ Since these same processes have allowed **mineralization** and **crystal formation**, They are collectively described as **crystalline rocks**.
- ✓ The Precambrian rocks are overlaid by recent rock formations. However, as surface rocks they cover 25% of the land mass of the country.

2.4.1 Precambrian

- ✓ They are found exposed in the following areas:
 - ✓ in the northern part: Western lowlands, parts of northern and central Tigray.
 - ✓ In the western Part: Gambella, Benishangul-Gumuz (Metekel and Asossa), western Gojjam, western Wellega, Illuababora, and Abay gorge.
 - ✓ In the southern Part: Guji, southern Omo, and parts of southern Bale and Borena.
 - ✓ In the eastern part: Eastern Hararghe.

2.4.2. The Paleozoic Era Geologic Processes (600 million - 225 million years ago)

- It lasted for about **375 million years**.
 - ✓ The major geological process was **denudation**.
 - ✓ The **gigantic mountains** that were formed by the **Precambrian orogeny** were subjected to **intense and prolonged denudation**.
 - ✓ Later, the gigantic mountain ranges were reduced to a “**peneplained**” surface.

2.4.2 The Palazoic...

- ✓ The sediments were transported southward (to form continental deposits) and eastward (to form marine deposits).
- ✓ Because of the limited deposition within Ethiopia, rocks belonging to this Era are rare in the country

2.4.3. The Mesozoic Era Geologic Processes (225-70 million years ago)

- This Era lasted for about **155 million years**.
 - ✓ It was an Era of alternate slow sinking and rising (epeirogenesis) of the landmass.
 - ✓ This process affected the whole present-day Horn of Africa and Arabian landmass.
 - ✓ At the same time the land was;
 - ✓ tilted eastward
 - ✓ lowered in the **southeast** and
 - ✓ higher in the **northwest**.

2.4.3 The Mesozoic...

- ✓ **The subsidence** of the land began at 225 million years ago.
- ✓ As the land sank slowly the sea invaded, from Somalia and Ogaden and slowly spreading northwestward, during late **Triassic period** and continued up to **Jurassic period**.
- ✓ As the shallow sea spread towards the land, sands were **deposited** over the **penexplained Precambrian rock surface**.

2.4.3 The Mesozoic...

- ✓ As the depth of the sea increased, **mud (shale)**, **gypsum** and later **lime** were deposited, which is associated with
 - ✓ the flourishing of marine life and
 - ✓ decaying and precipitating of their remains, as the sea stayed long.
- ✓ Hence, Mesozoic rocks are considered to have the greatest potential for **oil and gas deposits**.

2.4.3 The mesozoic...

- Through time,
 - compression by the overlying rocks and
 - by cementing minerals,
 - the sands were compacted to form **sandstone** (Adigrat Sandston) and
 - lime were compacted to form **limestone** (Hintalo limestone) layers.
- ✓ They are named after place names in Tigray where they might have been first identified.

Regression of the sea

- In the Horn of Africa and Ethiopia, **the slow rise of the land** and consequently the regression of the sea began in **the Upper Jurassic** and continued throughout the **Cretaceous period**.
- With the retreat of the sea, another process of **deposition** occurred.

2.4.3 The Mesozoic...

- ✓ In the country sedimentation ended with the **deposition of clay, silt, sand conglomerate** brought in from the land as the sea receded due **to uplift of the landmass.**
- ✓ **Gypsum, shale** and at last **sands** were laid over the Hintalo limestone.
- ✓ The uppermost layer is known as the **Upper sandstone**

2.4.3 The Mesozoic....

- ✓ By the end of the Mesozoic Era, when the land emerged out of the sea, three major sedimentary formations were laid and formed upon the **Precambrian rock surface.**
- ✓ These were
 - ✓ **the Adigrat or lower sandstone,**
 - ✓ **Hintalo limestone and**
 - ✓ **Upper Sandstone**

2.4.3 The Mesozoic ...

- ✓ Due to the
 - ✓ tilting of the landmass during the **transgression** and **regression** of the sea, and
 - ✓ the direction of the invading and retreating sea,
 - ✓ the age and
 - ✓ thickness of the Sandstone layers vary in a **Southeast - Northwest** direction.
- ✓ The Adigrat sandstone is **older and thicker** in the **southeast** and progressively **decreases** in age and thickness **northwestward**.

2.4.3 The Mesozoic ...

- ✓ The Upper sandstone is **thicker and younger** (Upper Cretaceous) in the **Southeast**, while in the **Northwest it is older and thinner**
- ✓ The Mesozoic sedimentary rocks cover 25% of the land mass of the country.
- ✓ The transgressing sea and Mesozoic sediments nearly covered the whole of Ethiopia.
- ✓ The **northwestern limit** as far as **central Tigray**, and **western slopes of Western highlands**.

2.4.3 The mesozoic...

- ✓ In most parts of Ethiopia, the Mesozoic rocks are overlaid by the **Cenozoic rocks**.
- ✓ old marine sediments are extensively found in the **Southeast lowlands**.
- ✓ Other exposures include
 - ✓ central Tigray, and
 - ✓ along the gorges of Abay and Wabishebele rivers.

2.4.3 The mesozoic...

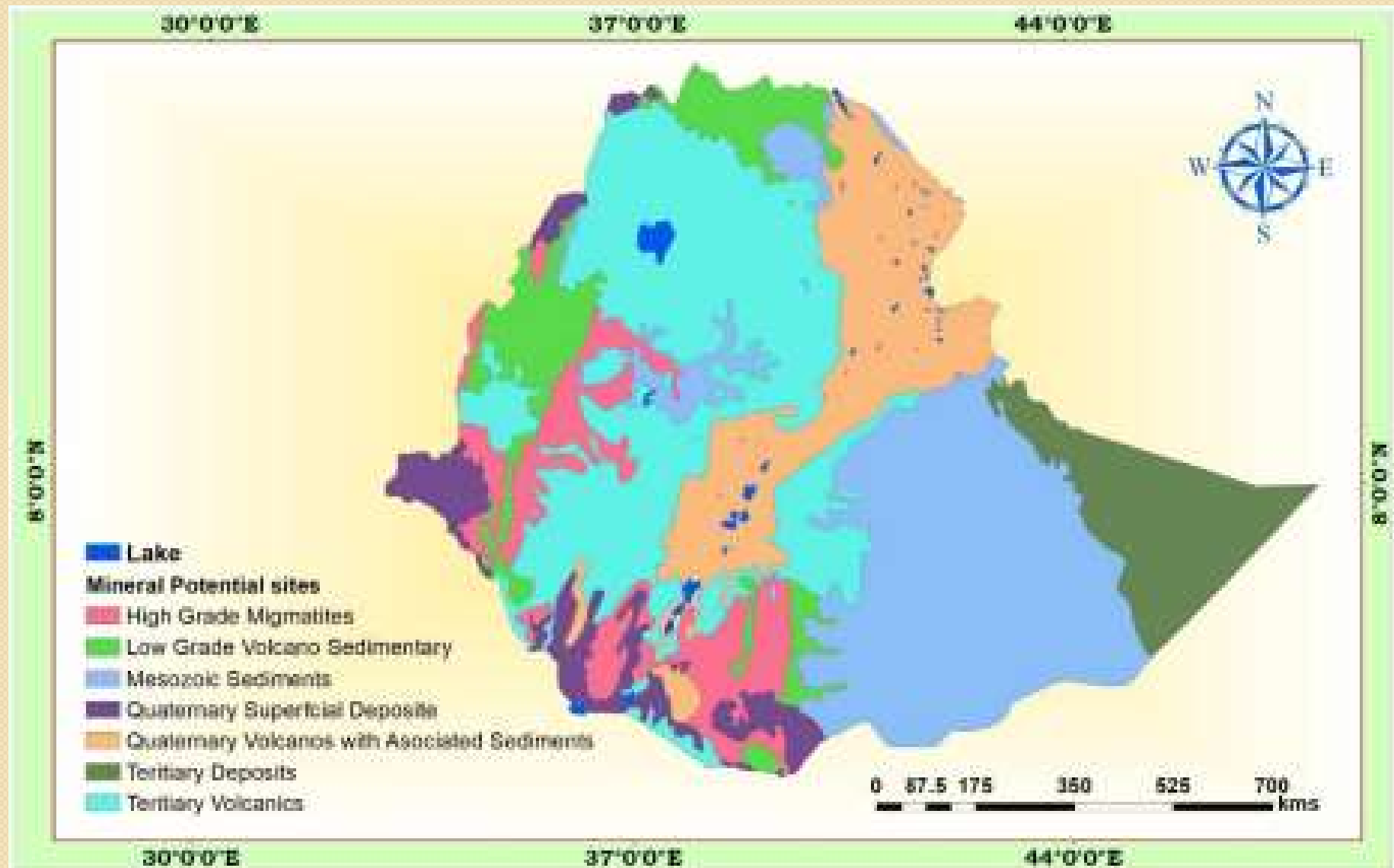


Figure 2. 1. Geological map of Ethiopia Source: CSA Shapefile, 2012

Thank you for today