4. Biostratigraphy

4.1 Fossils as a basis for stratigraphic subdivision

☆ Principle of faunal succession

Rocks formed during any particular interval of geologic time can be recognized and distinguished by their fossil content from rocks formed during other time intervals.
William Smith in England (late 1700s) was the first to utilize fossils for characterizing, subdividing, and correlation strata from one area to another.
Deshayes in France (1830), Bronn in Germany (1831), and Lyell in England (1833) all subdivided Tertiary strata based on fossils. Lyell split the Tertiary strata into four units --- Eocene, Miocene, Older Pliocene, Newer Pliocene --- on the basis of the proportions of living to extinct species in the rocks. Until early 1800s, rock successions were divided into chronostratigraphic units of eonothem (Phanerozoic eonothem), erathem (Cenozoic erathem), system (Cretaceous system, Tertiary system), and series (e.g. Pliocene series).

☆ Concept of stage

French paleontologist Alcide d’Orbigny (1842) defined “stages” as groups of strata containing the same major fossil assemblages. He divided the Jurassic system into ten stages and the Cretaceous system into seven stages. His subdivision of the above two systems was not accepted by later workers. Nonetheless, d’Orbigny’s concept of stages was a significant contribution of the discipline of biostratigraphy.

☆ Concept of zone

Albert Oppel in France (1856) defined “zones” that are characterized by more than two taxa and having boundaries based on two or more documented first and/or last occurrences of the included characterizing taxa. This zone is now named “Oppel zone” or “**concurrent range zone**”. It is a type of assemblage zone (see below). The concept of zone allowed subdivision of stages into two or more, smaller biostratigraphic units. “Zones” constitute the basic unit of biostratigraphic classification.

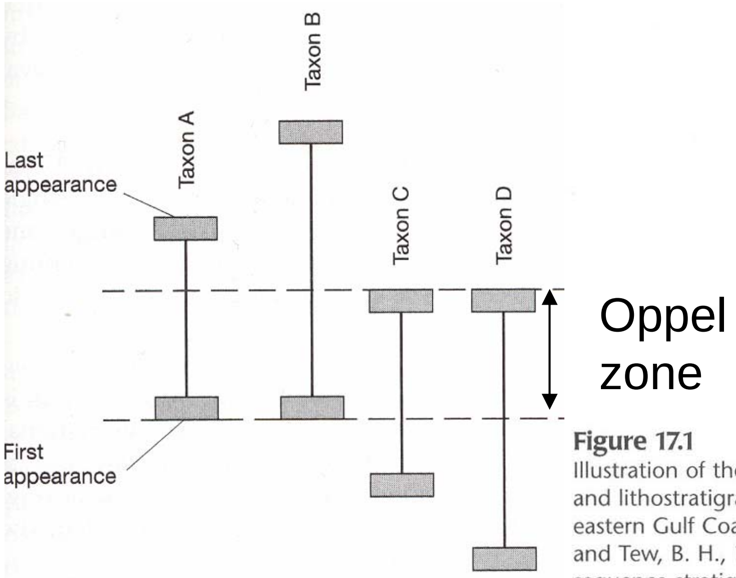


Figure 17.2
Diagrammatic illustration of an Oppel zone defined by overlapping ranges of two or more taxa.

Boggs (2001)

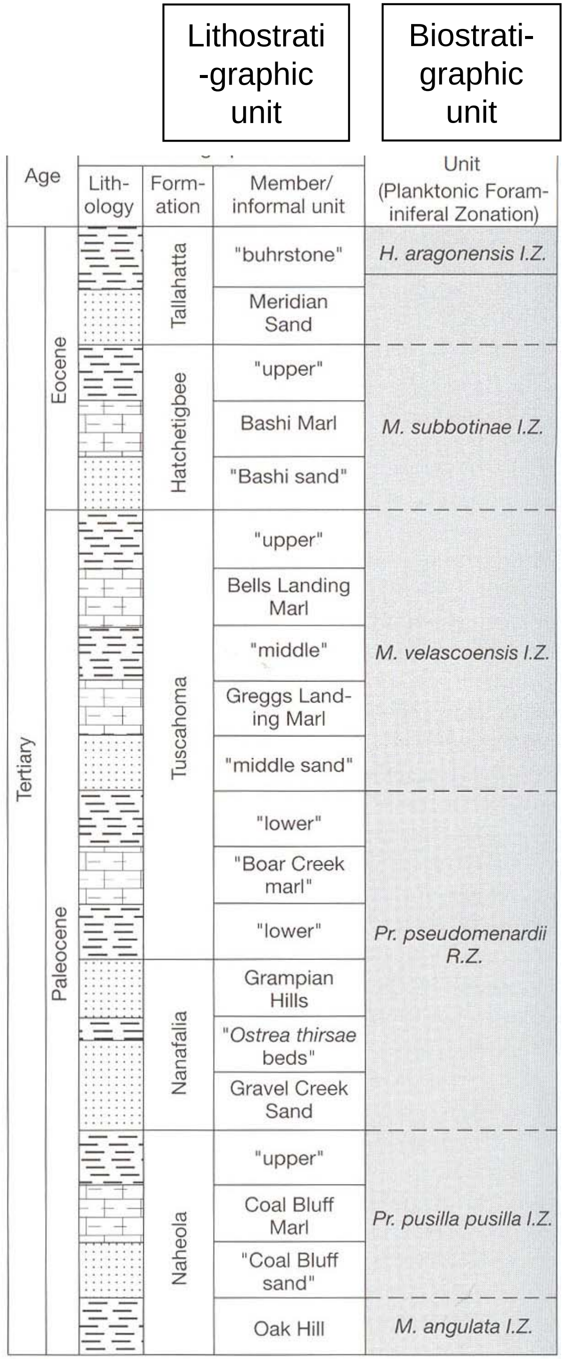


Figure 17.1
Illustration of the relationship between biostratigraphic units and lithostratigraphic units, Tertiary sedimentary rocks of the eastern Gulf Coastal Plain, U.S.A. [Based on Mancini, E. A. and Tew, B. H., 1995, Geochronology, biostratigraphy and sequence stratigraphy of a marginal marine shelf stratigraphic succession: Upper Paleocene and Lower Eocene, Wilcox Group, eastern Gulf coastal plain, U.S.A., *in* Berggren, W. A., D. V. Kent, M-P Aubry, and J. Hardenbol (eds.), Geochronology and global stratigraphic correlation, Fig. 1, p. 282, SEPM Spec. Publ. 54.]

4.2 Biostratigraphic Units

☆Principal categories of zones (interval, assemblage, and abundance zones)

A. Interval zone
Interval zone is a body of strata between two specific, documented lowest and/or highest occurrences of single taxa. There are three basic types of interval zones:
1. Taxon range zone (International Stratigraphic Guide [ISG], Salvador, 1994, Figure *a* as shown below): The interval between the lowest and highest occurrences of a single taxon.

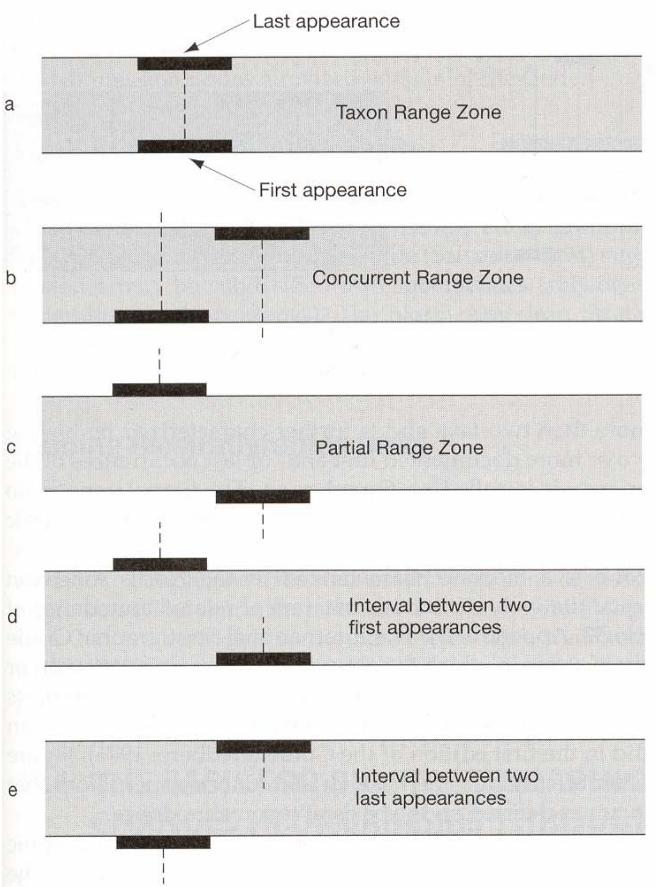


Figure 17.3
Diagram illustrating the principal kinds of interval zones as defined by the North American Stratigraphic Code (1983) and the International Stratigraphic Guide (1994).

2. Concurrent range zone and **partial range zone** (ISG, Figure b and c): The interval between the documented lowest occurrence of one taxon and the documented highest occurrence of another taxon. Concurrent range zone is used when the fossil occurrence results in stratigraphic overlap of the taxa (Figure b). When such occurrences do not result in stratigraphic overlap, the interval zone may be called a partial range zone (Figure c).

3. **The interval between documented successive lowest occurrences (Figure d) or successive highest occurrences of two taxa (Figure e).**

Boggs (2001)

B. Assemblage zone

An assemblage zone is a biozone characterized by the association of three or more taxa. If the zone is characterized by taxa without regard to their range limits, it is called an **assemblage zone**. If, on the other hand, it is characterized by more than two taxa and is further characterized by having boundaries based on two or more documented first and/or last occurrences of the included characterizing taxa, it is called an **Oppel zone**. Note that the Oppel zone is no longer recognized as a biozone in the International Stratigraphic Guide (Salvador, 1994).

Boggs (2001)

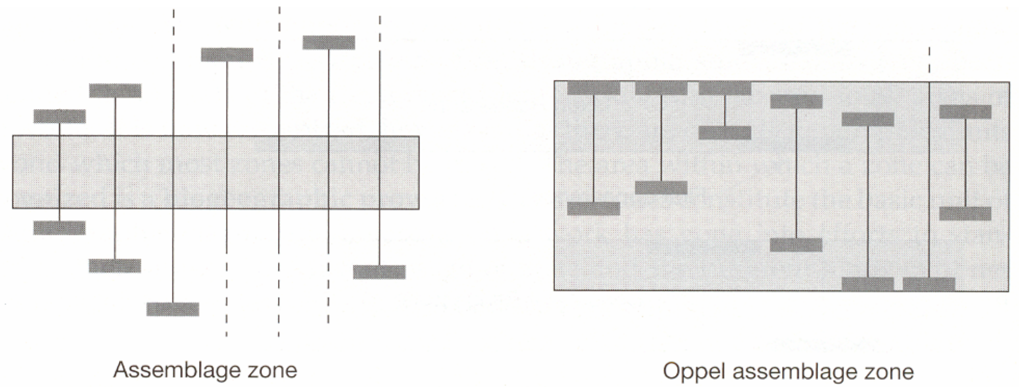


Figure 17.4
Two kinds of assemblage zones as defined in the North American Stratigraphic code.

C. Abundance zone

An abundance zone is a body of strata in which the abundance of a particular taxon or specified group of taxa is significantly greater than is usual in the adjacent parts of the section. The term “acme zone” is no longer used by ISG.

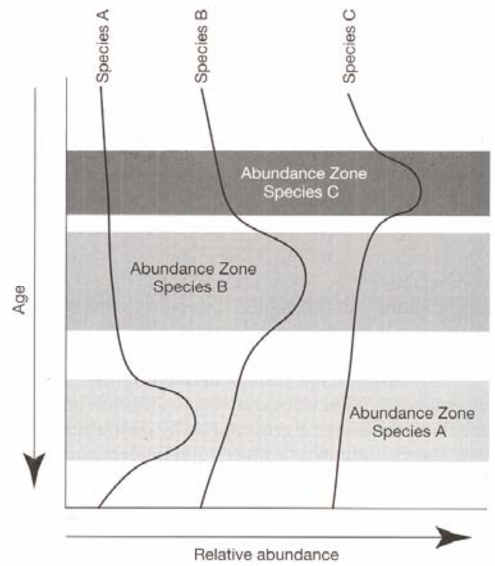


Figure 17.5
Schematic illustration of the abundance zones of three hypothetical fossil species. Note that each species reaches peak abundance (total number of individuals) at a particular time and then declines in abundance. Ages of the strata increase downward, and relative abundance increases to the right.

Boggs (2001)

Rank and naming of biostratigraphic units

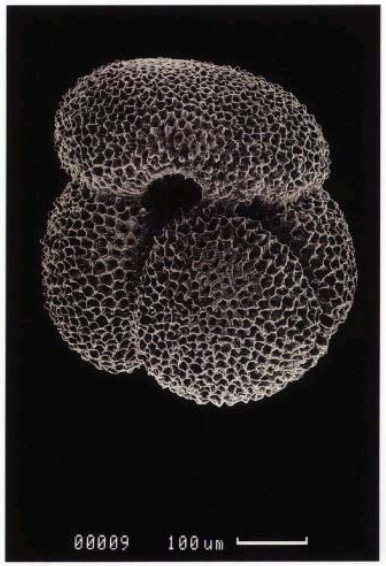
The zone, or biozone, is the fundamental unit of biostratigraphic classification. A zone may be divided into subzones and/or grouped into superzones. Each biozone is given a unique name, which is compound and designates the kind of biozone. The name may be based on (1) one or two characteristic and common taxa that are restricted to the biozone, reach peak relative abundance within the biozone, or have their total overlap within the biozone; and (2) Combination of letters derived from taxa which characterized the biozone.

However, alpha-numeric code designations (e.g., N1, N2, N3…) are informal and not recommended because they do not lend themselves readily to subsequent insertions, combinations, or eliminations. Example names are: *Exus albus* assemblage zone.

Calcareous nannofossils

Coccolithus pelagicus (Wallich)

Foraminifers



Alloglobigerinoides conglobatus (Brady)

EARLY MIOCENE TIME SCALE

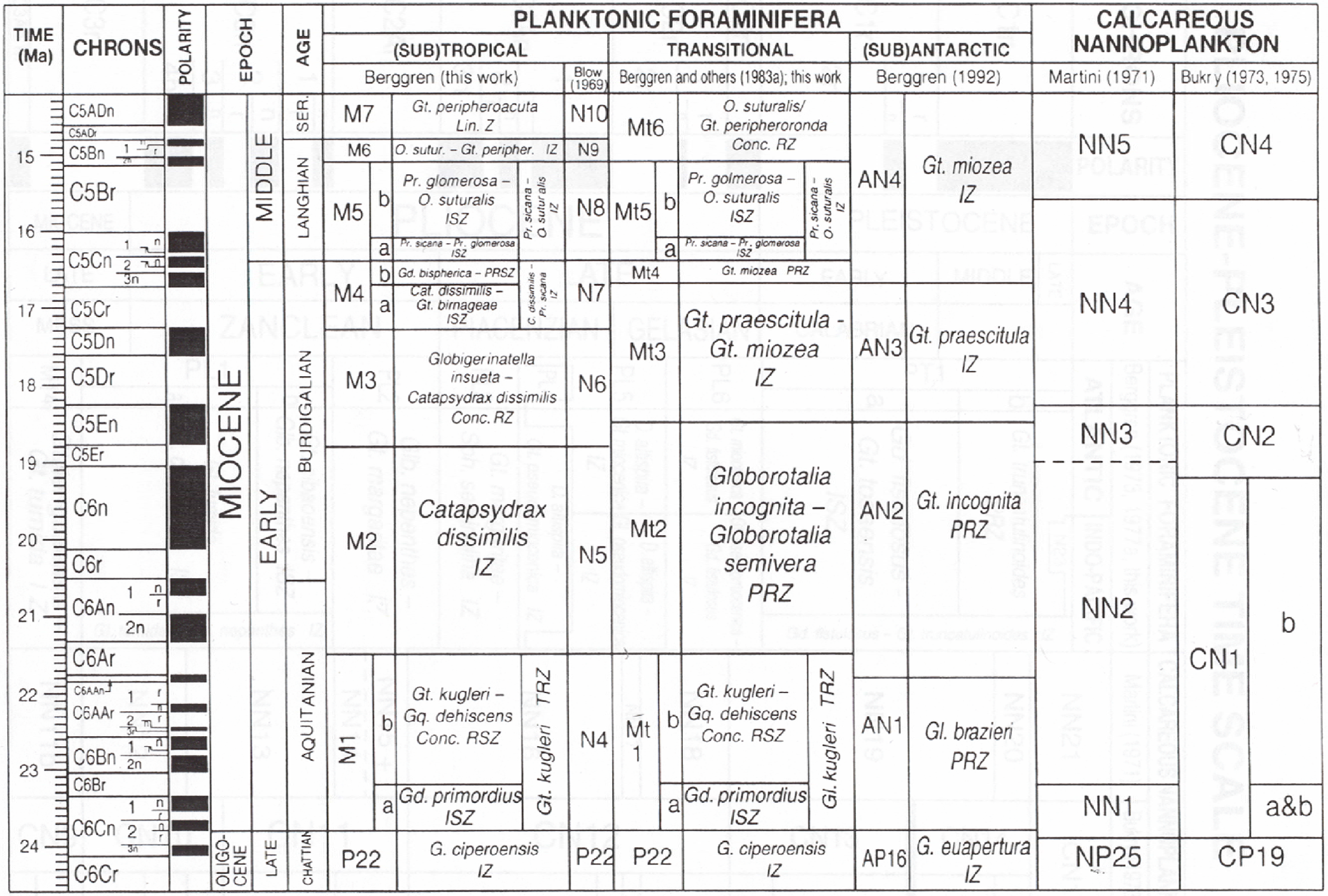


FIG. 4.—See Figure 1 for further explanation.

from Berggren et al. (1995)

4.3 Basis for Biostratigraphic Zonation: Changes in Organisms through Time

☆ Taxonomic classification (the Linnaean System)

Linne's basic classification scheme used a two-fold or binomial nomenclature. All beasties (plants and animals) were given two Latin names (**Genus** and **Species**) according to their morphology (their shape, size, ornamentation etc.). Here are some examples:

Genus	Species	General type
Tyrannosaurus	*rex*	A dinosaur
Pelicaria	*convexa*	A snail
Pinus	*radiata*	A pine tree
Escherichia	*coli*	A bacteria (*E. coli*) 大腸桿菌
Homo	*sapiens*	You and me

There are a couple of formatting things that you need to know about this binomial nomenclature. 1) the genus name is capitalized; the species name is not and 2) both names are italicized.

In addition, you may run into the terms **sp.** or **spp** (not italicized)**.** For example, *Palythoa* sp. or *Palythoa* spp. The first (sp.) is used when you do not specify a particular species. The second (spp.) means undistinguished species (i.e., it is the plural of sp.).

You may also occasionally see an authors name included with the species name, for example, *Archimedes wortheni* (Hall). Hall was the person credited with its description/naming.

The complete taxonomic grouping of animals goes as follows:
Kingdom (界：動物界 -- Animalia、植物界 -- Plantae、真菌界 -- Fungi、原生生物界 -- Protistae、原核生物界 -- Monera)
Phylum (門, about ninety Phylum)
Class (綱)
Order (目)
Family (科)
Genus (屬)
Species (種, several million species)

Example: The total classification of cats.

Phylum	Class	Order	Family	Genus	Species
Chordata 脊索動物門	Mammalia 哺乳綱	Carnivora 食肉目	Felidae 貓科	*Felis* 貓屬	*domesticus*
					leo
					onca
					concolor
				Panthera	*pardus* (leopard)
				Acinonyx	*jubatus* (cheetah)
			Canidae	*Canis*	*familaris* (dog)
					lupis (wolf)
					adjustus (jackal)
					latrans (coyote)
				Urocyon	*cinereoargenteus* (Grey Fox)
		Primates	Monkeys Humans, etc		
		Rodentia	Squirrels, Mices, Rats etc.		
	Aves (birds)				
	Reptilia				
Mollusca					
Arthropoda					
Annelida					

☆ Changes in species through time

Species variations are one-directional and nonreversible. Once a species has become extinct, it does not reappear in the fossil record. Two main factors drive evolution of species:
Gene mutation (or gene pool combinations) and Environmental change

Table 17.2 Estimated Mean Species Duration (in Millions of Years) for a Variety of Biological Groups

Biological group	Estimated mean species duration (Ma)
Marine diatoms	25
Benthic foraminifers	20–30
Planktonic foraminifers	>20
Bryophytes	>20
Marine bivalves	11–14
Marine gastropods	10–14
Higher plants	8–>20
Ammonites	~5 (but with a mode in the 1–2 Ma range)
Freshwater fish	3
Graptolites	2–3
Beetles	>2
Snakes	>2
Mammals	~1–2
Trilobites	>1

Source: Stanley (1985).

Boggs (2001)

Most species have limited time ranges, generally less than a couple of million years. One of the things that paleontologists try to do is to identify the age at which a species first evolves (this is called the FAD; the First Appearance Datum) and the age at which a species dies off (the LAD; last appearance datum).

A few definitions

First appearance datum (FAD)
The earliest (lowest) occurrence in a stratigraphic section for a particular species. First appearance occurs as members of a new species increase in numbers, they may eventually become abundant and widespread enough to show up in the geologic record.

Last appearance datum (LAD)
The latest (highest) occurrence in a section for a particular species. Last appearance occurs when the species is no longer able to adjust to shifting environmental conditions, its members decrease in number and eventually disappear.

Extinction
It refers to the disappearance by death of every individual member of a species or higher taxonomic group so that the lineage no longer exists.

Pseudoextinction (or phyletic extinction)
It refers to an evolutionary process whereby a species evolves into different species. Thus, the original species becomes extinct, but the lineage continues in the daughter species. For example, human beings today (*Homo sapiens*) replaced an earlier now extinct species (pseudoextinction) called *Homo sapiens neanderthalensis* (Neanderthal Man).

Index fossils
A species or genus of fossils that provides for especially precise correlation.
Ideally, index fossils should be: (1) independent of their environment [i.e. common in many kinds of sedimentary rocks]; (2) fast evolving [i.e. restricted to a narrow stratigraphic interval]; (3) geographically widespread; (4) abundant; (5) readily preserved; (6) easily recognizable (from other taxa).

Problems on identifying species boundaries (i.e. FAD/LAD), and on establishing the boundaries of biostratigraphic zones

1. Occurrence of fossils in local sections also controlled by environment during time of deposition.
2. The FAD of a new species in different provinces may show a time lag owing to lags in migration.

3. Sampling intervals (How small must they be to ensure that species boundaries are detected?)

4. Intermittent or punctuated patterns of sedimentation and erosion that yield an incomplete stratigraphic record, thus giving the appearance of punctuated speciation.

NOTE
The problem posed for biostratigraphy is to take the scrappy record we are given and make of it useful temporal correlations.

Coe (2003)

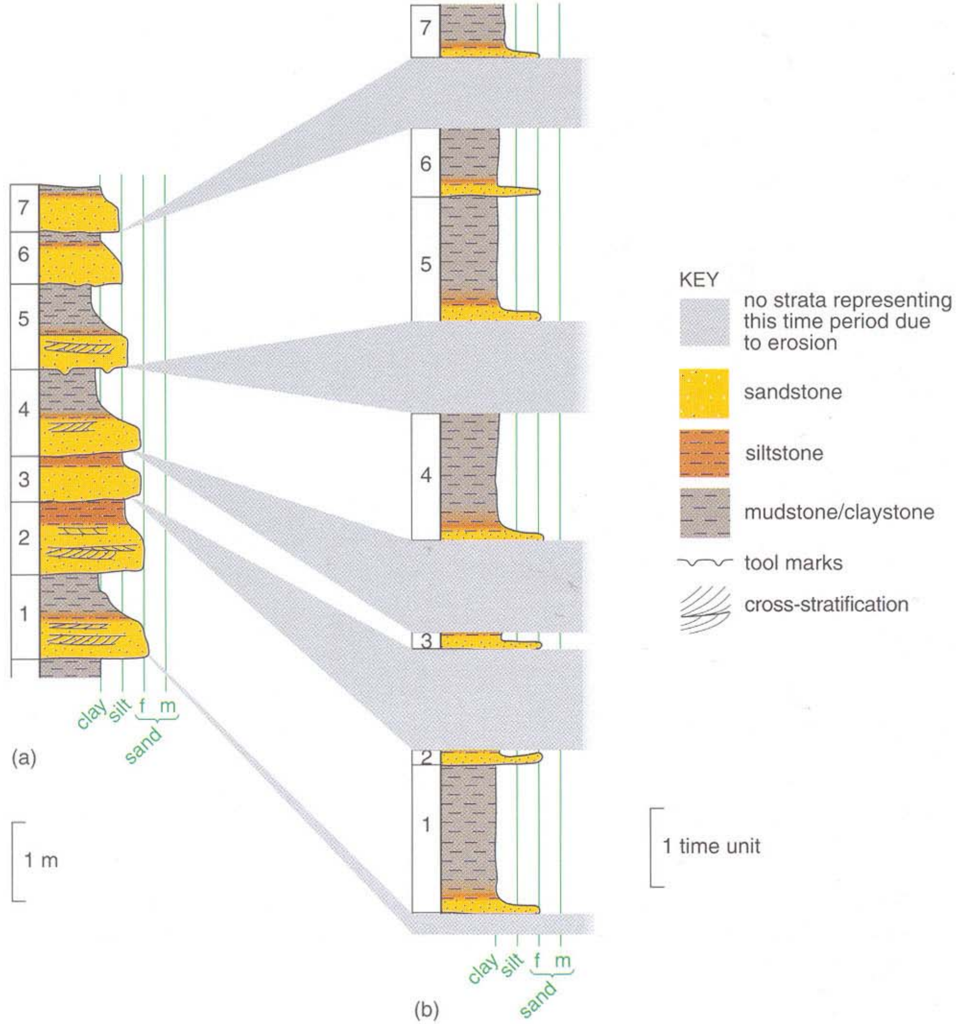


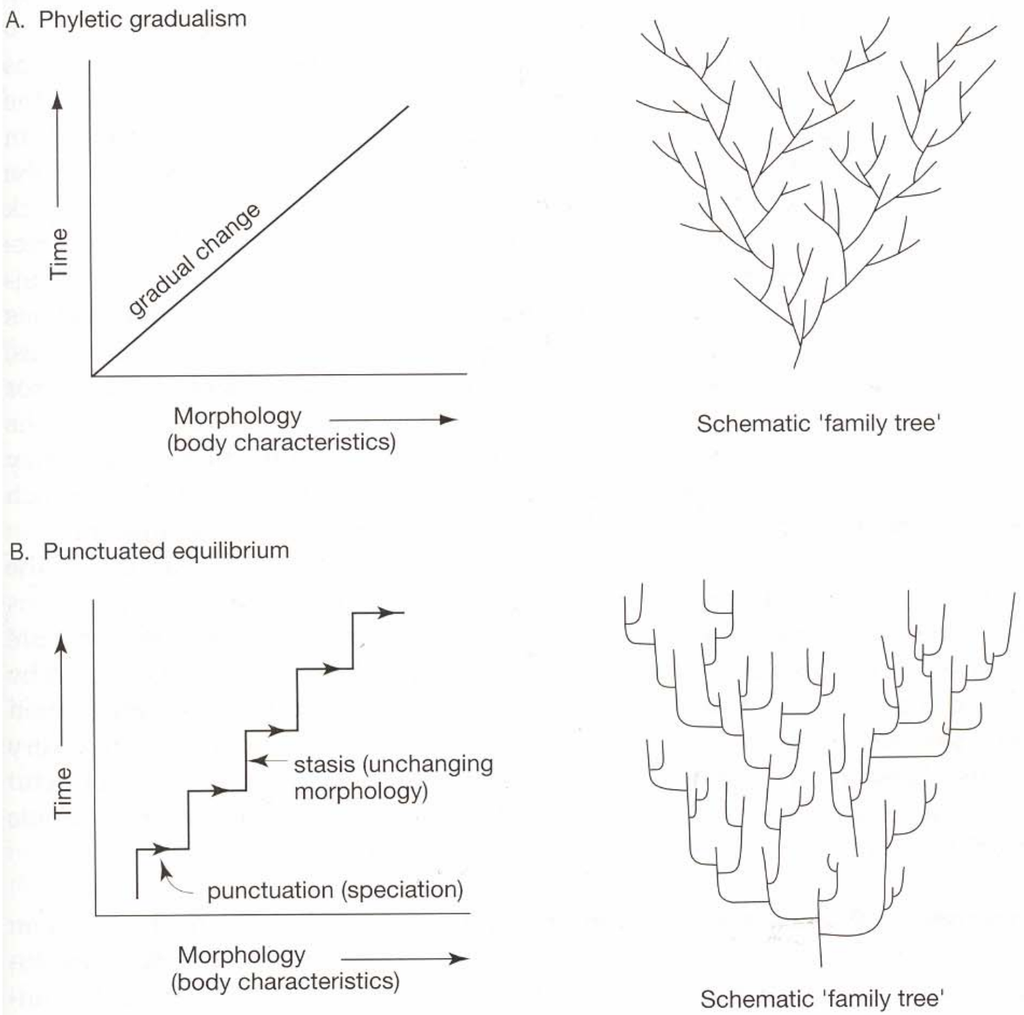
Figure 1.4 (a) Thickness and (b) chronostratigraphical representation of a succession of turbidites indicating how much time might be represented by gaps in the succession.

☆ Models and rates of evolution

Two views:

1. Phyletic evolution (or gradualism)

Evolution proceeds mainly as a gradual change by slow, steady transform of well-established lineages. The gradualist concept has been the traditional view of species evolution.

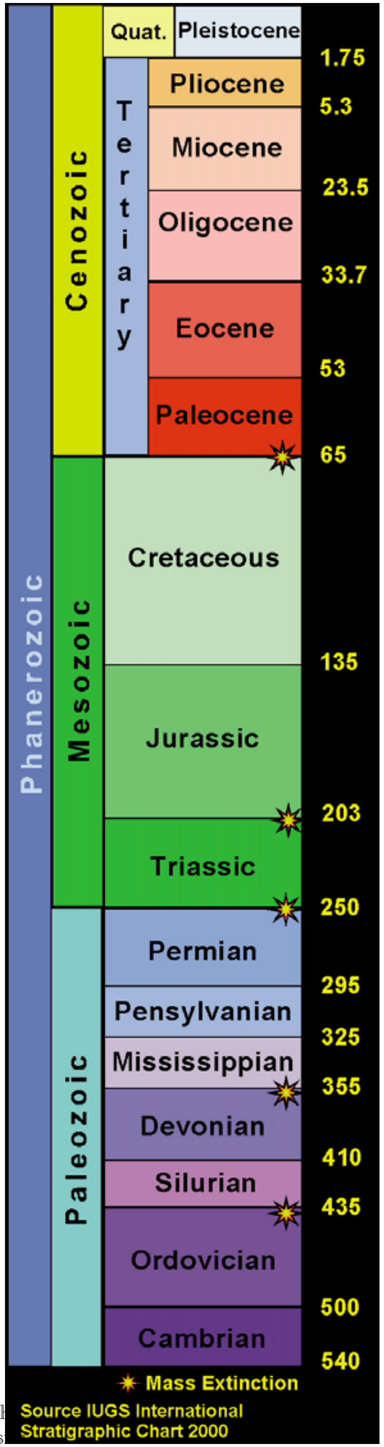


2. Punctuated equilibrium

Fossil populations are in stable equilibrium for long periods of time and change very little (called stasis), punctuated by sudden introduction of new species.

Boggs (2001)

Figure 17.8
Diagrammatic representation of gradualistic and punctuated models of evolution. [Schematic family trees after Stanley, W. H., 1979, Macroevolution, patterns and processes, W.H. Freeman and Company.]



☆Mass Extinctions

Five major extinctions (**Big five**)

1. End of Ordovician (~435 Ma)
2. End of Devonian (~355 Ma)
3. End of Permian (~250 Ma)
4. End of Triassic (~203 Ma)
5. End of Cretaceous (~65 Ma)

Boggs (2001)

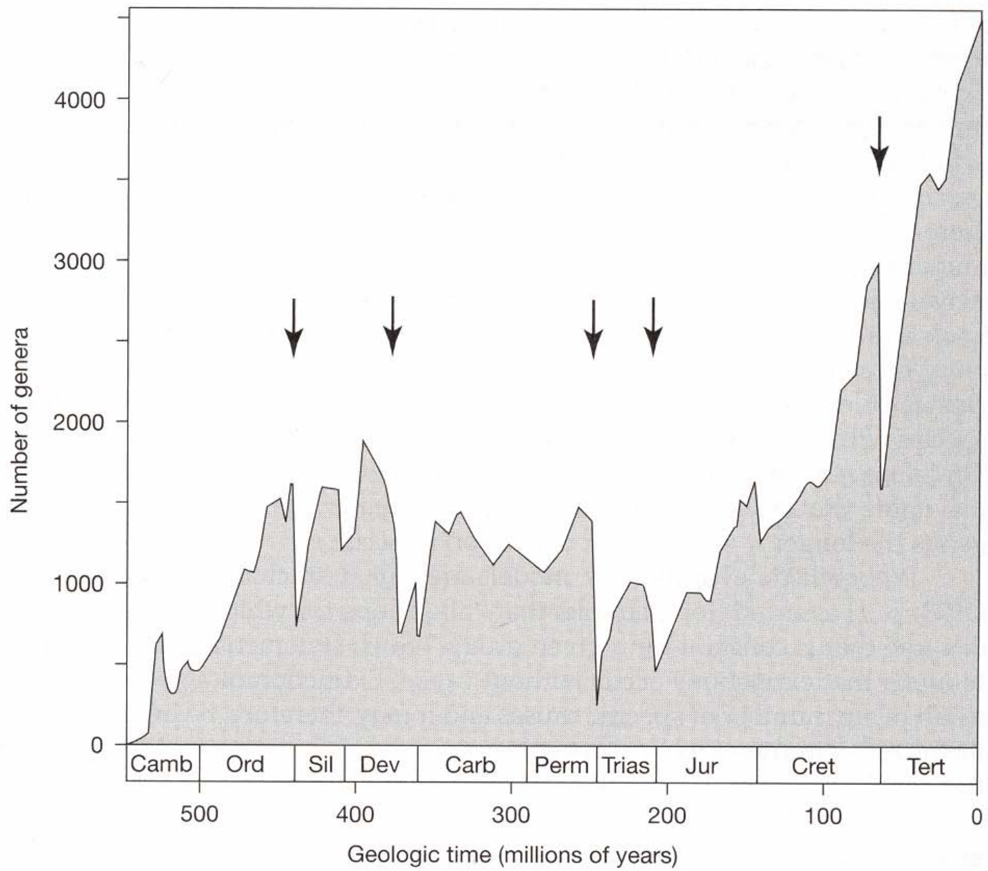


Figure 17.9
Diversity of marine animal genera (number of genera) during Phanerozoic time. Arrows point to the "big five," the five great mass extinctions. [After Sepkoski, J. J., Jr., 1995, Patterns of Phanerozoic extinction: a perspective from global data bases, *in* Walliser, O. H. (ed.), Global events and event stratigraphy: Springer-Verlag, Berlin, Fig. 1, p. 38. Reproduced by permission.]

Possible causes for mass extinctions

Extinction Event	Proposed Cause of Extinction					
	Bolide impact	Volcanism	Cooling	Warming	Regression	Transgression/ Anoxia
Late Precambrian						●
Late Early Cambrian					●	●
Late Cambrian			○			●
Late Ordovician			●	●	●	●
Late Devonian			○		○	●
Devonian-Carboniferous						●
Late Permian					●	
End-Permian		●		●	○	●
End-Triassic					●	○
Early Jurassic						●
Late Cretaceous			○			●
End-Cretaceous	●	●	●		●	○
End-Paleocene		●		●		●
Late Eocene			●			

● strong link ○ possible link

Boggs (2001)

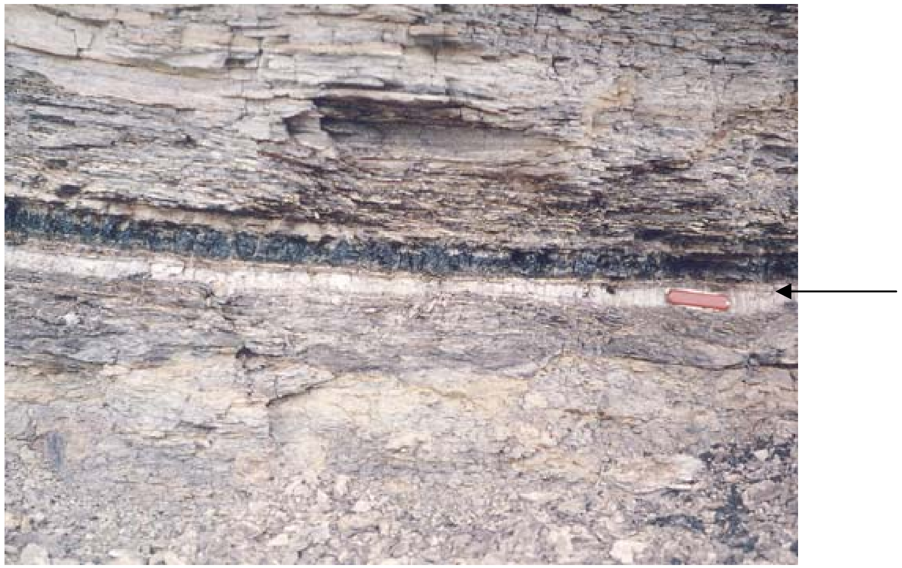
Figure 17.10
Proposed causes for the main Phanerozoic extinction events. [After Hallam, A., and P. B. Wignall, 1997, Mass extinctions and their aftermath: Oxford University Press, Table 11.1, p. 248. Reproduced by permission.]

The end of Cretaceous mass extinction (The K/T Boundary)

Sixty-five million years ago the curtain came down on the Age of Dinosaurs when a cataclysmic event led to mass extinctions of life. This interval of abrupt change in Earth's history, called the K/T Boundary, closed the Cretaceous (K) Period and opened the Tertiary (T) Period. At least 75 % of species on our planet were extinguished forever at this boundary.

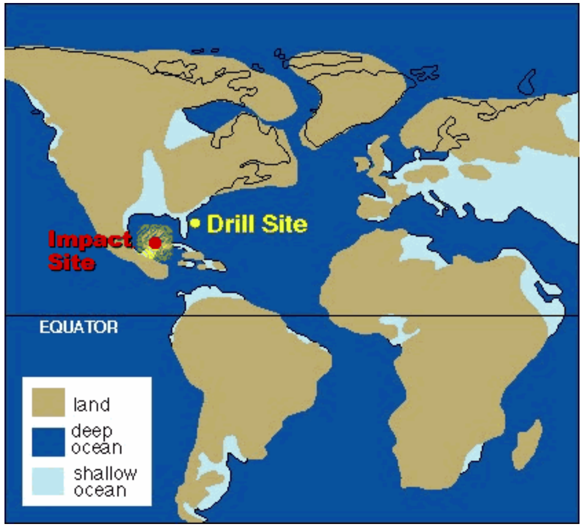
Rock deposited during the Cretaceous Period and Tertiary Period are separated by a thin clay layer that is visible at several sites around the world.

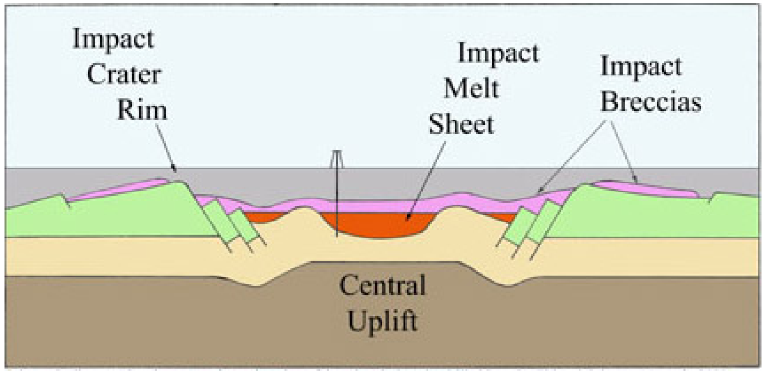
A team of scientists led by Luis Alvarez and his son Walter discovered that the clay layer contains a strikingly high concentration of iridium, and element that is much more common in meteorites/asteroids/comets than in Earth’s crustal rocks. Consequently, they proposed that an impacting asteroid or comet hit the Earth, generating the iridium anomaly, and causing the mass extinction event.



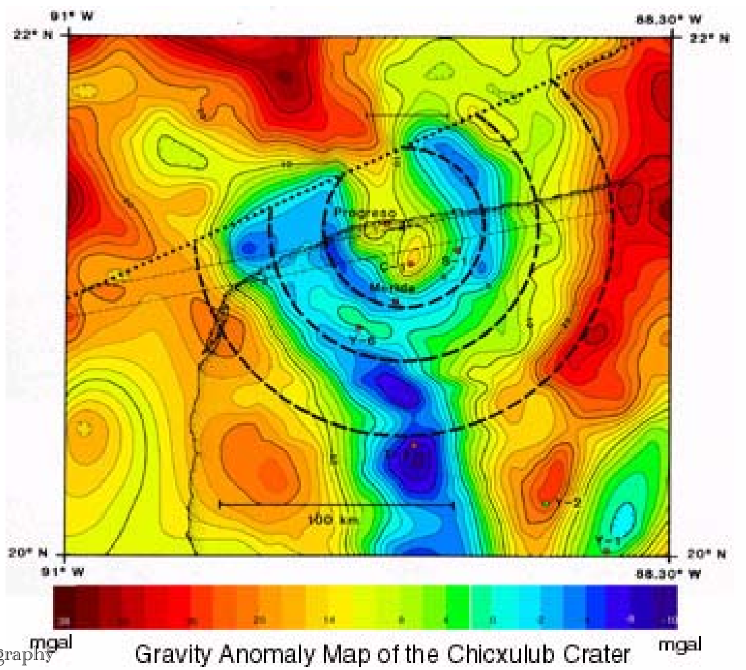
Photograph of the K/T boundary sequence at Raton Basin in Colorado. The light gray unit in the middle of the photograph (marked with the red knife) marks the K/T boundary (from: http://www.lpl.arizona.edu/SIC/impact_cratering/Chicxulub/Discovering_crater.html).

It is widely believed that an asteroid nearly 10 km wide slammed into what is now Mexico's Yucatan Peninsula about 65 million years ago. The impact blasted a180 kilometer-wide crater many kilometers deep into the Earth.



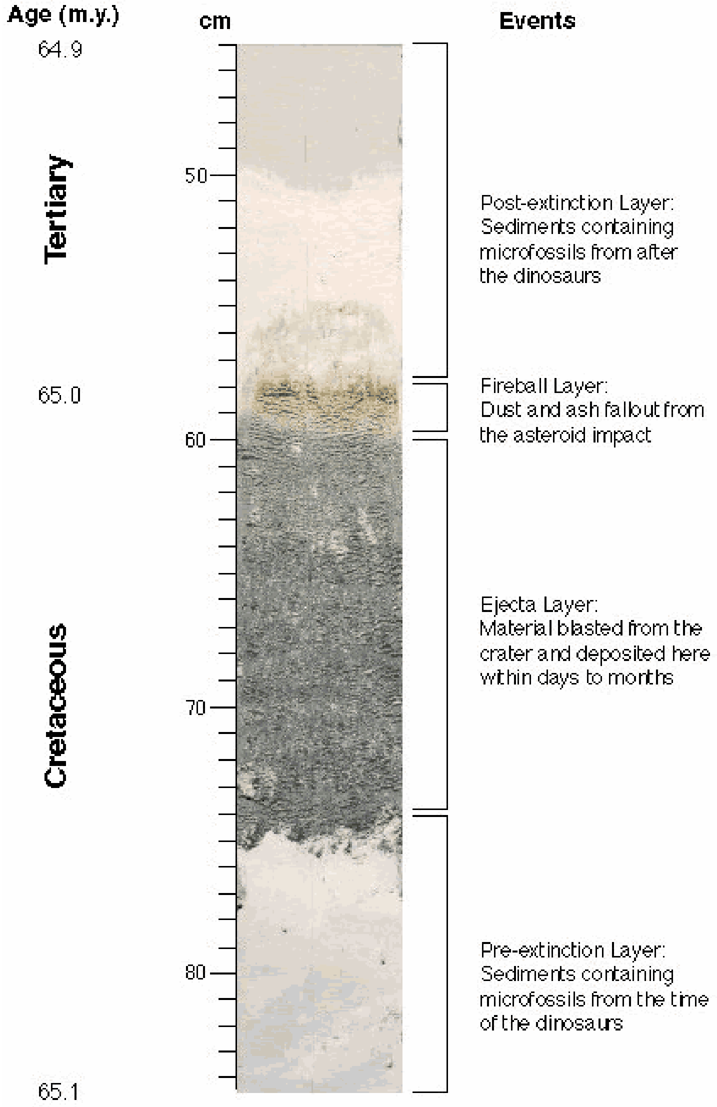


A cross section of the Chicxulub crater (from: http://www.lpl.arizona.edu/SIC/impact_cratering/Chicxulub/Discovering_crater.html).



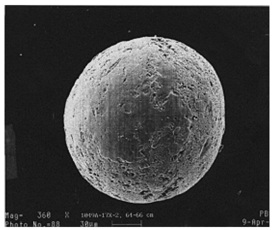
The heat of impact sent a searing vapor cloud speeding northward which, within minutes, set the North American continent aflame. This fireball and the darkness that followed caused major plant extinctions in North America. Environmental consequences led to global extinction of many plants and animals, including the dinosaurs.

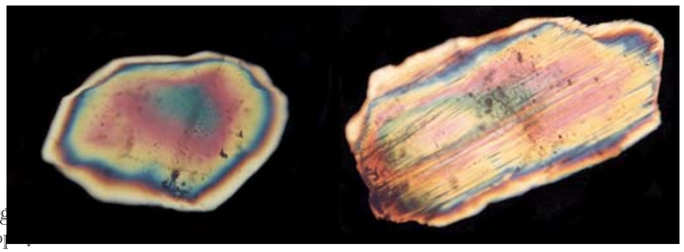
Gravity anomaly map of the Chicxulub crater in the Yucatan Peninsula, Mexico.



The drill ship *JOIDES Resolution* (ODP Leg 171B, 1997) obtained the core 480 km east of Florida - more than 1,920 km from the now buried impact crater. The core was drilled 2,658 m below the ocean surface and 128 m below the ocean floor.

Dust and ash fallout as well as material blasted from the crater are clearly evident in the deep-sea core. The boundary interval includes a 10-17 cm thick graded bed of green spherules capped by a fine-grained, rusty brown limonitic layer that is overlain by dark gray clay of the earliest Danian. This succession is interpreted as fallout from the Chicxulub impact structure on the Yucatan Peninsula and the succeeding deposition of lowermost Danian sediment following the K-T extinction event.





Examples of an unshocked quartz grain (left) and a shock-metamorphosed quartz grain (right) found in Haiti (from: http://www.lpl.arizona.edu/SIC/impact_cratering/Chicxulub/Discovering_crater.html)

4.4 Distribution of organisms in space: palaeobiogeography

☆Dispersal of organisms

Biogeographic province

Biogeographic province is the region within which a particular group or groups of plants or animals is distributed. Marine invertebrate organisms are utmost important in biostratigraphic studies. Therefore the following discussions are restricted to the said organisms.

Table 17.4 Classification of Marine Organisms by Habitat or "life style" — Boggs (2001)

Classification	Description	Example
Planktonic	Organisms that live suspended in the upper water column and which have only a very weak or limited ability to direct their own movements	
Phytoplankton	Have the ability to carry on photosynthesis; primary food producers, or autotrophs	Diatoms, dinoflagellates coccolithophoridae
Zooplankton	Do not carry on photosynthesis and thus cannot produce their own food (heterotrophs); feed on phytoplankton	Foraminifers, radiolarians, graptolites
Meroplankton	Spend only their juvenile stage as plankton; later become free-swimming or bottom-dwelling organisms	Larvae of most benthonic organisms such as molluscs
Pseudoplankton	Organisms distributed by waves and currents as a result of attachment to floating seaweed, driftwood, etc.	Mussels, barnacles, etc.
Benthonic	Bottom-dwelling organisms that live either on or below the ocean floor	
Sessile benthos	Benthos that attach themselves to the substrate (epifauna)	Crinoids, oysters, brachiopods
Vagrant benthos	Benthos that either creep or swim over the bottom (epifauna) or burrow into the bottom (infauna)	Starfish, echinoids, crabs, clams, worms
Nektonic	Organisms able to swim freely and thus move about largely independently of waves and currents	Mobile cephalopods, fish, sharks

Three types of marine invertebrate organisms on the basis of habitat: planktonic, benthonic, and nektonic.

Planktons are good for biostratigraphic zonation and correlation because of their widespread distribution.
Benthos are good for environmental interpretation because their remains are commonly preserved in the same environment in which they lived.
Nektons are less abundant in the fossil record than planktonic and benthonic organisms and have less value in biostratigraphic studies.

Barriers to Dispersal
Major factors that control the dispersal and distribution of species of marine invertebrate organisms are:

1. Temperature: Temperature barriers are most important latitutinally. Warm-water taxa vs. cold-water taxa
2. Geographic barrier: Geographic barriers arise out of the distribution pattern of landmasses and oceans and variations in water depths of the oceans.
3. Sea-level changes: Fluctuations in sea level cause significant interruptions in biogeographic provinces owing to variations in water depths on the continental shelves.
4. Plate movements: Major changes in the environmental framework of the marine realm occur as the geographic positions, configurations, and sizes of continents and ocean basins are changed by global plate tectonic processes.
5. Other barriers: Salinity difference, for example, constitute and important boundary between freshwater and marine provinces.

4.5 Combined effects of the distribution of organisms in time and space

The fossil record reflects the fact that both segregation into biogeographic provinces and organic evolution took place. Owing to **organic evolution**, we are able to correlate strata of a given age from one area to another and to work out the relative chronology of strata in a given area. Because many organisms were confined to **biogeographic provinces** in the past, however, we cannot always correlate time-equivalent strata from different environments because the organisms that existed in different biogographic provinces during the same period of time were different. Correlation between biogeographic provinces is difficult, and it is commonly not possible to make worldwide correlations.

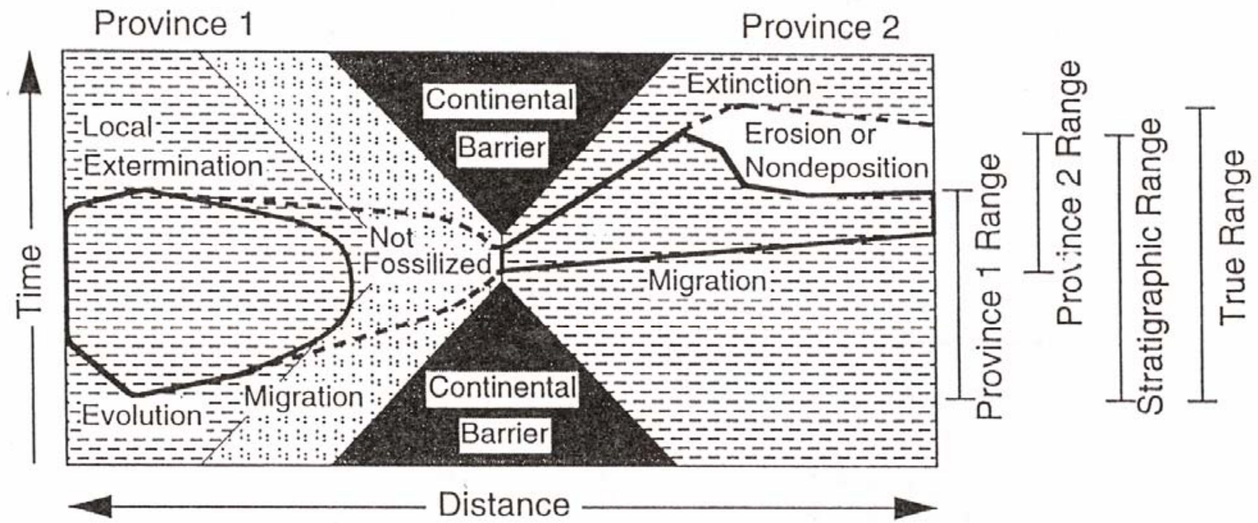


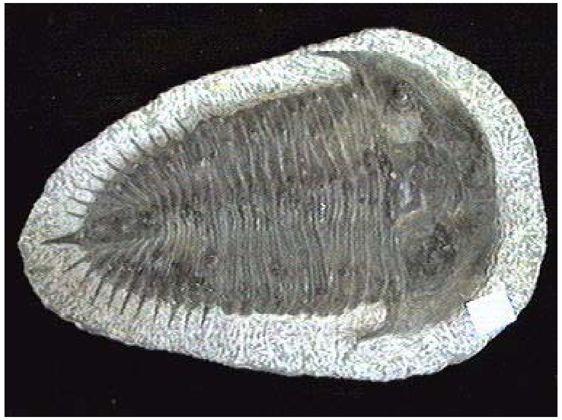
FIG. 2.—The geographic, stratigraphic, and true ranges of a hypothetical species. The first and last appearances of the species in the two provinces clearly differ temporally (modified from Hedberg, 1965 and Eicher, 1968).

4.6 Biocorrelation

☆Important macrofossil groups

Important macrofossil groups of marine invertebrate organisms for biostratigraphic zonation.

Trilobita (三葉蟲綱): e.g. **Trilobite** (三葉蟲)



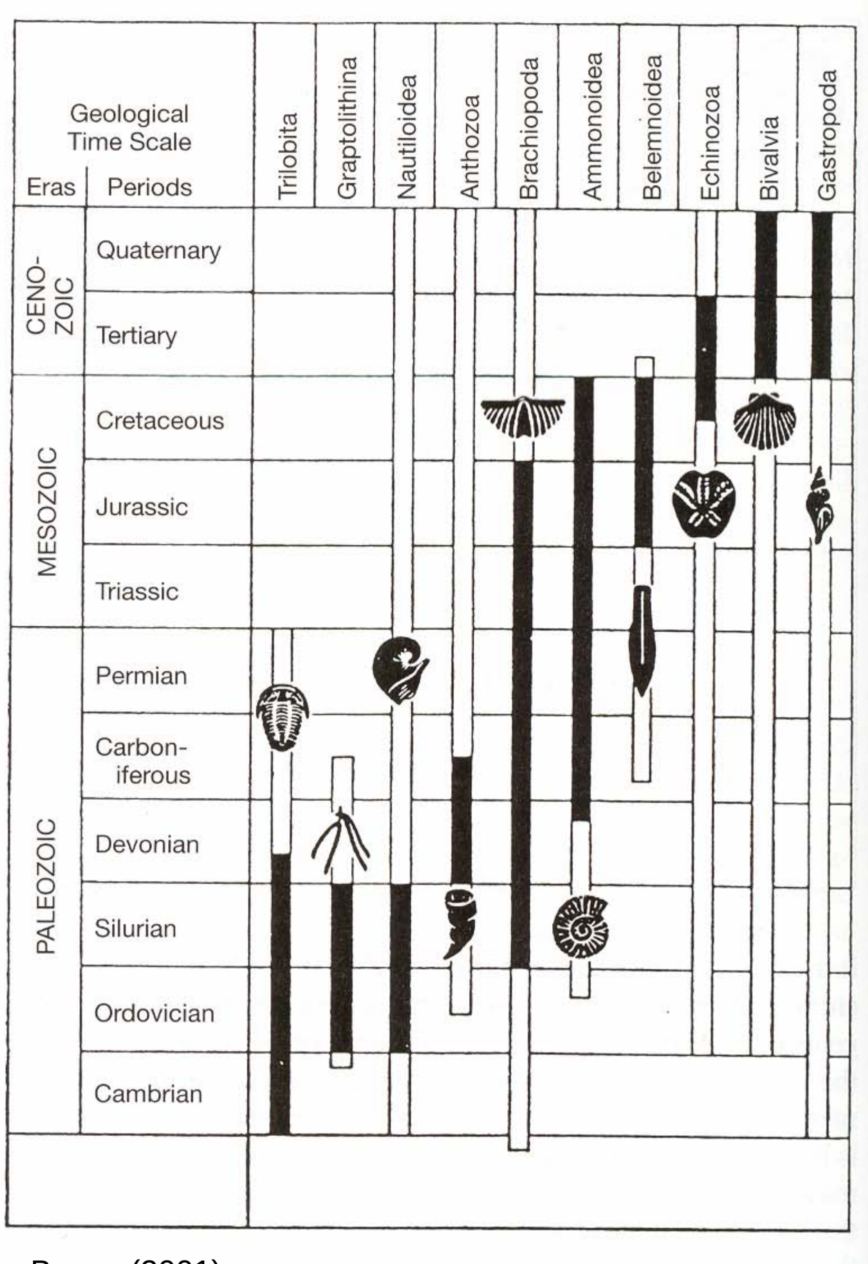


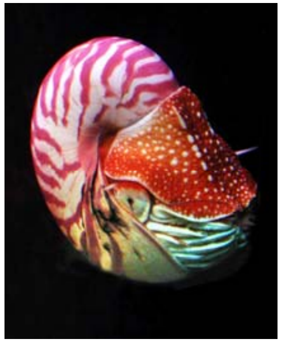
Figure 17.7
Some of the more important macrofossil groups of marine invertebrate organisms for biostratigraphic zonation. The white columns show the time span of distribution, the black columns the time span in which the organisms are important as index fossils. [From Thenius, E., 1973, Fossils and the life of the past, Fig. 50, p. 79, reprinted by permission of Springer-Verlag.]

Boggs (2001)

Graptolithina (筆石類):
e.g. **Graptolite** (筆石,
"writing on rock")

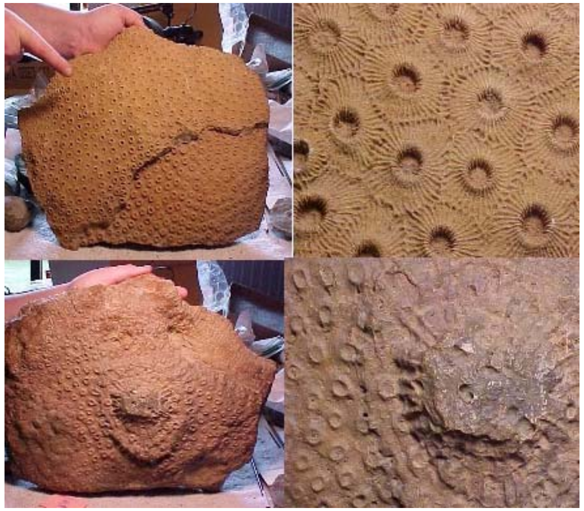
Brachiopoda (腕足動物門):
e.g. **Brachipod**

Nautiloidea (鸚鵡貝類):
e.g. **Nautilus**(鸚鵡螺)

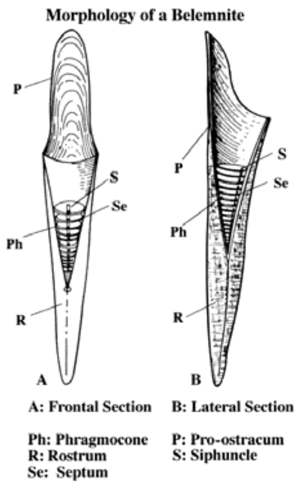


Ammonoidea (菊石類):
e.g. **Ammonite** (菊石)

Anthozoa (珊瑚蟲綱): e.g. **Coral** (珊瑚)



Belemnoidea (箭石類):
e.g. **Belemnite** (箭石)



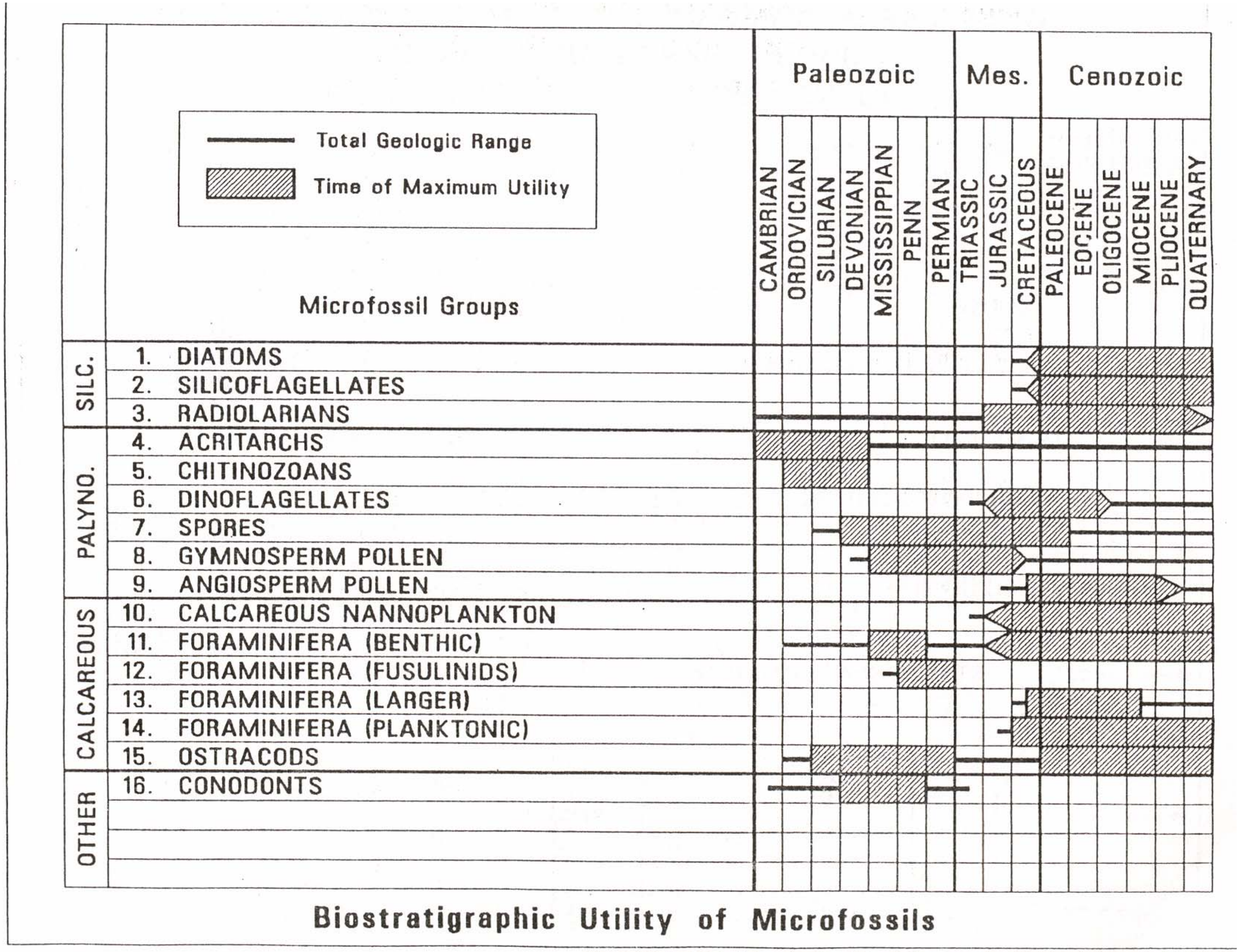
Echinozoa (棘皮動物亞門):
e.g. **Sea urchins** (海膽)

Crinoids (海百合)

Bivalvia (雙殼綱):
e.g. **Bivalve** (雙殼貝)

Gastropoda (腹足綱):
e.g. **Gastropod** (腹足動物)

☆**Important microfossil groups** for biostratigraphic zonation



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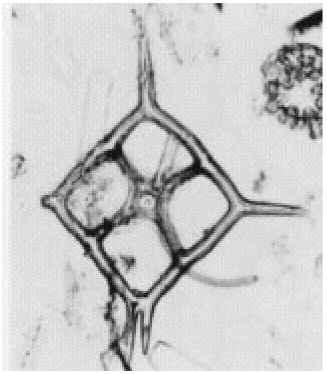
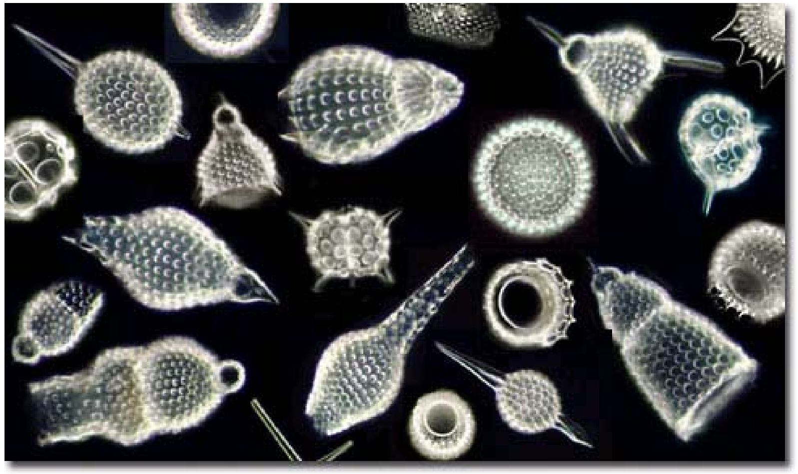
Diatoms（矽藻）

Silicoflagellates
(矽質鞭毛藻)

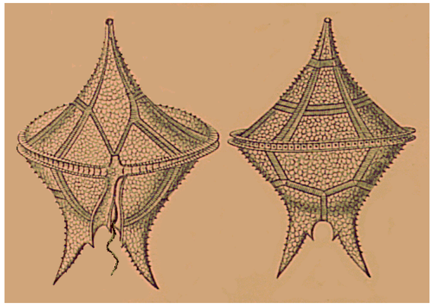


Radiolarians (放射蟲)

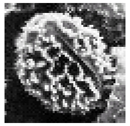


Acritarchs
Chitinozoans (殼質蟲)

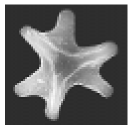
Dinoflagellates (腰鞭毛藻)

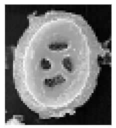


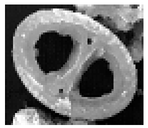
Spores (孢子)

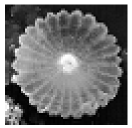


Calcareous nannoplankton
(鈣質超微化石)

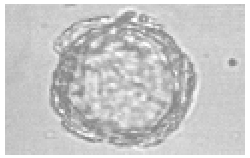


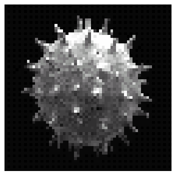






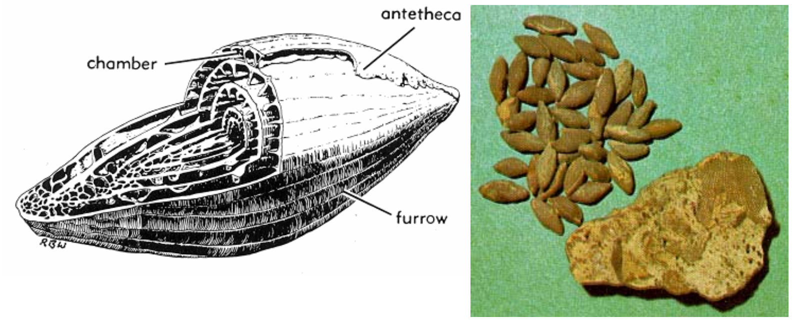
Gymnosperm pollen (裸子植物花粉)
Angiosperm pollen (被子植物花粉)



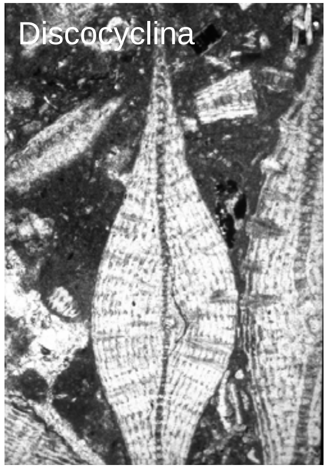


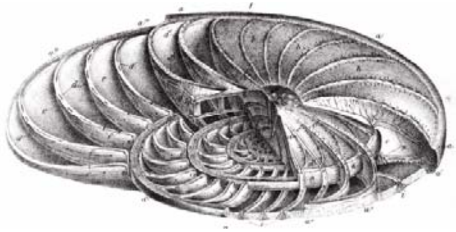
Foraminifera (benthic) (底棲性有孔蟲)

Foraminifera (Fusulinids) (紡錘蟲)



Foraminifera (larger) (大型有孔蟲)



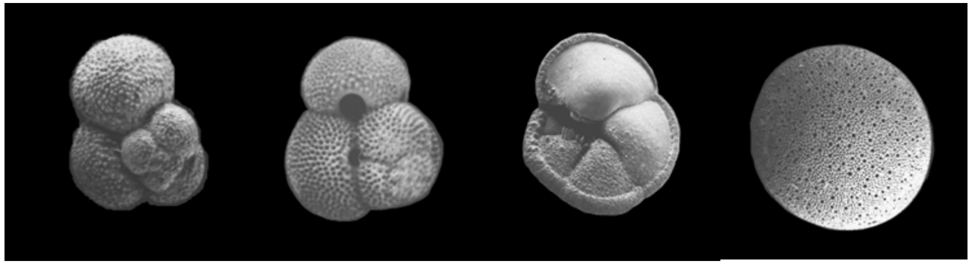


Operculina

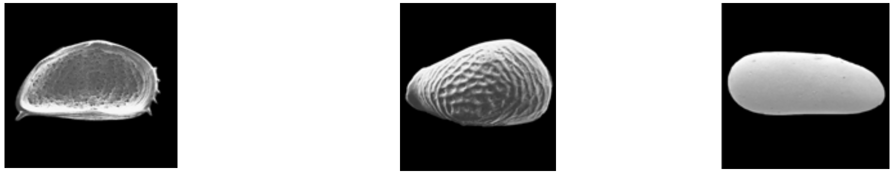
Nummulites

Lepidocyclina

Foraminifera (planktonic) (浮游性有孔蟲)

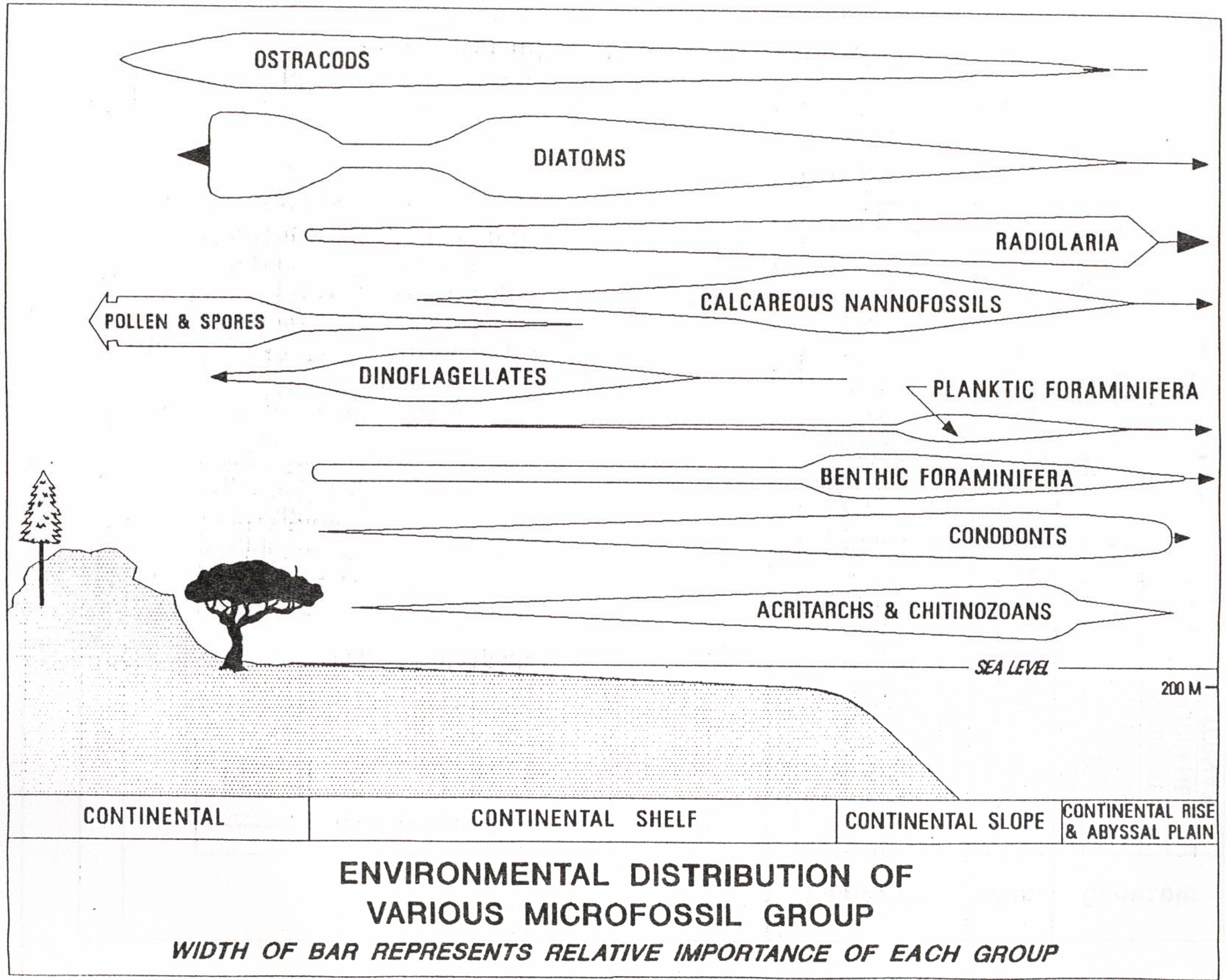


Ostracods (介形蟲)



Conodonts (牙形蟲)

Environmental distribution of important microfossil group



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☆Correlation by assemblage zone

Assembalge zones have particular significance as an indicator of environment, which may vary greatly regionally. Therefore, they tend to be of greatest value in <u>local correlations</u>.
The boundary between assemblage zones is inherently fuzzy because above and below the limits of this zone will be transition zones in which part of the characteristic fossil assemblage will be missing because it has not yet appeared or has already vanished.

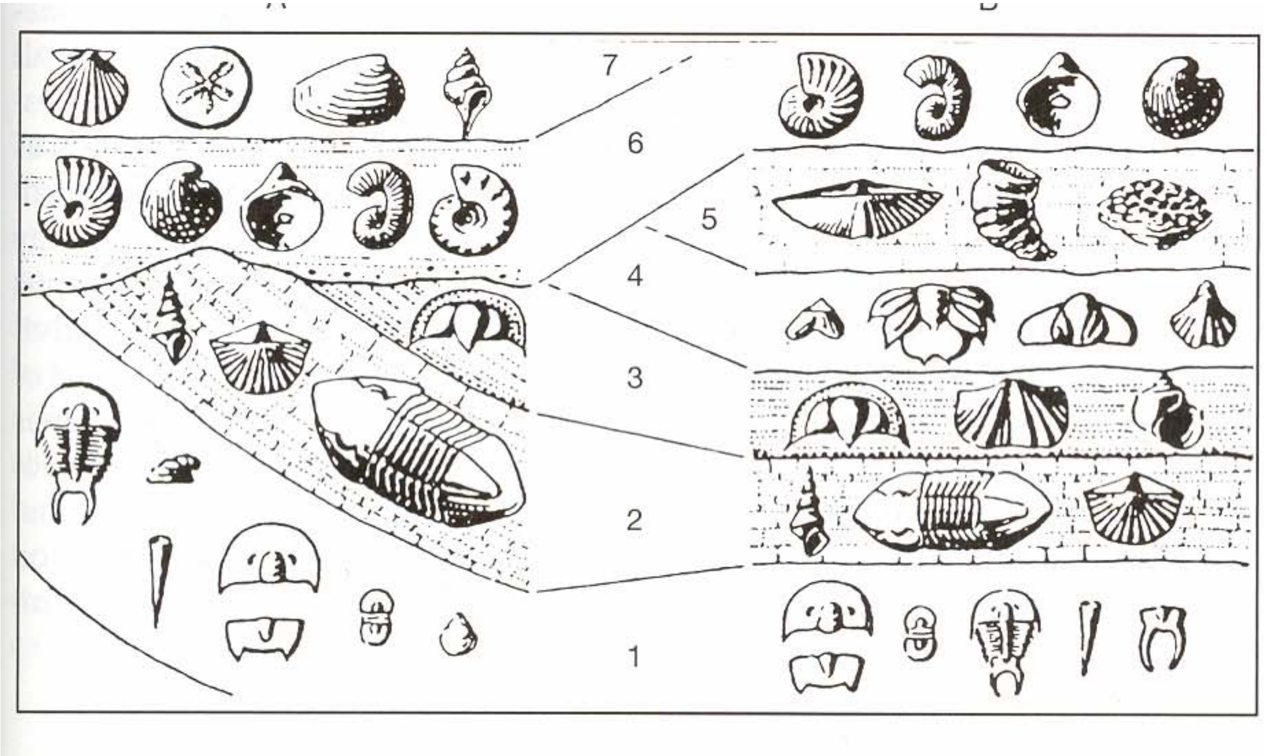
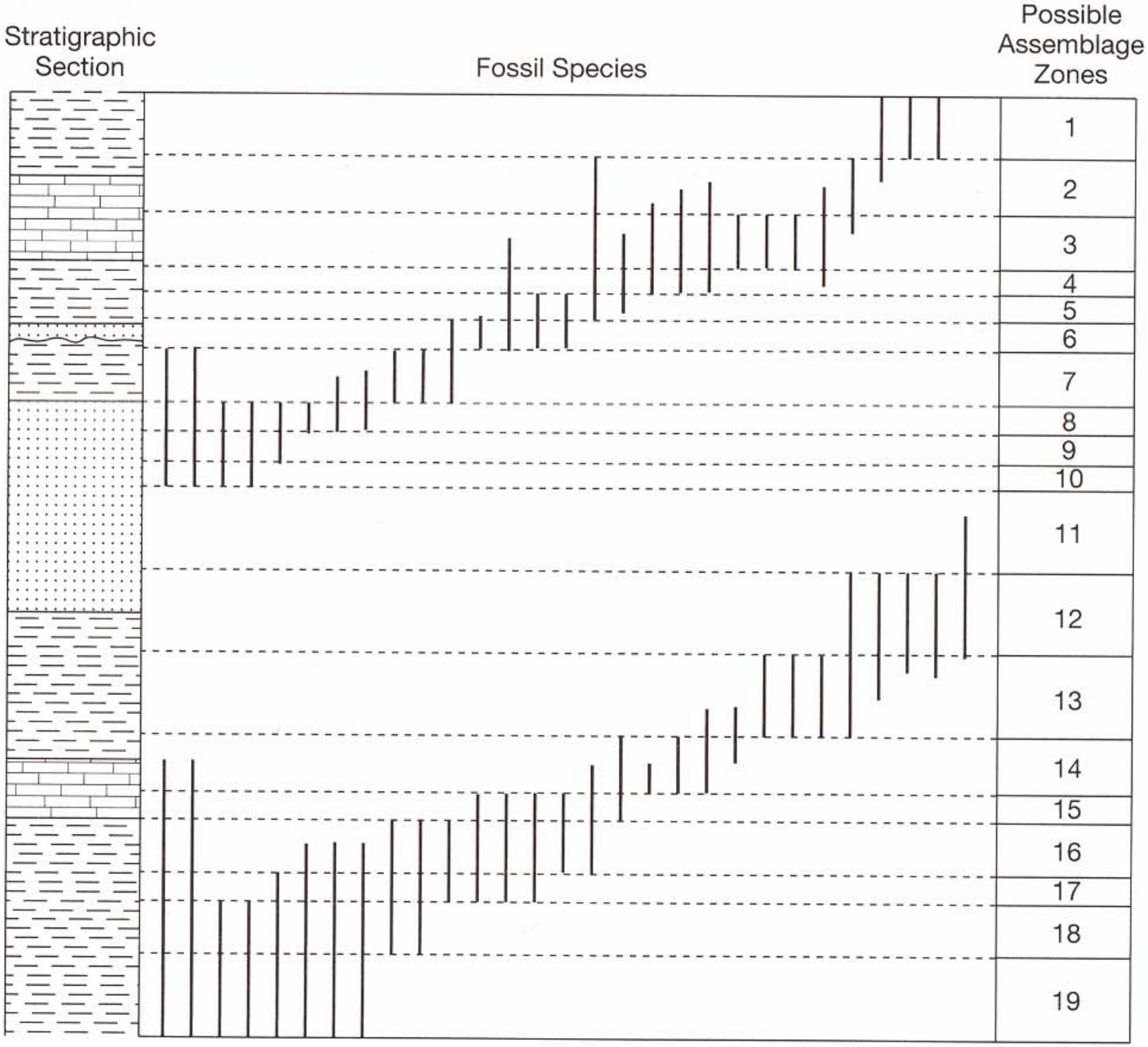


Figure 17.13
Diagram illustrating graphically the principle of correlation by fossil assemblages. [From Moore, R. C., C. G. Lalicker, and A. G. Fischer, 1952, Invertebrate fossils: McGraw-Hill Book Co., Fig. 1.3, p. 8, reproduced by permission.]

Boggs (2001)

Figure 17.14
Hypothetical stratigraphic section illustrating the large number of fossil taxa that may be involved in correlation by assemblage zones. Vertical black lines represent the composite ranges of the species found at various local sections. The column at the right shows one interpretation that could be drawn from these fossil data. [After Hazel, J. E., 1977, Use of certain multivariate and other techniques in assemblage zonal biostratigraphy: Examples utilizing Cambrian, Cretaceous, and Tertiary benthic invertebrates, *in* Kauffman, G. G., and J. E. Hazel (eds.), Concepts and methods of biostratigraphy: Van Nostrand Reinhold, Fig. 1, p. 289. reproduced by permission.]

Boggs (2001)



☆Correlation by abundance zones

Most abundance zones are unreliable and unsatisfactory for time-stratigraphic correlation.

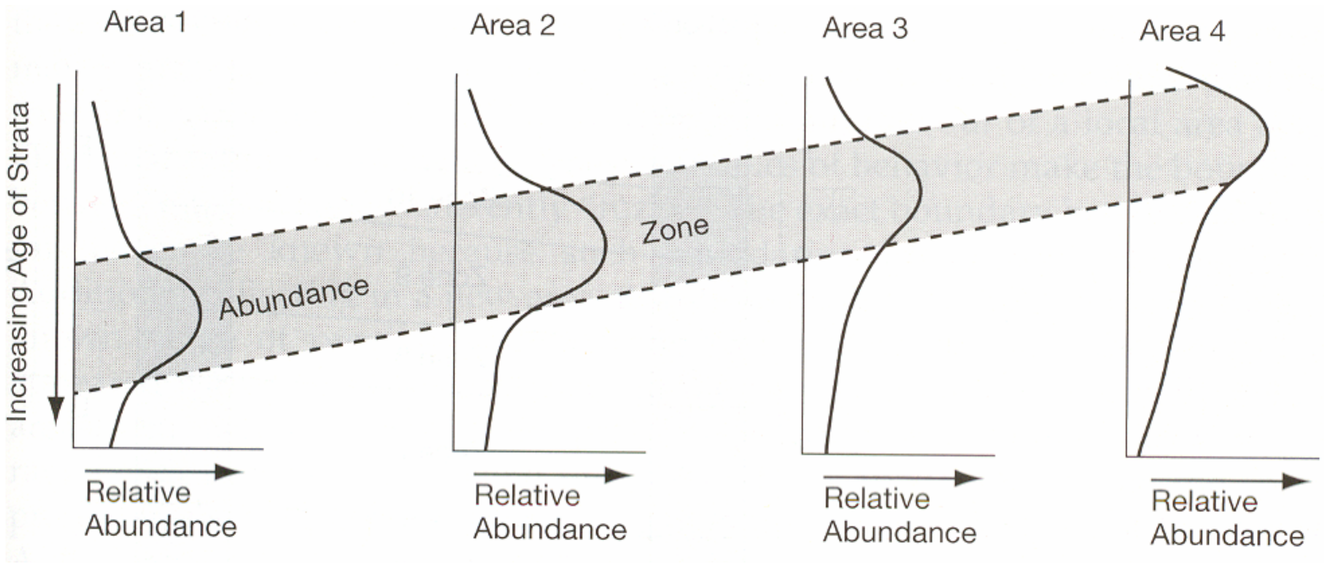


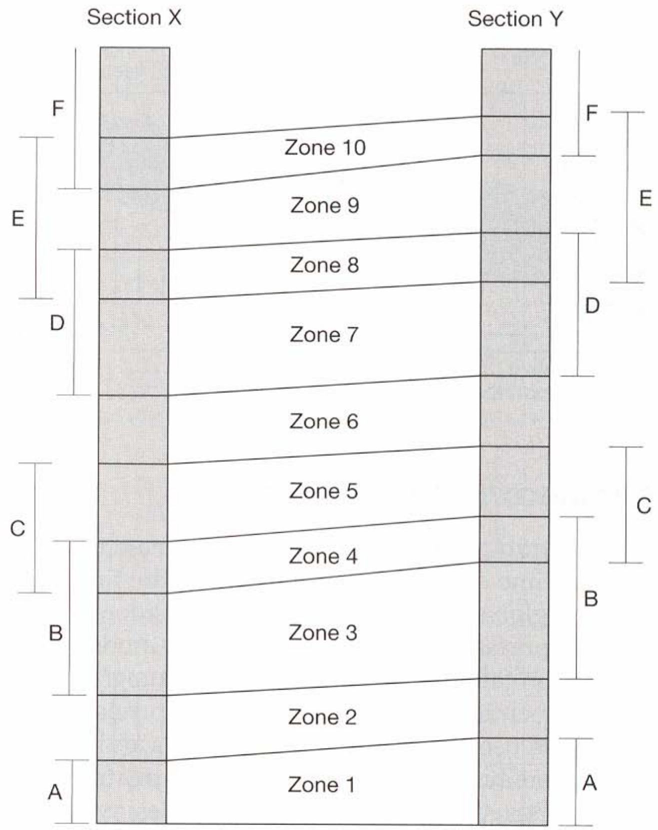
Figure 17.15
Schematic diagram illustrating why correlation by abundance zones may not yield a true time correlation. The same species may achieve its maximum abundance at different times in different localities. Relative abundance increases to the right.

Boggs (2001)

☆ Correlation by biologic interval zones

Taxon range zones and other interval zones

The first appearance of taxa tends to occur very rapidly. Thus, the interval between the first documented appearances of two taxa may represent a very short span of time, and the age of the strata in this interval may be nearly synchronous throughout their extent. Interval zones defined on the last appearances of taxa are commonly considered to have less time significance than those based on first appearances because extinctions of taxa commonly do not occur with the same suddenness that new species appear.



Boggs (2001)

Figure 17.16
Correlation between two hypothetical sections on the basis of interval zones. Note that several types of interval zones are used here for correlation. For example, Zone 1 is defined by the total vertical range of Species A (taxon range zone); Zone 2 is an interval zone defined by the last appearance of Species A and the first appearance of Species B; Zone 4 is formed by the overlapping ranges of Species B and C; and so forth.

Graphic method for correlating by taxon range zone

1. Establish reference section: A reference section should be the thickest section available, free of faulting or other structural complication, containing a large and varied fossil content. Establish the FAD/LAD of every single species and their positions in the stratigraphic section above an arbitrarily chosen point..

2. Establish other sections to be compared with the reference section.

Establishing data (stratigraphic columns and total range of taxa, i.e. FAD/LAD)

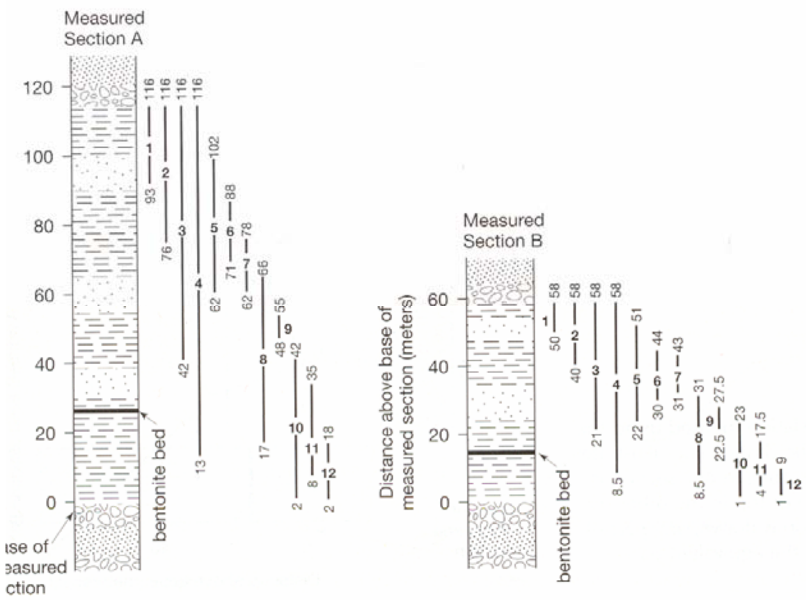
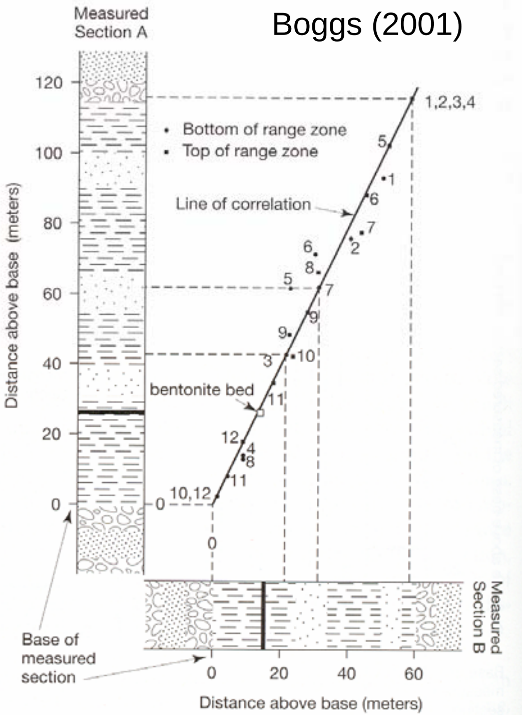


Figure 17.17
Two stratigraphic sections with ranges of fossil species (Species 1 through 12) graphed in meters above the base of the section. Section A and B contain identical fossils with identical time spans; however, Section B represents only half the rate of sediment accumulation. Use of these fossil ranges in A. B Shaw's (1964) graphic correlation method is illustrated in Figure 17.18. [After Eicher, D. L., Geologic time, 2nd ed., Prentice-Hall, Fig. 5.8, p. 112; data from Ericson and Wollin, 1968.]

Boggs (2001)

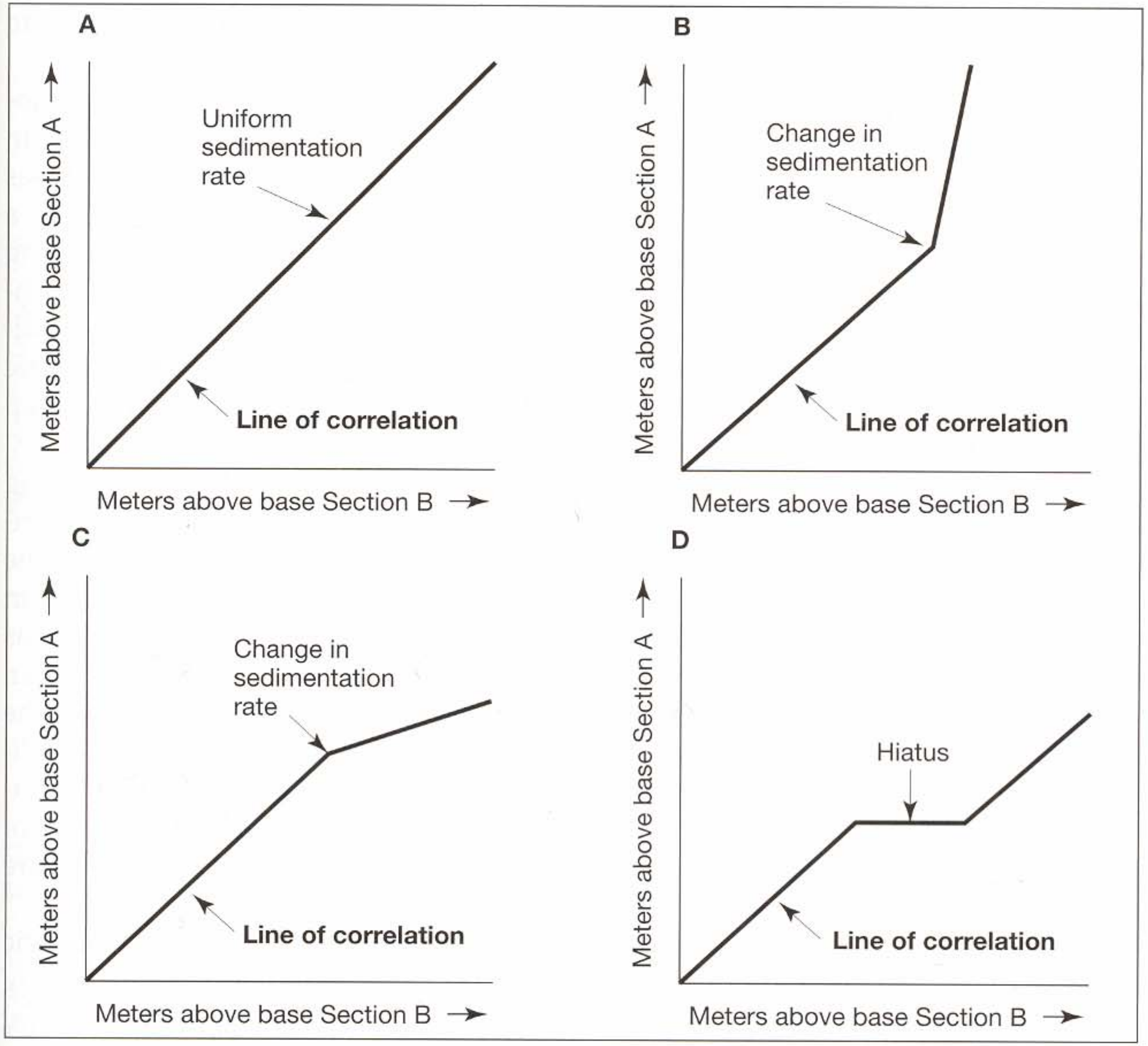
Graphic correlation and line of correlation



Boggs (2001)

Figure 17.18
Illustration of the graphic correlation method using the data shown in Figure 17.17. The dashed lines illustrate how the base or top of a range zone in one section is plotted against equivalent base or top in the other section. Once the line of correlation is drawn, any part of Section A can be correlated to the equivalent part of Section B.

Evaluating rate of sedimentation, unconformity/hiatus



Boggs (2001)

Figure 17.19
Effect of change in sedimentation rate on the shape of the line of correlation. (A) Uniform sedimentation rate in both Section A and B. (B) "Dogleg" in the line of correlation indicates a relative decrease in rate of sedimentation in Section B. (C) "Dogleg" indicates a relative decrease in rate of sedimentation in Section A. (C) A hiatus in deposition in Section A (caused by nondeposition, an unconformity, or possibly faulting) shows up as a horizontal segment in the line of correlation.