



Chapter Two

The Geology of Ethiopia & the Horn



Outline

2.1 Introduction

2.2 The Geologic Processes: **Endogenic** and Exogenic Forces

2.3 The Geological Time Scale and Age Dating Techniques

2.4 Geological Processes and the Resulting Landforms

2.4.1 The Precambrian Era

2.4.2 The Paleozoic Era

2.4.3 The Mesozoic Era

2.4.4 The Cenozoic Era

2.5 Rock and Mineral Resources of Ethiopia

2.1 Introduction

- ❖ Geology **studies** the **evolution of the earth**, the **materials** of which it is made of & the **processes** acting upon them.
- ❖ It is **concerned with events** that took place in the remote past & with **features** which are far beneath the earth's surface.

- 
- ❖ A great deal of **geological understanding** must be obtained by **inference**, using **clues** from what can be seen & what can be **measured**.
 - ❖ There are many **clues** not only the **rocks & landforms** which can be observed & studied at the Earth's surface, but also those provided by **indirect methods** such as **geophysics, geochemistry & geochronology**.

- 
- ❖ The earth's continents were once bunched up together into a **single huge continent** called **Pangaea**.
 - ❖ The large super continent was then **split into Gondwanaland** where Africa is a part & **Laurasia**; and later into smaller fragments over the last million years.
 - ❖ These then **drifted apart** to form the

- 
- ❖ **Alfred Wegener** proposed the hypothesis that the continents were **once assembled together** as a **supercontinent**, called the **Continental drift Theory**.
 - ❖ **Wegener's principal observations** were:
 - ✓ **Fit of the continents:** The opposing coastlines of continents often fit together.

- 
- ✓ **Match of mountain belts, rock types:** If the continents are reassembled as **Pangaea**, mountains in W. Africa, N. America, Greenland, & W. Europe match up.
 - ✓ **Distribution of fossils:** The distribution of **plants & animal fossils** on separate continents

2.2 The Geologic Processes: Endogenic & Exogenic Forces

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



❖ The external **(exogenic)** processes are **geomorphic processes**.

- include **weathering, mass transfer, erosion & deposition**.

- act upon the **volcanic & structural landforms** by modifying, roughening & lowering them down.

2.3 The Geological Time Scale & Age Dating Techniques

- ❖ The geological history is **divided** into **Eras**.
- ❖ Each Era is **divided** into **periods**.
- ❖ The Eras are given **names** that indicate the kind of life that existed in them.
- ❖ For instance, the:
 - Paleozoic Era (ancient) is **the age**

- 
- ❖ These **geological time divisions** **differ** from each other in terms of the:
 - **relative position of land & sea**
 - **type of climate**
 - **type of animal & plant life** that **developed & existed** during that Era or period.

- 
- ❖ The Earth is believed to have been **formed** approximately **4.5 billion years ago** & **the earliest forms of life** were thought to have originated approximately **3.5 billion years ago.**
 - ❖ The first major boundary is defined by what was believed at the time to be **the first appearance of life on**



❖ The geological time scale measures time on a scale **involving** four main units:

1. An **epoch** is the smallest unit of time on the scale & encompasses a period of millions of years.
2. Epochs are clumped together into larger units called **periods**.

- 
- ❖ The division of time units in the geological time scale is based on **the occurrence of significant geological events** (e.g. mass extinctions).

Age Dating Techniques

- ❖ There are **two techniques** of knowing the age of rocks:
 - 1. Relative age dating:** Relative dating uses **geological evidence** to assign comparative ages of fossils.
 - Example: when you find layers of rocks in a hillside, **younger rocks** are on top of **older rocks**.
 - 2. Absolute age dating:** Also known as **Radiometric techniques**. This technique was developed with **discovery of radioactivity** in 1896. The regular rates of decay for unstable, **radioactive elements** were found to constitute virtual 'clocks' within the earth's rocks.



Geological Processes and the Resulting Landforms

2.4.1. The Precambrian Era Geologic Processes

- ❖ It **covers 5/6th** of the Earth's history. Due to its remoteness in time & the absence of well-preserved fossils, our knowledge of the events is limited.
- ❖ The major geologic event of the Precambrian Era was **Orogenesis**.
- ❖ 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 & after the last **orogenesis**, there were long periods of denudation, which finally reduced these mountains to near-level (**peneplained**) rock surfaces.
- ❖ This 'levelled' surface was later (in the Mesozoic & Cenozoic Eras) covered by younger rock formations. Therefore, in most parts of Ethiopia rocks belonging to this Era are found beneath all other rocks, forming the basement rocks. Since, they had been subjected to **pressure & heat** from overlying weight earth movements (folding

- ❖ Since these same processes have allowed mineralization & crystal formation, the rocks are also collectively described as crystalline rocks. **The Precambrian rocks are overlaid by recent rock formations.**
- ❖ However, as surface rocks covering **25%** of the land mass of the country; they are found exposed in the following areas:
 - A. In the northern part:** Western lowlands, parts of northern and central Tigray.
 - B. In the western Part:** Gambella, Benishangul-Gumuz (Metekel and Asossa), western Gojjam, western Wellega, Illuababora, and Abay gorge.
 - C. In the southern Part:** Guji, southern Omo, and parts of southern Bale and Borena.

2.4.2. The Paleozoic Era Geologic Processes

- ❖ It lasted for about **375 million years**. The major geological process of this Era was **denudation**.
- ❖ The gigantic mountains that were formed by the Precambrian orogeny were subjected to **intense & prolonged denudation**.
- ❖ At the end, the gigantic mountain ranges were reduced to a 'peneplained' surface. **Undulating plain** with some residual features here & there was formed.
- ❖ The **sediments were transported** southward & eastward to form **continental**

2.4.3. The Mesozoic Era Geologic Processes

- ❖ It lasted for about 155 million years. It was an Era of alternate slows **sinking** & **rising** (**epeirogenesis**) of the landmass.
- ❖ This process affected the whole present-day **Horn of Africa & Arabian landmass**. At the same time, the land was tilted eastward &

- 
- ❖ The subsidence of the land began about 225 million years ago. As the land sank slowly the sea invaded it starting from **Somalia & Ogaden** and slowly spreading northwestward. This was in late Triassic. This phenomenon continued up to Jurassic period.
 - ❖ As the shallow sea spread towards the land, sands were deposited over the peneplained Precambrian rock surface.
 - ❖ As the depth of the sea increased, mud (shale), gypsum and later lime were deposited.

- 
- Through time, compression by the overlying rocks & by cementing minerals, the **sands & lime** were compacted to form sandstone & limestone layers, respectively. These are known as the Adigrat sand stone & Hintalo limestone layers.
 - In the Horn of Africa and Ethiopia, the slow rise of the land & consequently the

- 
- ❖ The uppermost layer is known as the **Upper sandstone**.
 - ❖ 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 sandstone, Hintalo limestone**

- 
- ♦ The transgressing sea & Mesozoic sediments nearly covered the whole of Ethiopia. The northwestern limit was as far as central Tigray, & western slopes of Western highlands.
 - ❖ In most parts of Ethiopia, the Mesozoic rocks are overlaid by the Cenozoic rocks. As surface rocks, these old marine sediments are extensively found in the Southeast lowlands. Other exposures include central Tigray, & along the **gorges of Abay & Wabishebele rivers.**

2.4.4. The Cenozoic Era Geologic Processes

- ❖ The Cenozoic Era is the **most recent** of the geologic Eras.
- ❖ The **tectonic & volcanic activities** that took place in this Era have an important effect in the making of the present-day landmass of Ethiopia & the Horn of Africa.
- ❖ The land was subjected to two major geologic events & other geologic processes. These geologic activities are:
 1. **Uplifting of the Arabo-Ethiopian landmass & outpouring of lava.**
 2. **Formation of the Rift Valley**

2.5 Rock and Mineral Resources of Ethiopia

- ❖ The occurrence of **metallic minerals** in Ethiopia is associated with the **Precambrian rocks**.
- ❖ These rocks **contain most of the metallic deposits** known at present.

2.5.1. Brief Facts and Current State of Main Minerals in Ethiopia

❖ Geological surveys proved that **Ethiopia has abundant mineral resources** of metals and precious metals, coal, and industrial minerals.

- ❖ **Gold:** Gold has been mined in Ethiopia for quite long time, mainly from Benishangul-Gumuz (Metekel) and Adola. Operating mines produce gold from primary sources in Dermidama, Sakoro and Lega-dembi. Secondary gold deposits are common in the following localities: Adola, Murmur Basin, Shakiso, Awata Basin, Dawa Basin, Ghenale Basin, Ujama Basin, Mekanisa (Guba and Wombera), Kaffa. In Gambella and Illuababora (Akobo River), in Sidama (Wondo), Borena (Negele-Yabelo area) and in Benishangul-Gumuz (Sherkole), west Wellega, Mengi-Tumat-Shangul areas to the Sudanese border, and the drainage of the Didessa and Birbir

- 
- ❖ **Gemstones:** occur in many parts of Ethiopia, mainly in Amhara and Oromia Regional States. Quality **Opal** was first discovered by local people in Wadla and Dalanta woredas, North Wello in Amhara Regional State.
 - ❖ **Potash:** The potash reserve in the Danakil (Dallol Depression) of the Afar region is believed to be significant.
 - ❖ **Gypsum and Anhydrite:** Very large

Clay

found in **Adola, Abay gorge & the Rift Valley lakes region.**

Marble

- Marble has been quarried in **west of Mekelle** and **south of Adwa in Tigray.**
- In the east in Galetti, Soka, Ramis, Rochelle, Kumi and other valleys of Chercher Mountain in West Hararghe.
- In the northwestern: **Gondar the Dabus**

2.5.2. Mineral Potential Sites of Ethiopia

- ❖ According to the Ethiopian geological survey, the geologic formations that host most mineral potentials of Ethiopia includes three major greenstone belts and other formations. These are:

1. The Western and South-western-greenstone belt: They contain various minerals: primary gold occurrences (Dul, Tulu-Kape, Oda-Godere, Akobo, Baruda, Bekuji-Motish and Kalaj); Yubdo Platinum, Base metals of Azali Akendeyu, Abetselo and Keta-Falruhu, Meluhdenite and

- 
2. The Southern greenstone belt: It is known as the Adola belt, which comprises the primary gold deposits and occurrences of Lega-dembi, Sakaro, Wellena, Kumudu, Megado-Serdo, Dawa Digati, Moyale and Ababa River; the columbo-tantalite of kenticha and Meleka, and the Adola nickel deposit and other industrial minerals.
 3. The Northern greenstone belt (Tigray): This belt comprises of the primary gold occurrences of Terakemti, Adi-Zeresenay, and Nirague. The base metals of Terer, Tsehafiembra and other parts of Tigray, Placer gold occurrences of Tigray.