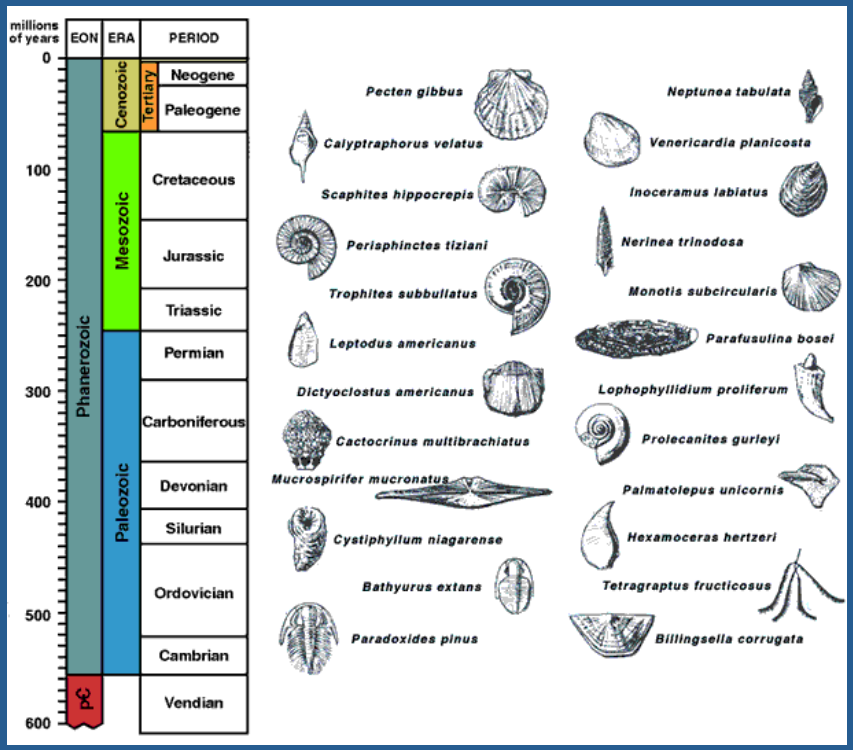
Biostratigraphy, Zones, and Index Fossils

- Biostratigraphy is the branch of stratigraphy which focuses on correlating and assigning relative ages of rock strata by using the fossil assemblages contained within them. Fossil assemblages are useful because the appearance of sediments of the same age can be very different depending on their depositional environments.

- A biozone is the fundamental unit of biostratigraphy. It is characterized by a specific assemblage of fossils present and is designated by the name of a distinctive index fossil. A biozone may be a few meters to several hundreds of meters thick and may be local to worldwide in lateral extent.

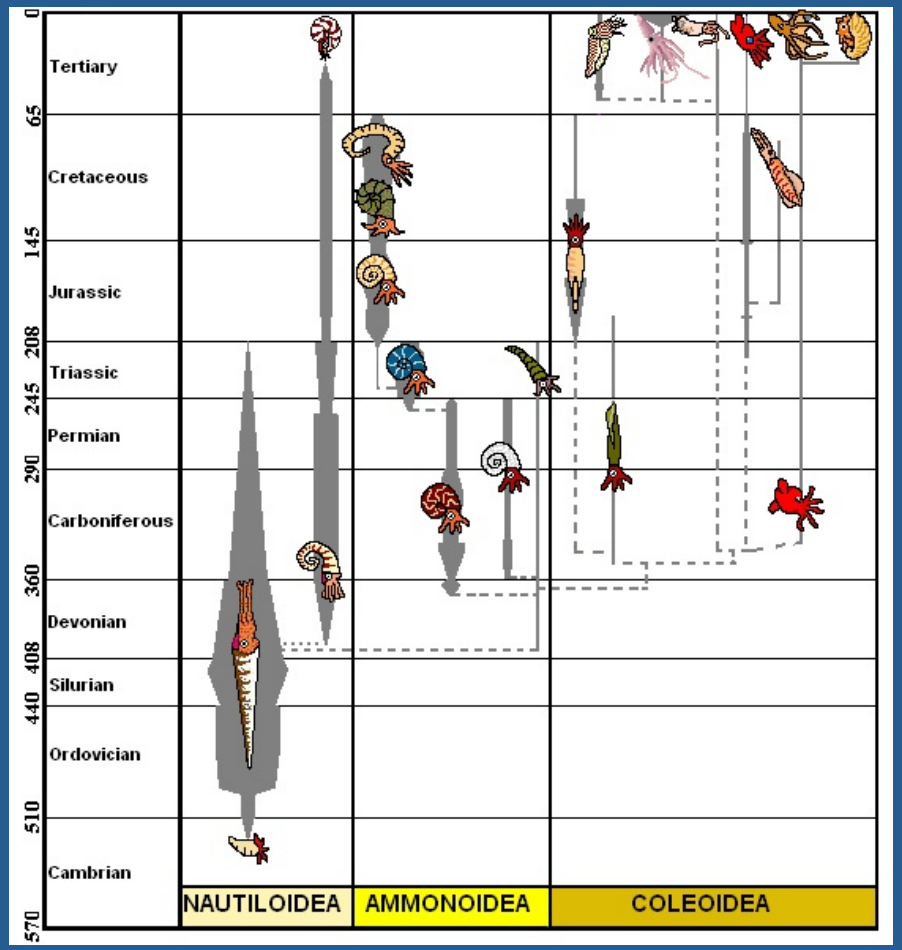
Index Fossils

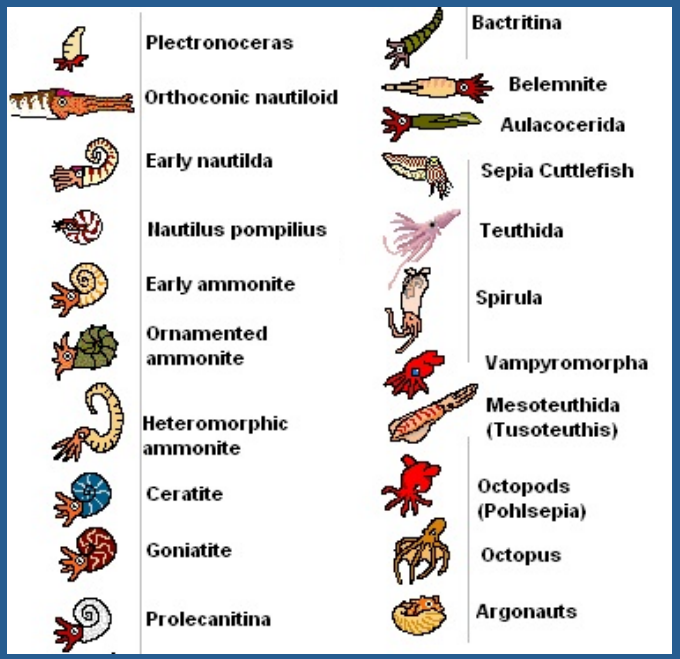
- To be useful for stratigraphic correlation, index fossils should be:
  - Independent of their environment
  - Geographically widespread
  - Rapidly evolving
  - Abundant
  - Easy to preserve
  - Easy to identify at the species level

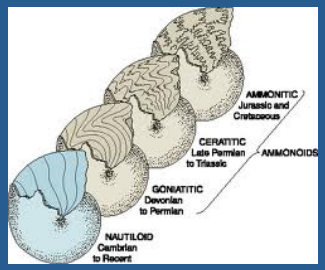


Geographically Widespread Index Fossils: Foraminifera

Rapidly Evolving Index Fossils: Ammonites







Index Fossils

Criteria / Fossil	Independent of environment	Fast to evolve	Geographically widespread	Abundant	Readily preserved	Easily recognised	Status as guide fossils
Graptolites	✓ (Plankton)	✓	✓ (Plankton)	✓	✓	✓ (Simple form)	Good (Ordovician to Silurian)
Ammonites	✓ (Free swimming)	✓	✓ (Free swimming)	✓	✓	✓ (Great diversity)	Good (Devonian to Cretaceous)
Corals	X (Need warm shallow sea)	X	X	✓	✓	✓	Poor (Carboniferous)
Echinoids	X (Bottom dwelling)	X	X	✓	✓	✓	Poor (Cretaceous)
Barnacles	X (Need rocky shore)	X	X	X	X	✓	Bad (not used)
Foraminifera	✓ (Plankton)	✓	✓ (Plankton)	✓	✓	✓	Good (Particularly Mesozoic to Recent)
Pollen	✓ (Wind blown)	✓	✓ (Wind blown)	✓	✓	✓	Good (Cretaceous to Recent)
Coccoliths	✓ (Plankton)	✓	✓ (Plankton)	✓	✓	✓	Good (Mesozoic to Recent)
Birds	✓ (Flying)	X	✓ (Flying)	X	X (Fragile bones)	✓	Bad (not used)

Figure 4.1 *Examples of good and bad guide fossils. The matrix illustrates how different fossil groups match up to the ideal criteria for a good guide fossil. It is important to note that each criterion is not necessarily of equal importance. For example, preservation potential is of greater importance than widespread distribution. Bird fossils, otherwise well-suited as guide fossils, are rarely preserved and therefore, make poor guide fossils*

- Many marine benthic organisms have a planktonic larval stage that lasts several weeks, during which ocean currents can disperse the larvae a considerable distance. In only a few thousand years, the organism will be distributed as widely as geographic barriers and the constraints of habitable temperatures allow.

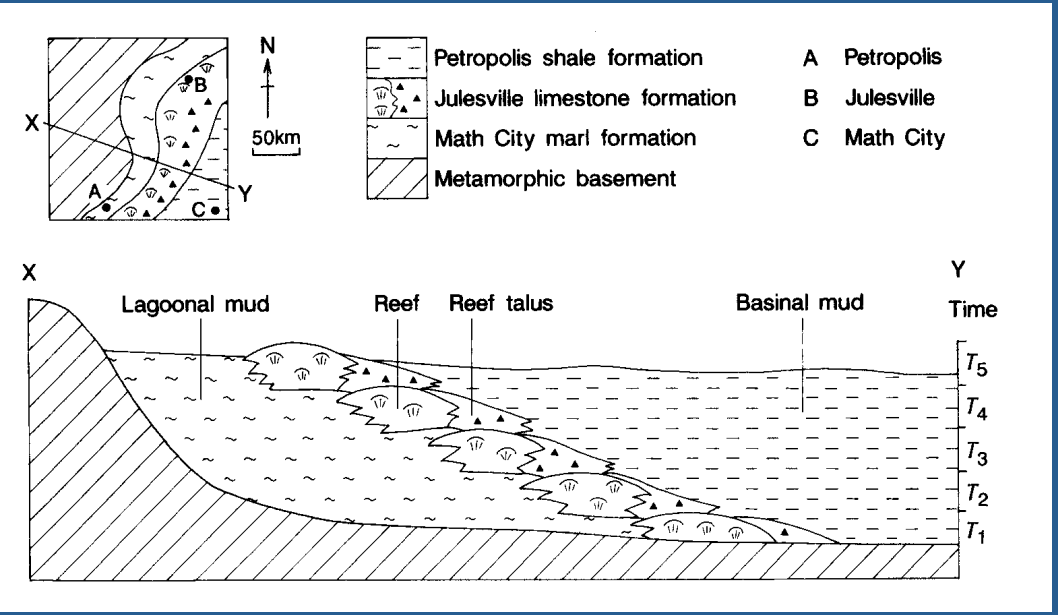
Diachronism

- Some lithostratigraphic and biostratigraphic units show evidence of simultaneous deposition over wide areas and can be considered to be synchronous units.

- Other units may be related to narrow depositional environments, which may be expected to shift laterally with advancing time. These units would differ widely in age depending on where they were deposited and are known as diachronous or time-transgressive units. Examples are found in strand-line deposits of advancing seas and among deltaic sediments.

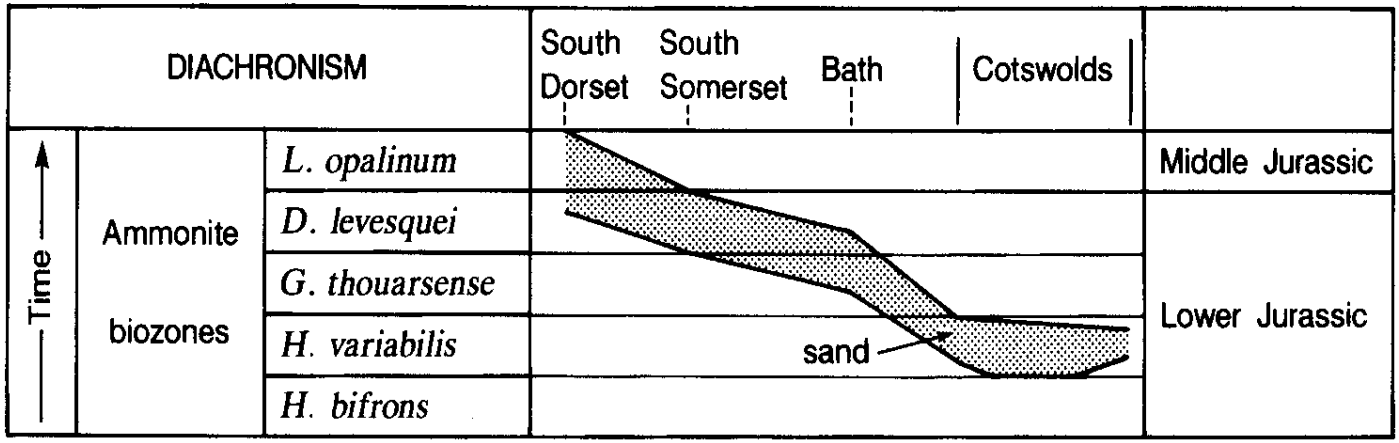
Diachronism

- In this hypothetical example, sedimentary facies migrate landward as sea level rises, creating formations of uniform lithology. As time advances, evolution or extinction will cause different fossil species to occur at different times in the same rock unit.



Diachronism

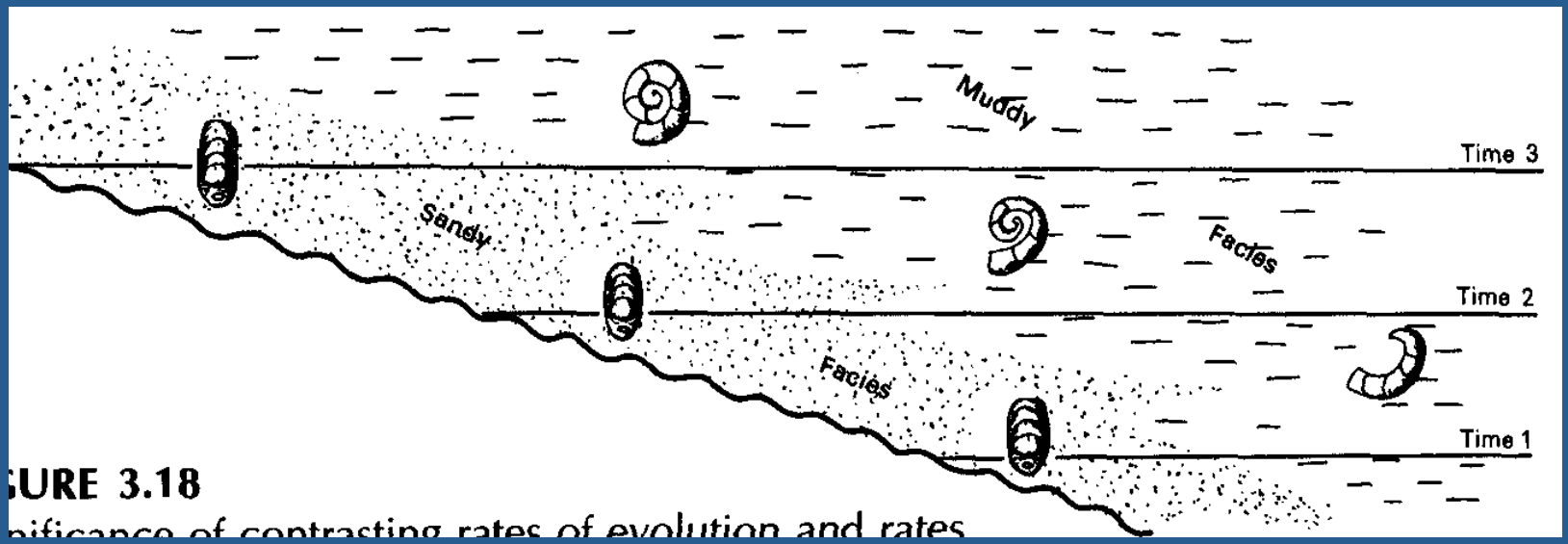
- Migration of a Lower Jurassic marine sandstone facies in southern England through progressively younger ammonite biozones.



The sand horizon was laid down at different times in different regions and is said to be DIACHRONOUS

Diachronism

- Time-transgressive nature of facies indicated by use of widespread, rapidly evolving cephalopods as index fossils rather than slowly evolving brachiopod tied to bottom environment.



URE 3.18
nificance of contrasting rates of evolution and rates

Diachronism

- Geologically instantaneous events such as the deposition of ash layers provides an isochronous horizon that may not coincide with lithologic boundaries.

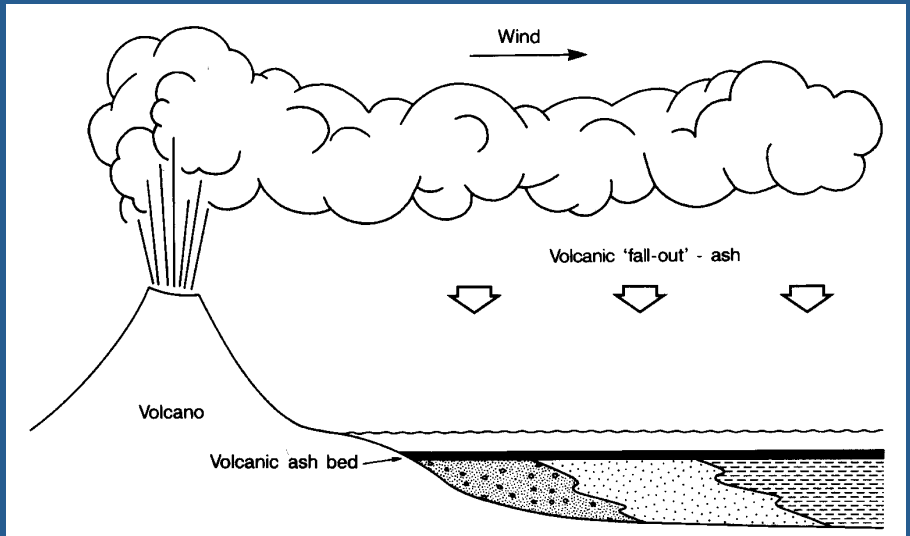


Figure 4.5 *Tephrostratigraphy: an example of event stratigraphy. The layer of volcanic ash is deposited across several different depositional environments or facies and provides an isochronous horizon*

Chronostratigraphy

- Chronostratigraphy is the branch of stratigraphy which studies the age of rock strata in relation to time.
- Its goal is to define relative geological time units using biostratigraphy within a geological region, and to extend these definitions worldwide in order to establish a global geological time scale.
- The global geological time scale may be refined using event stratigraphy.

Chronostratigraphy

- The best chronostratigraphic records are those which contain stratigraphic sections for a particular time interval having nearly continuous sedimentation and an abundant fossil record.
- Since gaps in time are common, the best records are usually those of short stratigraphic and time intervals.
- Placing single boundaries is much easier than choosing an interval showing both the top and bottom of a biozone. To avoid errors, the base of a time interval is defined at one place, not the top.

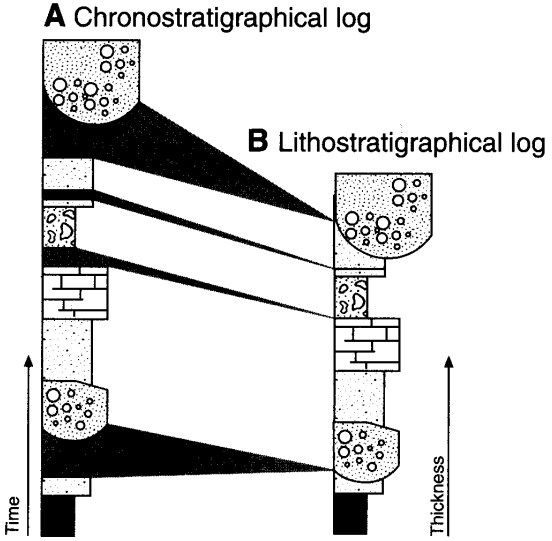
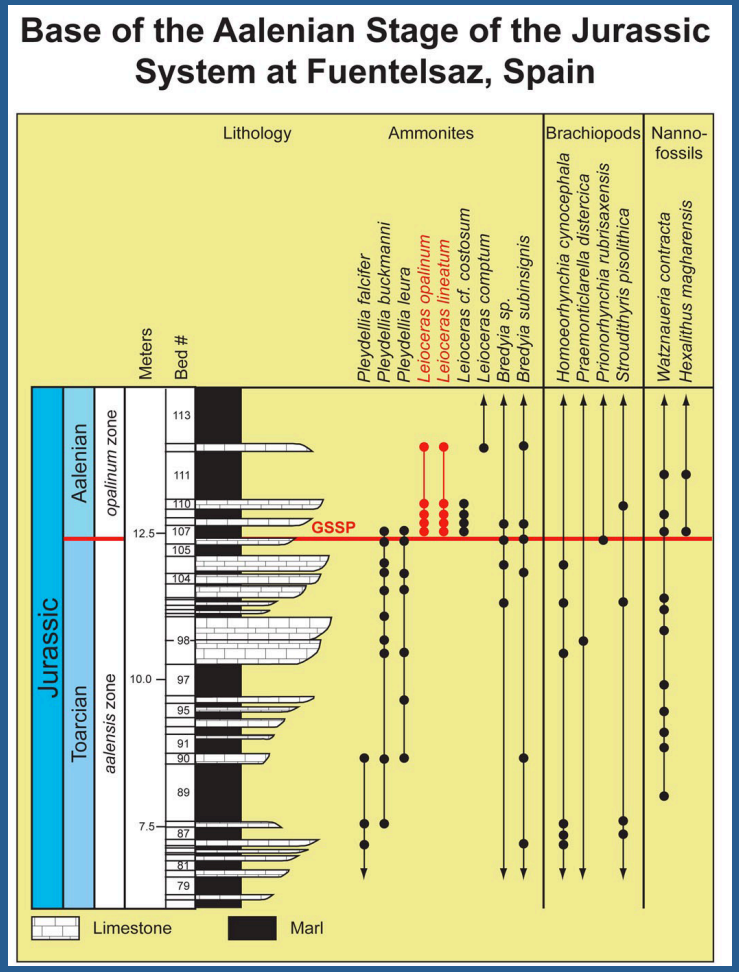


Figure 4.11 *The relationship of chronostratigraphy and lithostratigraphy. The same rock succession is plotted in (A) with time as the vertical axis, and in (B) with thickness as the vertical axis. Thickness is not a true indicator of time elapsed, because there are periods of non-deposition (hiatuses) which are clearly illustrated on the chronostratigraphical log.*

Global Boundary Stratotype Section and Point

- A Global Boundary Stratotype Section and Point, abbreviated GSSP, is an internationally agreed upon stratigraphic section which serves as the reference section for a particular boundary on the geologic time scale. Most, but not all, GSSPs are based on paleontological changes. Hence GSSPs are usually described in terms of transitions between different faunal stages.



Global Boundary Stratotype Section and Point

- Once a GSSP boundary has been agreed upon, a "golden spike" is driven into the geologic section to mark the precise boundary for future geologists (though in practice the "spike" need neither be golden nor an actual spike).

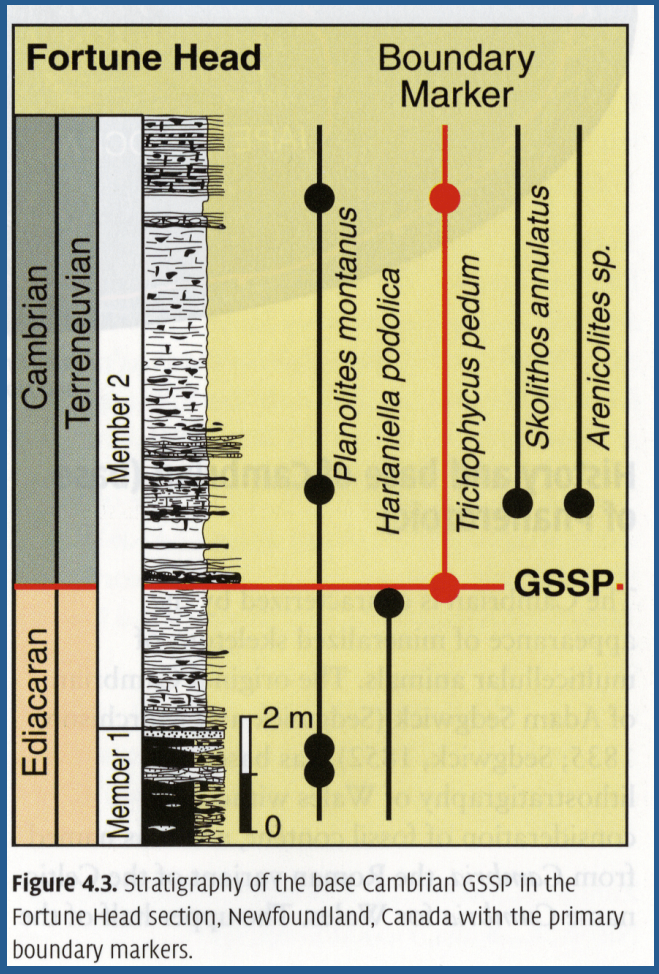


Figure 4.3. Stratigraphy of the base Cambrian GSSP in the Fortune Head section, Newfoundland, Canada with the primary boundary markers.

Global Boundary Stratotype Section and Point

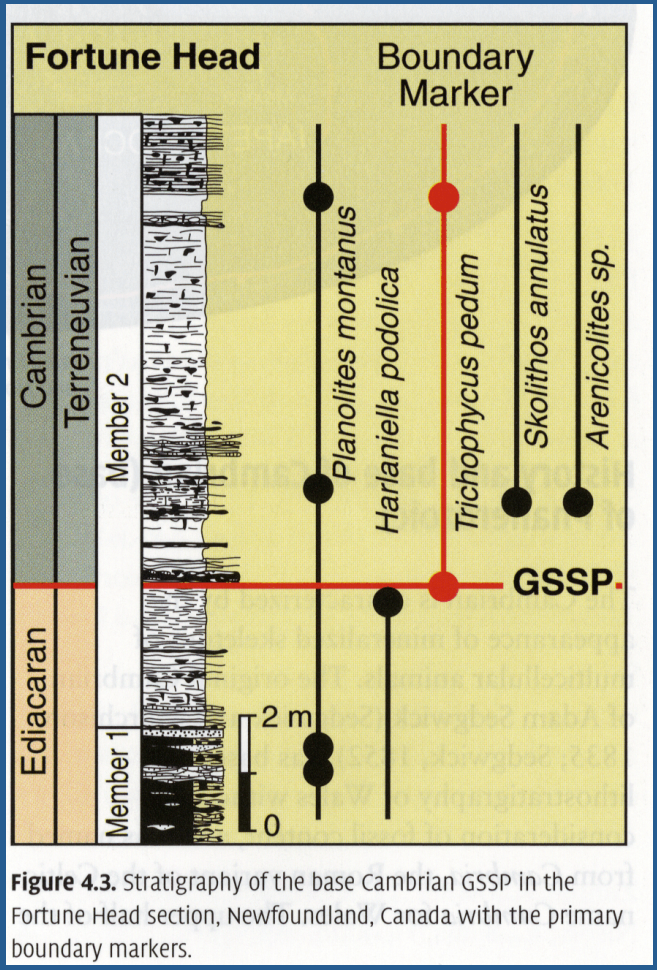


Figure 4.3. Stratigraphy of the base Cambrian GSSP in the Fortune Head section, Newfoundland, Canada with the primary boundary markers.

- The first appearance of vertical burrows in the geological record is used here to define the Precambrian-Cambrian boundary.

Global Boundary Stratotype Section and Point