

6. STRATIGRAPHY

6.1 Introduction

Stratigraphy is that branch of geology that deals with formation, composition, sequence, and correlation of stratified rocks. Stratigraphy can also be defined as the geological study of strata and their succession. It is the description, organization and classification of stratified rocks, particularly the sedimentary rocks. It is subdivided into lithostratigraphy and biostratigraphy.

Lithostratigraphy is the study of stratified sequence purely on the basis of lithological characteristics.

Biostratigraphy encompasses the various phases of biology and palaeontology applicable to stratigraphy study. It is the use of fossils in stratigraphy.

Stratigraphy seeks to interpret past events and record in rocks. It therefore aims to reconstruct the past geography, the pale climate and the paleo environment, if the planet earth from records of rocks and their enclosed fossils.

6.2 Geologic Time

Geologic time refers to long periods of time measured in millions to billions of years in the rock record. However, geologic time can also record events that might be only a few hours or minutes in duration, like a catastrophe.

Paleontologists have made a detailed record of the evolution of life through Earth's history. This record is the basis for the geologic time scale and is referred to as *relative time*. The geologic time scale subdivides the 4.5 billion year history of the Earth into shorter time periods, based on changes in fossils.

The broadest division of geologic time is the **Eon**. There are two Eons, the **Pre-Phanerozoic** (or Precambrian) and **Phanerozoic**.

The **Precambrian** stretches from the formation of the Earth 4.5 billion years ago until the start of the Phanerozoic Eon, about 560 million years ago. There are many fossils in Precambrian rocks, but they are almost all microscopic.

Phanerozoic means “visible life.” The rocks of the Phanerozoic Eon, which covers about the last 560 million years of Earth history, are characterized by abundant visible fossils. Eon can be subdivided into **Era**.

The phanerozoic is subdivided into three eras;

- (i) The **Paleozoic** (Ancient life)
- (ii) The **Mesozoic** (Intermediate life) and
- (iii) The **Cenozoic** (New life)

Most of the phanerozoic has been divided upon the basis of fossils found in rocks. Although some plants and animals did exist before that time, they were generally very primitive, and did not leave many “hard parts” to become fossilized. Only after the precambrian did shelly marine animals begin to flourish and diversify. Eras consist of several **periods** which in turn may be subdivided into lower, middle and upper parts. Figure 6.1 shows geologic time scale.

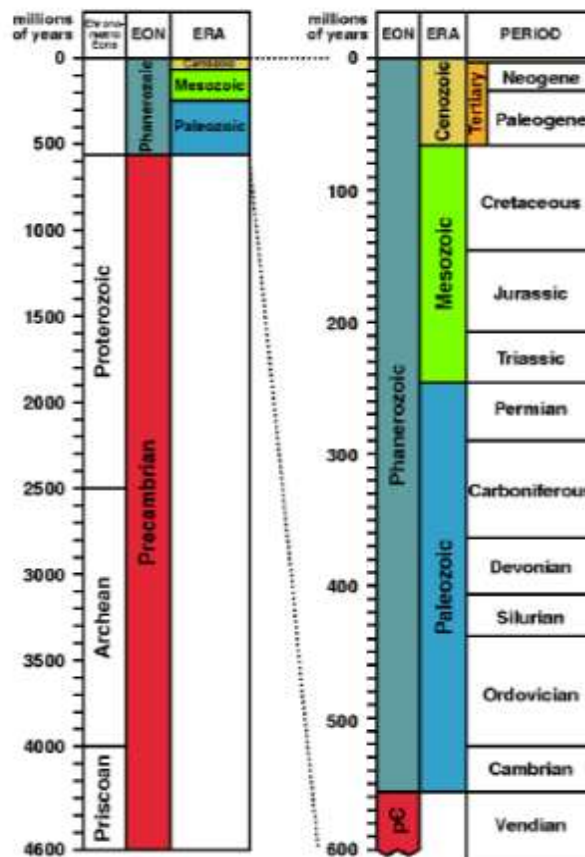


Figure 6.1: Geologic Time Scale

6.3 Principles of stratigraphy

Principles of stratigraphy: In stratigraphy study more commonly evoked principles are: (i) the law of original horizontality; (ii) the principle of superposition; (iii) the uniformitarian principle and (iv) the principle of faunal succession.

The law of original horizontality (Steno, 1669): This states that water laid sediments are deposited in the beds that are not far from horizontal and parallel or nearly parallel to the surface in which they are accumulated.

The principle of superposition: This states that the order of deposition of sediments is from the bottom upwards. Each layer of sedimentary rock (sediment) in a tectonically undisturbed sequence is younger than the one beneath it and older than the one above it (See Figure 6.2)

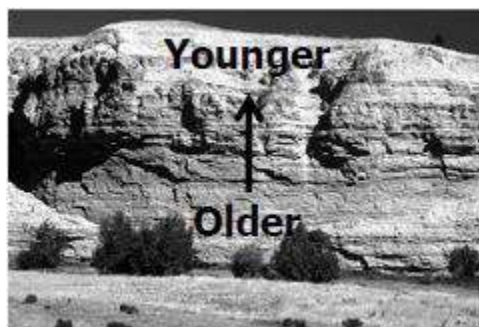


Figure 6.2: Layers of sedimentary rocks

The principle of uniformitarian (Hutton, 1700s): This states that the “present is the key to the past.” This means that rocks formed long ago at the earth’s surface may be understood and interpreted in terms of the physical processes operating today. The processes that shaped Earth throughout geologic time were the same as those observable today. Sometimes there are environments/conditions that do not have good modern analogues

The principle of fauna succession (William Smith, late 1700's): This principle states that the oldest fossils in a series of sedimentary rock layers will be found in the lowest layer. Progressively younger fossils occur in higher layers. This is the same concept as superposition, but it helped geologists realize that you can look at the age of these layers and assign relative dates. This parallels evolution. Younger organisms replace older organisms as the older ones become extinct.

6.4 Stratigraphy sequence

The first step in stratigraphy study is to identify and group stratas into lithological units like sandstone, shale, limestone, etc. The next is to establish sequence of the lithological unit in time. For this the principle of superposition is regarded as the basis of all stratigraphic undertaking. This generalization has been applied worldwide to establish the correct sequence of strata in **stratigraphic columns**.

Stratigraphic Columns: A stratigraphic column is a succession of sedimentary rocks in an area. This is subdivided and differentiated into significant and useful units. This is achieved based on the physical and biological characteristics of various horizons or levels that constitute the column. The biological characteristics are represented by the numbers and type of fossils present in the sequence. The lithology and unconformity represent the physical events. The basic unit into which the geological column is subdivided is the **formation**. A formation is characterized by the following:

- (a) A distinctive lithological composition or a distinctive interbedded or intergraded succession of lithological types
- (b) Observable lithological separation from adjacent units above and below, and
- (c) Traceability from exposure to exposure in the field or from well in the subsurface.

6.5 Transgression and Regression

The geologic history and the successive build up of rocks of many regions are influenced by natural phenomena such as worldwide **Orogenesis** and **Epirogeny**. The former is the process of mountain building while the latter is the depression of the levels. These phenomena result in abrupt uplifts and depression of portions of the earth's crust, withdrawal of sea from land surfaces known as **Regression** and invasion of land surface by the sea known as **Transgression** as well as the climate changes and biological changes as were recorded in fossils that occur in rocks. The changes leave their tell-tales of unconformities.

The two types transgression (depositional and erosional) result in a stratigraphic sequence in which deeper water facies overflow shallow marine deposits i.e. the sequence get finer upwards at any point (e.g. marine sediments over terrestrial sediments)

Regression can also be viewed in another light. Where the volume of sediments supplied to an area requires more energy for its removal than is available, baselevel uses and the surplus sediments accumulate, with the extension of land the facies prograde. The first concept results in erosional depression while the latter derived concept leads to depositional regression. Deltas are good examples of depositional regression.

6.5.1 Unconformities

Sedimentary rocks accumulate in successive layers of deposition, which are not only horizontal but parallel. The beds are said to lie conformably one on the other, causing stratification. When beds are deposited on a tilted, folded or eroded surface of an older series, so that an obvious demarcation boundary occurs, such a junction between the older and newer series is known as an **Unconformity**. Unconformity results from reversals of the local process of erosion and sedimentation in an area. There is nearly always an angular difference between the beds comprised in each series. When there is angular discordance between strata above and below (**Angular Unconformity**), but should the beds above and below such a junction be parallel, that is no angular discordance, but with the erosion surface showing significant relief, it is called **Disconformity**. When there is no relief on erosion surface, no angular discordance, it is referred to as **Paracomformities**.

The term **Non-Conformity** refers to a type of unconformity in which sedimentary rocks are deposited in layers over a stratum over a layer of igneous rocks.

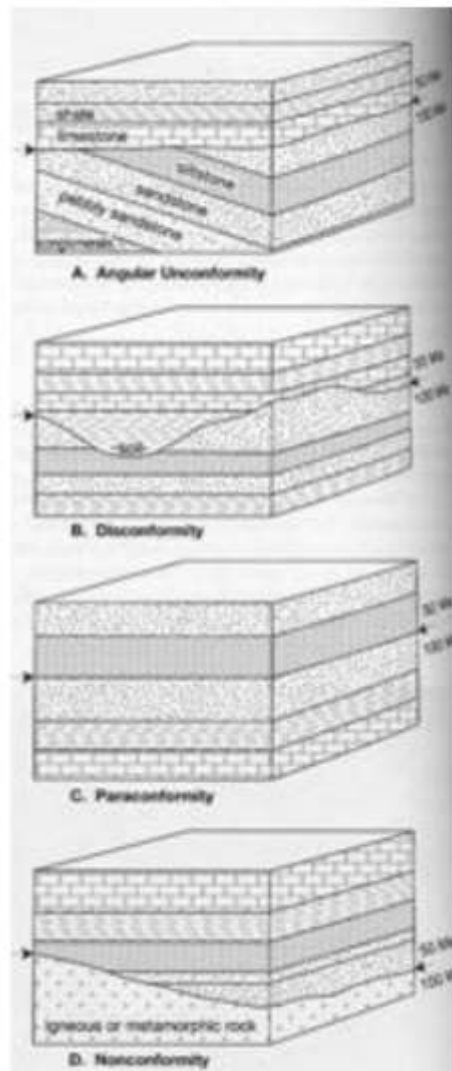


Figure 6.3: Unconformities

6.6 Significance of stratigraphy

The established succession or sequence of sedimentary rock implies relative ages and this has some engineering significance. Site investigation for sensitive structures like dam, nuclear power plants, bridges, high rise buildings aim to establish the soil rock interface as boring depths for the structures are usually taken as far down on the bedrock. In other civil engineering structures, the boring depths are taken as far down as to all beds whose physical behaviour is likely to have a bearing on the stability of the proposed superstructure.

Knowledge of local stratigraphy is also very important in mineral resource exploration and exploitation, particularly petroleum hydrocarbons. Carbonate reefs remain the only type of stratigraphy feature that has been particularly discovered and mapped successfully by reflection seismic technique.

The knowledge of depositional stratigraphy of an area is of vital importance in predicting the most favourable area for oil accumulators.

6.7 Fossils

Fossils are recognizable organic structures or impression of such structures, preserved mainly in sedimentary rocks. The term implies enormous age as it is used only for remains of organisms. They occur only in strata of 600 million years and younger. However, precambian limestones in Zimbabwe bear records of plant life- calcareous algae. This occurrence takes the record of life back in time to 2600 million years – the age of the limestone. Fossils are most abundant in rocks laid down in relative shallow seas. They are relatively sparse or lacking in rocks of continental origin.

6.7.1 Significance of fossils

The study of fossils has contributed much to the broader fields of economic geology and historical geology. Of far more significance in the former fields is the role of fossils in petroleum exploration and oil field development. Distribution of hydrocarbons in the field often depends on underground geologic structure and especially on how the deeply buried strata are flexed, filled and folded.

Correlation of beds from wells to wells using species of foraminifera affect in part, some insight on how to determine the sub-surface structure. Worldwide correlation of beds of several kilometers apart is affected in part on the basic fossil content. In general, resolution in fossil correlation is claimed to be better than that provided by radiometric methods or by physical stratigraphy.

In interpreting the past as records in rocks and the fossils content recourse is made to the uniformitarian principle. In projecting of the present to the past, insight can be gained into the

past ecology, the past climate, the past geography and environment of deposition of strata bearing fossils.