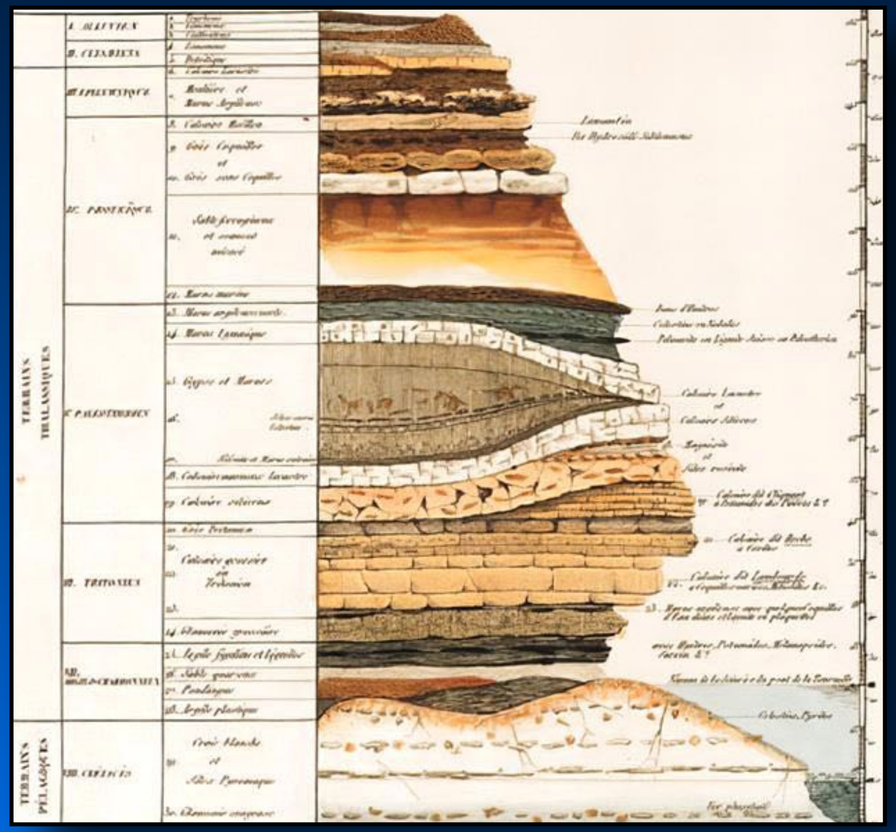
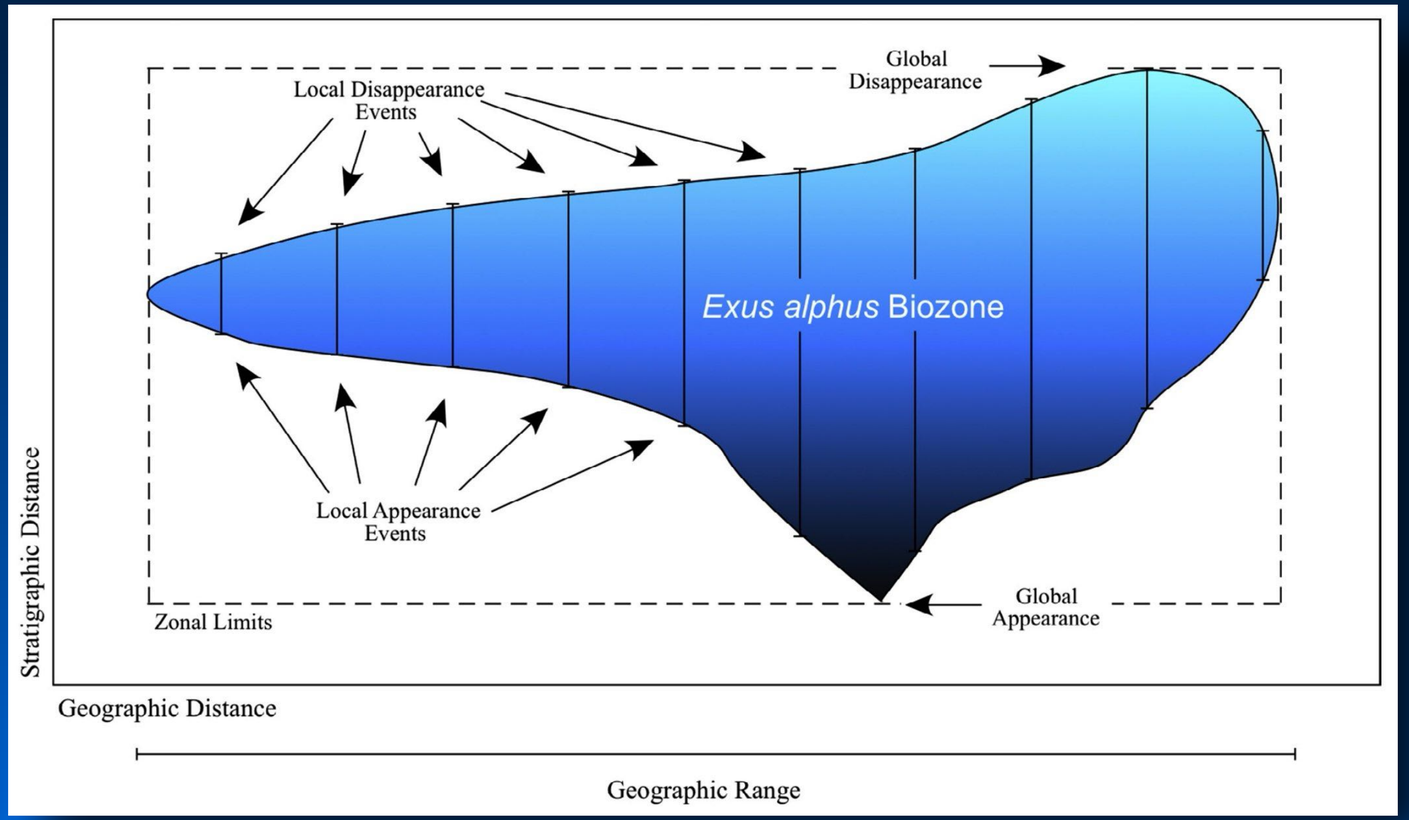
NJU Course

Principles of Paleobiology

Stratigraphy: Zonation & Correlation

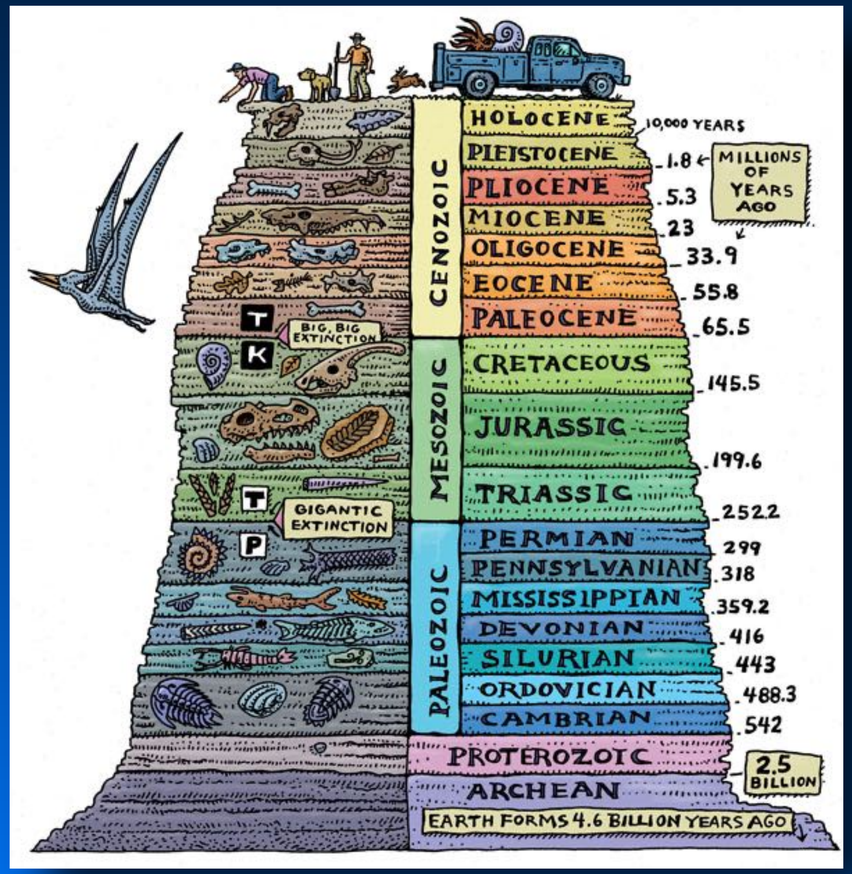


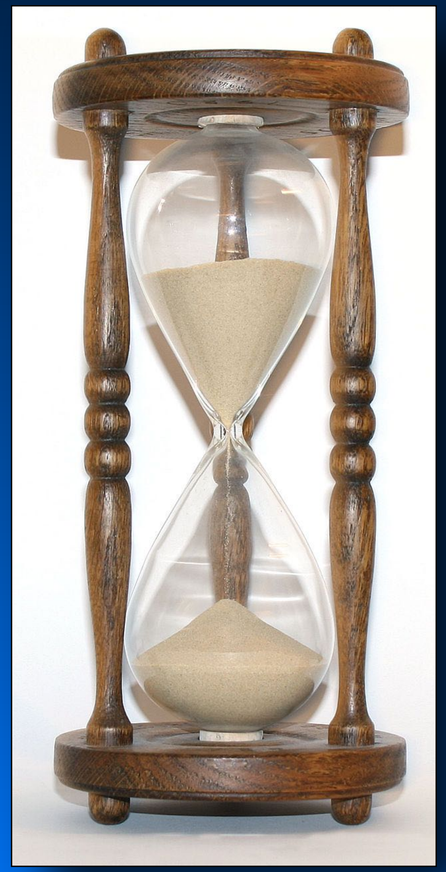


Stratigraphy: Zonation & Correlation

Stratigraphy

Stratigraphy - The branch of geology that studies rock layers.





Stratigraphy: Zonation & Correlation

Stratigraphy

Stratigraphy - The branch of paleobiology that establishes the temporal context of paleobiological data.

- Owing to the laws of superposition, original horizontality, and crosscutting relations stratigraphic relations can be used to infer relative time sequences.
- Fossils are typically used to assign relative ages to rock layers, though other sources of information may also be helpful in this respect.
- In some cases rock layers may contain materials that can be used to assess the absolute time of formation of the layer.

Stratigraphy: Zonation & Correlation

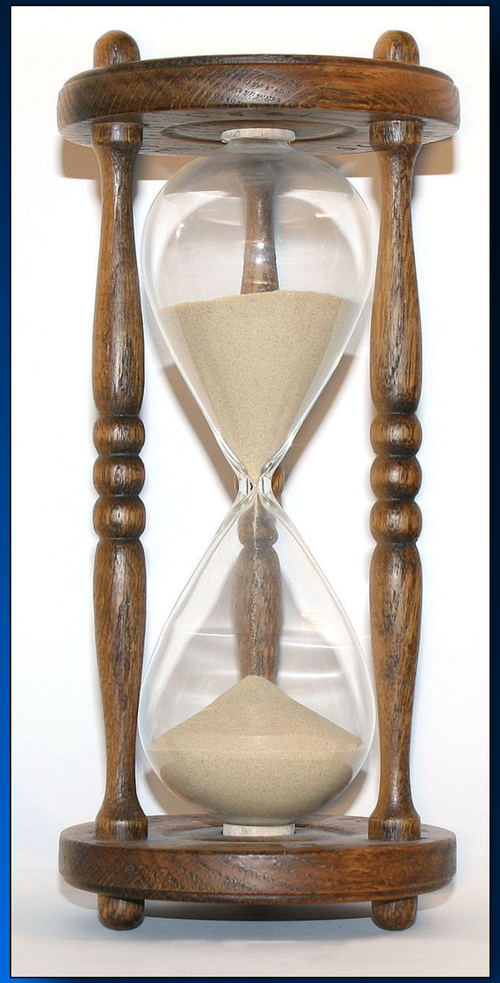
What is Time?

Time is …

- … the scale against which observable events can be ordered into a sequence.
- … the scale against which the durations of events, and/or the intervals between them can be measured.

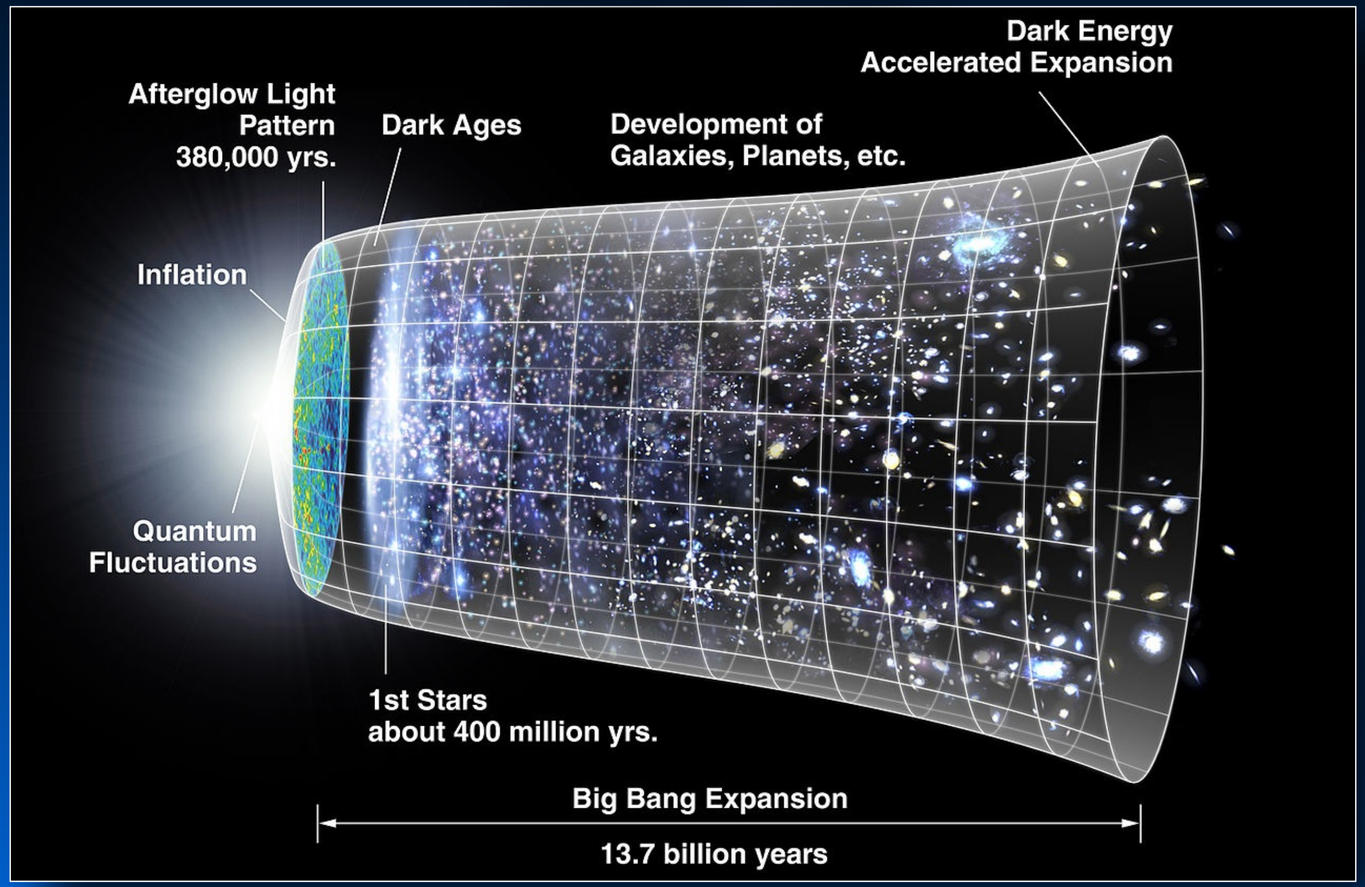
But what kind of scale does time represent? Is it constant or variable? Directional or cyclic? Finite or infinite? Is it a “thing” or merely a convenient concept?

Philosophers, theologians, and scientists as diverse as Socrates, St. Agustine, Newton, Kant, and Einstein have all expressed fundamentally differing views regarding the precise nature of time.



Stratigraphy: Zonation & Correlation

What is Time?



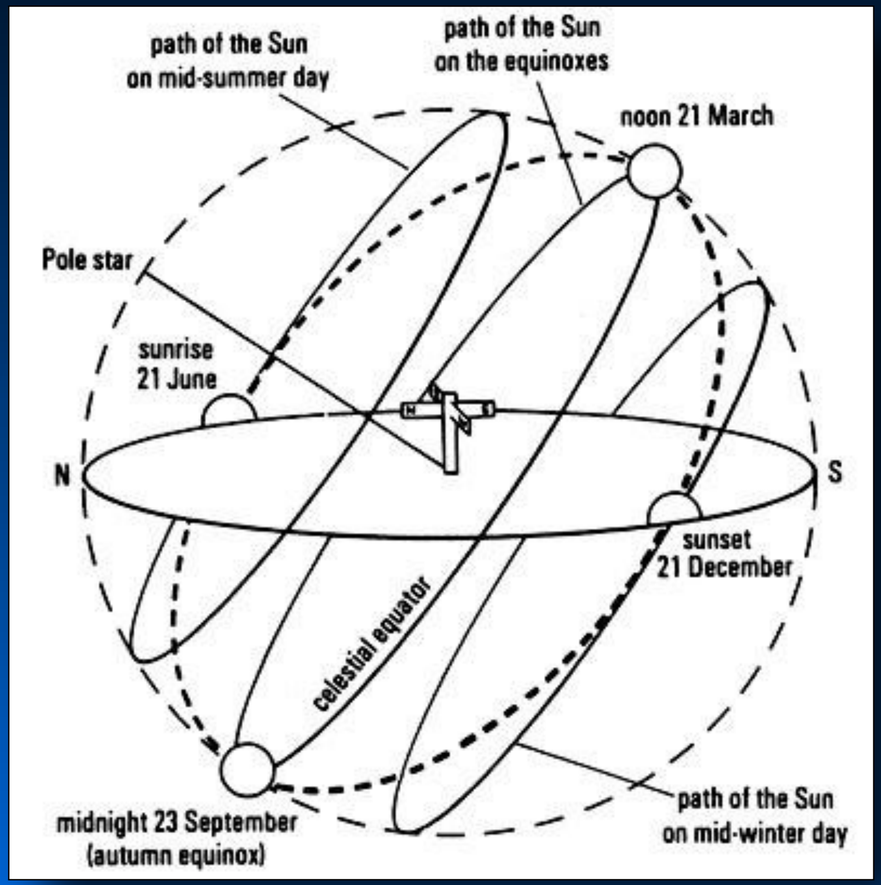
By convention we measure time via reference to the motion of objects. For example, the age of the universe is estimated to be 13.7 billion years based on the distance to the furthest galaxies and the speed at which they are moving away from the Earth.

Stratigraphy: Zonation & Correlation

What is Time?

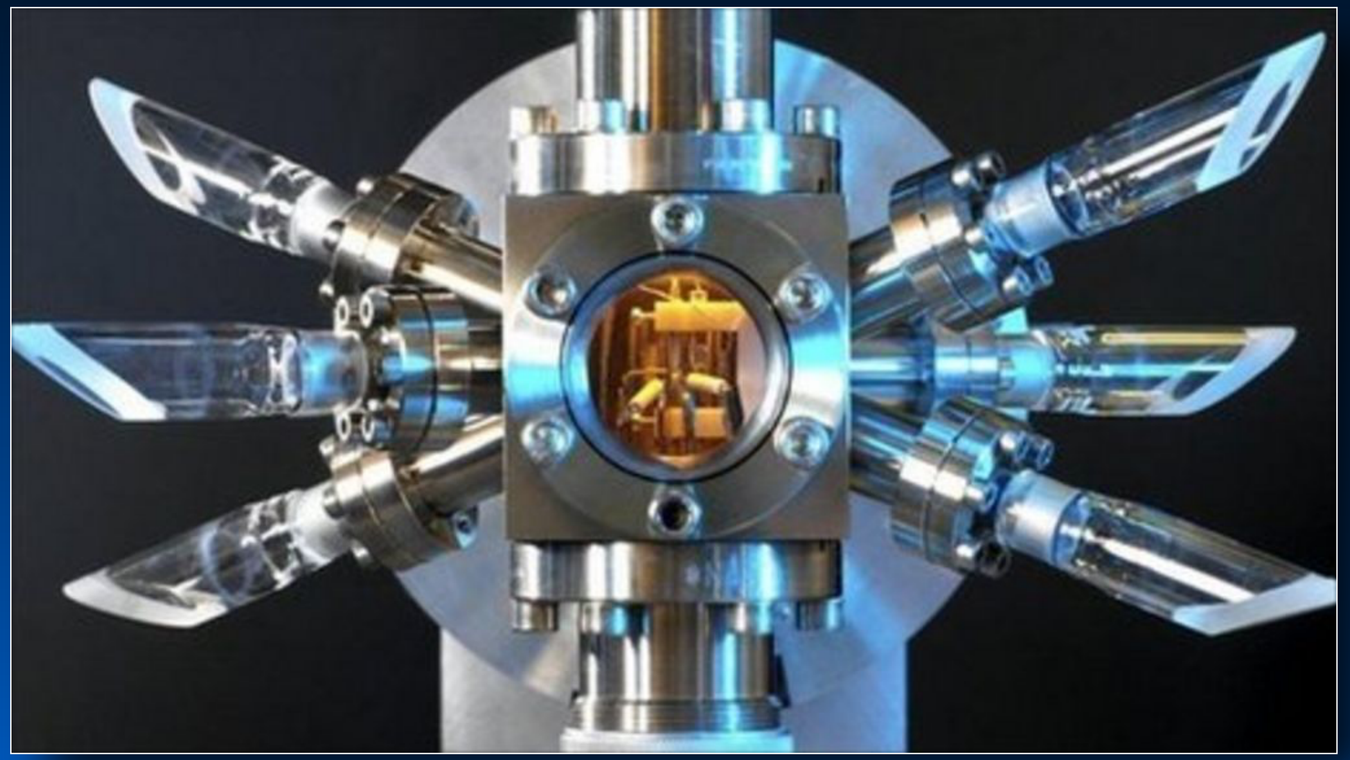
In ancient times a year was defined as the time interval between Sol (the sun) reaching its absolute maximum height above the horizon and the day as the time interval between the sun reaching successive maximum heights above the horizon.

Later it was discovered these variations were the result of the Earth turning on its rotational axis (day) and that axis being inclined to the plane of the Earth's orbit around the sun at 23.5°.



Stratigraphy: Zonation & Correlation

What is Time?

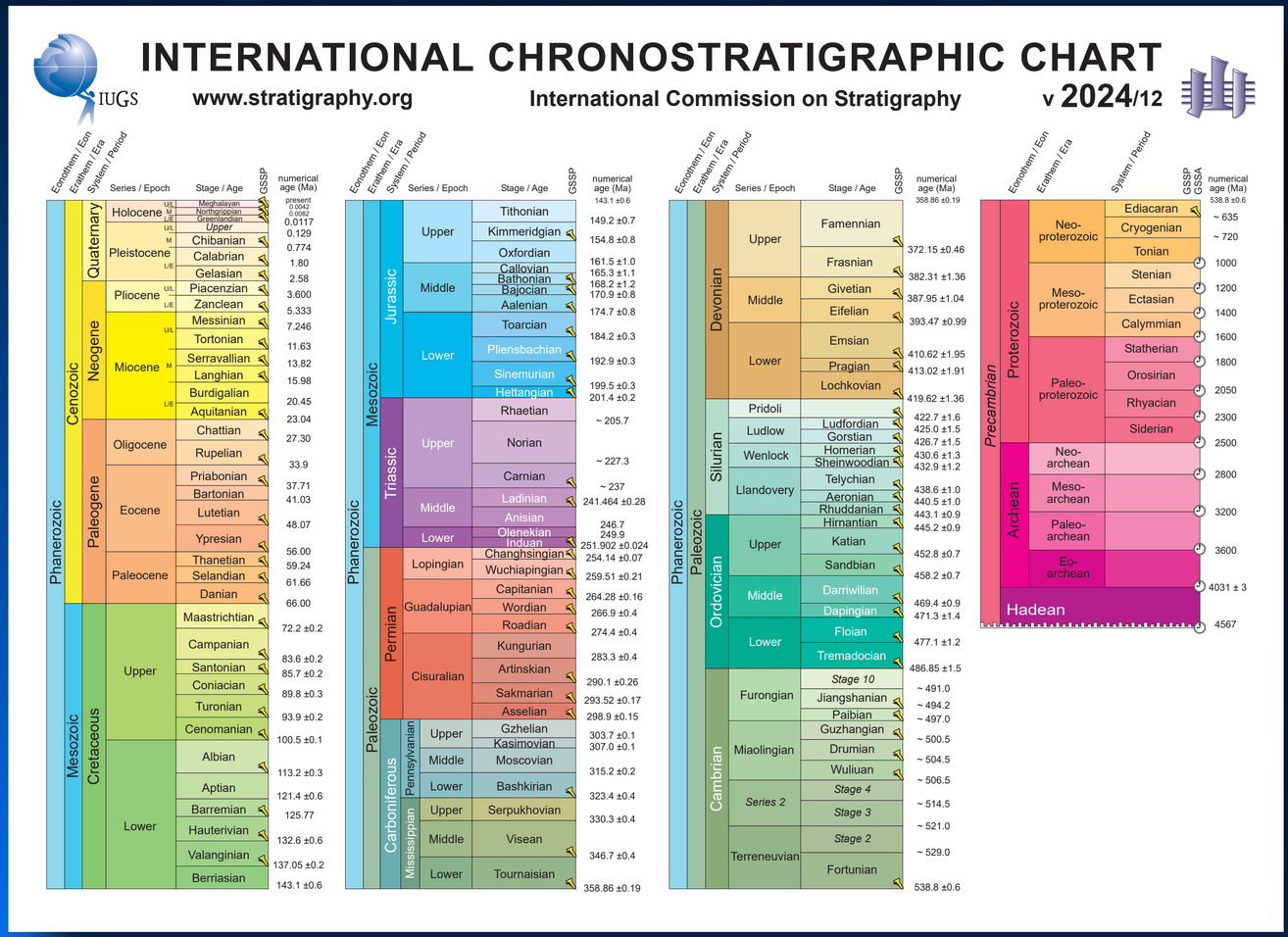


We still reference time to the motion of objects. Watches count minutes and hours as the time required for the second and hour hands to complete one cycle of the watch face. Atomic clocks — currently the world's most accurate — measure the intervals of time required by electrons as they oscillate between energy levels. Here 1 sec. is defined as 9,192,631,770 oscillations of the Cs^{133} atom.

Stratigraphy: Zonation & Correlation

Stratigraphy

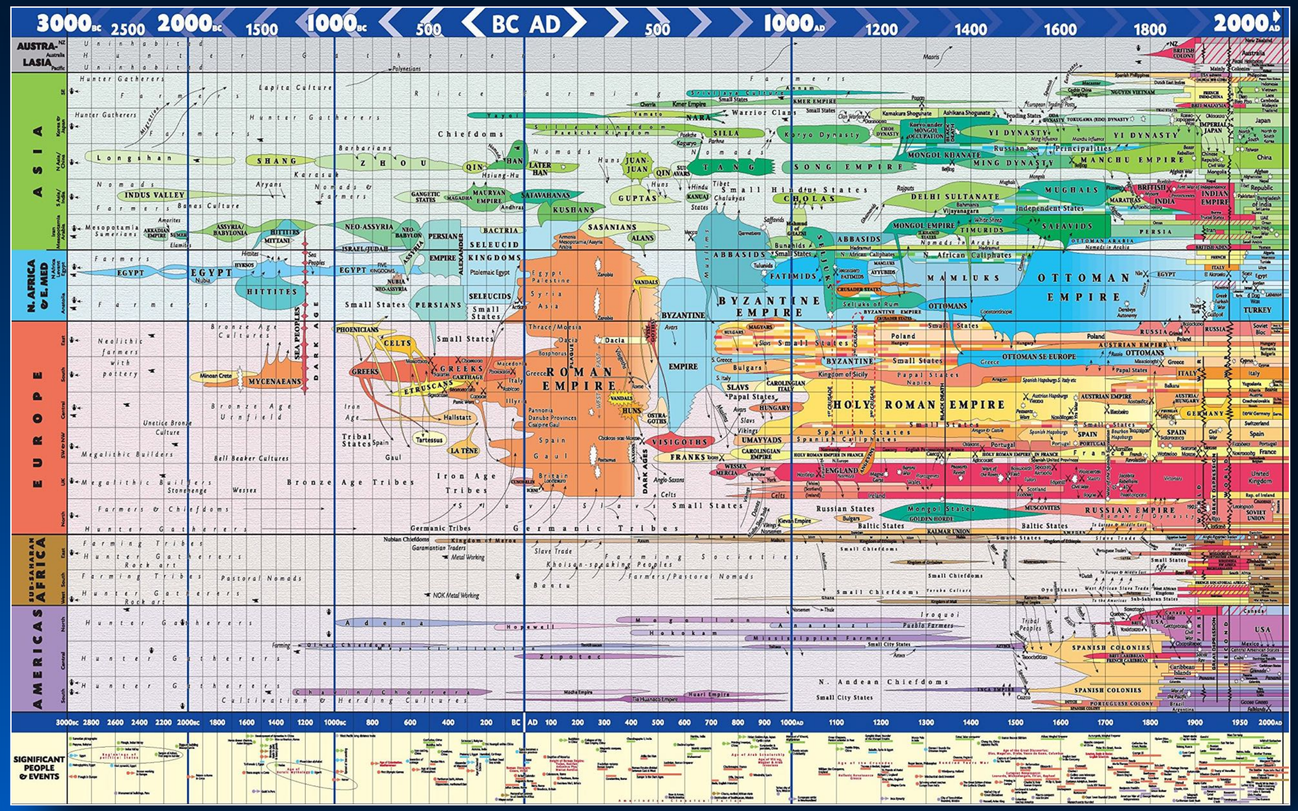
How Do We Tell Time in the Stratigraphic Record?



Stratigraphy: Zonation & Correlation

Historical Time?

1. 4000 BC Origins of Civilization
2. 3000 BC The Ancient Middle East
3. 2700 BC _____
4. 2600 BC Ancient India
5. 2000 BC Ancient China
6. 2000 BC _____
7. 1600 BC Native Americans
8. 800 BC-476 AD Ancient Rome
9. 500-1050 _____
10. 610 The Origins of Islam
11. 1096-1291 _____
12. 1050-1350 The Late Middle Ages
13. 1300 _____
14. 1517 The Protestant Reformation
15. 1534 Henry VIII
16. 1543 _____
17. 1492 Europeans Explore Overseas
18. 1625 Parliament
19. 1651 _____
20. 1789 The French Revolution
21. 1804 _____
22. 1800-1914 The Age of Imperialism
23. 1914-1918 _____
24. 1917 The Russion Revolution
25. 1939-1945 _____
26. 1945-1991 The Cold War New



Historians work with two time scales, the first is the scale of absolute time which is determined by physics, but the second is the scale of relative time in which time major time intervals are defined by major cultural transitions (e.g., political changes, technological innovations). This relative time scale is produced by a process termed “periodization”.

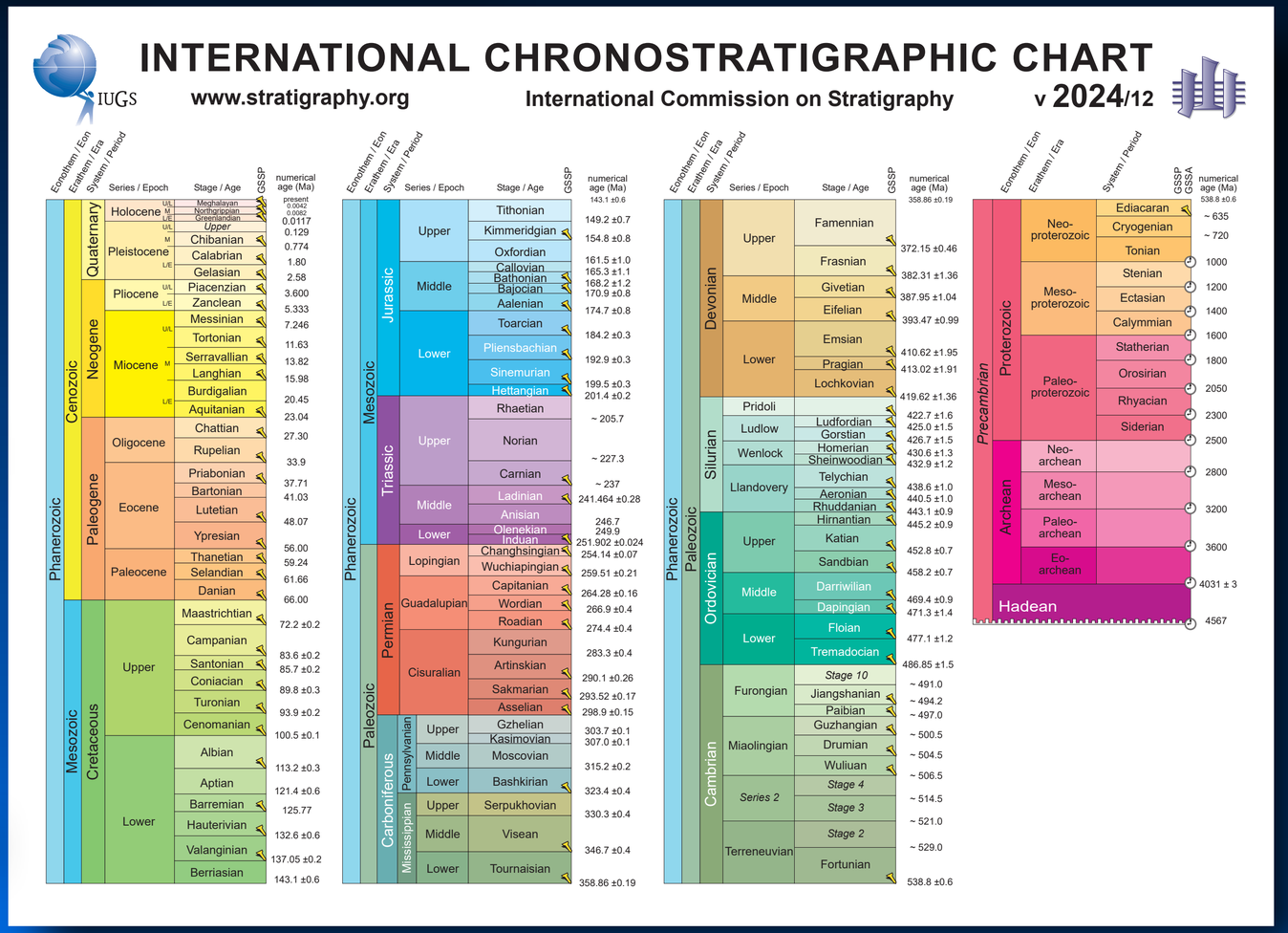
Stratigraphy: Zonation & Correlation

Geological Time Scale

Like historians geologists and stratigraphers work with both numerical (geochronologic) and relative chronostratigraphic – or periodized – time scales.

Both these scales can be found in all modern representations of the geologic time scale. It's important to understand the difference between the two.

For day-to-day stratigraphic work, the relative (chronostratigraphic) time scale is the more useful because it is by far the more stable.



Stratigraphy: Zonation & Correlation

Types of Stratigraphy

Lithostratigraphy

- The branch of stratigraphy that characterizes rock layers by their lithological (= physical) content.
  - Formation - the smallest mappable rock unit possessing a distinctive suite of lithological characteristics.
  - Superior (e.g., groups) and inferior (e.g., members, beds) can be recognized.
  - Many ways to define a lithostratigraphic unit.
  - No necessary time (= chronostratigraphic) implication.

Stratigraphy: Zonation & Correlation

Types of Stratigraphy

Biostratigraphy

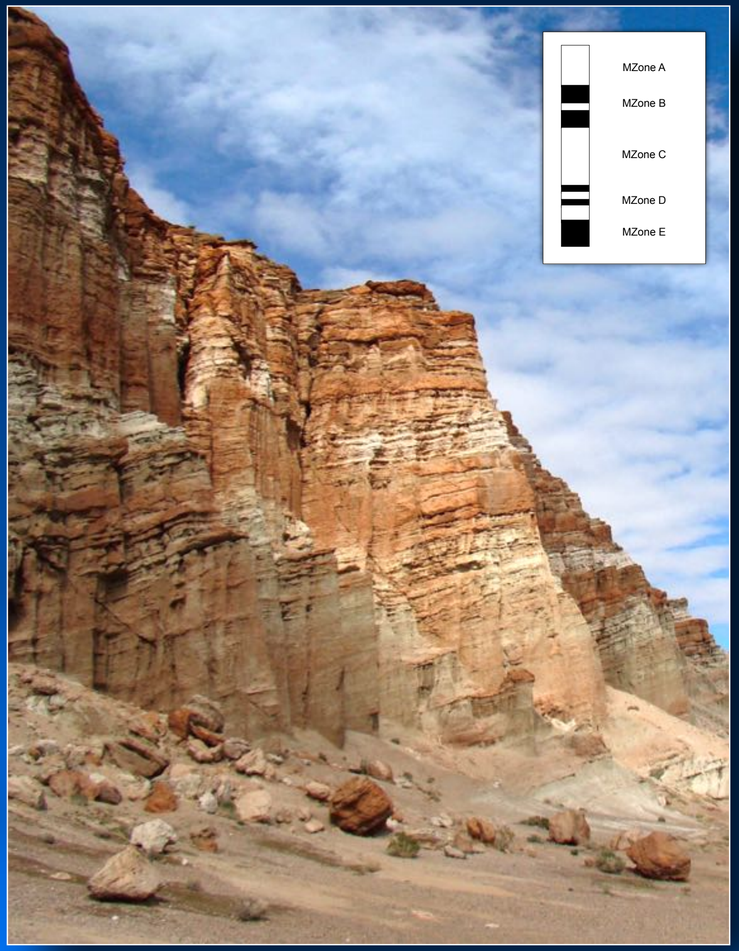
- The branch of stratigraphy that characterizes rock layers by their fossil (= biotic) content.
  - Zone - any rock unit distinguishable from other rock units by its fossil content.
  - Many ways of defining a zone.
  - No need for zones to be mappable.
  - No necessary time (= chronostratigraphic) implication.

Stratigraphy: Zonation & Correlation

Types of Stratigraphy

Magnetostratigraphy

- The branch of stratigraphy that characterizes rock layers by their remnant magnetic polarity.
  - Magnetozone - any rock unit distinguishable from other rock units by minerals possessing a characteristic magnetic polarity.
  - No need for magnetozones to be mappable.
  - Magnetozones not unique (must use other criteria to be identified).
  - Practically speaking magnetozone boundaries cannot be assumed to be isochronous, but magnetic polarity reversals are effectively isochronous.

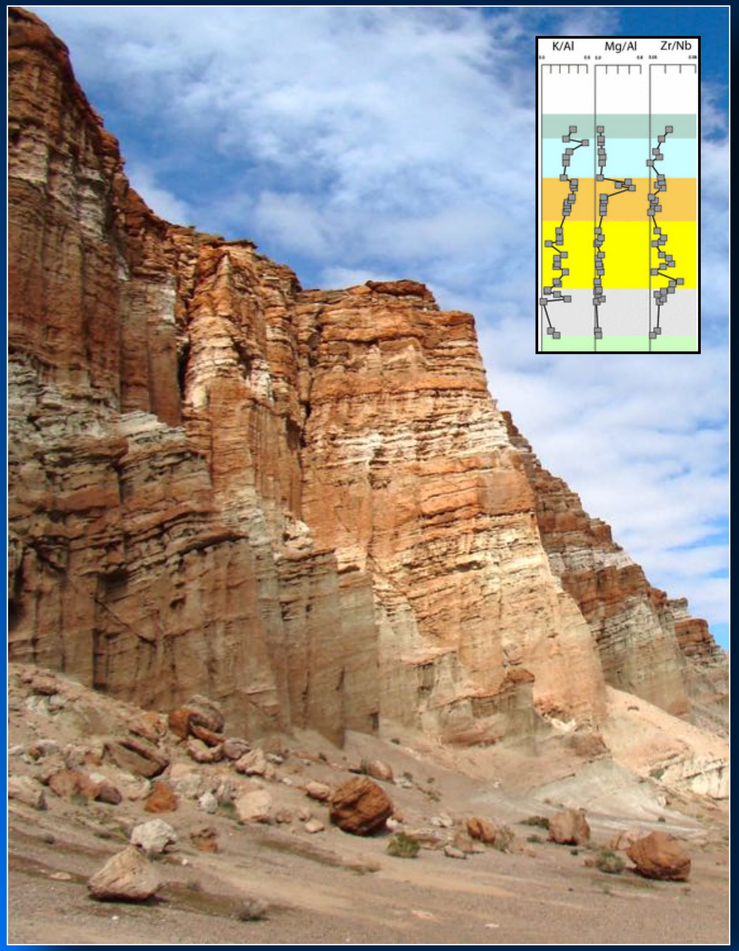


Stratigraphy: Zonation & Correlation

Types of Stratigraphy

Chemostratigraphy

- The branch of stratigraphy that characterizes rock layers by their chemical/isotopic content.
  - Chemozone - any rock unit distinguishable from other rock units by minerals possessing a characteristic chemical/isotopic content.
  - No need for chemozones to be mappable.
  - Chemozones not unique (must use other criteria to be identified).
  - Practically speaking chemozone boundaries cannot be assumed to be isochronous, but, when used in conjunction with other data can support an interpretation of isochrony.

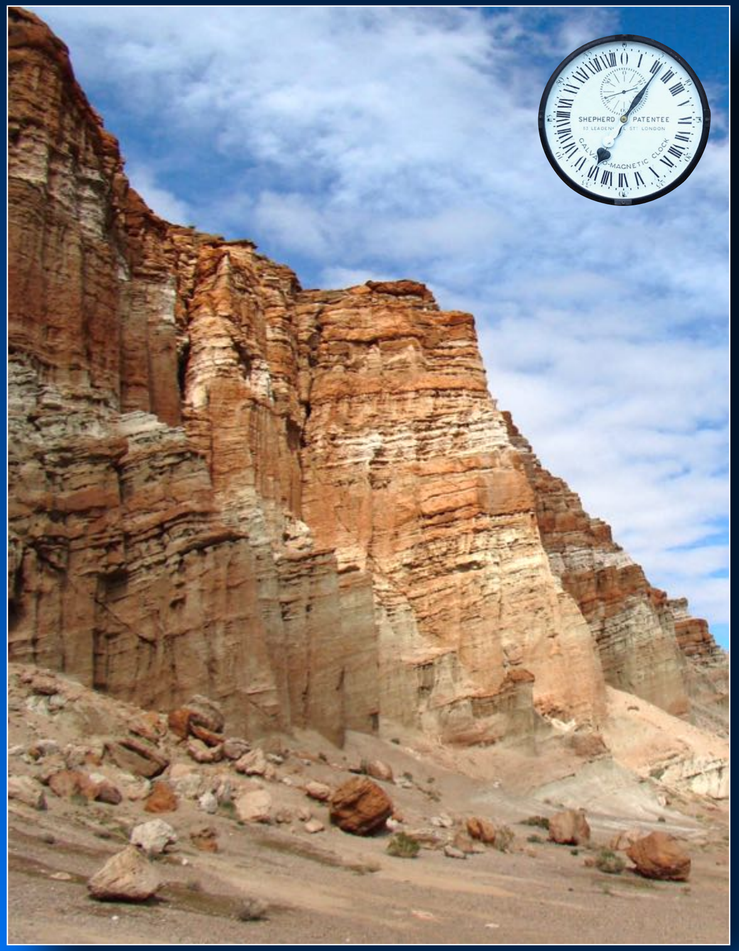


Stratigraphy: Zonation & Correlation

Types of Stratigraphy

Chronostratigraphy

- The branch of stratigraphy that characterizes rock layers by their relative time of origin/deposition.
  - Chronozone - any rock unit distinguishable from other rock units by different time relations.
  - No need for chronozones to be mappable.
  - Chronozones are unique but cannot be observed directly; they must be inferred based on other stratigraphic criteria.
  - Chronozone boundaries are isochronous.

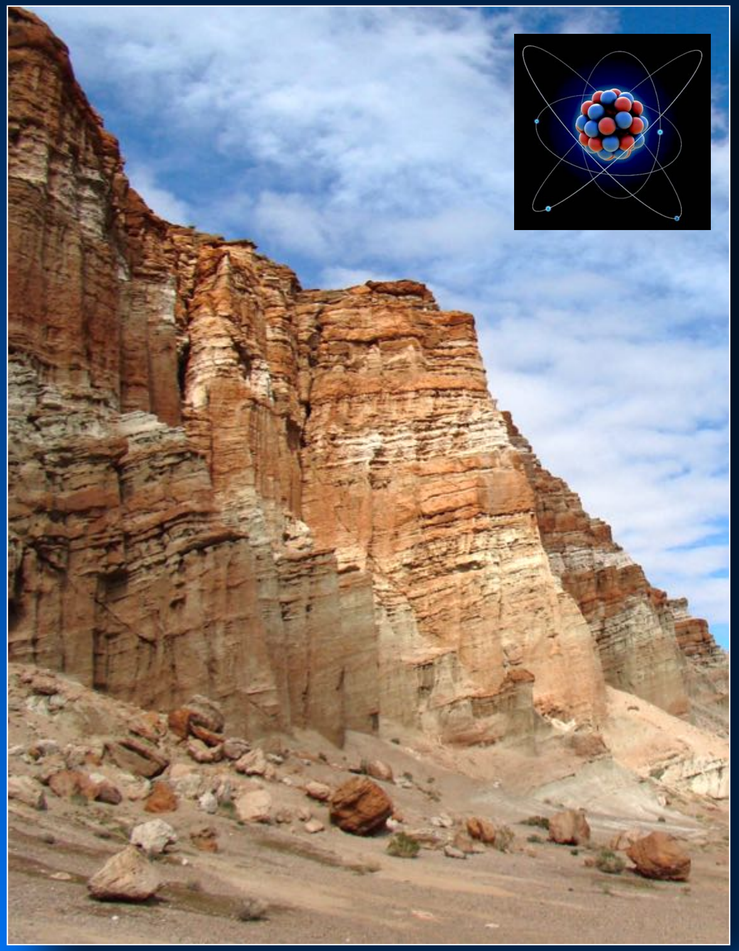


Stratigraphy: Zonation & Correlation

Types of Stratigraphy

Geochronology

- Methods
  - Radiometric (radioisotopic) dating
  - Fission-track dating
  - Cosmogenic nucleotide dating
  - Luminescence dating
  - Incremental dating
  - Dendrochronologic dating
  - Ice core dating
  - Varve dating

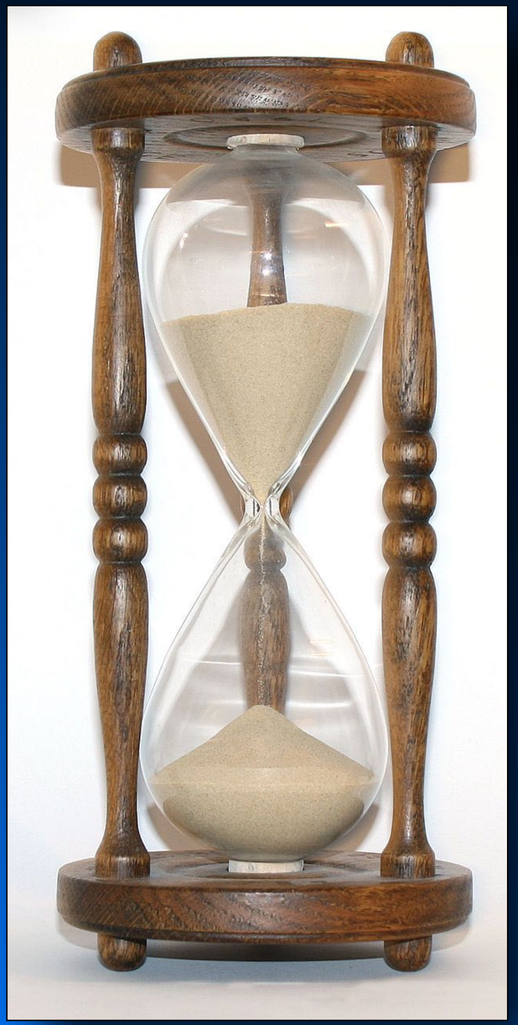


Stratigraphy: Zonation & Correlation

Geochronology versus Chronostratigraphy

The difference between chronostratigraphy and time (= geochronology) is symbolized by the hourglass.

- Geochronology is the amount of time it took for the sand to fall from one reservoir to the other.
- Chronostratigraphy is the amount of sand that was deposited in the lower reservoir in that time interval.



Geological Time Systems		
Chronostratigraphy	Geochronology	Example
Eonothem	Eon	Phanerozoic
Erathem	Era	Mesozoic
System	Period	Cretaceous
Series	Epoch	Upper Cret.
Stage	Age	Maastrichtian
Chronozone	Chron	*B. occidentalis* Biozone

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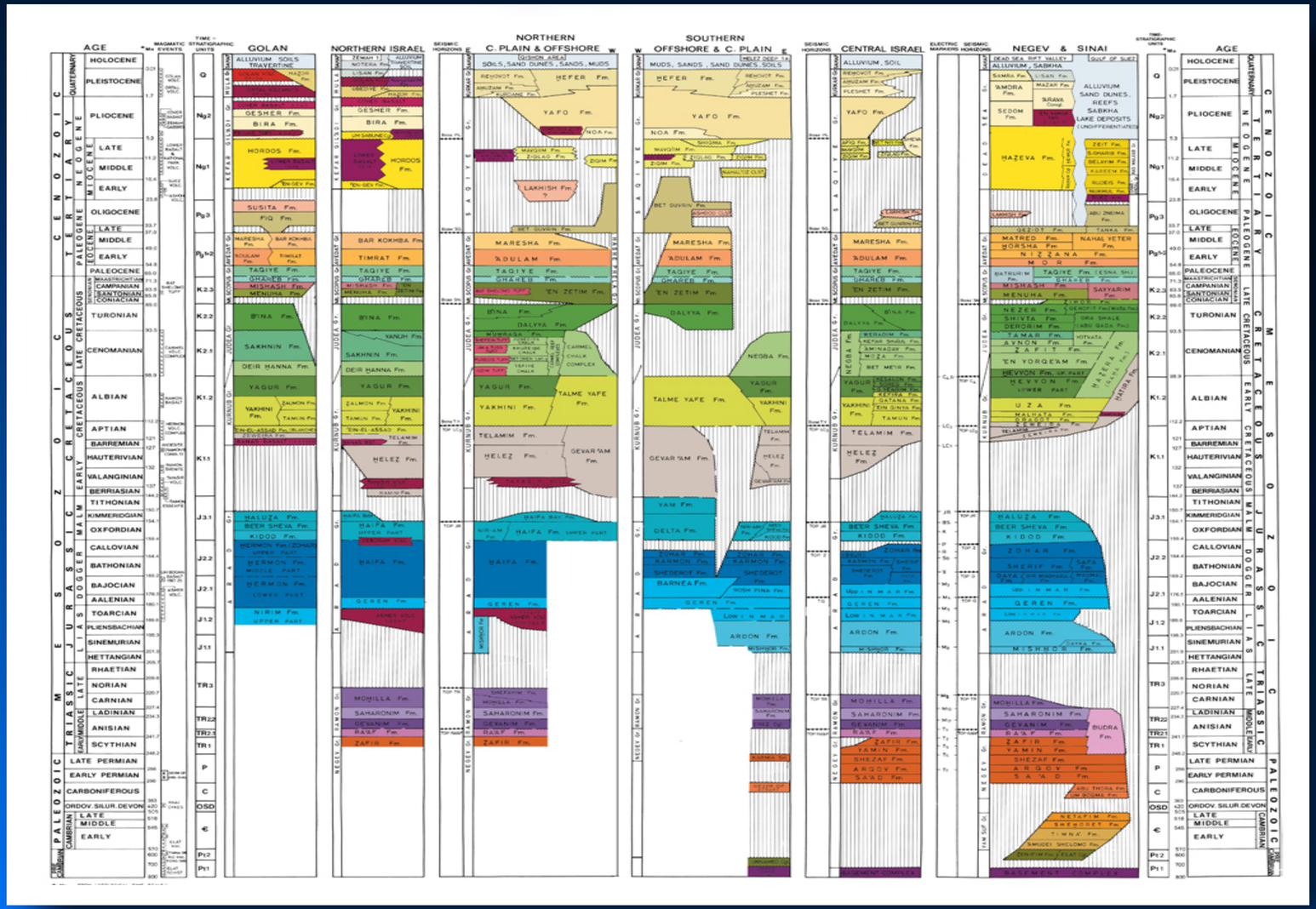
Stratigraphic Correlation



Stratigraphy: Zonation & Correlation

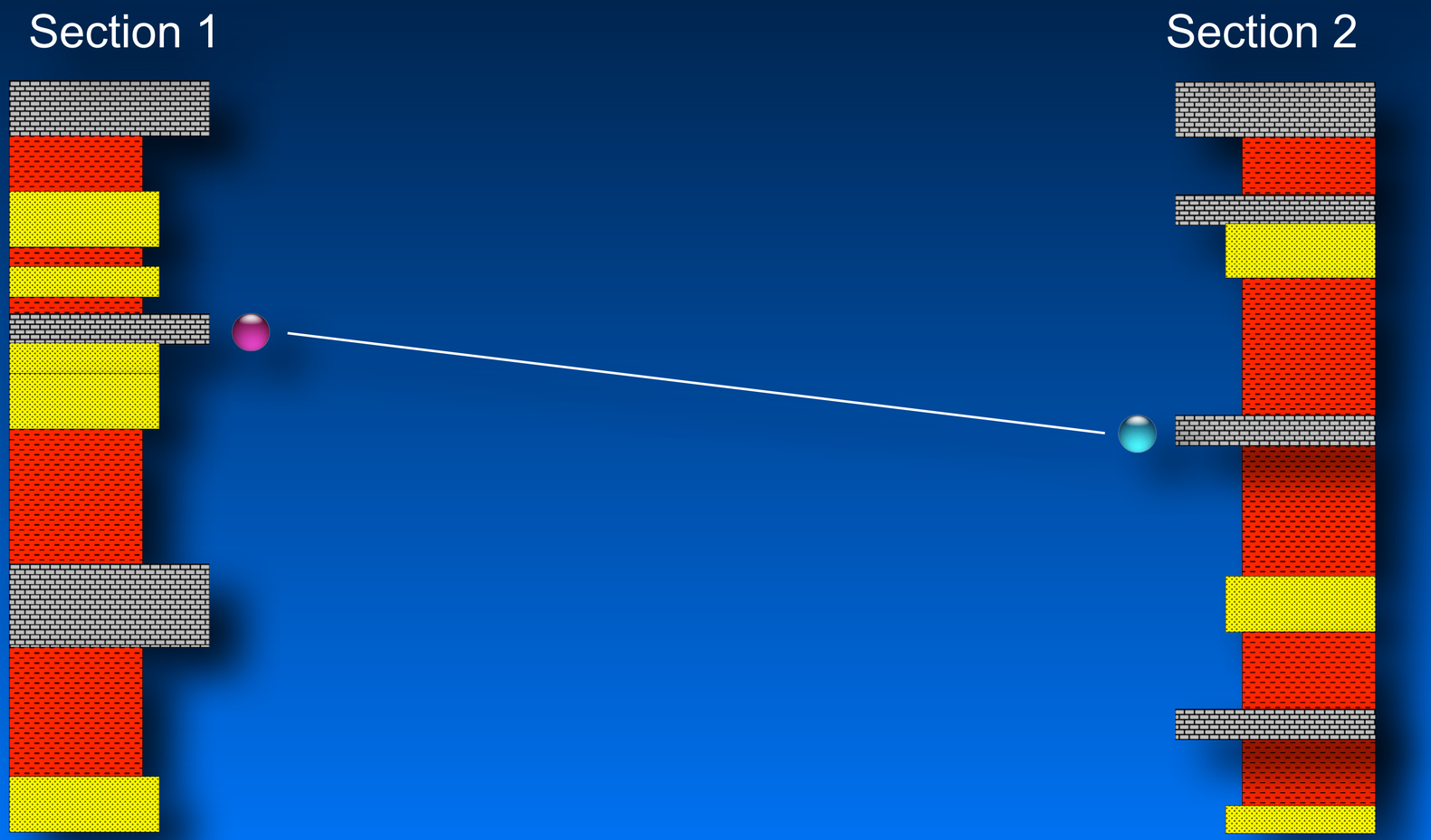
Stratigraphic Correlation

The determination of the contemporaneity of geological units or events in the histories of two or more locations.

Stratigraphy: Zonation & Correlation

Stratigraphic Correlation

Isochrony/Homochrony - The condition of being equivalent in absolute time.



Stratigraphy: Zonation & Correlation

Stratigraphic Correlation

Diachrony - The condition of being non-equivalent in absolute time.

Stratigraphy: Zonation & Correlation

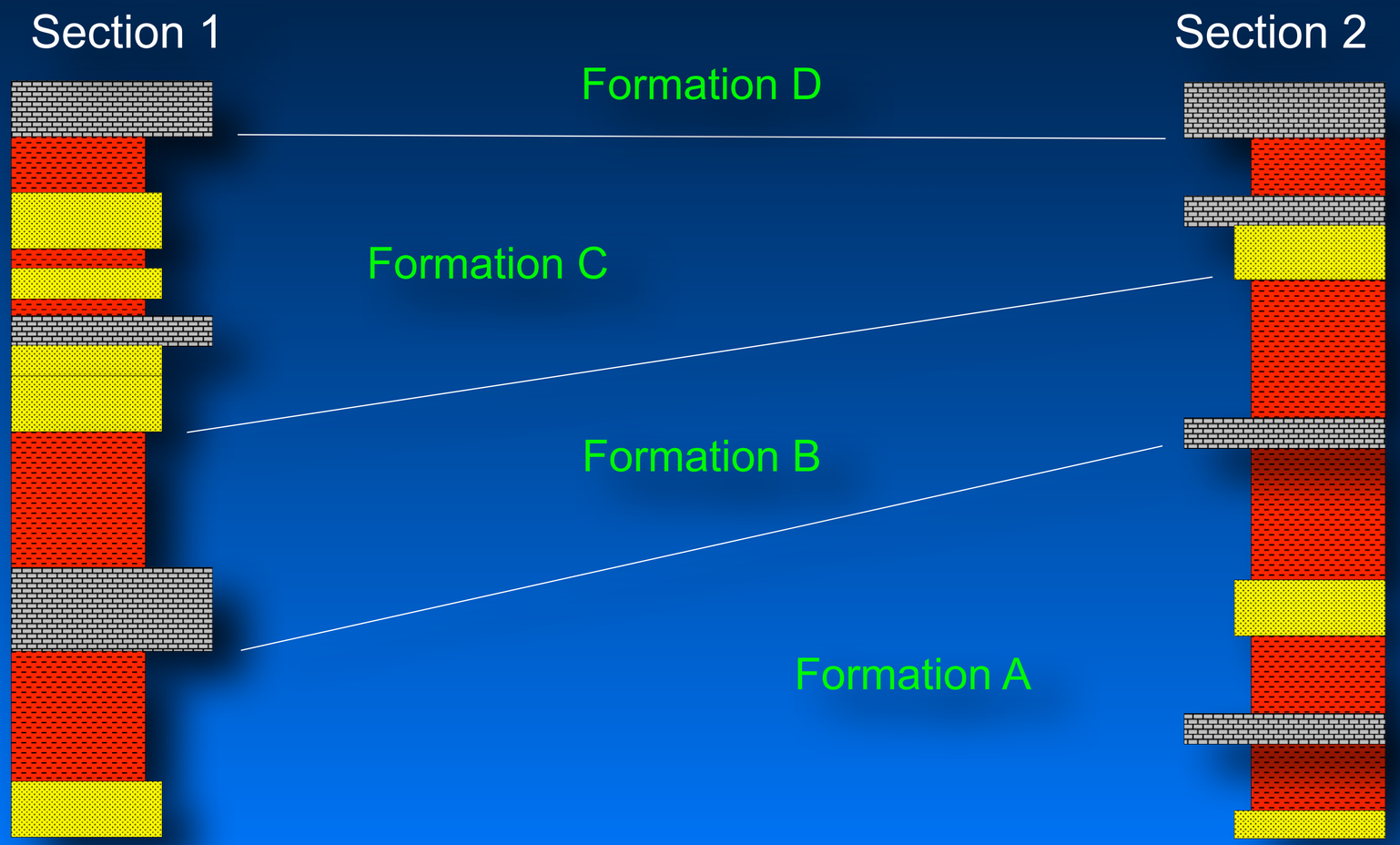
Lithostratigraphic Correlation

The branch of stratigraphy that characterizes rock layers by their lithological (= physical) content

Stratigraphy: Zonation & Correlation

Lithostratigraphic Correlation

The matching of lithozones in different stratigraphic sections or cores based on similarities or differences in their zone-defining lithologies.

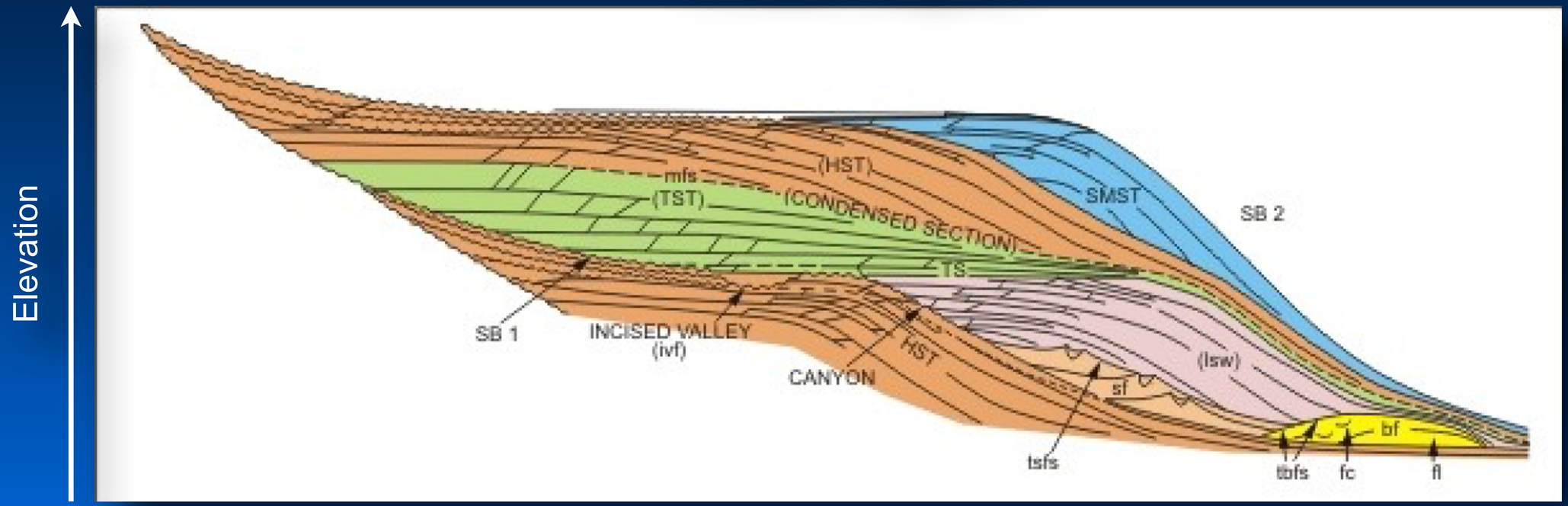


Stratigraphy: Zonation & Correlation

Sequence Stratigraphy

The analysis of sedimentary deposits in a time-stratigraphic context.

Wheeler Diagram



Abbreviations: SMST, Shelf Margin System Tract; HST, Highstand System Tract; SB1, Sequence Boundary 1; MFS, Maximum Flooding Surface; FSF, Falling stage Fan; LST, Lowstand System Tract; Unconformity, Subaerial hiatus; LSW, Low stand wedge; SB2, Sequence Boundary 2; TST, Transgressive System Tract; ivf, Incised Valley Fill.

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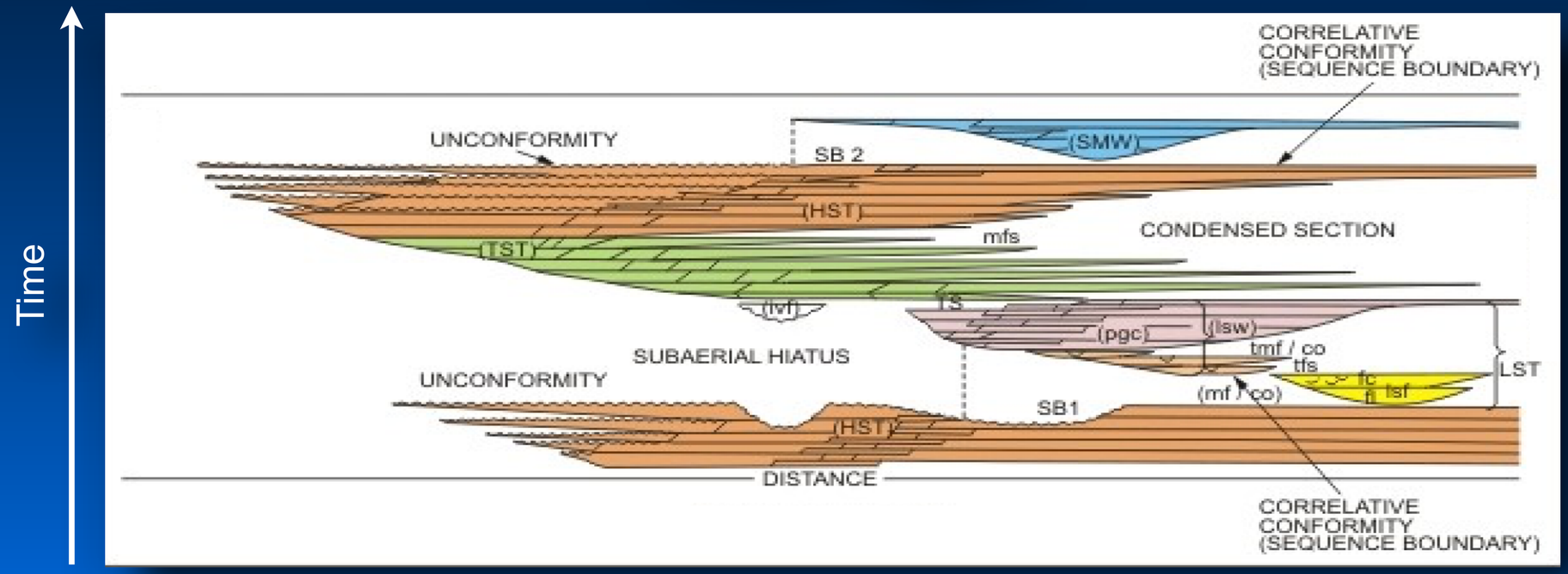

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Stratigraphy: Zonation & Correlation

Lithostratigraphic Correlation

Lithostratigraphic units per se have no chronostratigraphic significance. Some may have been deposited over a short time interval (e.g., tuffs, bentonite). But all must be assumed to be diachronous.

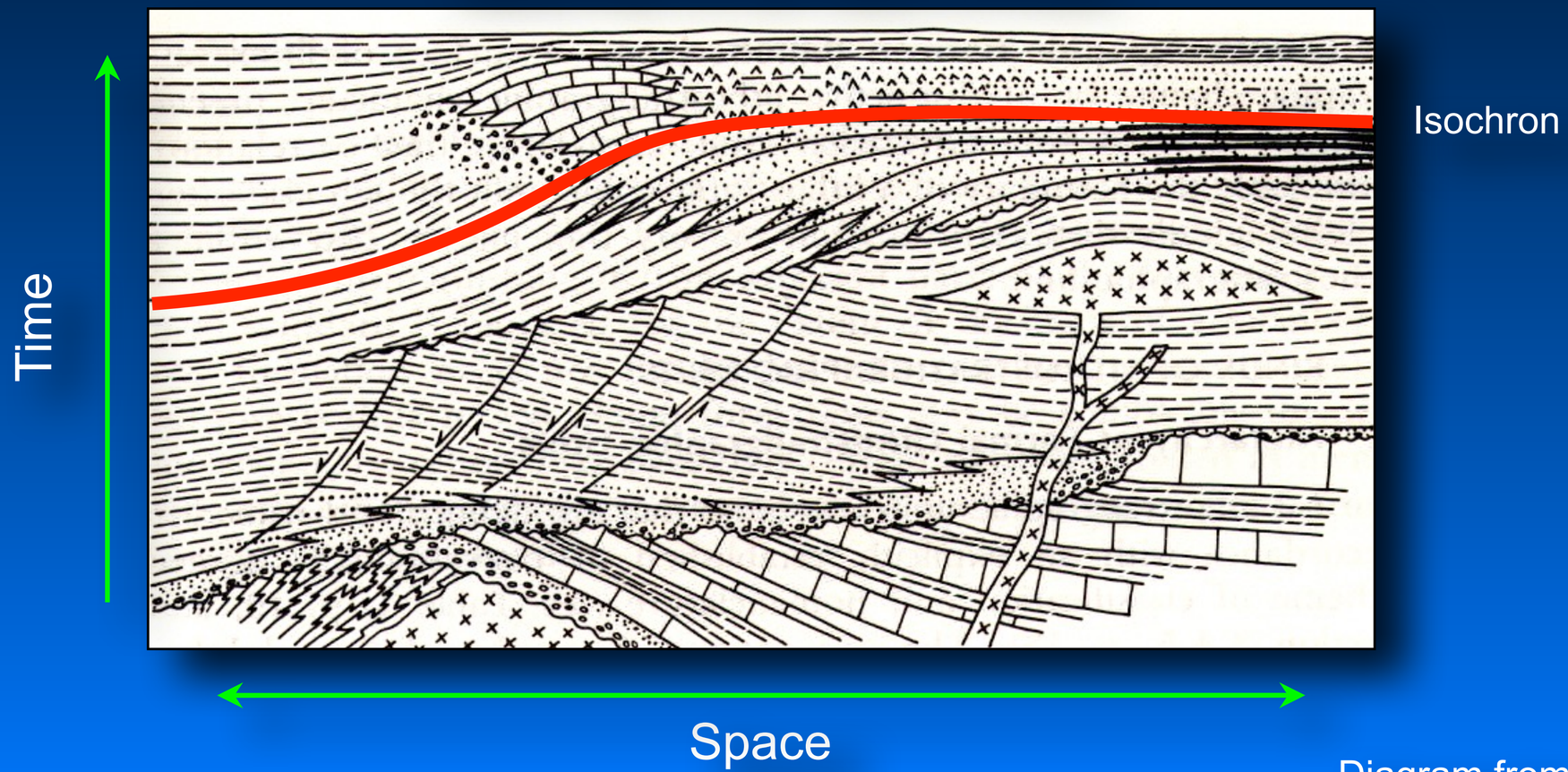

Diagram from Hedberg (1976)

Stratigraphy: Zonation & Correlation

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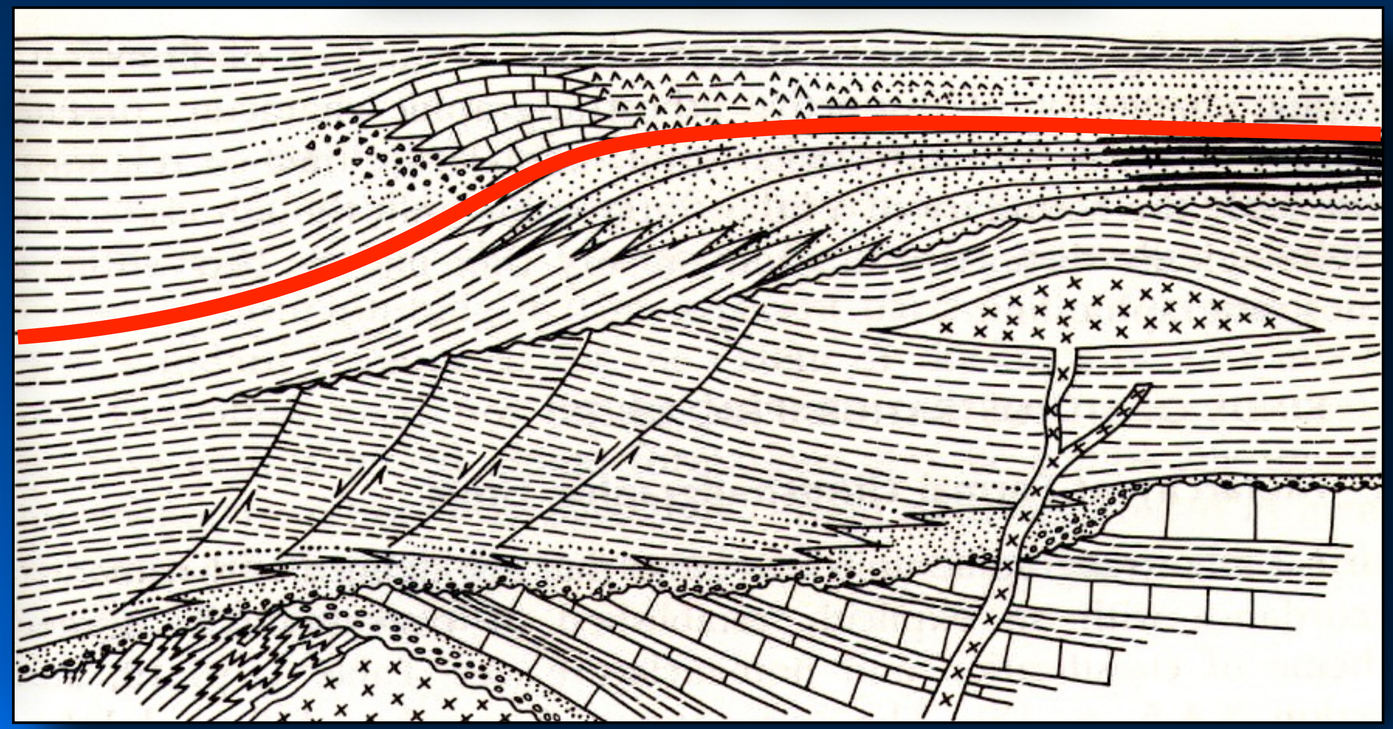

Diagram from Hedberg (1976)

Stratigraphy: Zonation & Correlation

Biostratigraphy

The branch of stratigraphy that deals with the fossil content of strata and with their organization into units based on the distribution of fossils.

Stratigraphy: Zonation & Correlation

Biostratigraphic Correlation

The matching of biozones in different stratigraphic sections or cores based on similarities or differences in their zone-defining taxa.