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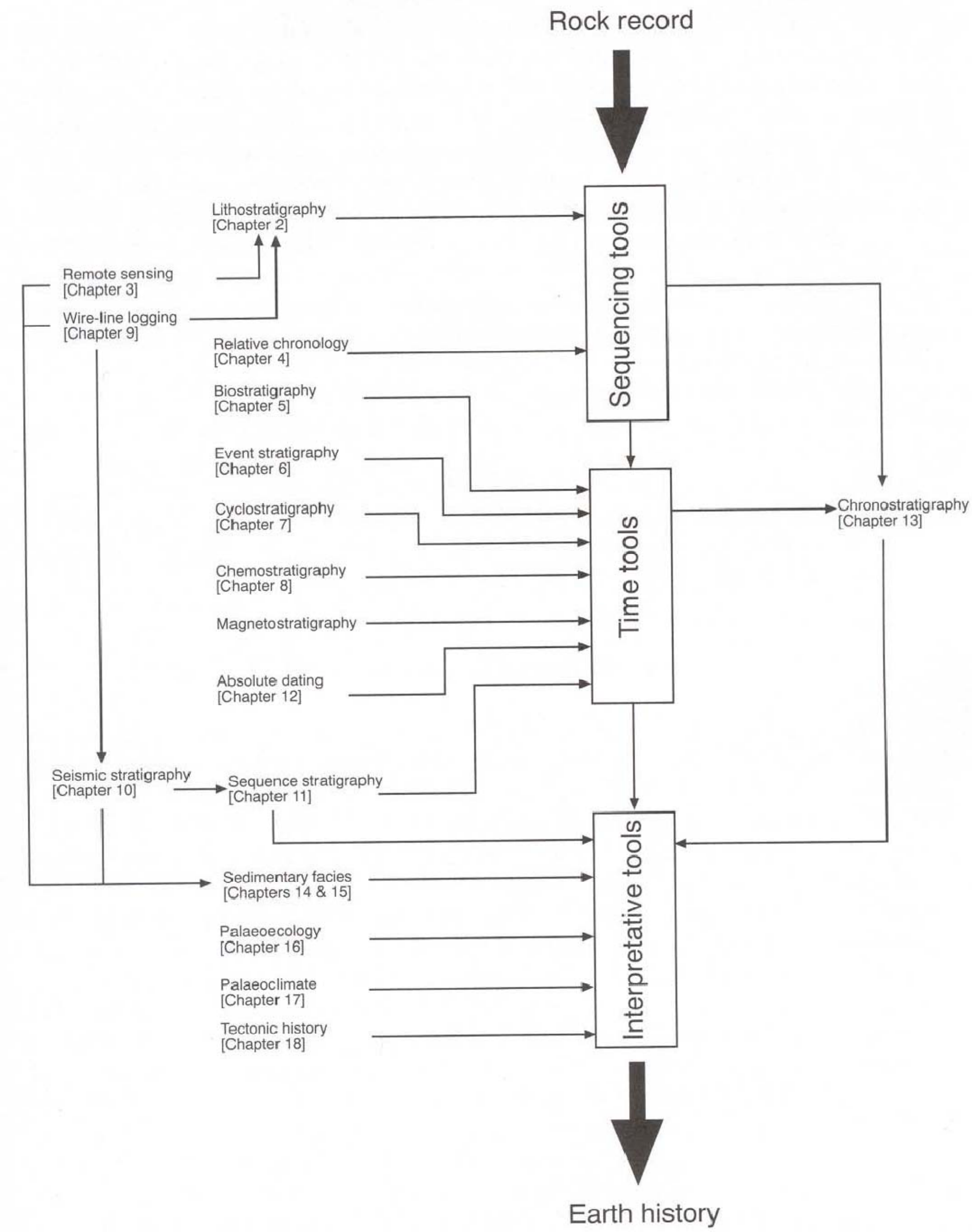
عنوان المحاضره بالعربي	مقدمه في الطبقات/ 1
عنوان المحاضره بالانكليزي	Introduction

Definition

Stratigraphy is the study of the stratified or sedimentary rocks: their nature,arrangement, and correlation from place to place. It enables geological events, as recorded in the rocks, to be placed in their correct sequence and is thus the key to the earth history.



A brief history of the study of Stratigraphy

☆ **John Strachey** (English, 1719) & **J. G. Lehmann** (German, 1756): Principle of superposition: The sedimentary rocks were laid down layer by layer. The
upper layer, in an undisturbed section, must be younger than the lower.

☆ **Abraham Gottlob Werner** (A German civil engineer, late 1700s, Neptunist): He argued that almost all rocks (including igneous rocks) are formed by sedimentary processes, accumulating on the bottom of oceans, lakes or rivers.

☆ **James Hutton** (A Scottish medical doctor and farmer, 1726-1797, Plutonist): The founder of modern geology. He is sometimes referred to as the “Father of Geology”. He made two important observations: (1) igneous origin for igneous rock (1785), and (2) Hutton’s unconformity (1788), an angular unconformity in Scotland that separates Silurian marine strata below and Devonian continental
strata above.

☆ **William Smith** (An English civil engineer, 1769-1839): He is sometimes referred to as the “Father of Stratigraphy”. He laid the foundations of biostratigraphy by correlating rock unit using their fossil contents.

☆ **George Cuvier** (A French anatomist, 1769-1832): He and his co-workers, A. Brongniart and J. B. Elie de Beaumont, argued that catastrophic, sudden,but infrequent upheavals of mountain ranges were responsible for the
environmental changes and the destruction of much of the contemporary biota. This idea is coined “catastrophism”

☆**Charles Lyell** (A British lawyer, 1797-1875, an Oxford graduate): He authored the “Principles of Geology” (1830-33). This book is sometimes read as the work that created the modern earth sciences, established their first “paradigm” or somehow “discover time”. Lyell argued that causes that now visible around us (volcanoes, rivers, tidal currents, earthquakes, storms) are of the same kind that have acted in the past, and have done

so with the same degree of intensity as in the present. This concept is coined
“uniformitarianism” . In other words, the laws of nature are constant. This has sometimes been summarized by the catchphrase “the present is the key to the past”.

I) Introduction

Sedimentary rocks are formed by materials, mostly derived from the weathering and erosion of the pre-existing rocks (Igneous, metamorphic or even sedimentary rocks), which are transported and then deposited as sediments on the earth's surface. These sediments are then compacted and converted to sedimentary rocks by the process of lithification (rock formation). Diagenesis may be broadly defined as the processes of physical and chemical change which take place within a sediment after its deposition and before the onset of either metamorphism or weathering (Fig. 1).

Fig. 1.

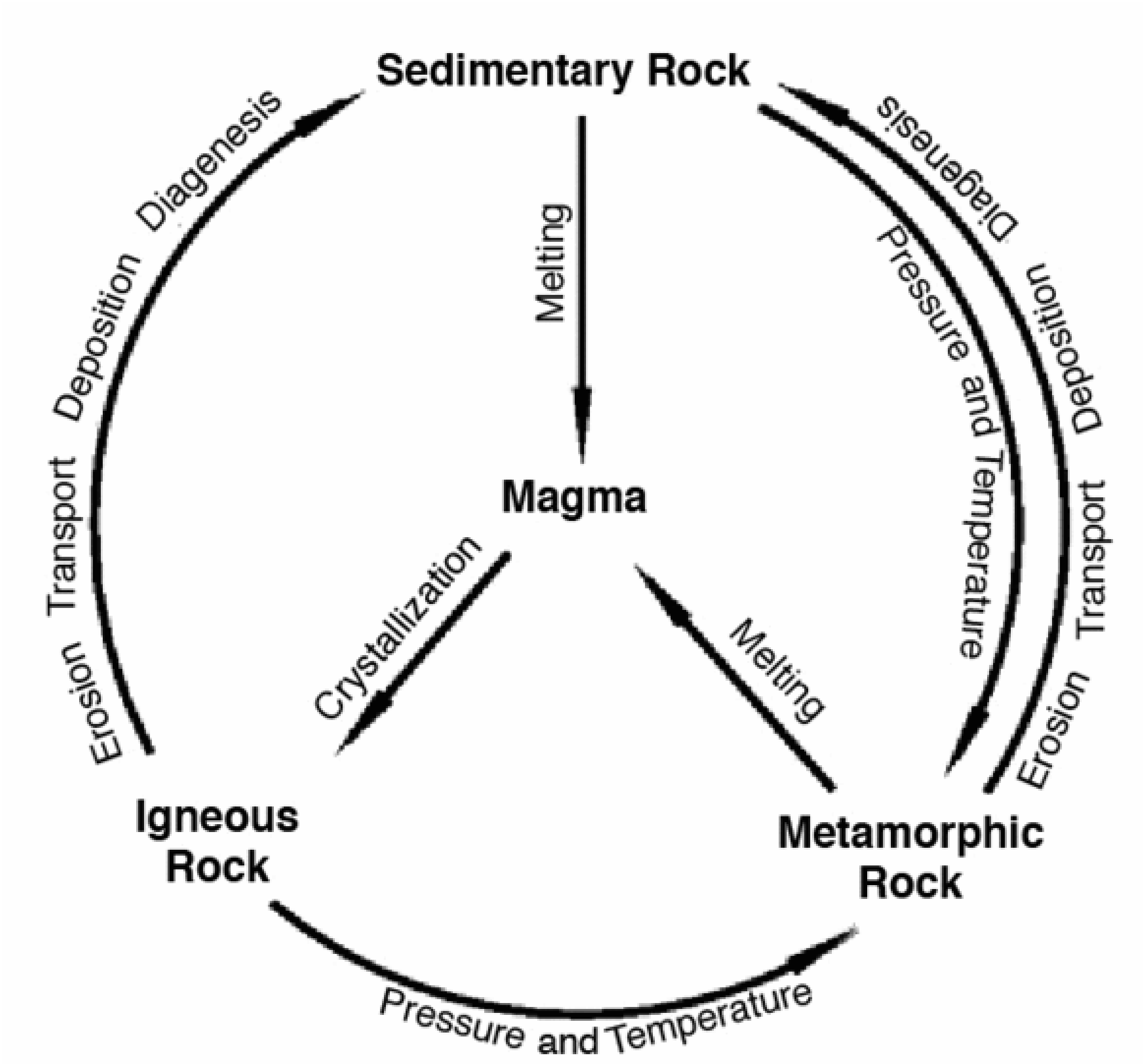


Fig. 1. Rock Cycle

An important part of applied stratigraphy is the description, classification and interpretation of sedimentary rocks – a study known as ***sedimentation*** or ***sedimentology***. A distinction is made between ***processes of sedimentation*** (weathering, transportation, deposition, and lithification) and ***products of sedimentation*** – sedimentary rocks. ***A sediment*** is a deposit of a solid material of earth's surface from any medium (air, water, ice) under normal conditions of the surface. ***A sedimentary rock*** is the consolidated or lithified equivalent of a sediment.

A description of any sedimentary rock delineates its ***texture***, ***structure***, and ***composition***. Texture refers to the characteristics of the sedimentary particles and the grain-to-grain relations among them. Larger features of a deposit, such as bedding, ripple marks, and concretions, are sedimentary structures. Sediment composition refers to the mineralogical or chemical make-up of sediment.

Most sediments are of two main components, a ***detrital fraction*** (pebbles, sand, mud), brought to the site of deposition from some source area, or a ***chemical fraction*** (calcite, gypsum, and others) formed at/or very near the site of accumulation. The components may be mixed in any proportions, yielding sediments ranging from pure types (quartzose sandstone) to intermediate types (such as shaly limestone).

There are ***two*** main classes of sedimentary rocks, which differ in their mode of origin, clastic rocks and nonclastic rocks.

The ***clastic rocks*** are represented by rocks such as conglomerates, sandstones and shales. They are composed of rock fragments and detrital grains, produced by the physical and chemical weathering of older rocks. These particles are transported from their place of origin by the flow of air, water and ice across the earth's surface, accumulating as sedimentary deposits once the flow of transporting medium so declines that the particles cannot be moved any further. Deposition occurs progressively since the larger and heavier particles require more energy to be transported in comparison with the smaller and lighter particles. This results in a sorting of the particles to form deposits of decreasing grain size away from their source.

The ***nonclastic or marine rocks*** (***chemical*** and ***organic rocks)*** comprise such rocks as limestones, dolomites, cherts, evaporites and coal. These rocks are mainly composed of chemically or biologically formed material produced in solution by chemical weathering, which accumulates in sea water as the result of evaporation. This material in solution may be abstracted by direct precipitation to form chemical sediment (e.g. evaporites; gypsum, anhydrite and rock salt), or it may be extracted by organisms to form shells and skeletons, which then accumulate as organic sediment (fossiliferous limestone, chert). Coal and oil shale considered as organic sediments since they derived from the remains of tropical plants subjected to pressure and carbonization processes.

Detrital rocks commonly have ***fragmental texture***, whereas chemical rocks have ***crystalline texture***. Fragmental texture is characterized by broken, abraded, or irregular particles in surface contact, crystalline texture by interlocking particles, many having crystal faces or boundaries.

The detailed texture of a sedimentary rock is largely determined by the size, shape of the particles and by their arrangement in the aggregate. In mechanically transported sediments (clastics, detrital rocks), five properties of the particles influence the final texture of the deposit (fig. 2):

1. Grain size,
2. Shape (roundness, shericity),
3. Orientation,
4. Mineralogical composition,
5. Packing.

Fig(2).

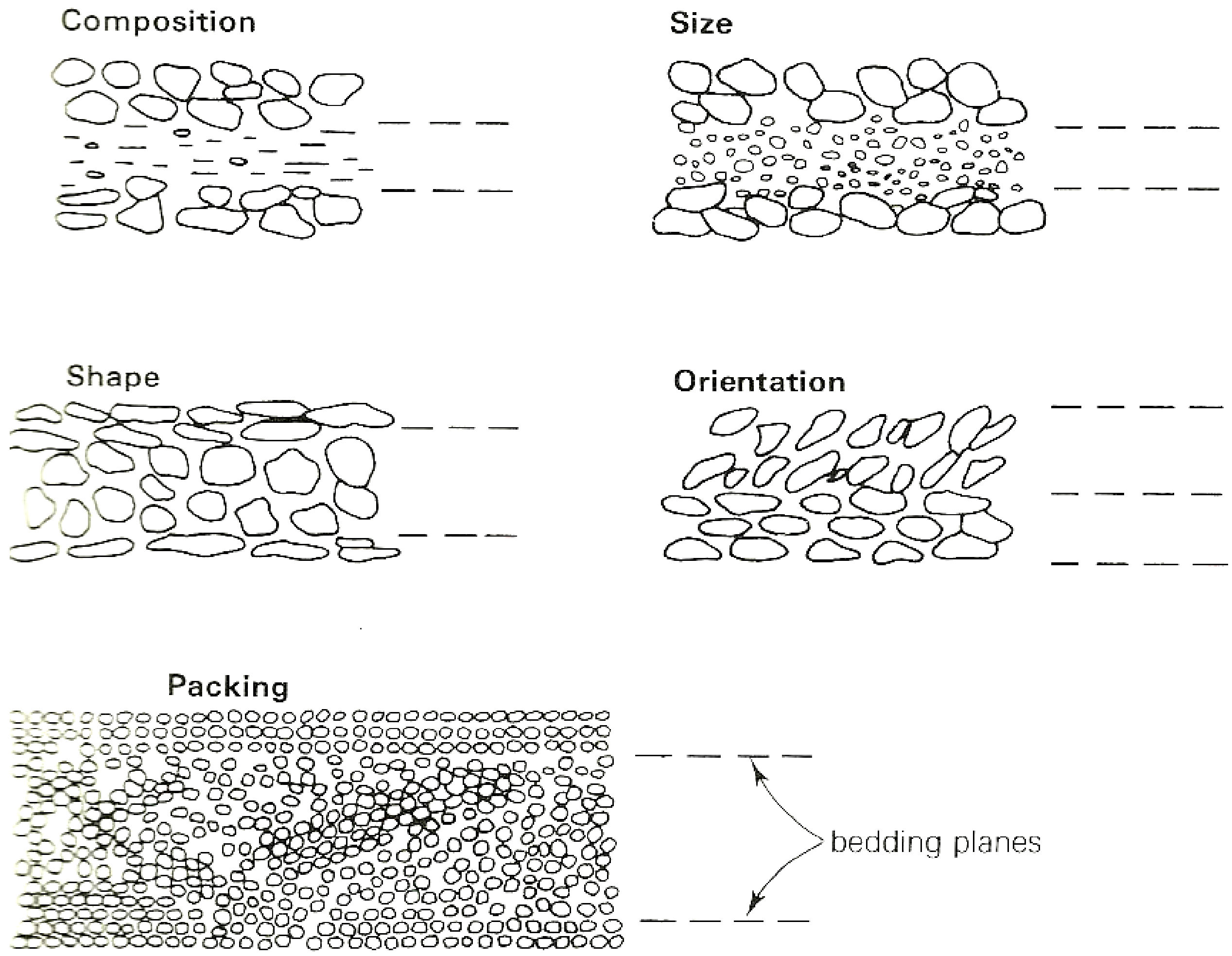


Fig. 2. Bedding as the product of different combinations of grain composition, size, shape, orientation and packing (modified after Pettijohn, Potter & Siever 1972, and Griffiths 1961).

II) Stratigraphic Concepts

Stratigraphy can be defined as the branch of geologic science concerned with the description, organization and classification of the stratified sedimentary rocks as a basis for interpreting the geological history of the earth's crust. The study of the stratigraphy starts with establishing the chronological order in which a sequence of sedimentary rocks was originally deposited at the earth's surface. This is known as the stratigraphic order of the sedimentary rocks. What is known as a stratigraphic sequence can be established by placing the sedimentary rocks in their chronological order.

All bedded rocks can be treated stratigraphically, i.e. to establish age relations between beds. However, the term “stratigraphy” is used primarily in the context of sedimentary research. Stratigraphy involves the study, subdivision and documentation of sedimentary successions,

and on this basis to interpret the geological history they represent. In order to reconstruct an environment or special events in the geological past, regionally or even globally, it is necessary to correlate sedimentary horizons from different areas. It is important to establish which sedimentary units were deposited at the same time or by the same or similar sedimentological or biological processes, even if they are not quite contemporary. Correlation is generally a question of what is possible to achieve with the available amount and quality of data.
We usually have no possibility of determining definitely which beds were deposited at the same time, but attempt to use all the information available in the rocks. This information falls into five main categories:

(1) ***Rock composition and structures*** resulting from sedimentological processes. **(2) Fossil content**, which is a result of biological, environmental and ecological evolution throughout geological history. **(3) Content of radioactive fission** *products in minerals or rocks* which may be used for age dating. **(4) Magnetic properties of rock strata**. **(5) Geochemical features of sediments**. These correlation methods are so different that it has been found useful to work with three forms of stratigraphy which can be used in parallel:

1. ***Lithostratigraphy:*** Classification of sedimentary rock types on the basis of their composition, appearance and sedimentary structures.

2. ***Biostratigraphy:*** Classification of sedimentary rocks according to their fossil content.

3. ***Chronostratigraphy:*** Classification of rocks on the basis of geological time.

Sedimentary rocks are the basic materials of the science of stratigraphy. Natural outcrops, excavations, quarries, mines, and well bores serve to make these materials abundantly available for study. Sedimentary rocks generally occur in the form of layers which were deposited on top of one another to form a stratified sequence as shown in figure (3). Each layer (greater than 1 cm thick) is known as ***bed*** or ***stratum*** (pl: strata), whereas layer less than 1 cm is termed ***lamina***. The layered nature of sedimentary rocks which results from such a mode of formation is termed ***bedding*** or ***stratification***.

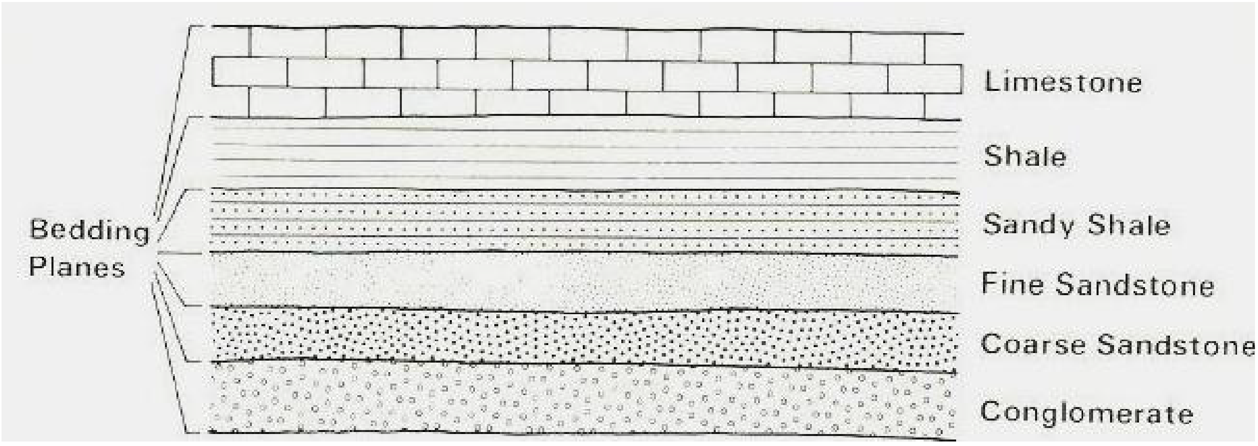


Fig. 3. Diagram showing the bedding or stratification of sedimentary rocks with beds of different lithology (conglomerate, sandstone, sandy shale and limestone) separated from one another by bedding planes.

Sedimentary rocks usually differ from one another in lithology, which is a general term referring to the overall character of a rock, as seen particularly in the field. The lithological differences reflected in the beds of the sedimentary rocks are usually defined by differences in mineral composition, grain size, texture, color, hardness and so on, which allow the individual beds of sedimentary rock to be recognized (fig. 4).

fig. 4. Showing the bedding or stratification of sedimentary rocks with beds of different lithology

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The surfaces separating the individual beds of sedimentary rock from one another are known as ***bedding planes***. They are commonly defined by a more-or-less abrupt change in lithological character which occurs in passing from one bed to the next. However, they may simply be defined by planes of physical discontinuity between beds of otherwise similar lithology, along which the rock will split.

The thickness of individual beds generally varies from several centimeters to a few meters, while their lateral extent may be measured in kilometers. Accordingly, beds of sedimentary rock typically form thin but very widespread layers, which eventually disappear as their thickness decreases to zero. Such beds may retain a lithological identity, or they may show a gradual change in lithological character, as they are traced throughout their outcrop. Some deposits of sedimentary rock show rapid changes in thickness so that they do not have such a parallel-sided form. For example, elongate bodies of sandstone and conglomerate are laid down in river channels and along shore lines, wedge-shaped bodies of breccia and conglomerate are banked against buried hills, volcanoes and coral reef. However, such examples are exceptions to the general rule that most beds of sedimentary rocks occur effectively in a tabular form as parallel-sided layers which extend laterally for a considerable distance before they eventually disappear as their thickness decreases to zero.

A bedding plane generally represents the original surface on which the overlying bed of sedimentary rock was deposited. Such a surface is simply known as a surface of deposition. Since sedimentary rocks are deposited on the earth's surface, such a bedding plane corresponds to this surface just before the overlying rocks were laid

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This implies that sedimentary rocks were originally deposited as nearly if not quite horizontal beds. Accordingly, sedimentary rocks are generally deposited with what is known as a low initial dip, unless they were deposited on a sloping surface. Such exceptions are only likely where sedimentary rocks are deposited on the flanks of deltas, coral reefs, volcanoes and hill slopes. The beds rarely have an initial dip greater than 30º from the horizontal, even under these circumstances. They are usually found to flatten out as they are traced away from such prominences, until they eventually become horizontal or nearly so.

III) The Stratigraphic Principles

First Principle: the Principle of Superposition: that "Sedimentary layers are deposited in a time sequence, with the oldest on the bottom and the youngest on the top".

Second Principle: the Principle of Original Horizontality of Beds

Third Principle: the Principle of Uniformitarianism: that "the present is the key to the past".
Fourth Principle: the Principle of Cross-Cutting Relationships: that "a feature cuts across a bed must be younger than it".
Fifth Principle: the Principle of Faunal and Floral Succession: that "strata may be dated and correlated by the sequence and uniqueness of their fossil content".
Sixth Principle: the Principle of Inclusions: that "fragments of an older bed can be included in a younger bed, but not vice versa".

IV) Modern Stratigraphic Classification

Geologists can do no more than recognize, define, and name the natural groupings of strata that are inherent in the local stratigraphic section. In each case recognition and definition are based on direct observations of the tangible features and characteristics of the strata and are independent of interpretations regarding the significance of these observations. It is convenient to refer to these natural differentiates of the stratigraphic column as **observable units**.
The stratigraphic units may be differentiated into two main classes: **1. Observable** stratigraphic units, and **2. Inferential** stratigraphic units (table 1).
1- Observable Stratigraphic Units:
The multiplicity of tools and techniques available to present-day stratigraphers for making observations on the characteristics of sedimentary rocks exposed in outcrop or penetrated in bore holes makes possible the recognition of a wide variety of tangible groupings of strata based on these observations.
Two classes of observable units; **a) Lithostratigraphic units** based on lithologic characteristics, and **b) Biostratigraphic units** differentiated by paleontologic characteristics.
a) Lithostratigraphic units: Mappable assemblages of strata distinguished and identified by objective physical criteria observable in the field and in the subsurface studies (Groups, formations, members, etc).
An outline of the classification of stratigraphic units is presented in the following table.

Table of stratigraphic units

A- OBSERVEBALE UNITS

1- Rock stratigraphic (lithostratigraphic) units

a-Formal rock units

- Supergroup(rarely applied)

-Group
-Subgroup(rarely applied)
-Formation
-Member, tongue, lentile
-Bed

b-Informal units
-Sequence
-Bed(oil sands, quarry layers, key and marker beds)
-Heavy mineral zone, insoluble residue zone
-Electric-log zone, radioactivity zone, velocity zone
-(marker defined) unit

2-Biostratigraphic units

a-Assemblage zone

Subzone
Zonule

b-Range zone

logal range zone

c-Concurrent range zone

B-INFERENTIAL UNITS

1-Time-stratigraphic(chronostratigraphic)units	**Geologic time units**
--	Eon
--	Era
System------------------------------------	Period
Series--------------------------------------	Epoch
Stage---------------------------------------	Age

2-Ecostratigraphic units

a-Ecozone

b-Geologic-climate units

Glaciation
Stade
Interstade
Interglaciation

Brookfield, M.F.,2004. Principles of Stratigraphy. Blackwell Publishing, 340P.