

1. Earth's current age determined using radioactive material in rocks. (Rutherford)
 - a. James Ussher: compiled using bible time
 - b. George Louis De Buffon: molten iron dating
 - c. John Joly: ocean salt-level dating
 - i. Not valid due to the ocean doesn't get increasingly salty over time
2. Deep time: the multi million year time frame which the earth has existed
3. Mineral: a naturally occurring inorganic crystalline solid with a characteristic chemical composition, a highly ordered atomic structure, and specific physical properties.
4. Rock: aggregate of minerals
 - a. **Igneous Rocks:** formed by the cooling of magma or lava. Generally composed of interlocking crystals of varying sizes.

intrusive	extrusive
Inside the crust	outside
Large crystals	Small crystals

- b. **Metamorphic:** form as the result of the transformation of an existing rock via heat, pressure and/or the action of fluids. Such conditions commonly occur deep in the Earth's crust. The study of metamorphic rocks can help provide information about the processes that occur deep in the subsurface.
- c. **Sedimentary:** form via the sedimentation of materials, commonly in layers sometimes called **strata** or sedimentary beds. Sedimentary rocks can be generated by physical, chemical, and/or biological processes. **Diagenesis** is a term used to refer to the transformation of sediments into a sedimentary rock. Diagenesis commonly occurs as sediments are buried below successively younger strata. Provide clues to Earth's past including climate, ancient geography, and life forms.
 - i. **Clastic sedimentary rocks:** Most sedimentary rocks are produced by the erosion of pre-existing rocks producing fragments or **grains** that are transported and deposited at various distances from the site of

erosion. Clastic sediments can be deposited anywhere they can settle out of by gravity from the media that is transporting them (water or air). The largest, but by no means exclusive, depositional area (or basin) for sediments are the oceans. Characteristics for **deposit near source**: grains are more coarse due to short travel, higher proportion of unstable minerals (quartz being the most stable at the surface), poor **sorting** (variation in clast/grain sizes in a sediment), also called **immature sediment**

ii. **Calcium carbonate**: biologically precipitated sediment

iii. **Evaporites**: intense evaporation of water forms salt crystals

5. **Stratigraphy**: how rock layers (beds or strata) are arranged
6. **Principle of Original Horizontality**: sediments are deposited horizontally
7. **Principle of Superposition**: lowest materials were deposited first
8. **Principle of lateral continuity**: layers of sediment initially extend laterally in all directions
9. **unconformities**: periods of non-deposition of sediment or active erosion of strata
 - a. **Disconformity**: exists where the layers above and below an irregular erosional boundary have the same orientation.
 - b. **Nonconformity**: develops where sediments are deposited on top of an eroded surface of igneous or metamorphic rocks
 - c. **Paraconformity**: strata on either side of the unconformity are parallel, there is little apparent erosion. Sometimes difficult to detect.
 - d. **Angular unconformity**: strata is deposited on tilted and eroded layers (such as at Siccar Point)
10. **Relative dating**: Working out the history of a geological section using stratigraphy, does not provide actual age. One should account for:
 - a. The rate of accumulation of sediment might not be constant;
 - b. Periods of non-deposition or active erosion may have occurred;
 - c. During diagenesis, sediments are compressed and compacted so that the vertical extent of sedimentary rocks may not represent the original vertical extent of sediment.
11. **Uniformitarianism**: the rock cycle, though not every rock follows it

12. Actualism: although most geological processes (like the uplift or erosion of mountains) are very slow, some geological processes (such as volcanic eruptions or the impacts of meteorites) can cause changes that are relatively geologically instantaneous.

L2

Sedimentary environments: where sediments are deposited

- **Deposits:** course to dense, positive correlation with shore-distance and negative correlation with water turbulence
- **CaCO₃:** after all clastic sediments have been deposited

Sedimentary Facies: all of the characteristics that can be used to define a particular sedimentary unit.

- sediment type (e.g. sandstone, mudstone, limestone): **cross-bedded sandstone facies**
- presence of any sedimentary structures (example: ripples, cross bedding): **rippled siltstone facies**
- the fossil content: **fossiliferous mudstone facies**
- **Ocean levels: temporal timeline, controls distribution of facies**
 - No change: rate of sediment deposits equal sea level change.
 - **Transgression (rising sea level):** Shore line moves towards the land, facies will also move towards the land. Creates slanted deposition of sediments towards the land.
 - **Regression (falling sea level):** Shore line moves towards the ocean, facies will also move out. Creates slanted deposition of sediments towards the ocean.
- **Stratigraphic logs:** Data from vertical successions of strata, width represents grain size.
- **Walther's Law:** "Facies that occur in a conformable (i.e. demonstrating no unconformities) vertical succession of strata were deposited in laterally adjacent depositional environments."

How Ocean Levels Change:

- **Crust collision** (mountain making): local fall in sea level
- **Isostatic redress:** pressure applied to the crust by glaciers deforms it downwards and pushes the mantle away. Upon rebound of the crust as glaciers melt and mantle comes back, ocean levels may rise or fall.

- Rebound at **current** site: local sea level **fall**
- After-effects at **surrounding** sites: local sea level **rise**
- **Melting of Glaciers**: global/eustatic rise of sea levels
- **Spreading Ridge/ seafloor spreading**: can cause rises in region ocean levels, eustatic if not recycled at the same rate
 - rapid seafloor spreading produce high elevation (fat) profiles. These ridges occupy volume in the ocean basin and displace water onto continents. **Main reason.**
 - Slower sea floor spreading rates produce lower elevation (thin) profiles and displace less water.
- Water expansion due to heat can change eustatic levels on the long run
- **Coeval** (at the same time) factors need to change the current sea level significantly

L3

Lithostratigraphy: the study and classification of strata

- Bed: a lithologically distinct layer
- Member: a collection of beds with related characteristics
- **Formation**: a collection of lithostratigraphic units that can be recognized and mapped over a wide area
- Group: a collection of related yet distinct formations
- Supergroup: a collection of related yet distinct groups

Chronostratigraphy: geological age defined for Earth history. eg. the Cretaceous

Biostratigraphy: using fossils as time pieces to date time

Da Vinci: fossils were once living in oceans but lifted to mountains by unknown events

William Smith: "Principle Of Faunal Succession": "fossils succeed one another through time in a regular determined order".

Georges Cuvier: Ideas about Extinction

Quenstedt and Oppel: Fossil Ranges

Fossil range: time range from the evolution of a fossil to its extinction. Such a fossil is called a **zone fossil**.

- **Rapidly Evolving**: the fossil defines a "short period" of time. If long-ranging forms were used, the subdivisions of geological time would be too broad and lack resolution.

- Widespread Across Different Facies and Biogeographical Provinces: the fossil must occur in as wide an area as possible so correlation between areas separated by great distances can be established. The fossil must not be "tied" to a particular sedimentary environment, or be facies dependent. Eg. graptolites.
- Relatively Common
- Easy to Identify

Biozone: a time interval defined by the occurrence of a particular fossil(s)

Type Sections: internationally agreed section that represents a period of geological time.

Stratotypes bases to form type sections:

- continuous sedimentation: to record the max amount of geological information
- Few unconformities so any gaps in the record are minimized.
- Little structural (folding and faulting) disturbance or metamorphism. Folding and faulting complicate the interpretation of a geological section and metamorphism can remove or seriously degrade the quality of any fossils/isotopic/sedimentological information that was present.
- Rich in fossils to aid in correlation.

Absolute dating: (also called radiometric or radioactive dating) uses an understanding of radioactive decay to date rocks.

- Only valid in a closed system where no material has been lost, eg. igneous rocks.
- Factor causing losses:
 - Weathering can cause leakage of isotopic material
 - Metamorphism resets the isotopic clock such that any date obtained from the rock would date from the time of metamorphism and not the original formation of the rock
 - Apart from a very few exceptional cases, radiometric techniques cannot be used on sedimentary rocks, the most common rocks at the Earth's surface.