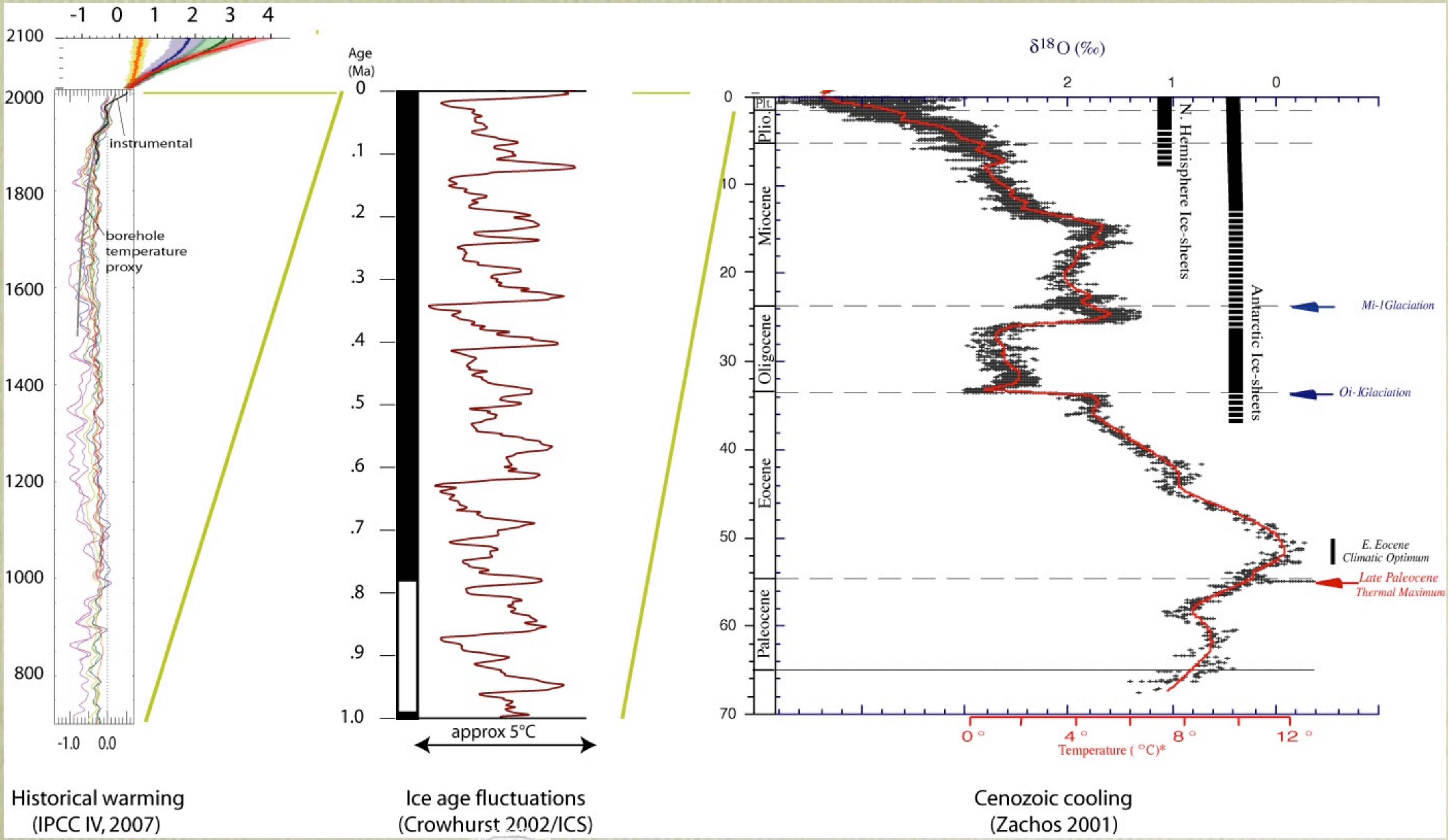
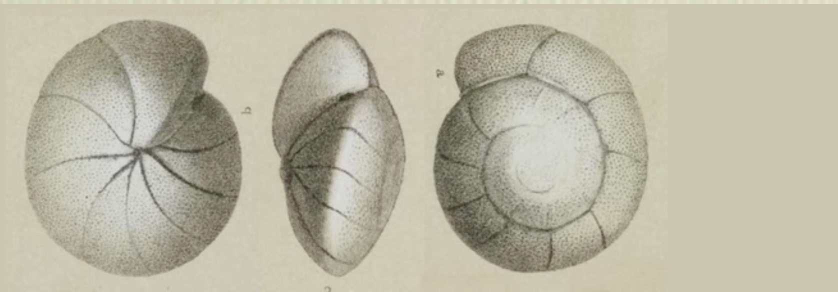
Timescales & biostratigraphy

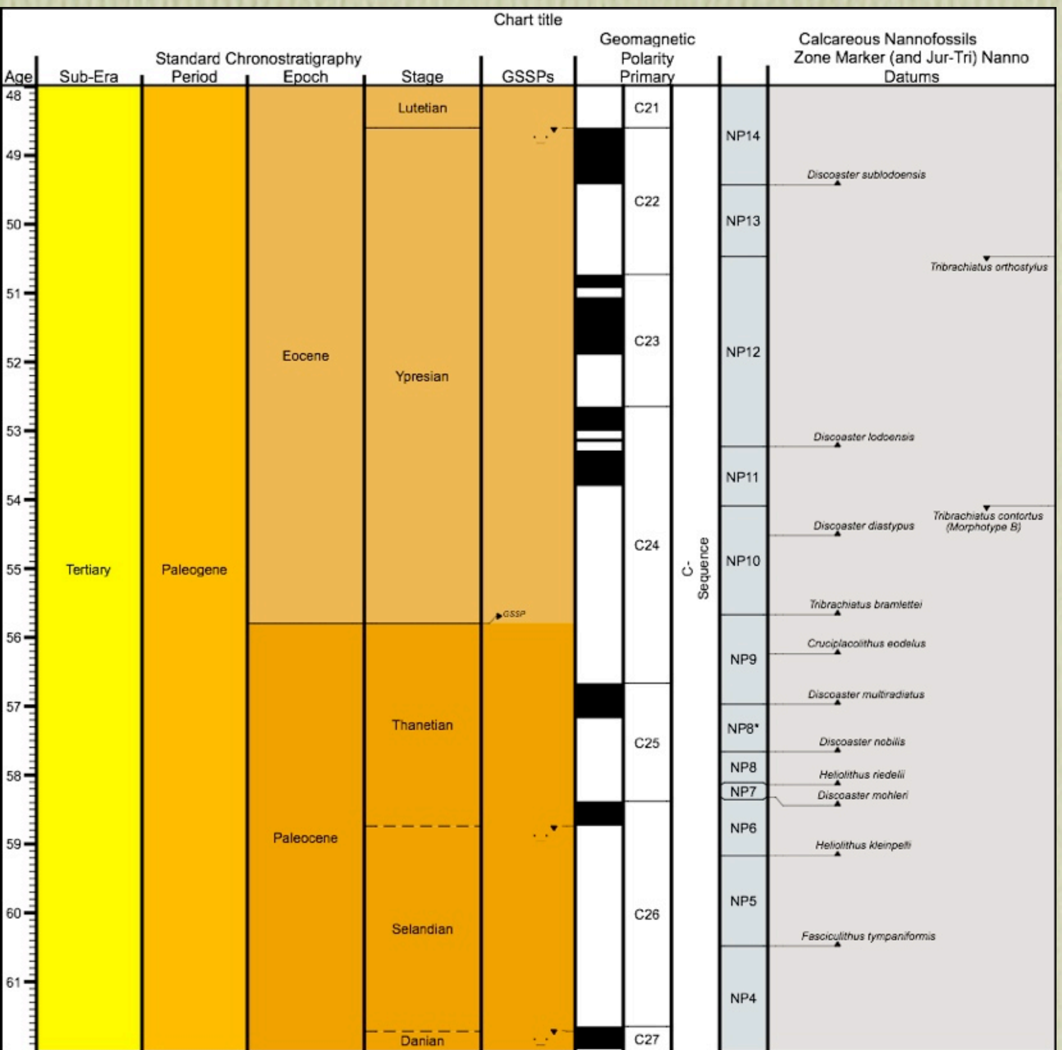
Global change on three time scales



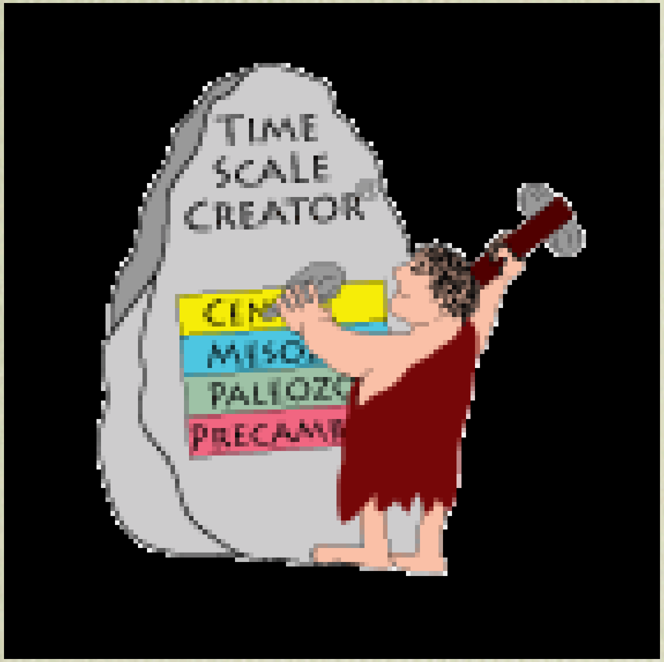


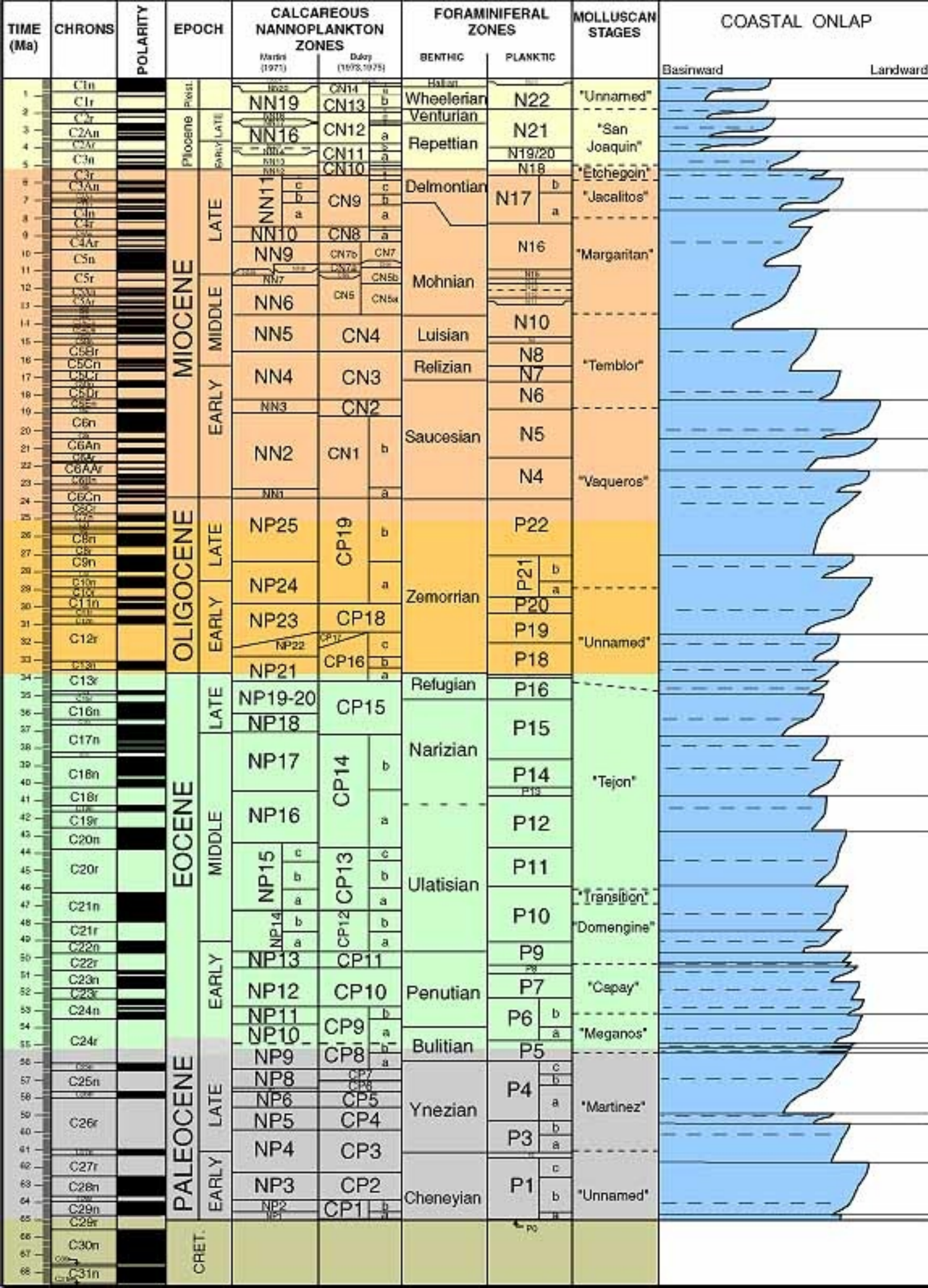
Time Scale Creator

https://engineering.purdue.edu/Stratigraphy/tscreator/index/index.php



freeware java program





Integrated timescale

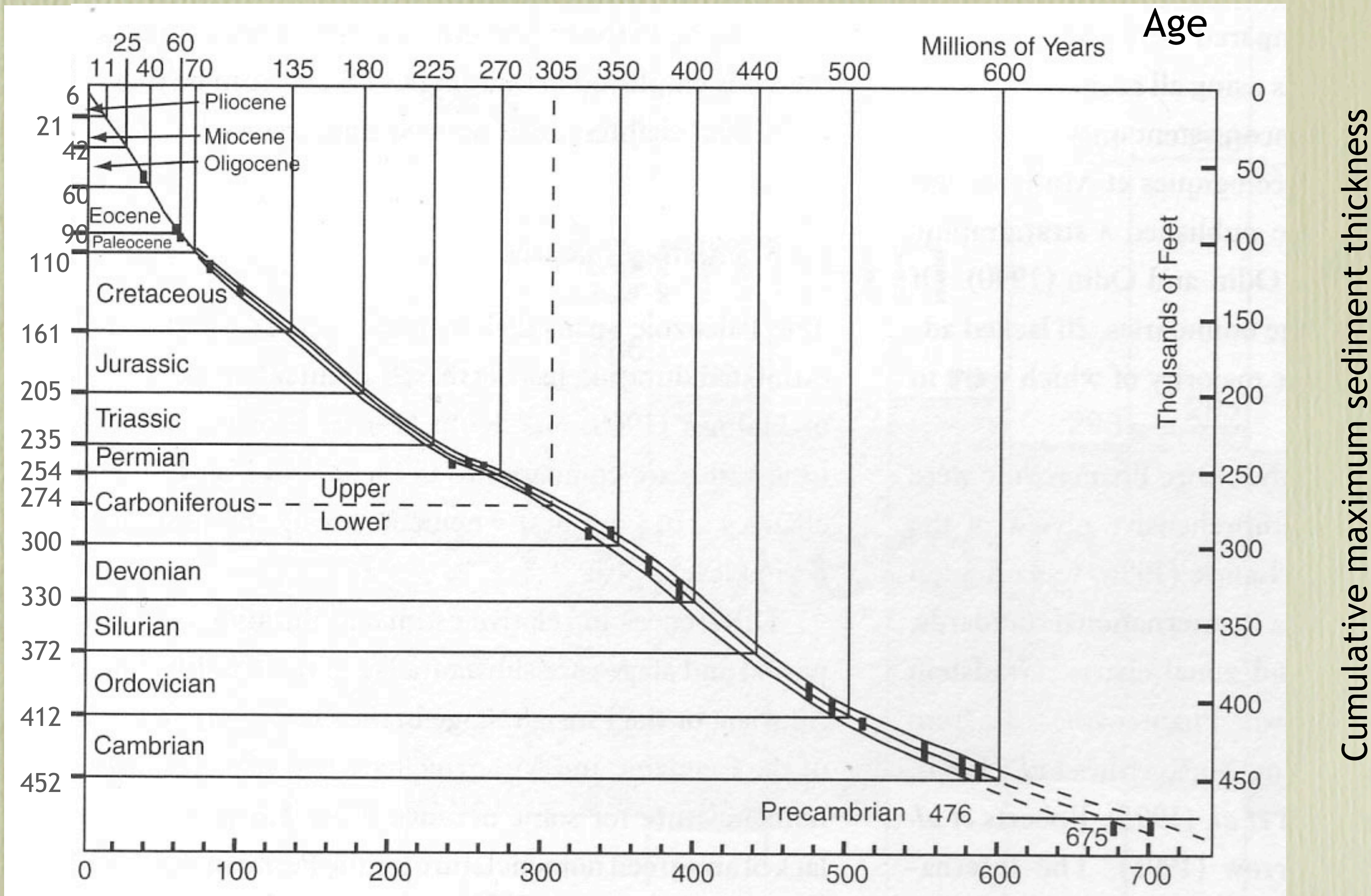
Example of an integrated timescale (for Cenozoic of California)

Including

- Geomagnetic polarity
- Chronostratigraphy (epochs)
- Standard planktonic zonations (forams and nannos)
- Local benthic foram and molluscan assemblage zonations
- Coastal onlap/sequence stratigraphy

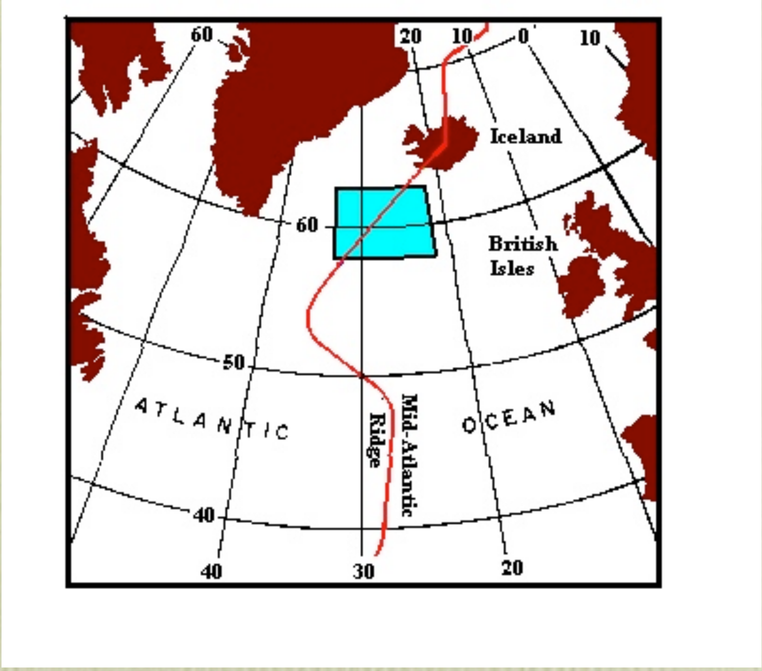
Everything nicely cross-correlated AND scaled to absolute time (in Ma)

Holmes 1960 timescale scaling

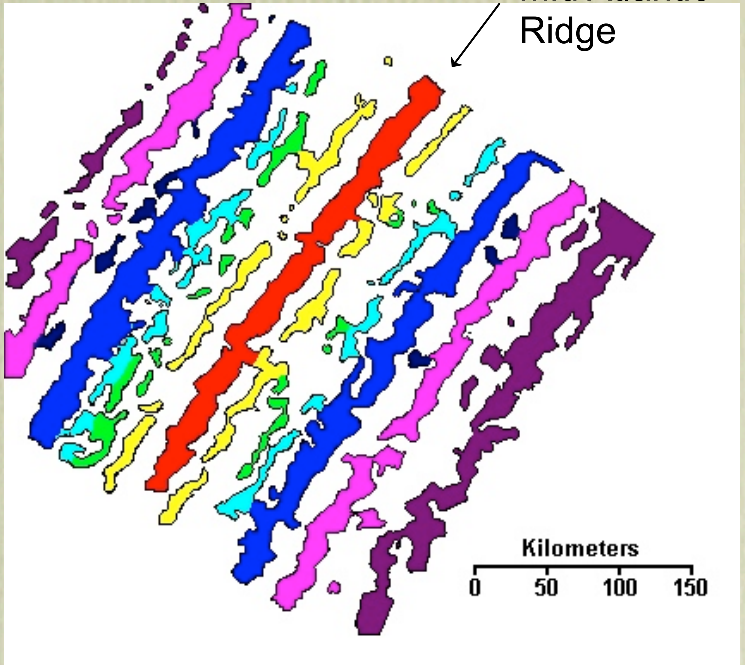


Before radiometric dating the best estimate of geological time were based on thickness of sediment pile. Holmes (1937, 1960) ingeniously combined sediment thickness and very limited radiometric data to produce an age model for the geological column -> time-scale

Geomagnetic Polarity Timescale (GPTS)

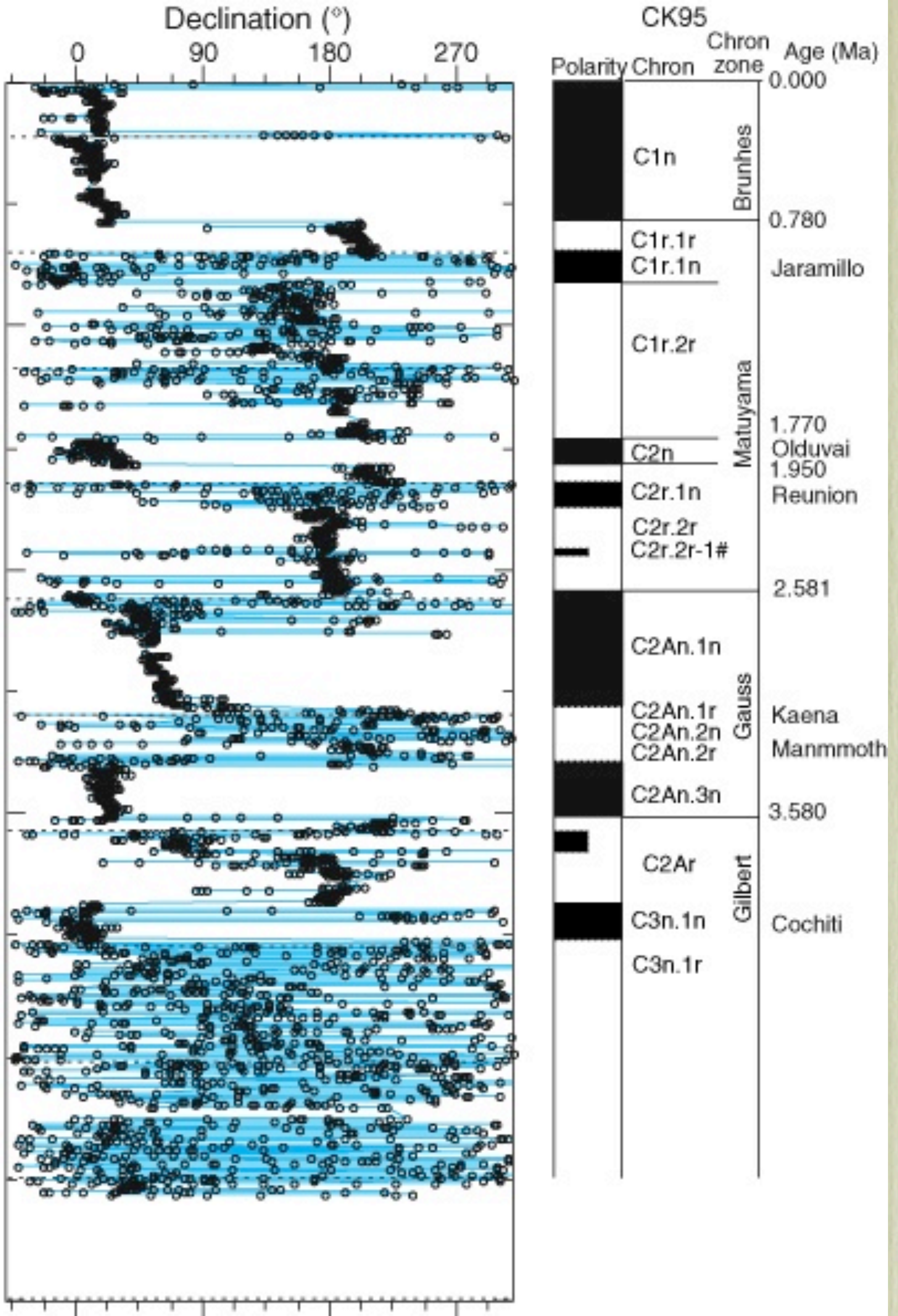


Mid Atlantic
Ridge



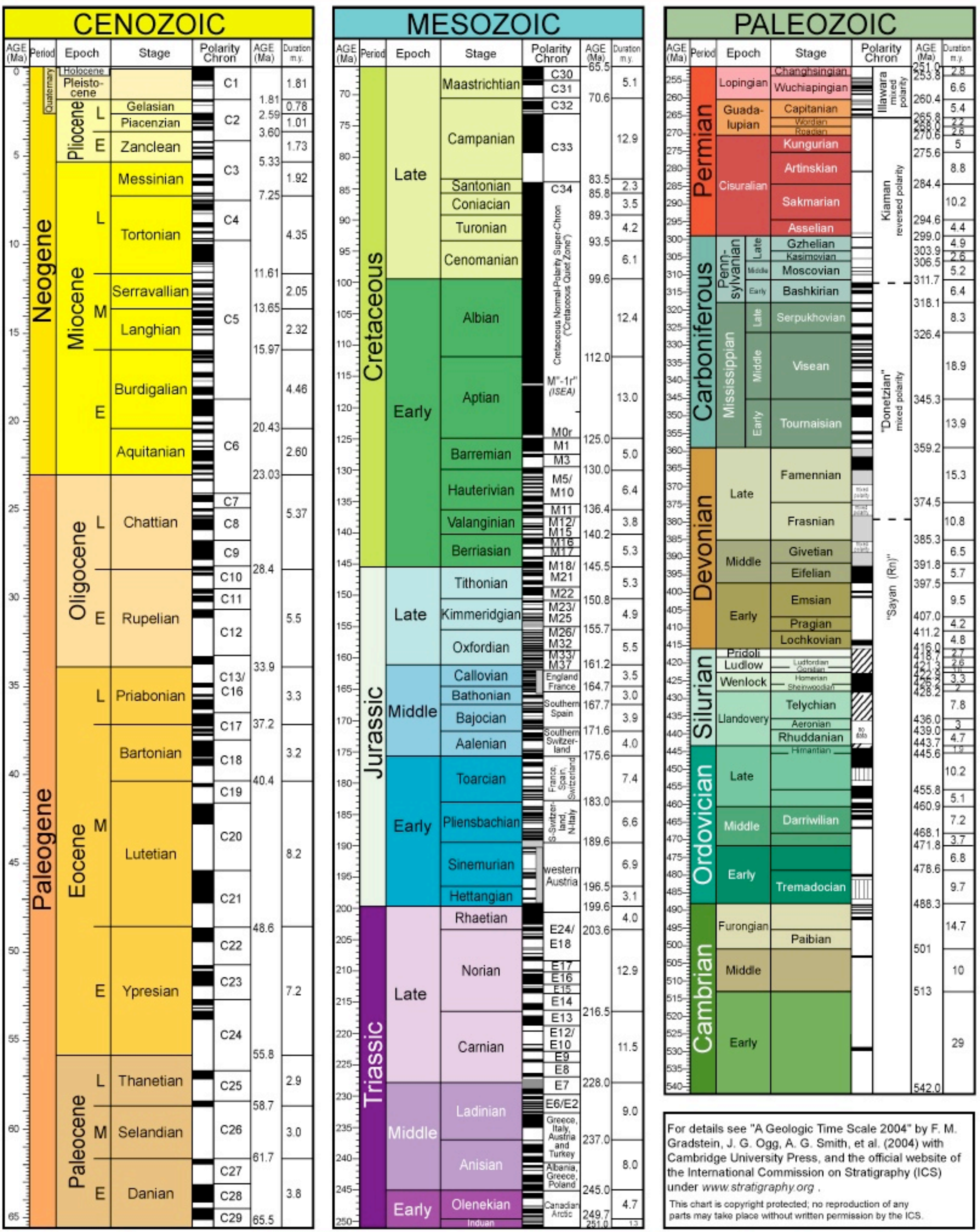
- basic pattern from sea-floor spreading record
- calibration to absolute ages from
  - dating of oceanic basalts
  - dating of terrestrial lava flows of known placement in geomagnetic sequence
- knowledge of GPTS is constantly being refined -> recalibration of ages assigned to timescale

Example of ODP core magnetic record



sediementary magnetisation is weak in biogenic sediments

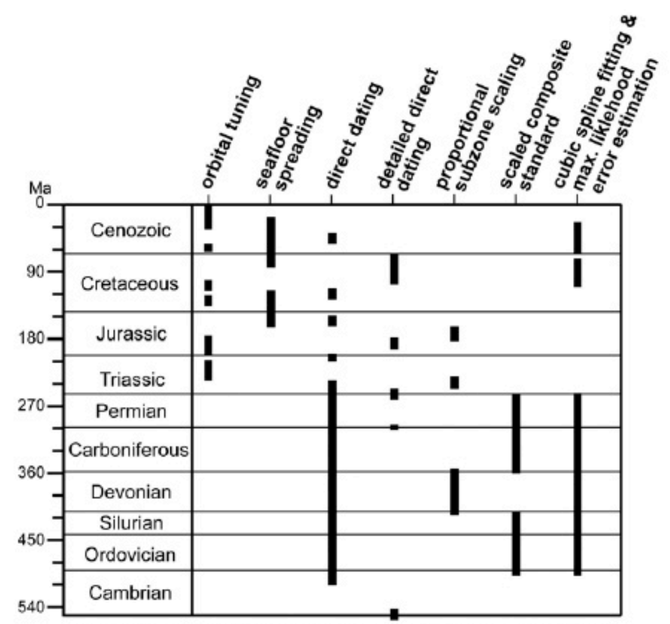
but allows direct correlation of plankton biostrat and magnetochronology



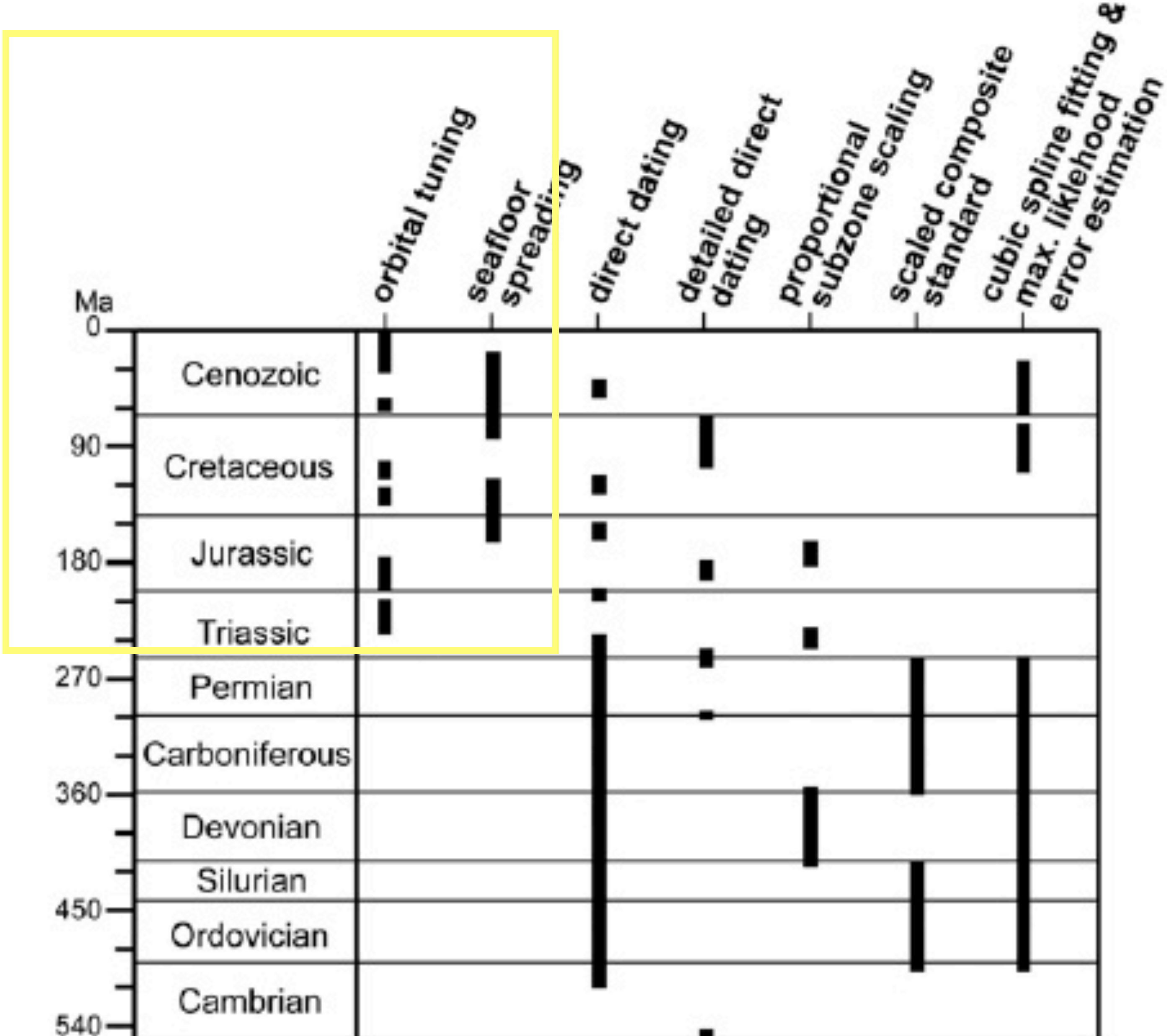
2004 Timescale

pre-Jurassic no sea-floor record so geomagnetic record from local sequences

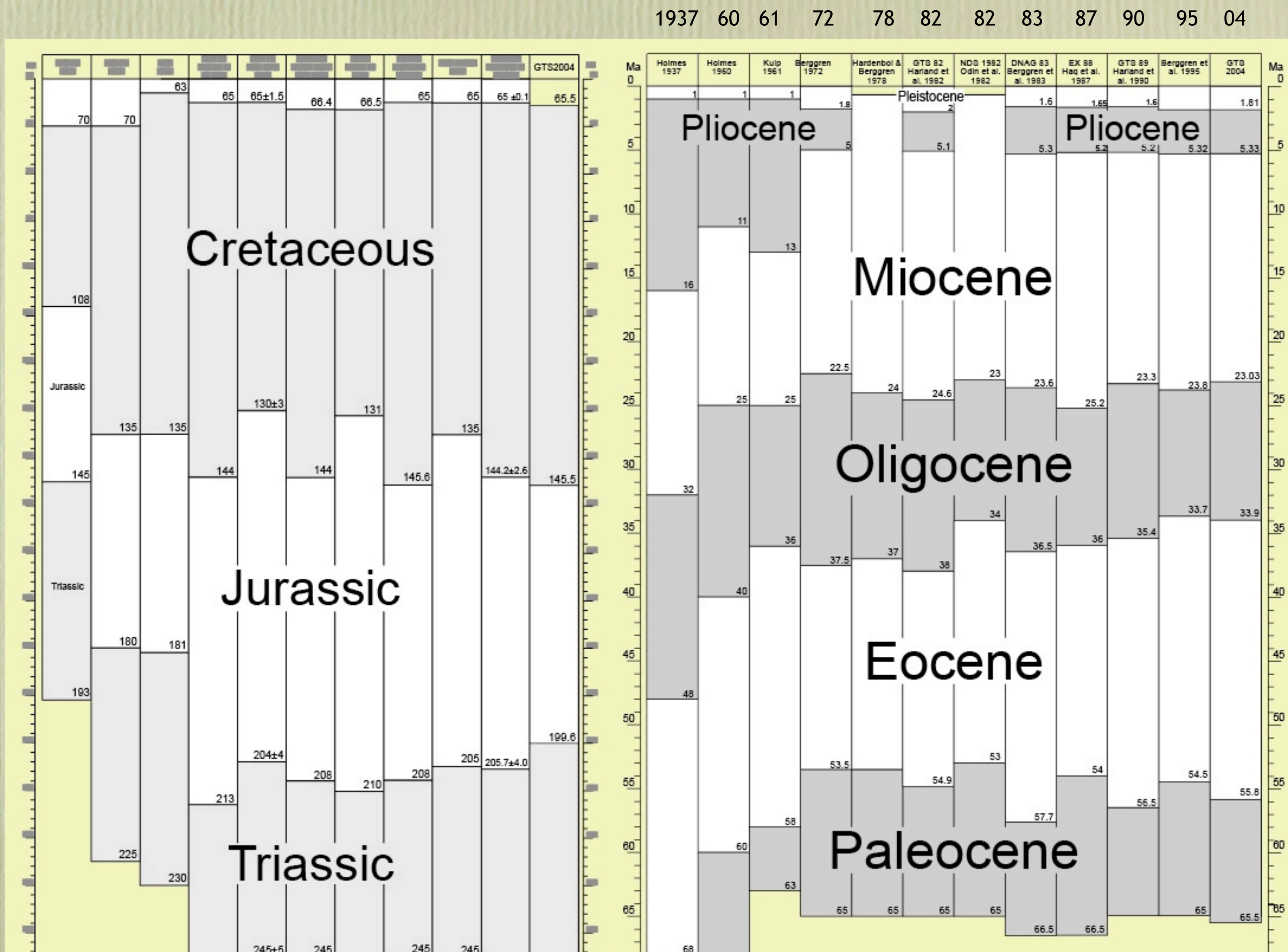
calibration and dating by a range of techniques



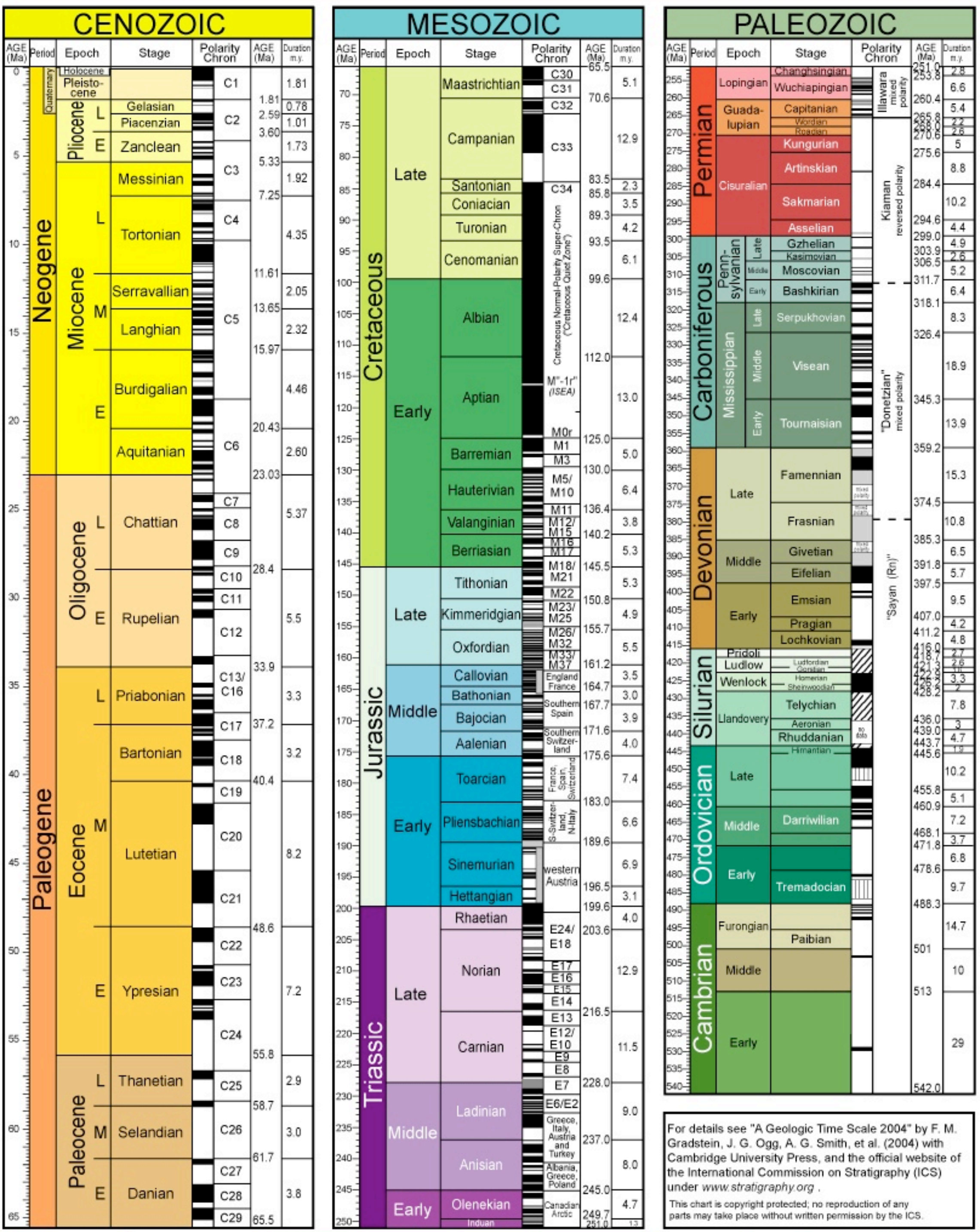
Methods used to construct Geologic Time Scale 2004 (GTS 2004)



Methods used to construct Geologic Time Scale 2004 (GTS 2004)

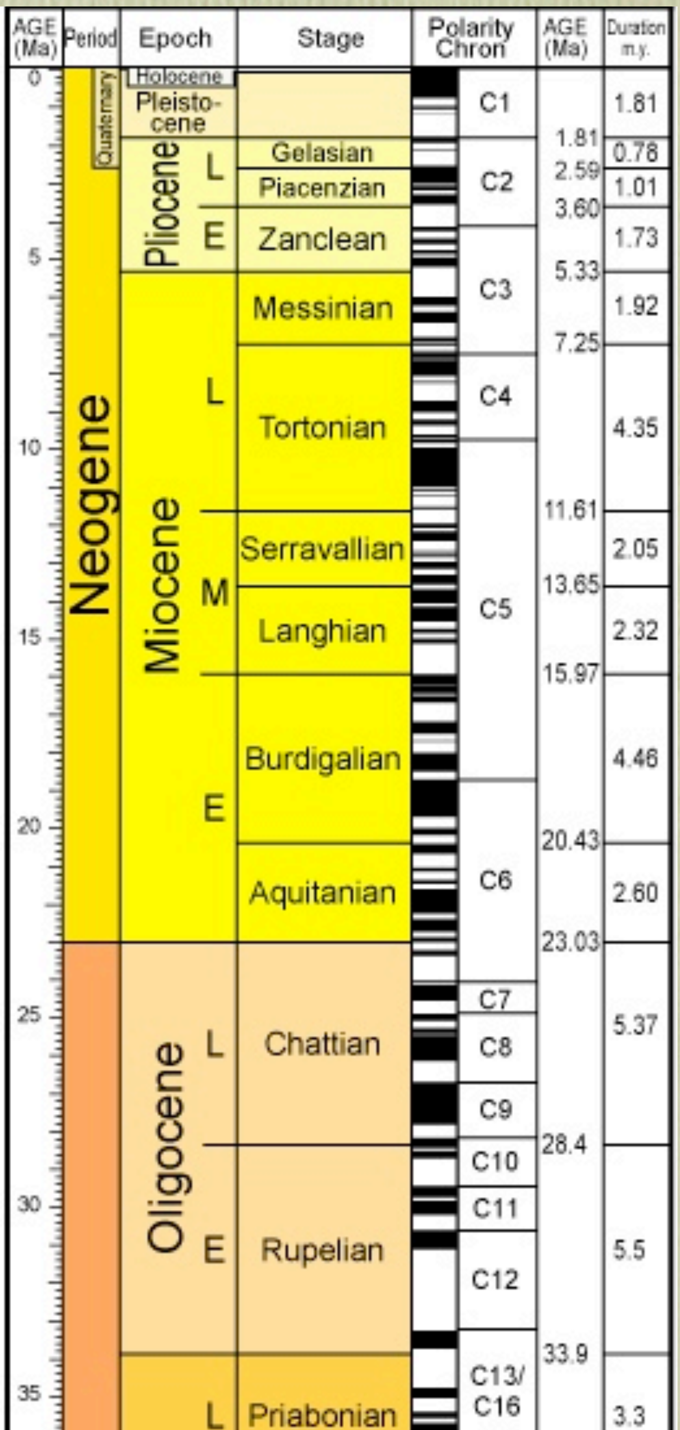


changes in Time Scale ages from Holmes 1937 to 2004



Chronostratigraphy - Periods

the major subdivisions of geological time, the periods (Neogene,Cretaceous, etc.) mostly reflect major changes in biota related to global change events



Chronostratigraphy

subdivision of time into named sub-units - stages

based primarily on classic European areas where fossiliferous sediments of that age happened to be studied

e.g. Burdigalian, Aquitanian

Integration process

1. Date traditional stage stratotype
2. Study sequences from all over the world
3. Choose good level for **base** (global event, good marker, magnetochron)
4. Choose stage stratotype and place *golden spike* at base

- Iterate and argue

End Result

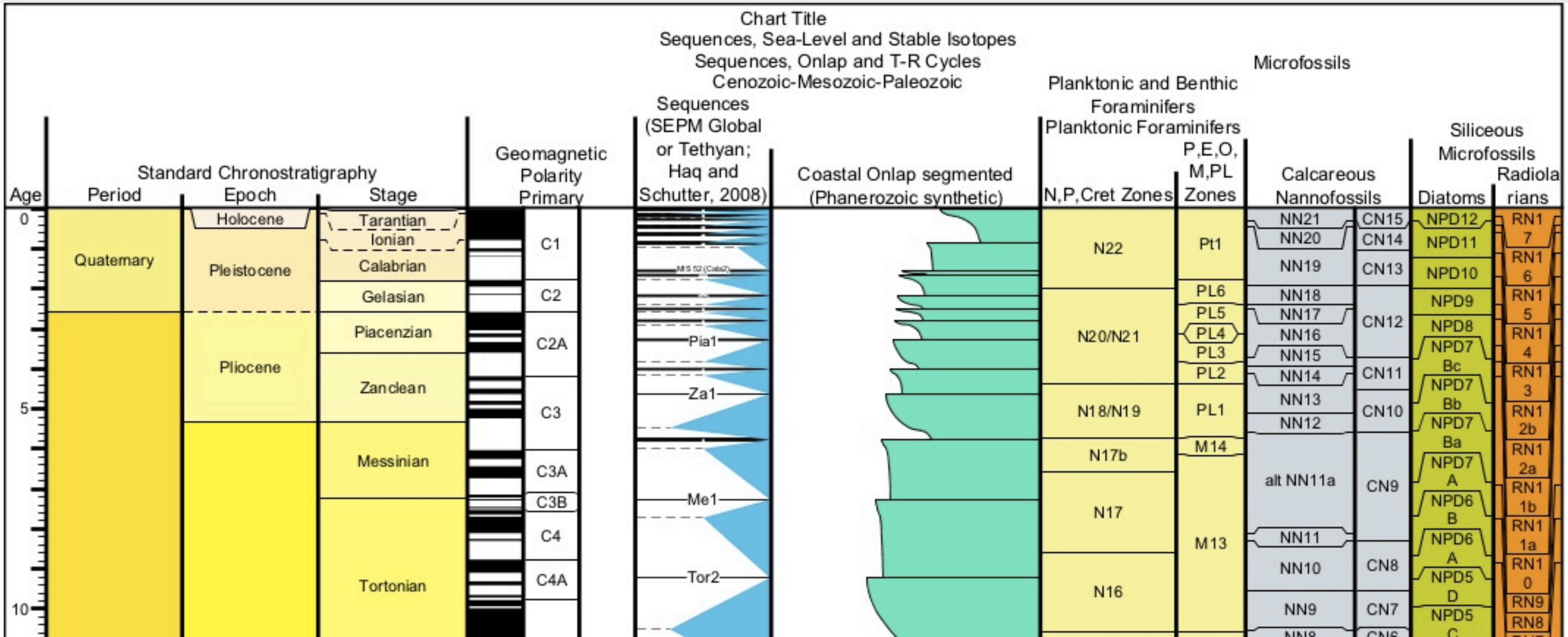
In modern literature stage names are arbitrary names for +/- arbitrary intervals of geological time

In older (pre 1970s) literature Oligo-Miocene stage names are more or less randomly assigned to late tertiary rocks based on authors guestimation of what sort of age they may be

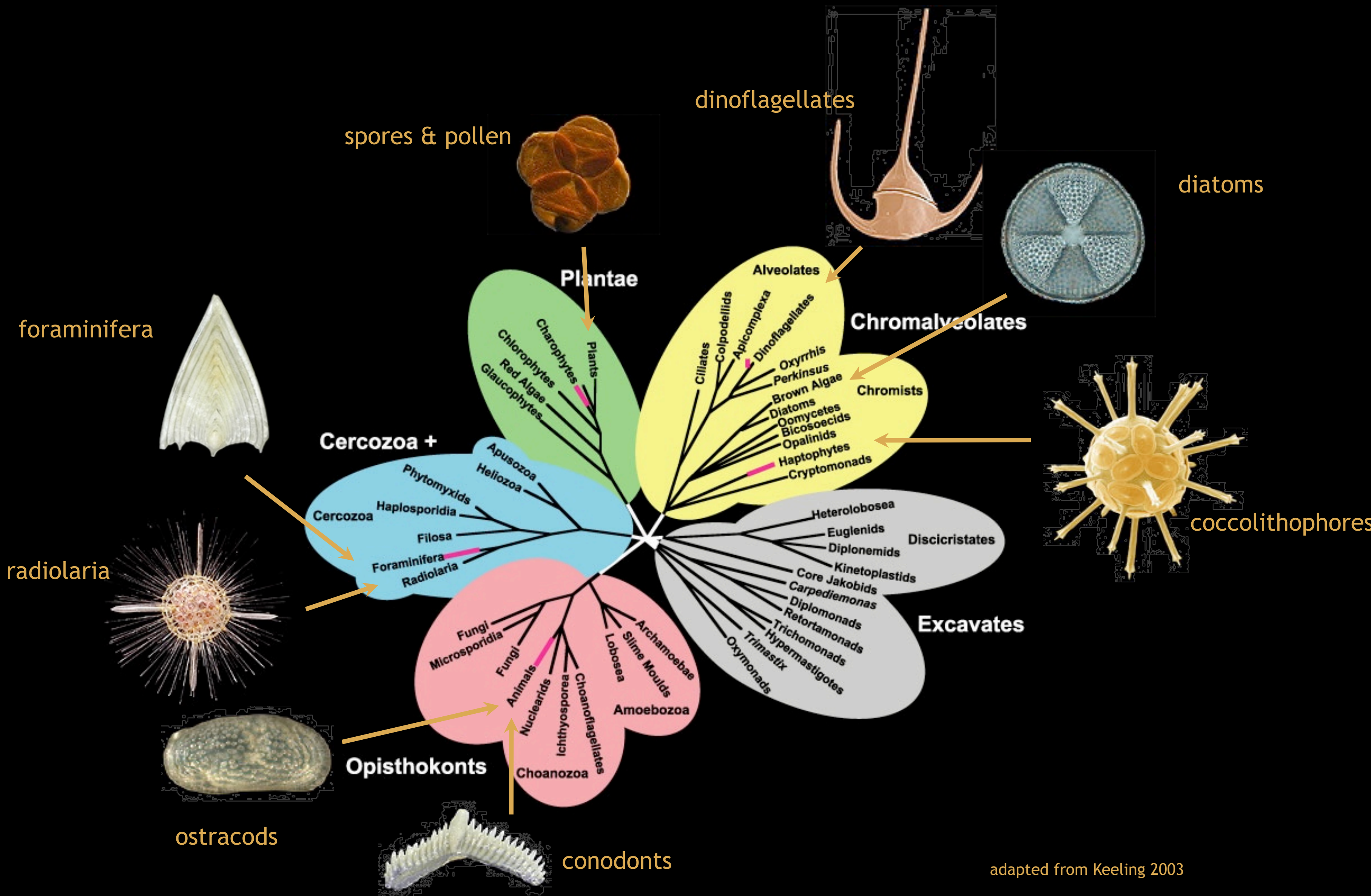
Biostratigraphy

prime practical means of telling where we are

In the Cenozoic predominantly by planktonic microfossils



Microfossil groups against a phylogeny of Eukaryotes



adapted from Keeling 2003

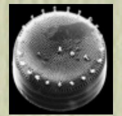
CALCAREOUS
preparation usually
disaggregation

SILICEOUS & PHOSPHATIC
preparation usually
disaggregation
+ HCl cleaning
(HF etching used for rad cherts)

ORGANIC - PALYNOMORPHS
preparation usually
disaggregation
+ HCl cleaning
+ HF cleaning

PHYTOPLANKTON

COCCOLITHOPHORES & OTHER CALCAREOUS NANNOFOSSILS
Algae (haptophytes) with composite exoskeleton of calcite plates - coccoliths or nannoliths.
Range: L. Triassic - R
Usual size: 2-20μm

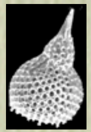


DIATOMS
Algae with opaline silica valves (=frustules). Wide ecological range, planktonic and benthic, marine & non marine.
Range: E. Cret - R
Usual size: 10-100μm

DINOFLAGELLATES & ACRITARCHS
Algae (dinophytes) which form cellulosic resting cysts, and their probable ancestors (acritarchs)
Range: dinos - E. Jur-R,
Acritarchs - Pre-Cambrian - R
Usual size: 50-500μm

ZOOPLANKTON

PLANKTONIC FORAMS (Globigerinaceae)
Planktonic descendants of benthic forams, typically with globular chambers.
Range: E. Cret-R (useful from Albian)
Usual size: 50-500μm

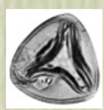


RADIOLARIA
Unicellular protozoa with elaborate opaline silica shell.
Range: E. Palaeozoic - R
Usual size: 0.1-1mm

CHITINOZOA
Flask shaped tests, of uncertain origin
Range: Ordovician-Devonian
Usual size: 0.1-1mm

SMALLER BENTHIC FORAMS
Unicellular chambered protozoa with variable wall structure - main groups:
hyaline calcite (e.g. rotaliids)
porcellaneous aragonite (milioilids)
agglutinate (textulariids)
Range: Cambrian - R
Usual size: 50-500μm

CONODONTS
Phosphatic, tooth-like apparatus of primitive chordate.
Range: Cambrian-M. Triassic
Usualsize: 0.2-2mm



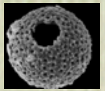
SPORES & POLLEN
Reproductive bodies of plants
Range: E. Paleozoc - R
Usualsize 20-200μm

LARGER BENTHIC FORAMS
Internally complex forams with symbiotic algae. Various groups e.g. Fusulinids (Late Palaeozoic), Nummulites (Palaeogene). Wall structure variable
Usual size 5-50mm

OSTRACODS
Crustacea with bivalved calcite shell, most common in inner shelf and non-marine environments
Range: Cambrian-R
Usual size: 0.1-1mm

Calpionellid

Silicoflagellate



Calcisphere (*Thoracosphaera*)

MISCELLANEOUS MINOR GROUPS
CALPIONELLIDS - calcareous flask shaped zooplankton, Tethyan, Tith-Berr.

SILICOFLAGELLATES - siliceous tests of chrysophyte algae, 10-100μm, Late Cret - R.

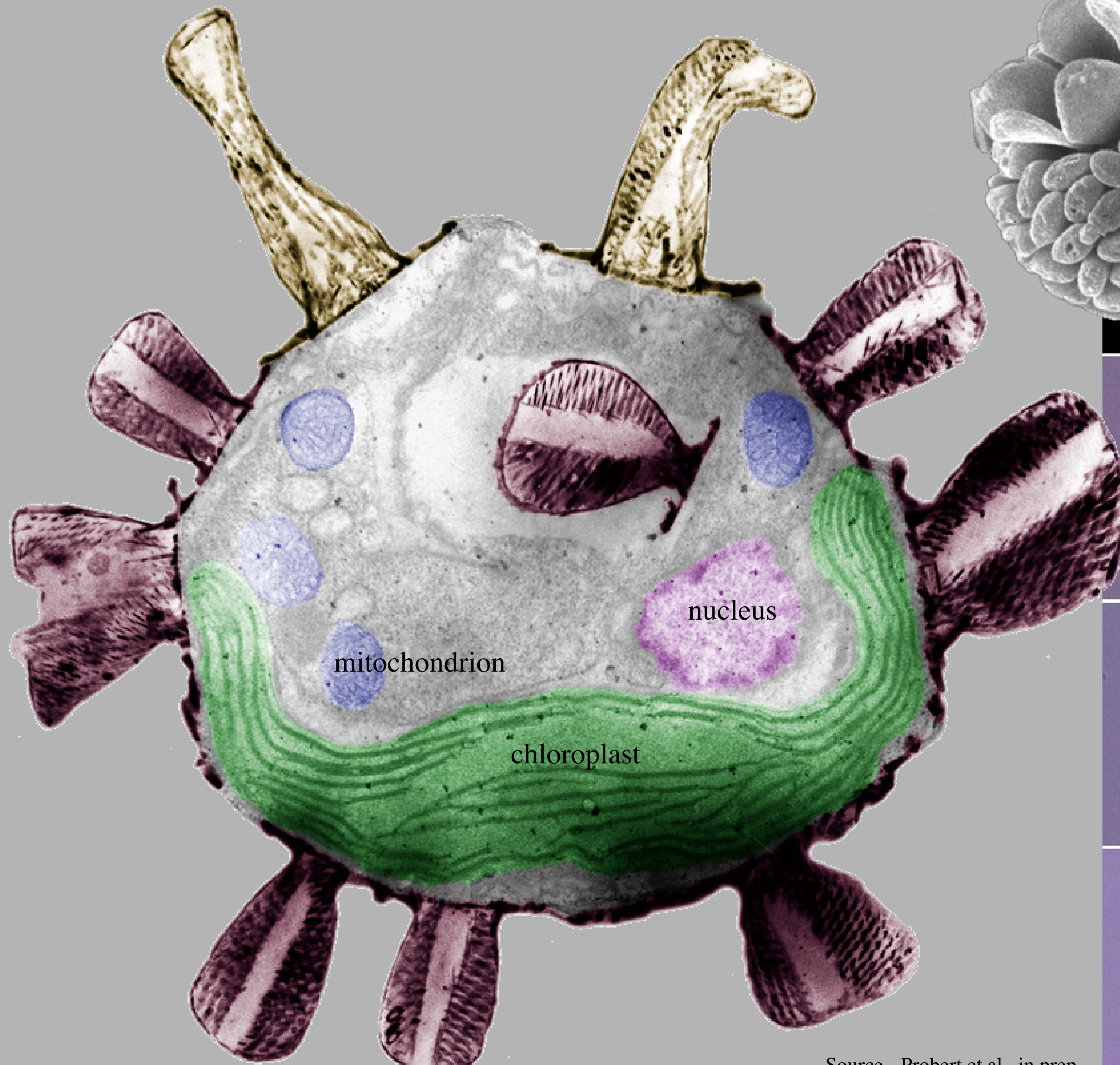
CALCISPHERES - calcareous dinophyte cysts, 10-100μm, Late Triassic -R

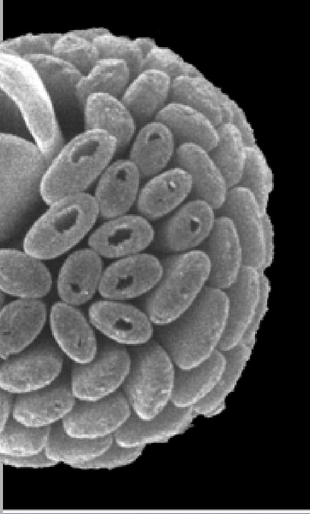
ICHTHYOLITHS - fish teeth (phosphatic), 0.1-1mm.

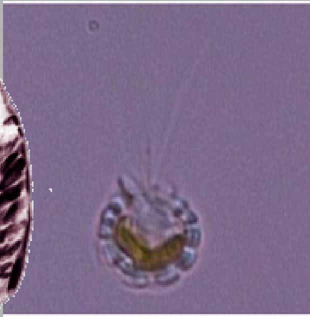
PTEROPODS - aragonitic planktonic snails, 0.5-5mm, Palaeocene-R

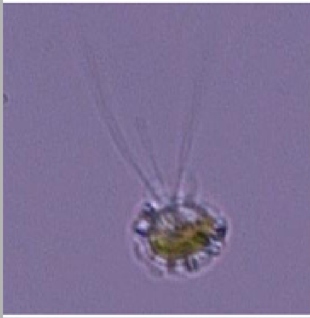
Overview of microfossil groups

Algirosphaera robusta



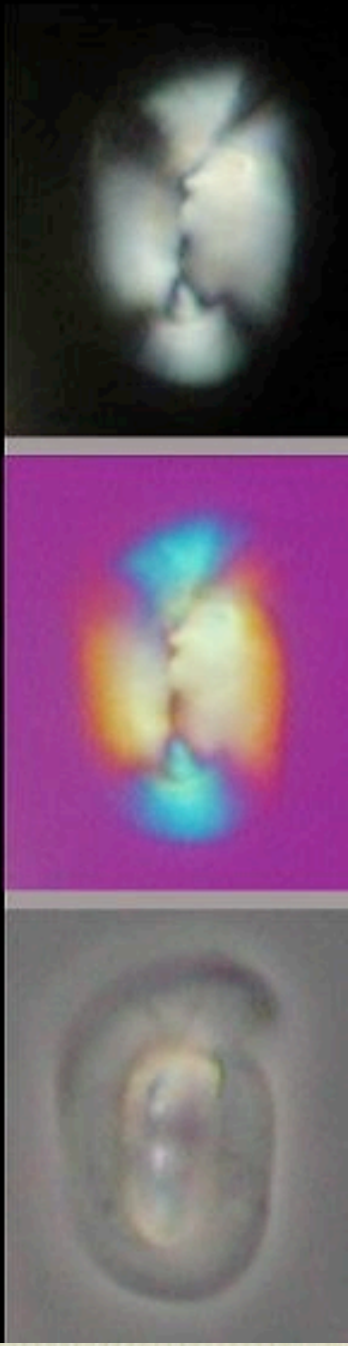






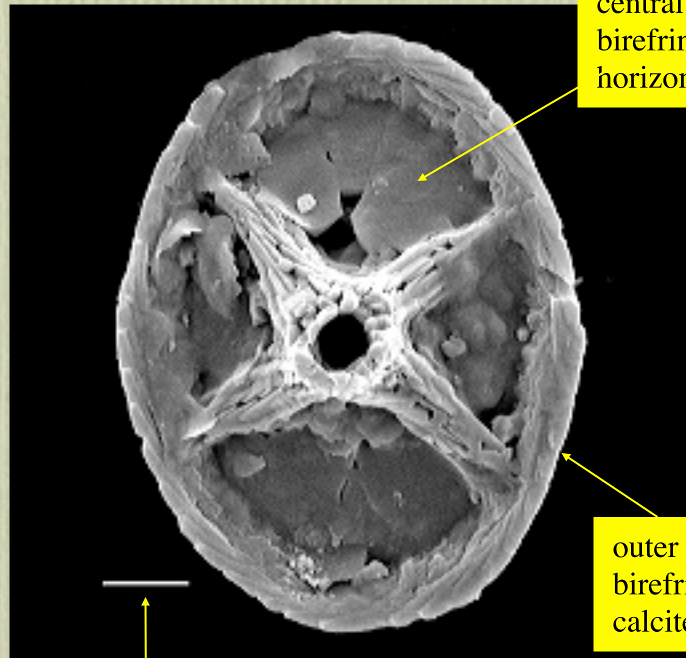
Source - Probert et al., in prep.

coccolithophores

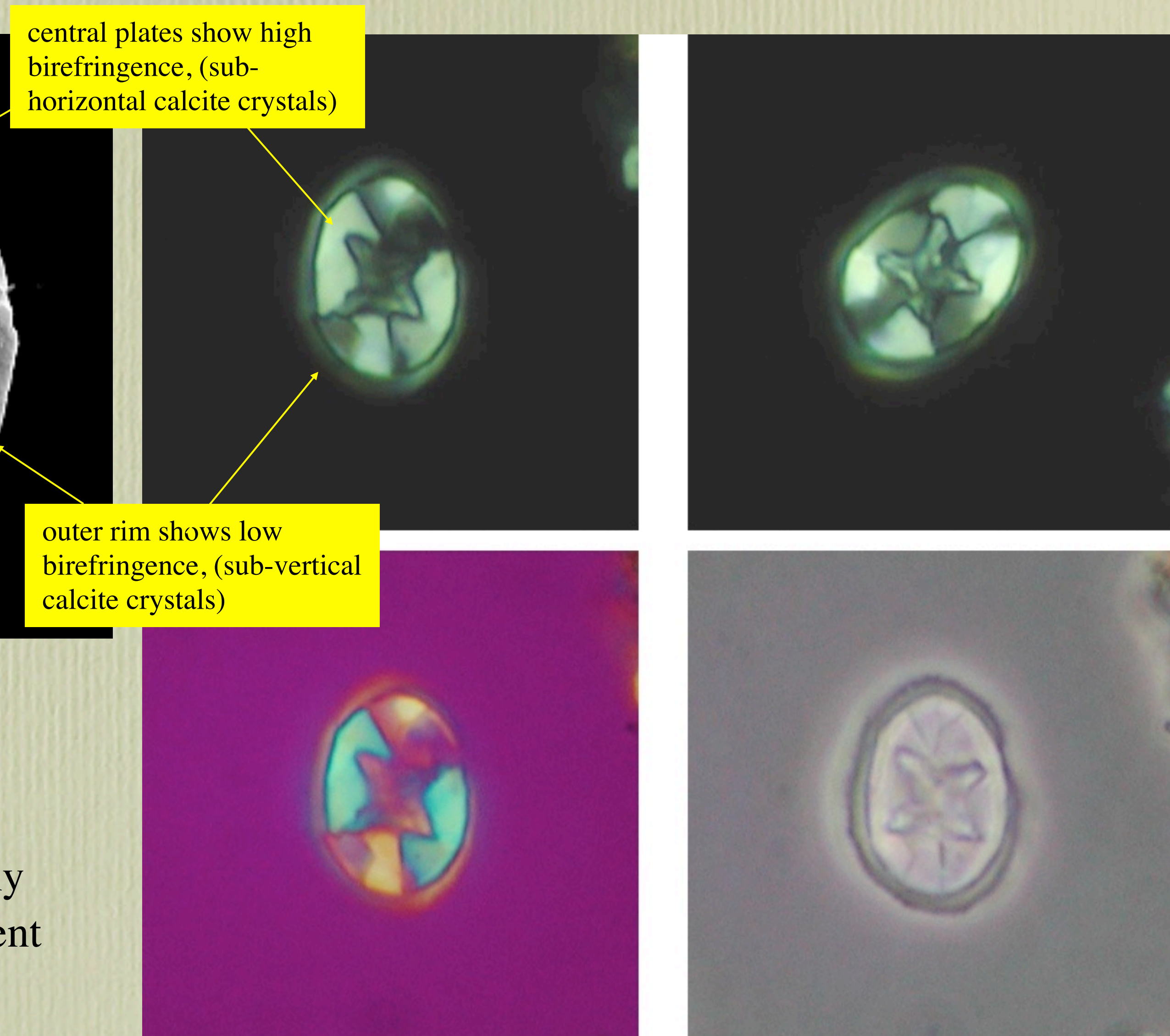


SEM vs. Light Microscopy

Eiffellithus turriseiffelii a typical Late Cretaceous coccolith



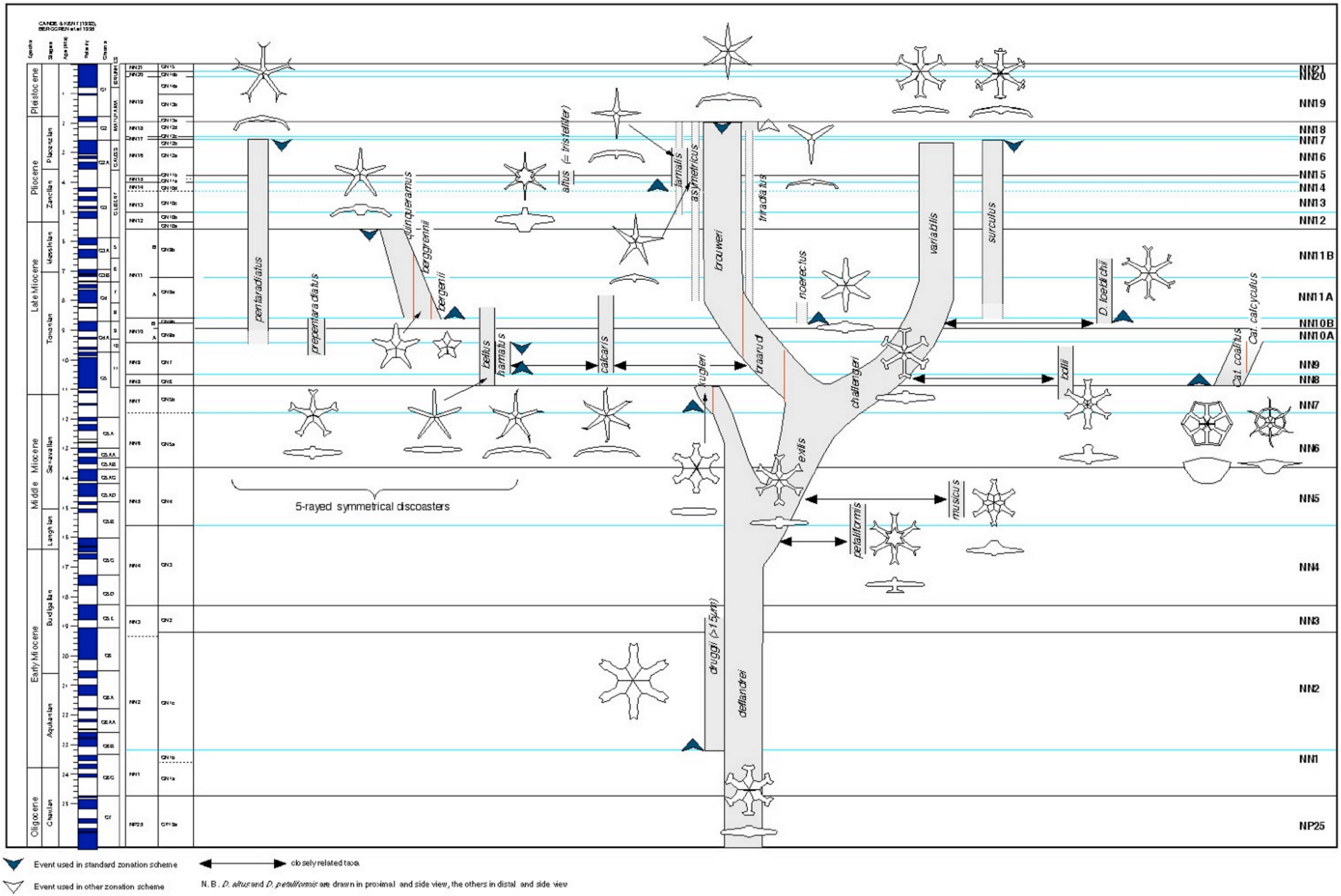
1 micron



gypsum (1 lambda) plate

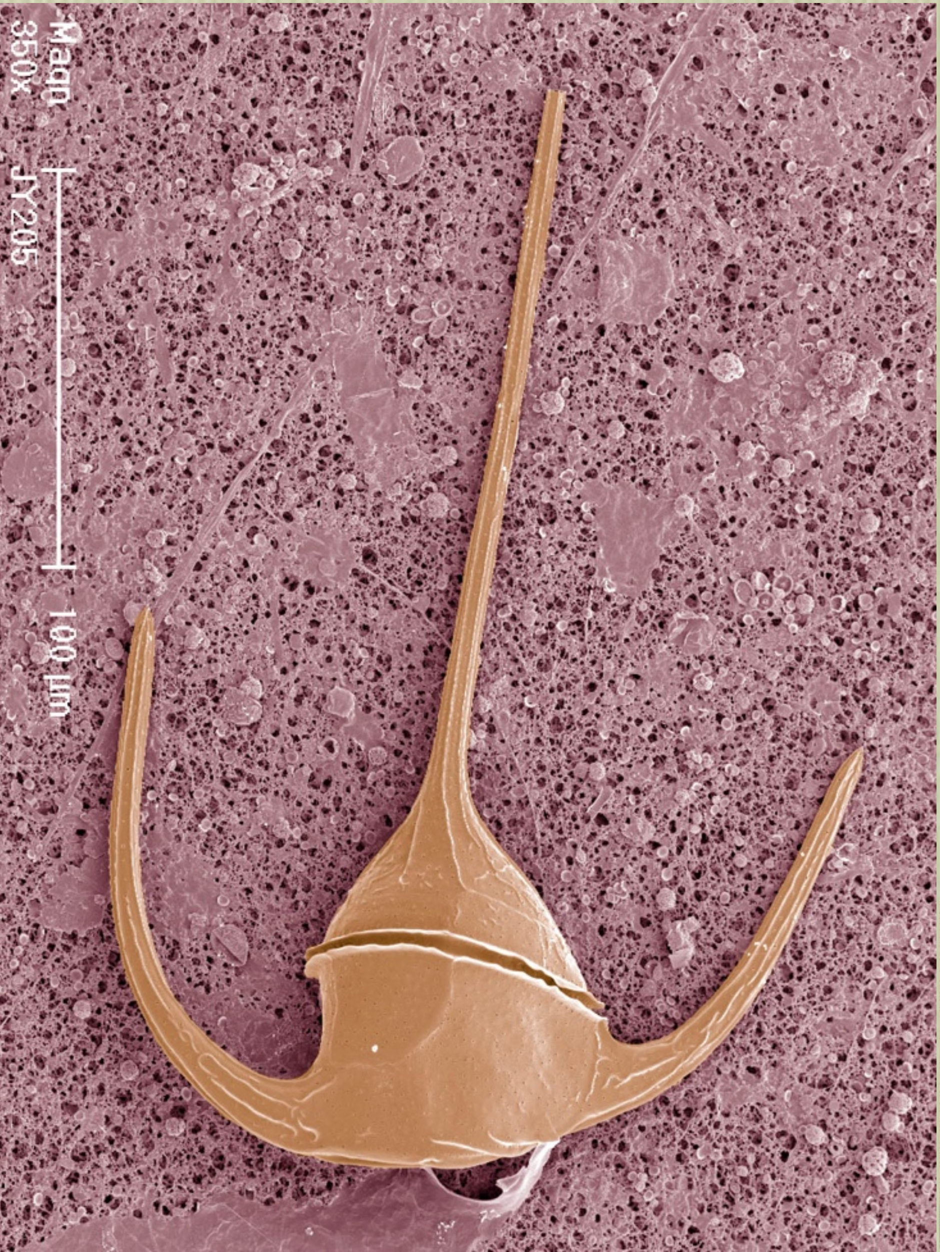
phase contrast

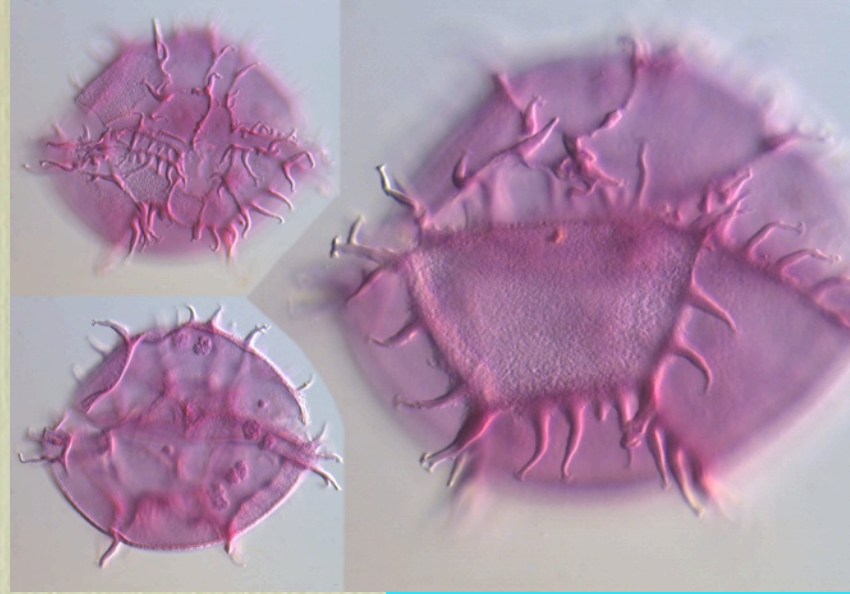
Pseudo-extinction figure reflects basic crystallography features which are not evident in SEM

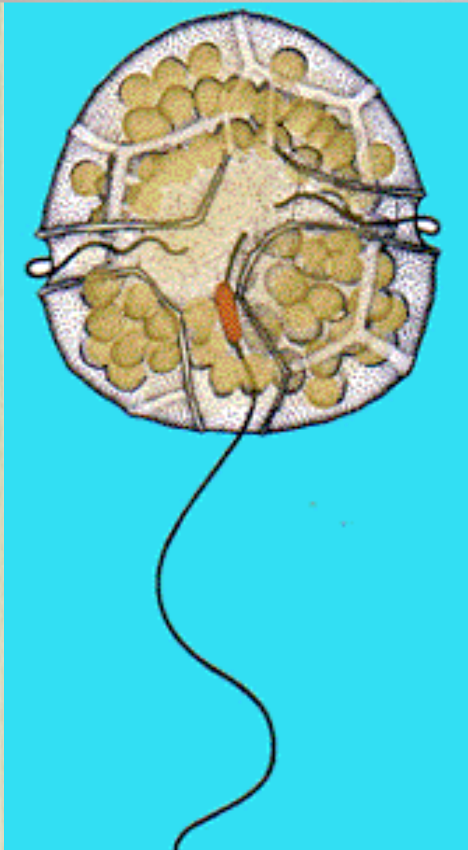


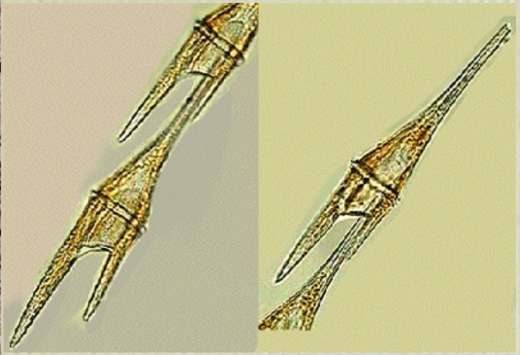
Neogene discoasters - from Young (1998)

Dinoflagellates

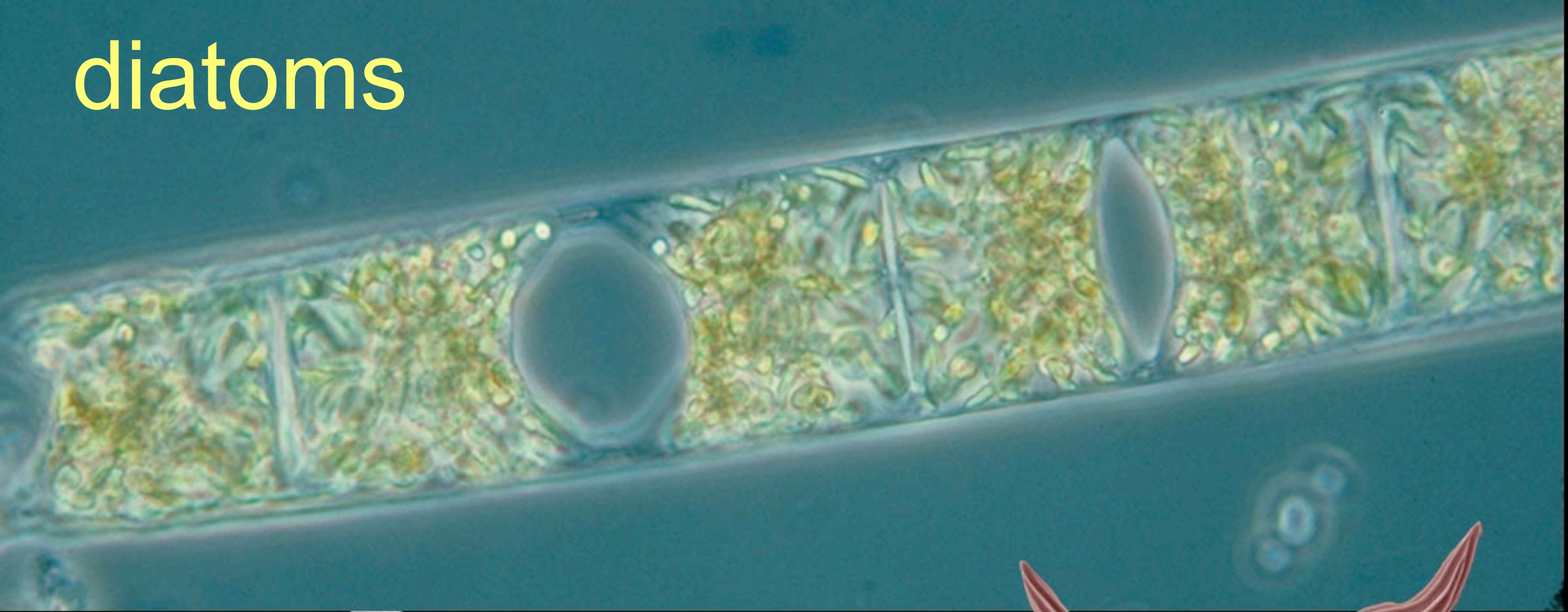


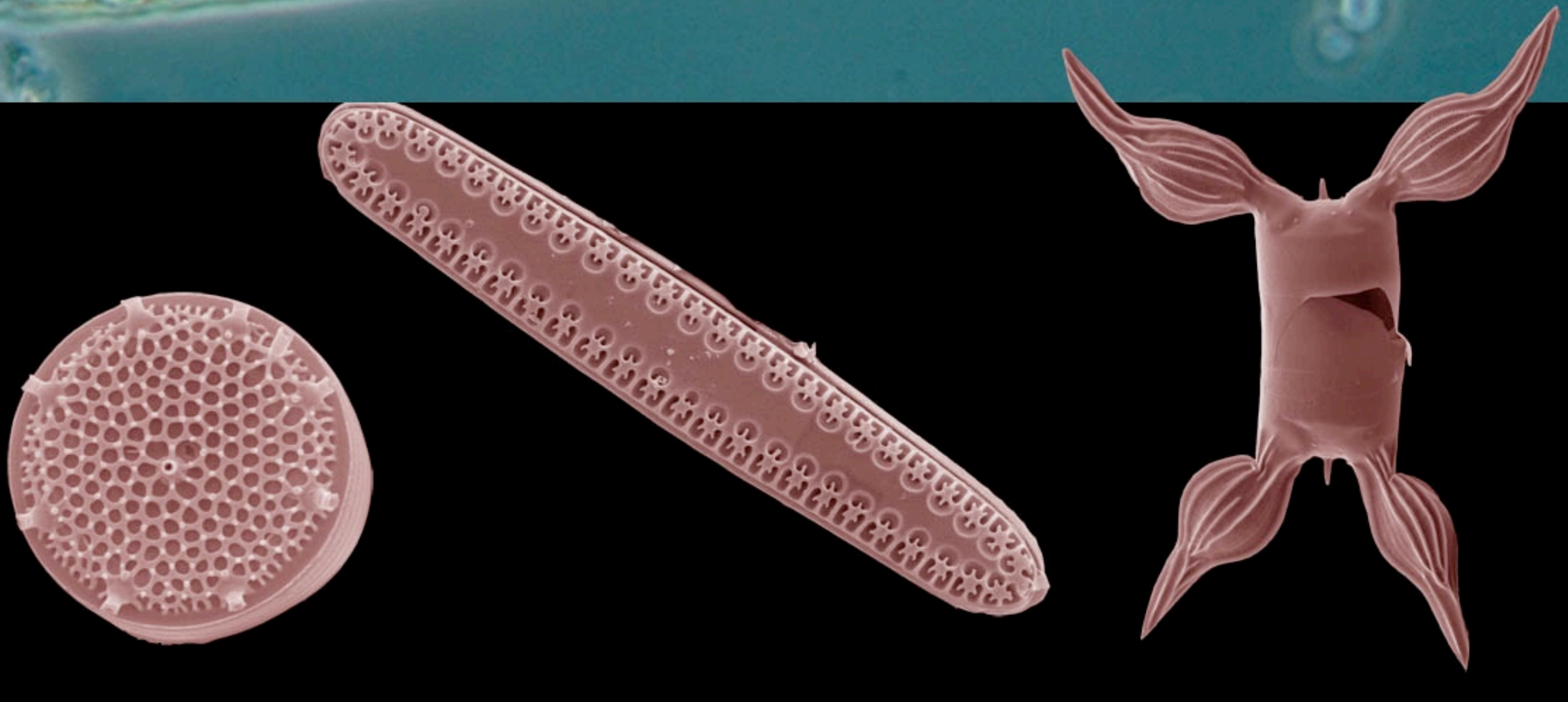




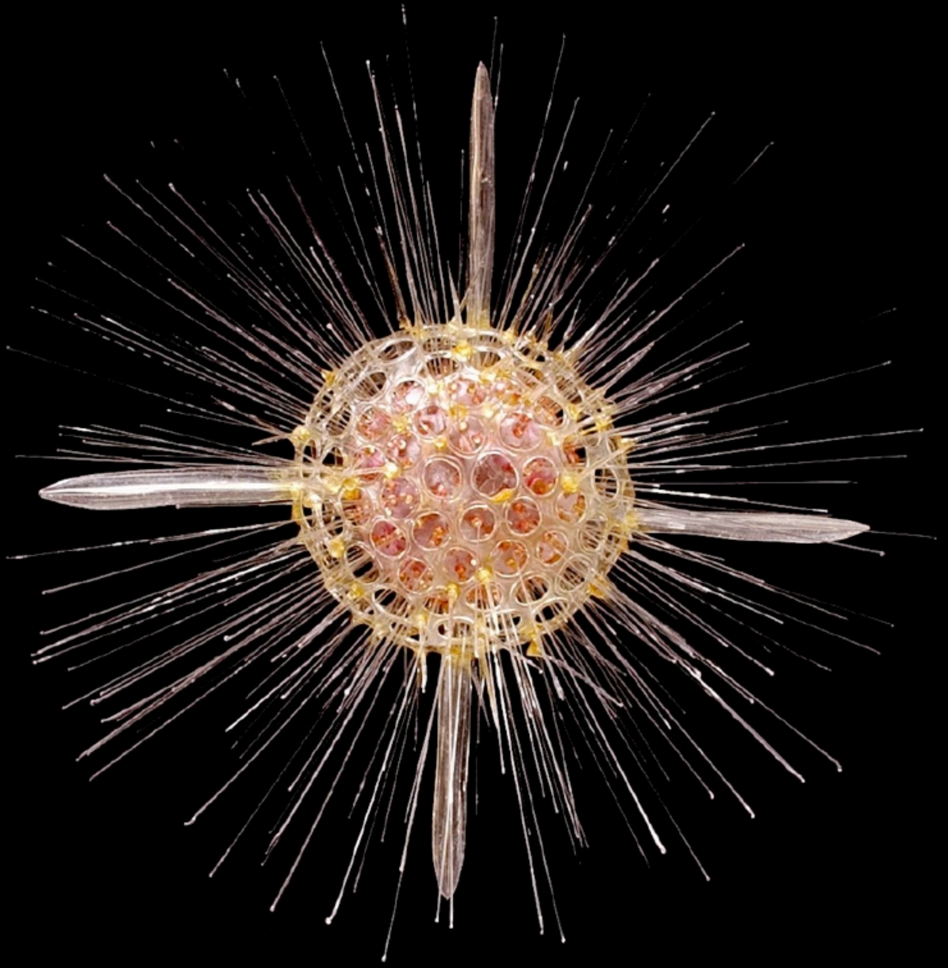


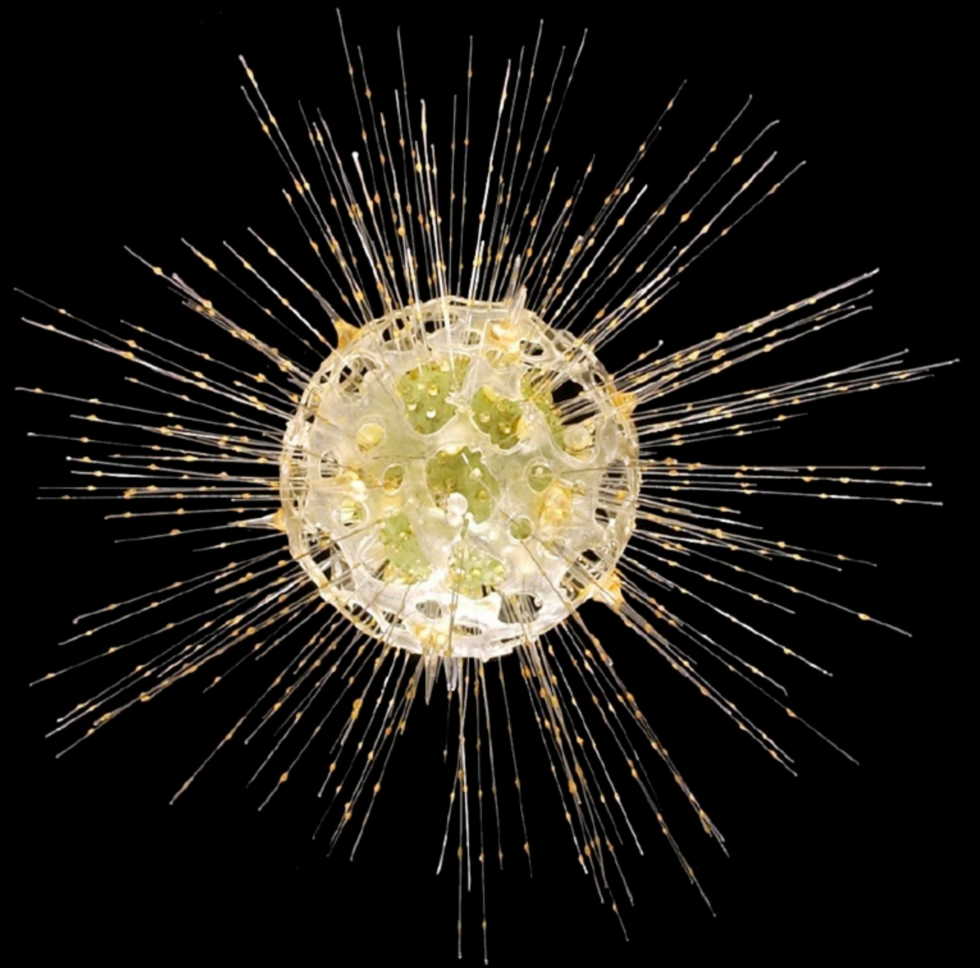
diatoms

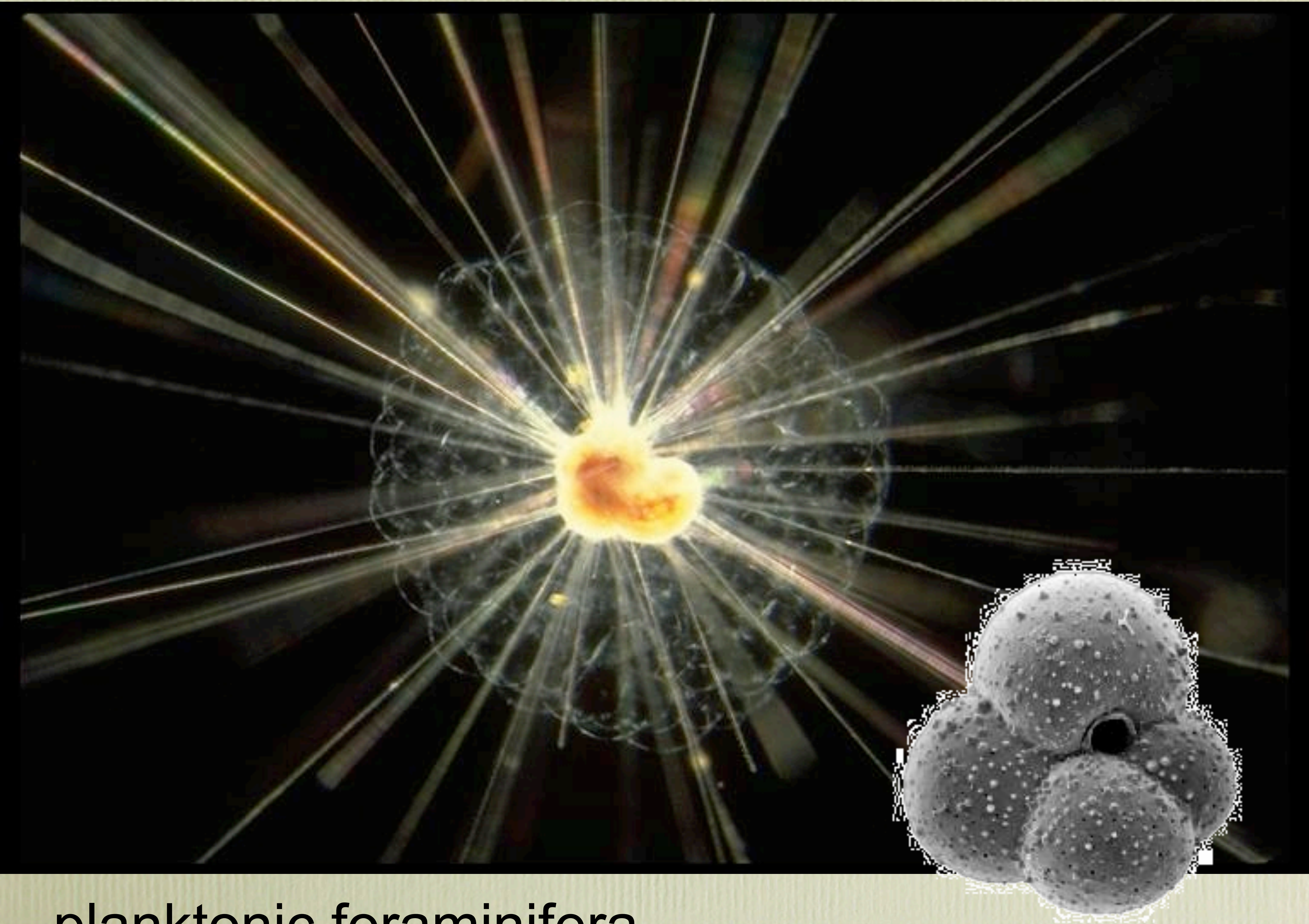




radiolaria







planktonic foraminifera

smaller benthic foraminifera

larger benthic foraminifera - complex and with symbionts

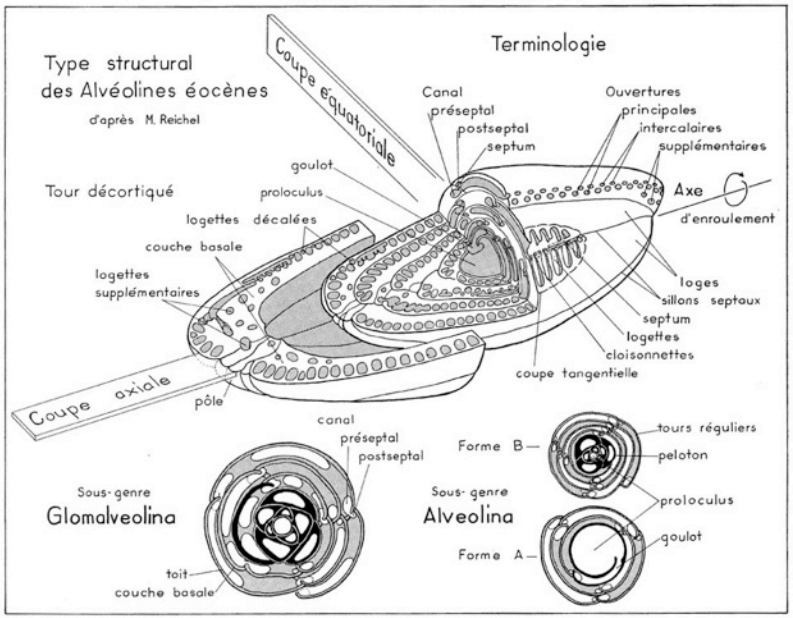


Fig. 9. Terminologie des éléments structuraux chez le genre *Alveolina*. Le stade népionique chez les sous-genres *Glomalveolina* et *Alveolina* s. str. est indiqué en noir.

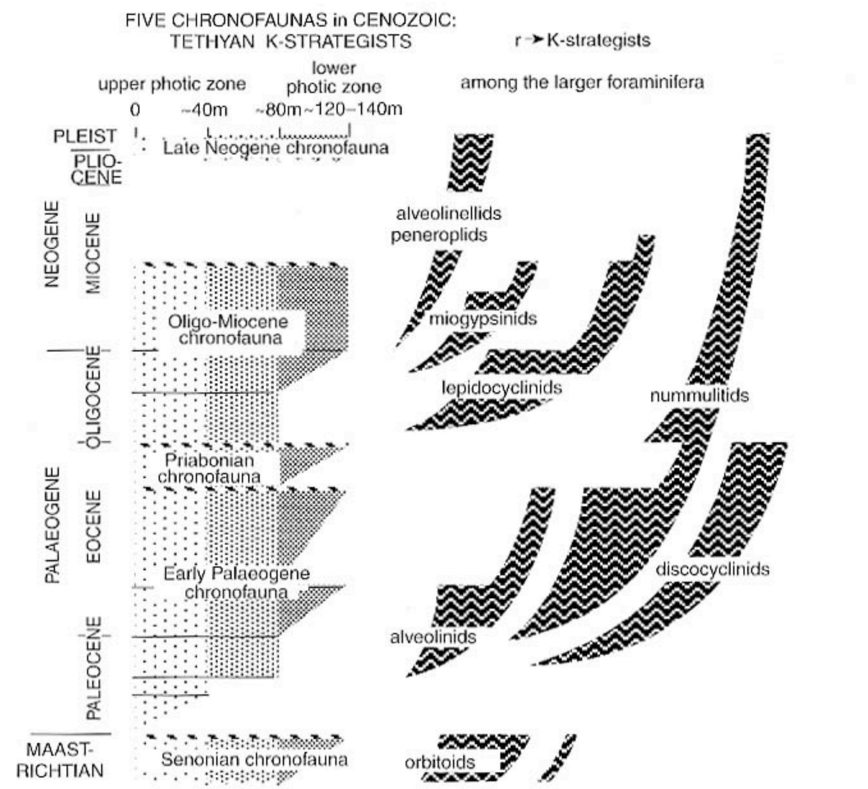
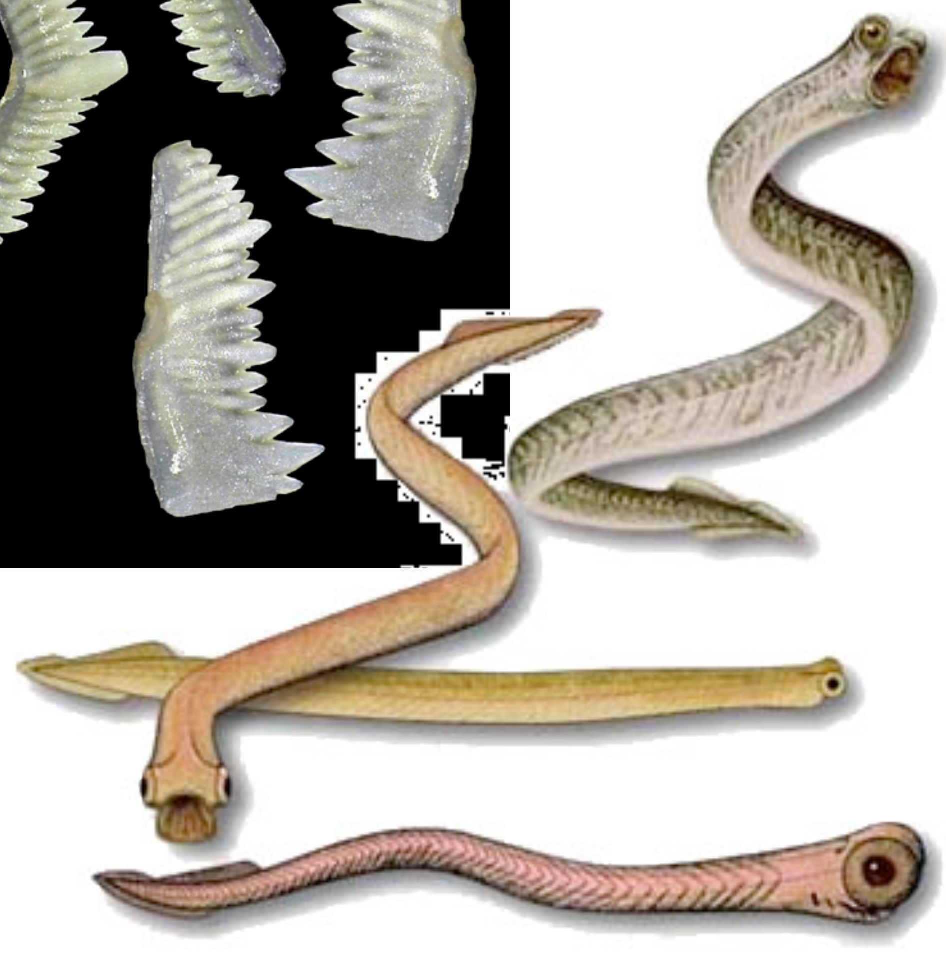


Figure 4.21 Iterative evolution of the larger benthic foraminifera, from McGowran and Li (2000) based heavily on the work of Hottinger (1982, 1997), especially the notion that larger foraminifera iteratively adopted ecological K-strategy in the neritic realm (diversity, size, internal complexity and number of spaces, other photosymbiotic adaptations). *Left*: blocks represent distribution of large foraminifera within the photic zone through time, using generic lists in Hottinger (1997, Table II) where time is divided into sub-epochs, space into three parts of the photic zone. Some lower-photic boxes are half-filled to indicate the presence of only a few genera. Heavy cable pattern: major extinction horizons of K-strategists, terminating the evolution and expansion of chronofaunas (Chapter 6). *Center and right*: trajectories of the major groups independently adopting neritic K-strategy, adapted from Hottinger (1982) with permission.


Early Eocene larger benthic forams
Quaternary International
Quaternary Research

ostracods (bivalved crustacea)



conodonts

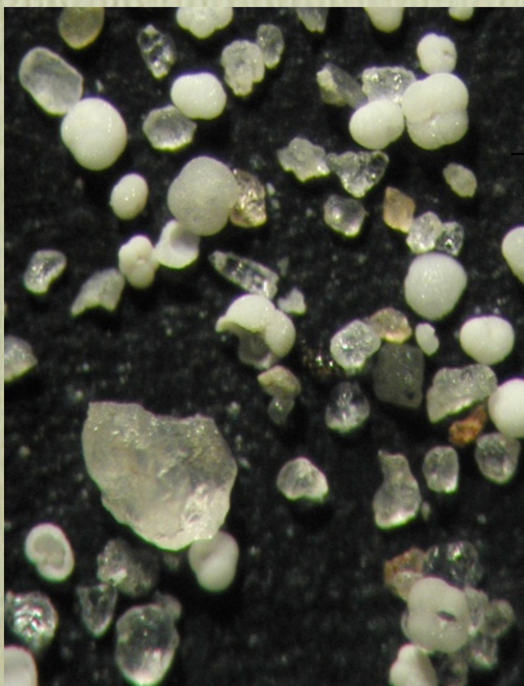
spores and pollen

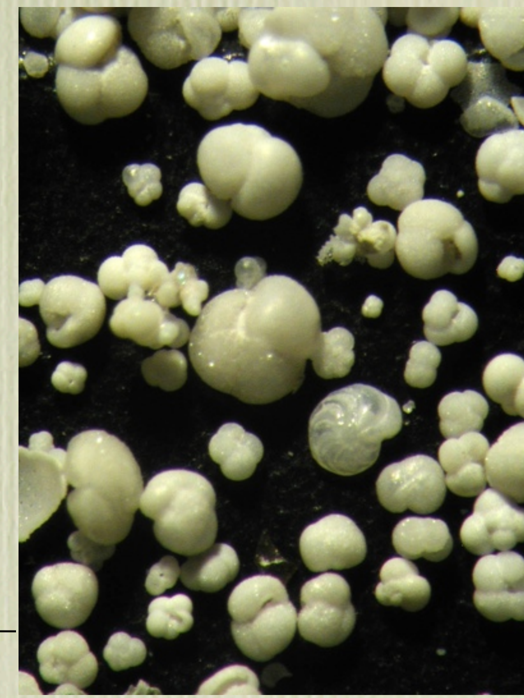
in both industrial and academic drilling microfossils are the only fossils available


H 898

glacial-

iceberg dropstone





dark-> sand & mud

glacial

light-> plankton shells

interglacial

TABLE 14
Distribution of Calcareous Nannofossils in the Basal Paleocene at Site 356

Age: Early Paleocene

Zone NP 4

Group	Site 356 Sample (Interval in cm)	25-1, 125	25-2, 70	25-3, 70	25-4, 70	25-5, 70	25, CC	26-1, 70	26-2, 70	26-3, 70	26-4, 70	26-5, 70
	Depth Below Sea Floor (m)	370.5-380						380-389.5				
	Overall Abundance	C	C	C	A	A	C	C	C	A	A	A
	Etching (1,2,3)	2	1	2	1	2	1	1	1	1	1	1
	Overgrowth (1,2,3)	2	1	2	1	2	1	1	1	1	1	1
Coccolithaceae	*Chiasmolithus consuetus*		R				R		R	1	R	R
	C. danicus	R	R	R	R	R	R	F	F	F	R	R
	Cruciplacolithus notus	F	F	F	F	F	F	R	R	F	R	R
	Cruciplacolithus primus	R	R	R	R	R	R	R	F	F	F	F
	C. tenuis	F	F	F	R	F	F	F	R	R	F	F
	Ericsonia cava	C	C	C	C	C	C	A	C	C	C	A
	E. robusta	F	F	F	F	C	C	F	F	F	F	F
	E. subpertusa	F	F	F	C	F	F	F	F	C	F	F
	Markalius inversus		R			R			R	R	R	
	M. reinhardtii											
Prins.	*Prinsius dimorphosus* (?)											
	P. martinii	C	C	A	A	A	C	C	F	C	C	C
TC	*Scapholithus rhombiformis*									R		R
	Thoracosphaera sp.	C	F	F	F	F	F	F	F	F	F	F
Bra.	*Braarudosphaera* sp.	R										
	Micrantholithus sp.											
C	*Lanternithus duocavus*											
Zygodiscaceae	*Neochiastozygus chiastus*											
	N. cf. *N. denticulatus*											
	N. imbriei											R
	N. modestus					F	F	R	R	F	F	F
	N. perfectus	R	R	R	R	R	R					
	N. cf. *N. perfectus*										R	R
	N. cf. *N. saepes*								R	R	R	R
	Neococcolithes cf. *N. protenus*								R	R	R	F
	Neochiastozygus sp. indet.	C	F	F	R	R	R	F	F	C	C	C
	Crepidolithus sp.											
	Zygodiscus sigmoides	F	F	F	F	F	C	F	F	F	F	F
D	*Biantholithus sparsus*											
F	*Fasciculithus magnus*			R	1	F	R	R	R			
Incertae sedis	*Acanthoica* ? sp.		R			R					R	
	Biscutum sp.											
	Ellipsolithus macellus		R	R	R	R	R	R	R	R	R	R
	Hornibrookina edwardsii											
	H. teuriensis				R		R		R	R	R	R
	Lapideacassis sp.											
	Scampanella sp.				1	1	1			1	1	

Zone NP 3

Group	Site 356 Sample (Interval in cm)	26-6, 70	26, CC	27-1, 70	27-2, 70	27-3, 70	27-4, 70	27-5, 70	27-6, 70	27, CC	28-1, 70	28-2, 70	28-3, 70	28-4, 70
	Depth Below Sea Floor (m)	380-389.5		389.5-399						399-408.5				
	Overall Abundance	C	C	A	A	A	A	A	A	C	A	A	A	C
	Etching (1,2,3)	2	2	1	1	1	1	1	1	1	1	1	1	1
	Overgrowth (1,2,3)	1	1	1	1	1	1	1	1	1	1	1	1	1
Coccolithaceae	*Chiasmolithus consuetus*				R	R	R	R						
	C. danicus	R	F	F	R	F	R	F	R	F	F	R	R	F
	Cruciplacolithus notus	R	R	R	R	R	R	R	R	R	R	F	F	F
	Cruciplacolithus primus	F	F	F	F	F	F	F	F	F	F	C	F	F
	C. tenuis	F	F	F	F	F	F	F	F	F	F	F	C	F
	Ericsonia cava	A	A	A	C	A	A	C	C	C	C	C	C	C
	E. robusta	R												
	E. subpertusa	F	F	F	F	F	F	F	F	F	R	F		
	Markalius inversus	R	R	R	R	R	R	R		R		R	R	
	M. reinhardtii			R				R			R			
Prins.	*Prinsius dimorphosus* (?)											C	C	C
	P. martinii	C	C	F	C	C	F	F	A	A	A	C	C	
TC	*Scapholithus rhombiformis*	R	R	R	R									
	Thoracosphaera sp.	F	F	F	F	F	F	F	F	F	F	F	F	F
Bra.	*Braarudosphaera* sp.					R			R					
	Micrantholithus sp.													
C	*Lanternithus duocavus*													
Zygodiscaceae	*Neochiastozygus chiastus*		R	R										
	N. cf. *N. denticulatus*					R	F	R	R			R	R	
	N. imbriei	R	R	R	R									
	N. modestus	F	F	R	R		R	R	R	C	R	R	R	F
	N. perfectus													
	N. cf. *N. perfectus*	R	R	R										
	N. cf. *N. saepes*		R	R	R	F								
	Neococcolithes cf. *N. protenus*	R	R	R	R	R	R	R		R	R	R		
	Neochiastozygus sp. indet.	F	C	F	F	F	F	F	R	R	R	R	R	F
	Crepidolithus sp.													
	Zygodiscus sigmoides	F	C	F	F	F	F	F	F	C	F	F	F	F
D	*Biantholithus sparsus*							R					R	
F	*Fasciculithus magnus*													
Incertae sedis	*Acanthoica* ? sp.									R				
	Biscutum sp.										R			
	Ellipsolithus macellus													
	Hornibrookina edwardsii			R	R	R		R		R	R		R	R
	H. teuriensis	R	R	R	R	R		R		R	R			
	Lapideacassis sp.												R	
	Scampanella sp.												R	

Zone NP 2

Group	Site 356 Sample (Interval in cm)	28-5, 70	28-6, 94	28, CC	29-1, 10	29-1, 22	29-1, 30	29-1, 40	29-1, 50	29-1, 60	29-1, 70	29-1, 81	29-1, 90
	Depth Below Sea Floor (m)	399-408.5			408.5-411.5								
	Overall Abundance	C	C	C	C	C	C	C	C	A	C	C	C
	Etching (1,2,3)	1	1	1	1	1	2	1	1	1	1	1	2
	Overgrowth (1,2,3)	1	1	1	1	1	1	1	1	1	1	1	1
Coccolithaceae	*Chiasmolithus consuetus*												
	C. danicus												
	Cruciplacolithus notus	R	R	R	R								
	Cruciplacolithus primus	F	C	C	C	C	C	C	C	A	C	F	F
	C. tenuis	C	F	F	C	F	F	F	F	F	R	R	R
	Ericsonia cava	C	C	C	F								
	E. robusta												
	E. subpertusa												
	Markalius inversus		R		R		R	R	R		R	R	R
	M. reinhardtii	R		R	R			R	R				
Prins.	*Prinsius dimorphosus* (?)		C	F							F	C	C
	P. martinii												
TC	*Scapholithus rhombiformis*												
	Thoracosphaera sp.	C	C	C	F	C	C	C	C	F	C	F	A
Bra.	*Braarudosphaera* sp.		R	R			R	R			R	C	C
	Micrantholithus sp.		R									F	F
C	*Lanternithus duocavus*	R	R			R				R	F	R	F
Zygodiscaceae	*Neochiastozygus chiastus*												
	N. cf. *N. denticulatus*				R	R	R	R	R	R	R	R	R
	N. imbriei												
	N. modestus	F	F	F	F	F	F	C	R				
	N. perfectus												
	N. cf. *N. perfectus*												
	N. cf. *N. saepes*			R	R								
	Neococcolithes cf. *N. protenus*												
	Neochiastozygus sp. indet.	F	F	F	F	F	F	F	F	F	F	F	?R
	Crepidolithus sp.				R			R	R				
	Zygodiscus sigmoides	F	F	F	F	F	F	F	F	C	F	F	F
D	*Biantholithus sparsus*							R			R		
F	*Fasciculithus magnus*												
Incertae sedis	*Acanthoica* ? sp.						R						
	Biscutum sp.												
	Ellipsolithus macellus							r					
	Hornibrookina edwardsii												
	H. teuriensis												
	Lapideacassis sp.												
	Scampanella sp.												R

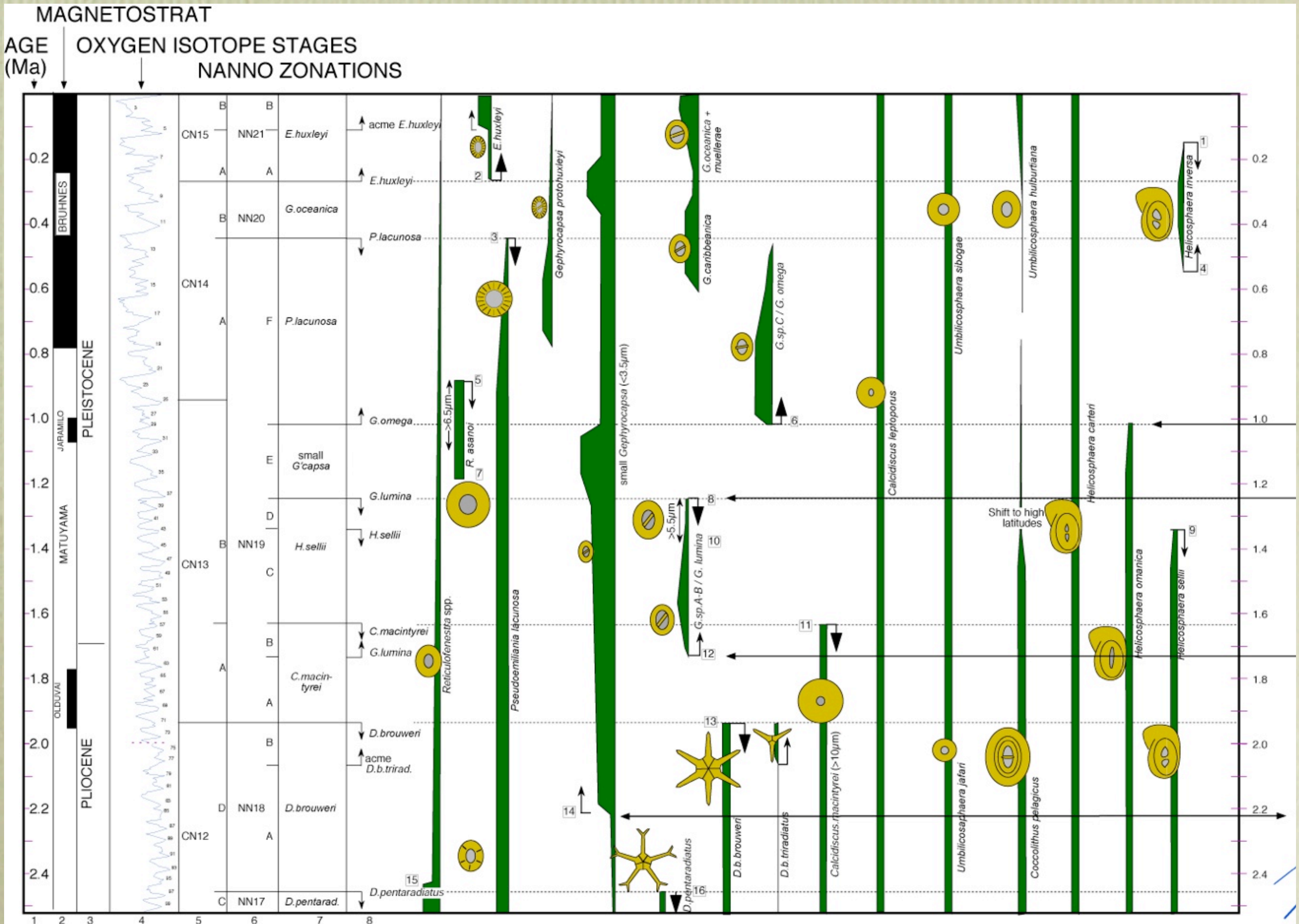
Zone NP 1

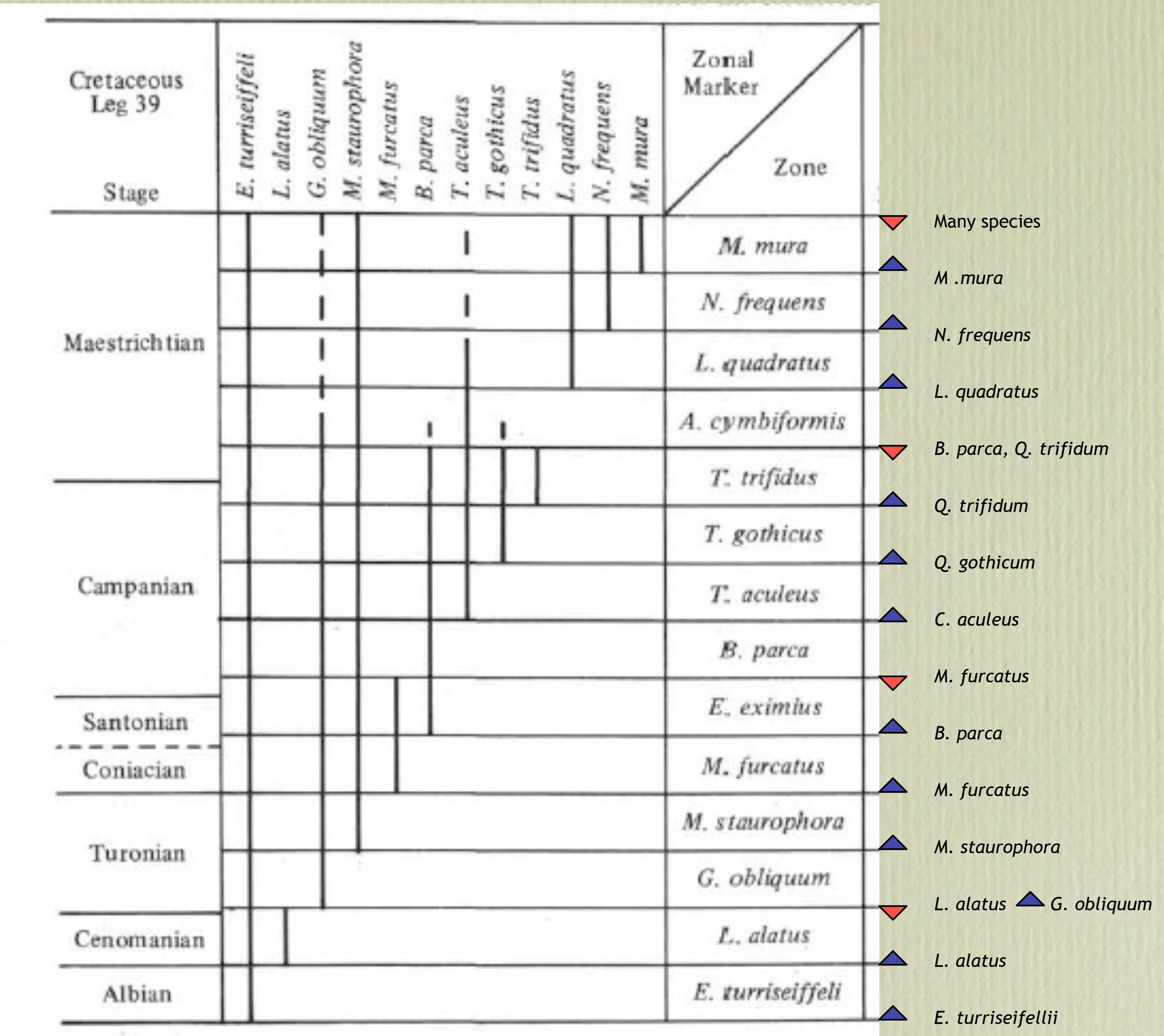
Group	Site 356 Sample (Interval in cm)	29-1, 100	29-1, 110	29-1, 118	29-1, 140	29-2, 10	29-2, 30	29-2, 50	29-2, 70	29-2, 90	29-2, 110	29-2, 140	29-3, 10	29-3, 20	29-3, 30
	Depth Below Sea Floor (m)	408.5-411.5													
	Overall Abundance	C	F	F	C	C	F	C	C	C	C	C	C	C	C
	Etching (1,2,3)	2	2	2	1	1	2	1	1	1	1	2	1	1	1
	Overgrowth (1,2,3)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Coccolithaceae	*Chiasmolithus consuetus*														
	C. danicus														
	Cruciplacolithus notus														
	Cruciplacolithus primus	F	?F	?F	?F										
	C. tenuis														
	Ericsonia cava					?									
	E. robusta														
	E. subpertusa														
	Markalius inversus	R	R	R	R	R	R	R		R		R	R	R	R
	M. reinhardtii					R				R	R	R	R	R	
Prins.	*Prinsius dimorphosus* (?)	C													
	P. martinii														
TC	*Scapholithus rhombiformis*														
	Thoracosphaera sp.	C	A	A	C	C	C	C	C	C	C	C	C	C	C
Bra.	*Braarudosphaera* sp.	R	R	R	F			R				R	R		
	Micrantholithus sp.	R													
C	*Lanternithus duocavus*			R	R			R	R	R					
Zygodiscaceae	*Neochiastozygus chiastus*														
	N. cf. *N. denticulatus*	R	F	R	F	F	R	R	F	F	F	R	R	R	R
	N. imbriei														
	N. modestus														
	N. perfectus														
	N. cf. *N. perfectus*														
	N. cf. *N. saepes*														
	Neococcolithes cf. *N. protenus*														
	Neochiastozygus sp. indet.			?R	?R	?R		?R	?R	?R	?R	?R	?R	?R	
	Crepidolithus sp.													R	
	Zygodiscus sigmoides	R	F	R	F	F	R	F	R	F		R	R	R	R
D	*Biantholithus sparsus*							?R		?R				R	R
F	*Fasciculithus magnus*														
Incertae sedis	*Acanthoica* ? sp.	R	R	R		R									
	Biscutum sp.	R		R						R			R	R	
	Ellipsolithus macellus														
	Hornibrookina edwardsii														
	H. teuriensis														
	Lapideacassis sp.														
	Scampanella sp.														

Distribution chart - from Perch-Nielsen 1977, *IRDSDP* **39**

Shows all primary data, includes abundance data, includes zonal interpretation, includes preservation data
Useful sorting of species

Biostratigraphy - microfossils are the prime means of determining the age of sediments, especially in the Cenozoic





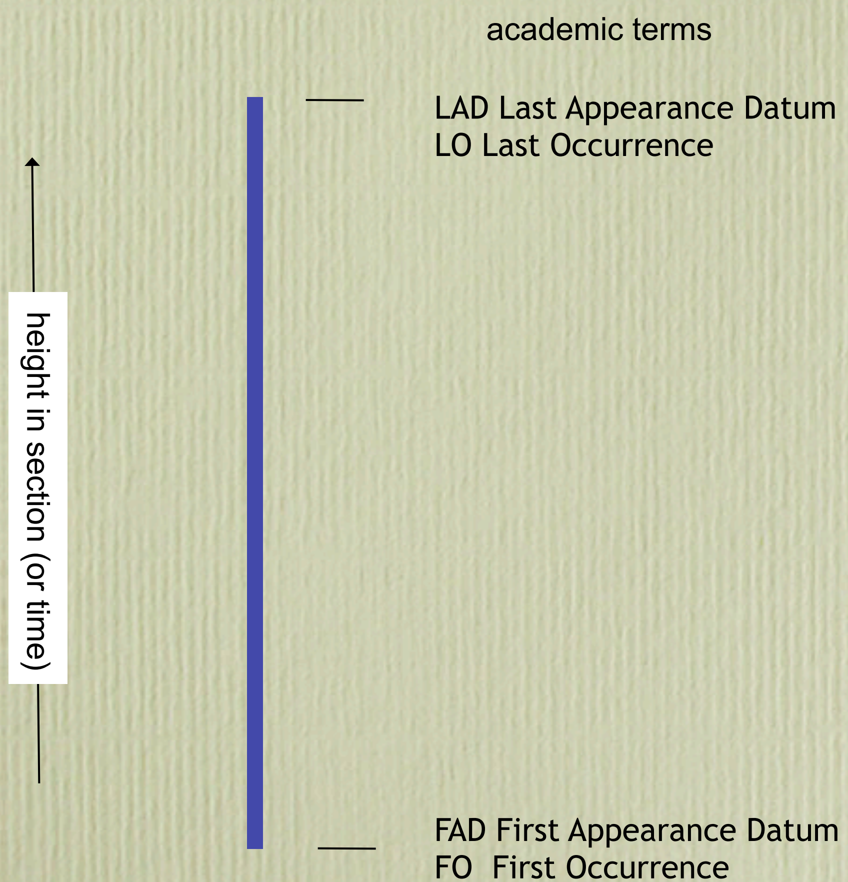
Typical plankton zonation
ad hoc mix of first and last occurrences, and every type of zone (including mutuaL absence zones which do not occur in the textbooks).

Datums are more important than zones

But numbered zones are very useful for communication

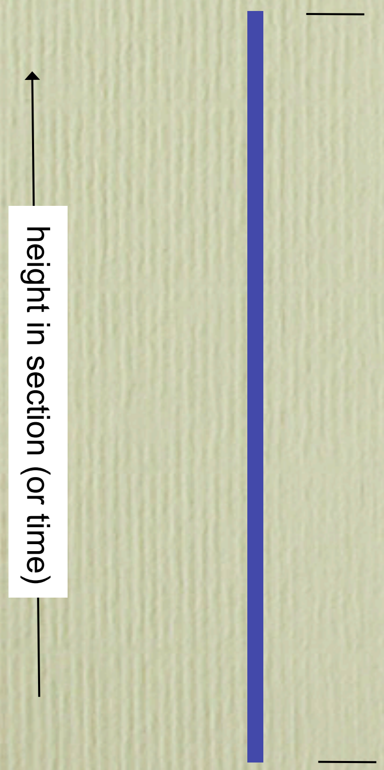
Some irritating terminology

for describing the stratigraphic range of a taxon



Some irritating terminology

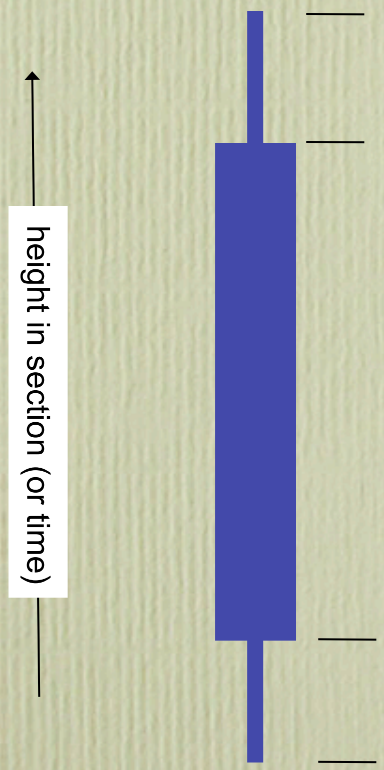
for describing the stratigraphic range of a taxon



academic terms	industrial terms
LAD Last Appearance Datum LO Last Occurrence	FDO First Downhole Occurrence Top
FAD First Appearance Datum FO First Occurrence	LDO Last Downhole Occurrence Bottom

Some irritating terminology

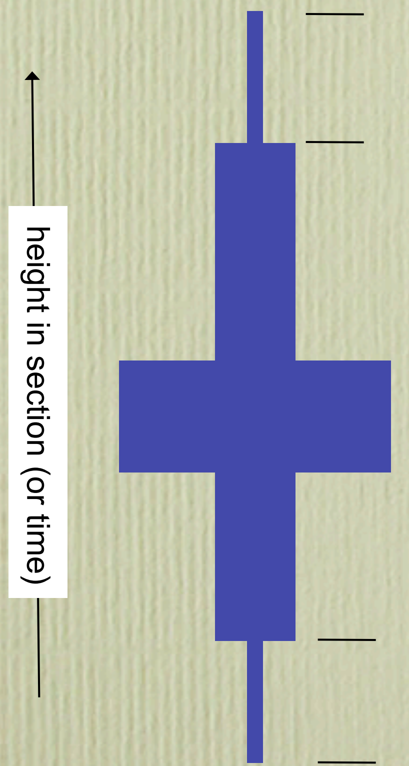
for describing the stratigraphic range of a taxon



academic terms	industrial terms
LAD Last Appearance Datum LO Last Occurrence	FDO First Downhole Occurrence Top
LCO Last Common Occurrence	
FCO First Common Occurrence	
FAD First Appearance Datum FO First Occurrence	LDO Last Downhole Occurrence Bottom

Some irritating terminology

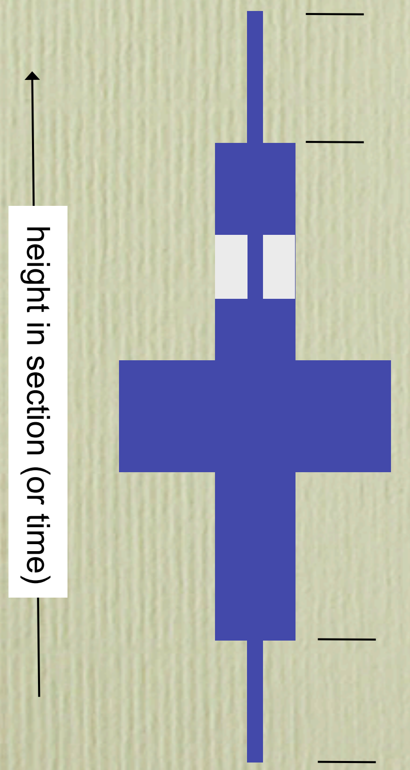
for describing the stratigraphic range of a taxon



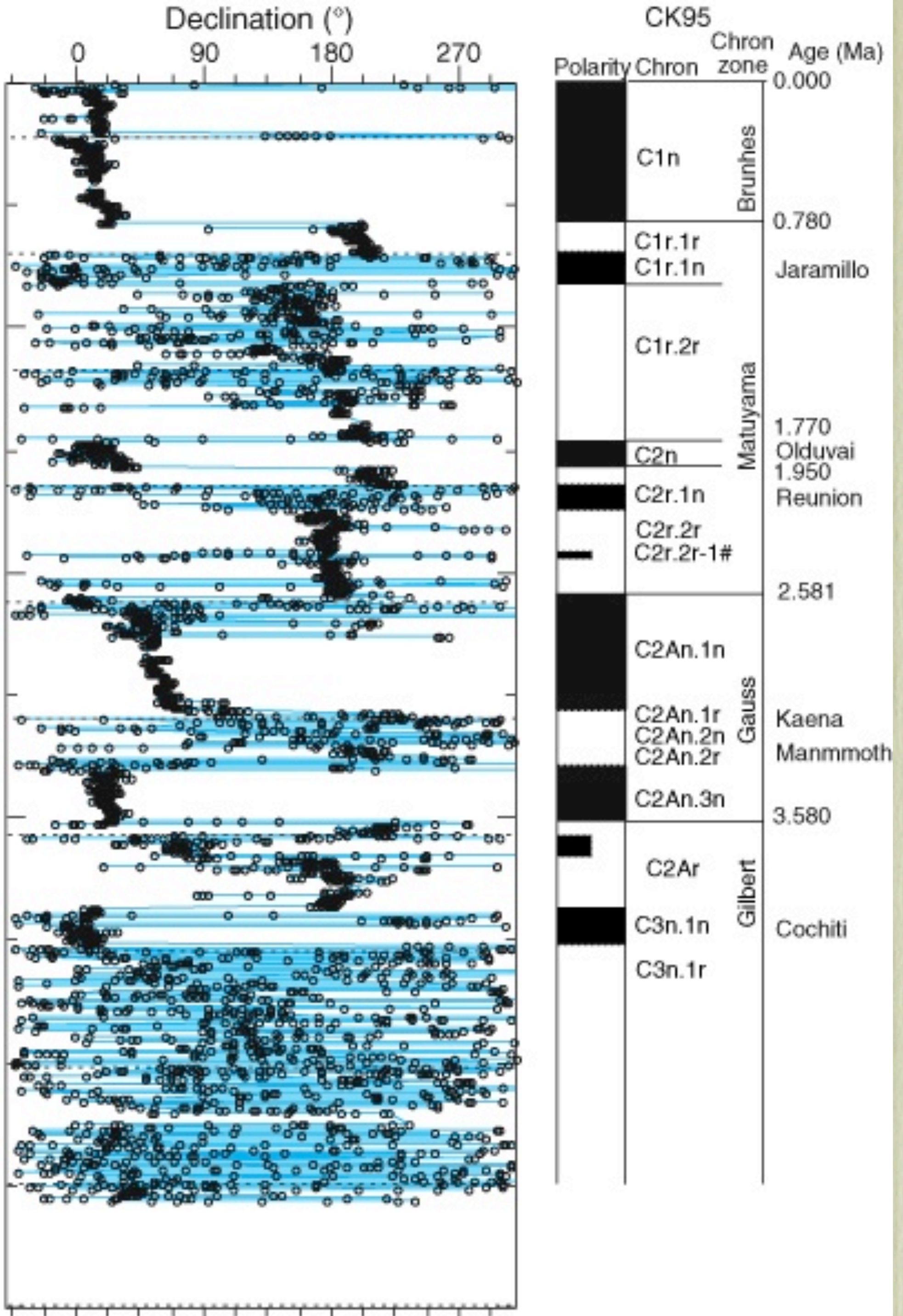
academic terms	industrial terms
LAD Last Appearance Datum LO Last Occurrence	FDO First Downhole Occurrence Top
LCO Last Common Occurrence	
Acme	
FCO First Common Occurrence	
FAD First Appearance Datum FO First Occurrence	LDO Last Downhole Occurrence Bottom

Some irritating terminology

for describing the stratigraphic range of a taxon



academic terms	industrial terms
LAD Last Appearance Datum LO Last Occurrence	FDO First Downhole Occurrence Top
LCO Last Common Occurrence	
Paracme	
Acme	
FCO First Common Occurrence	
FAD First Appearance Datum FO First Occurrence	LDO Last Downhole Occurrence Bottom



Example of ODP core magnetic record

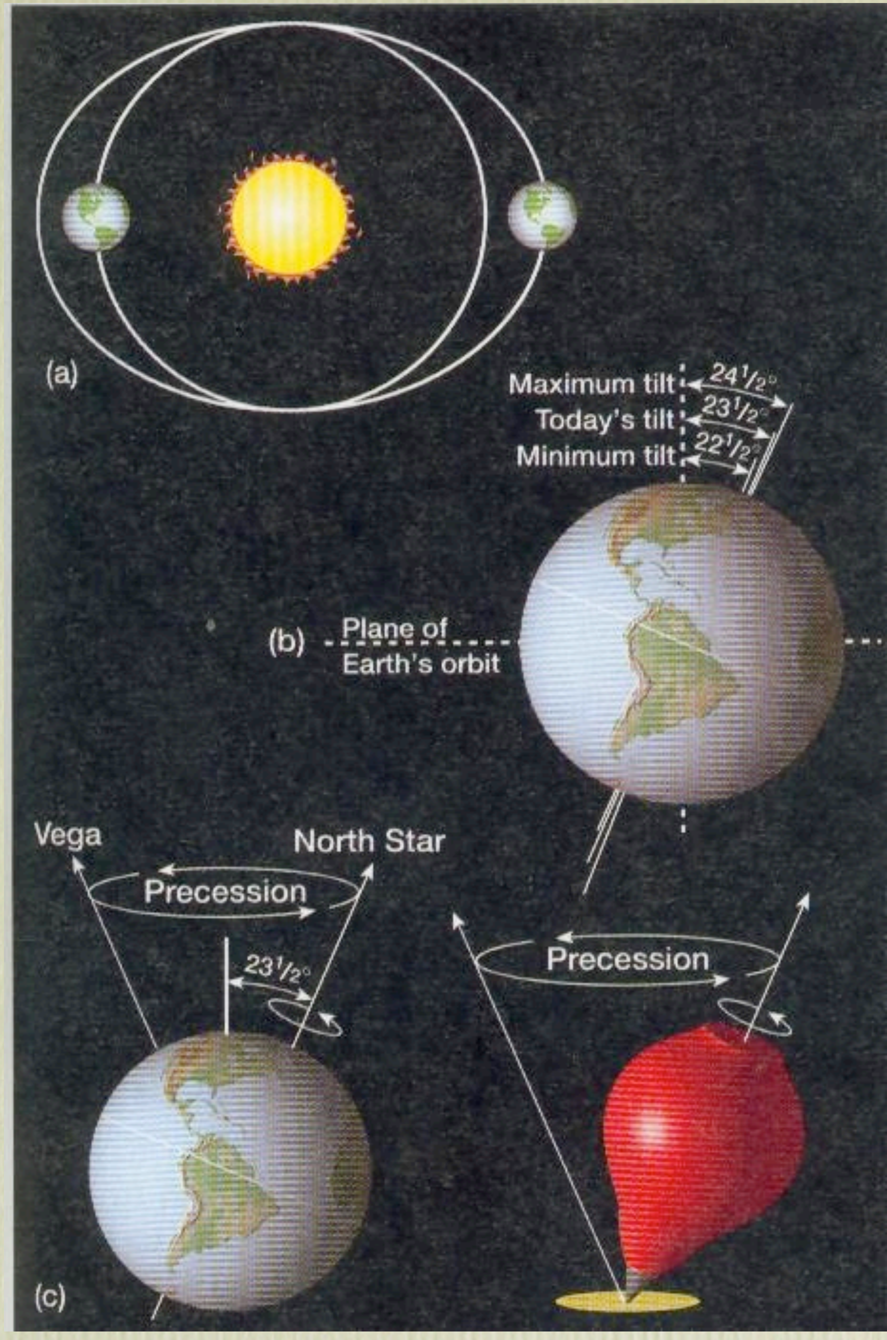
sediementary magnetisation is weak in biogenic sediments

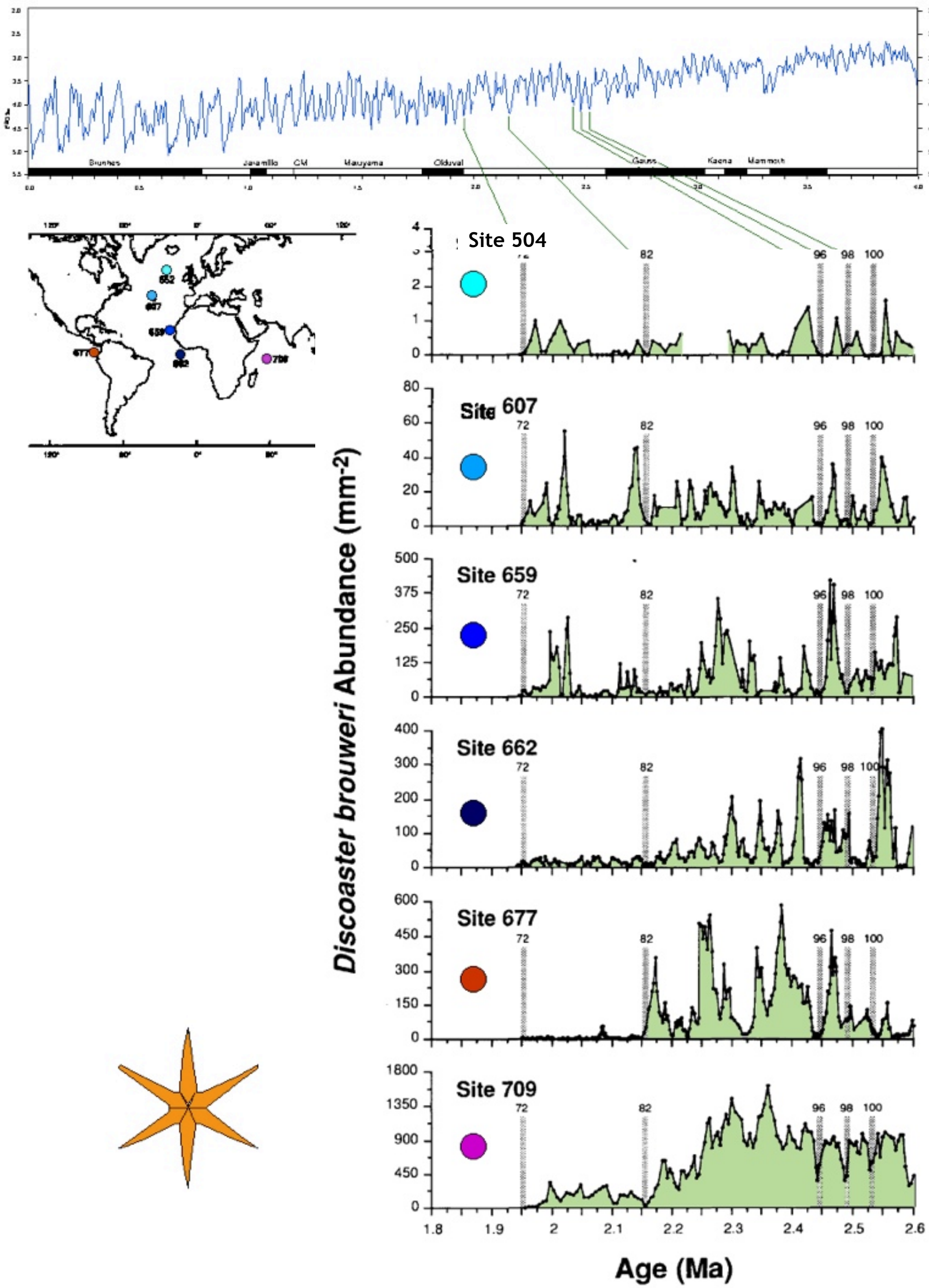
but allows direct correlation of plankton biostratigrphy and magnetochronology

Cyclostratigraphy

Gravitational interactions of the planetes cause changes in the earth's orbit and so temporal and spatial distribution of solar flux

1. Precession ca 20ka
2. Obliquity ca 40ka
3. Eccentricity ca 100 & 400ka





From Chapman & Chepstow-Lusty 1997, *Palaeo3*, **134**, 109-125

Orbital Cyclostratigraphy

provides timescale on 20-100ka resolution

Multiple applications e.g.

- recalibration of timescale
- analysis of diachrony
- very high resolution age-depth models

- cyclostrat can be used to study diachrony and non-diachronous events (eg LO of *D. brouweri)* can then be used to tie-point floating segments of stratigraphy

Cenomanian work of Gale et al.

Comparative logging around the UK -> beds are traceable -> must have an environmental origin.
212 beds recognised within the Cenomanian, which is 4Ma long (so ca 20ka/bed)

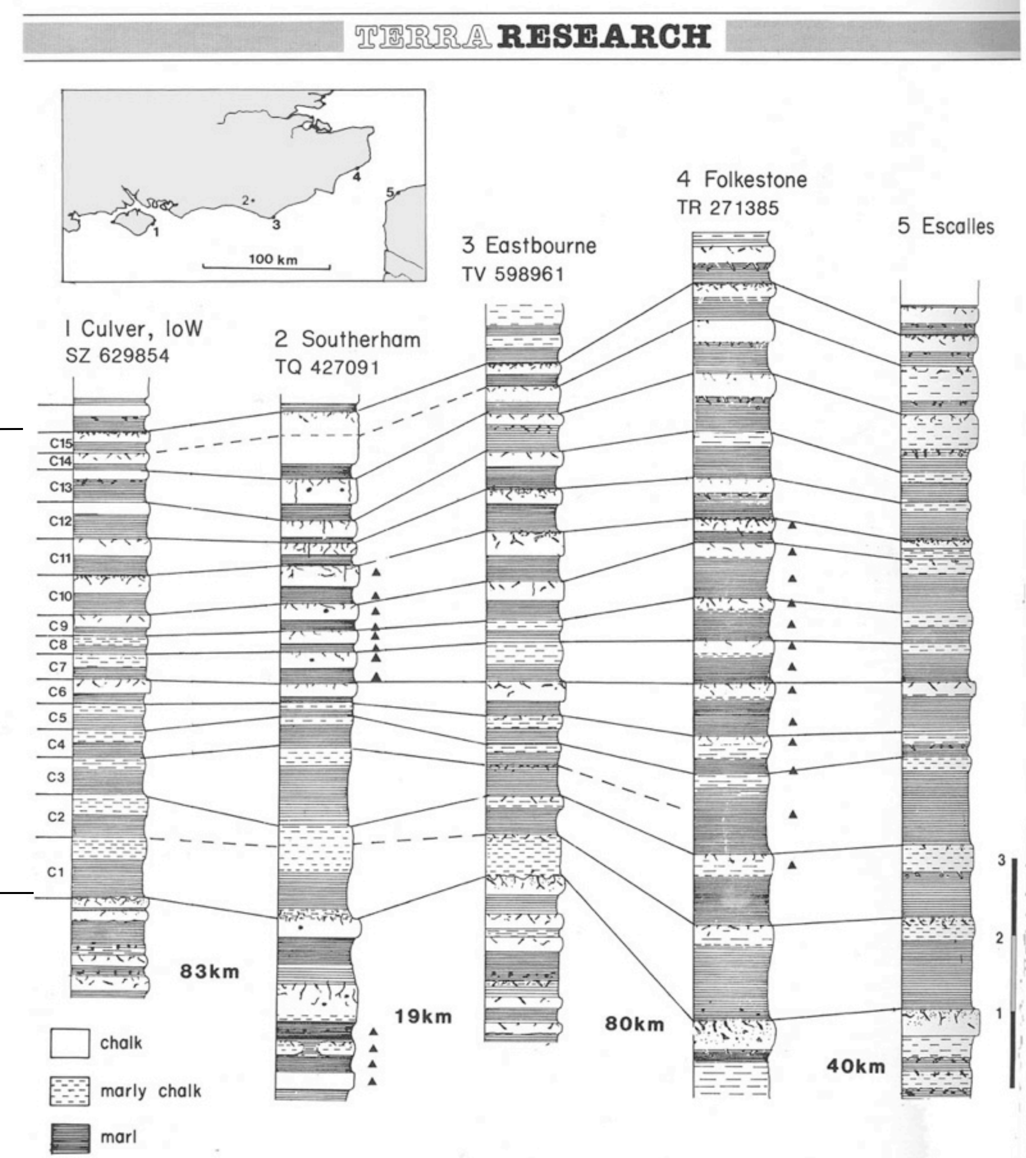


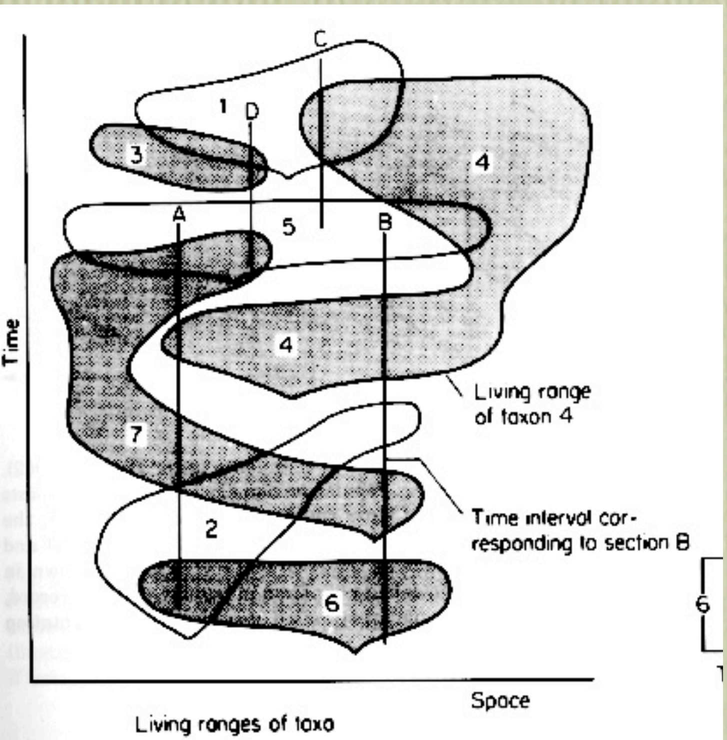
Fig. 2. *Correlation of 3 sets of chalk marl couplets (mid-Cenomanian,* Acanthoceras rhotomagnese *Zone) across the northern Anglo-Paris Basin, numbered C1–C15. The individual couplets are believed to represent 20 kyr cycles. Small black triangles record the occurrence of the rhynchonellid brachiopod* Orbirhynchia mantelliana*. Map shows positions of localities. Scale in metres.*

Graphic Correlation technique for assembling “true” sequence of bioevents

1. Graphically compare sequence of events in two wells -> synthesise info from them into a composite standard

2. Compare sequence from another well with standard -> improve model

3. Carry on with process until nice reliable model of bioevent sequence has been built up



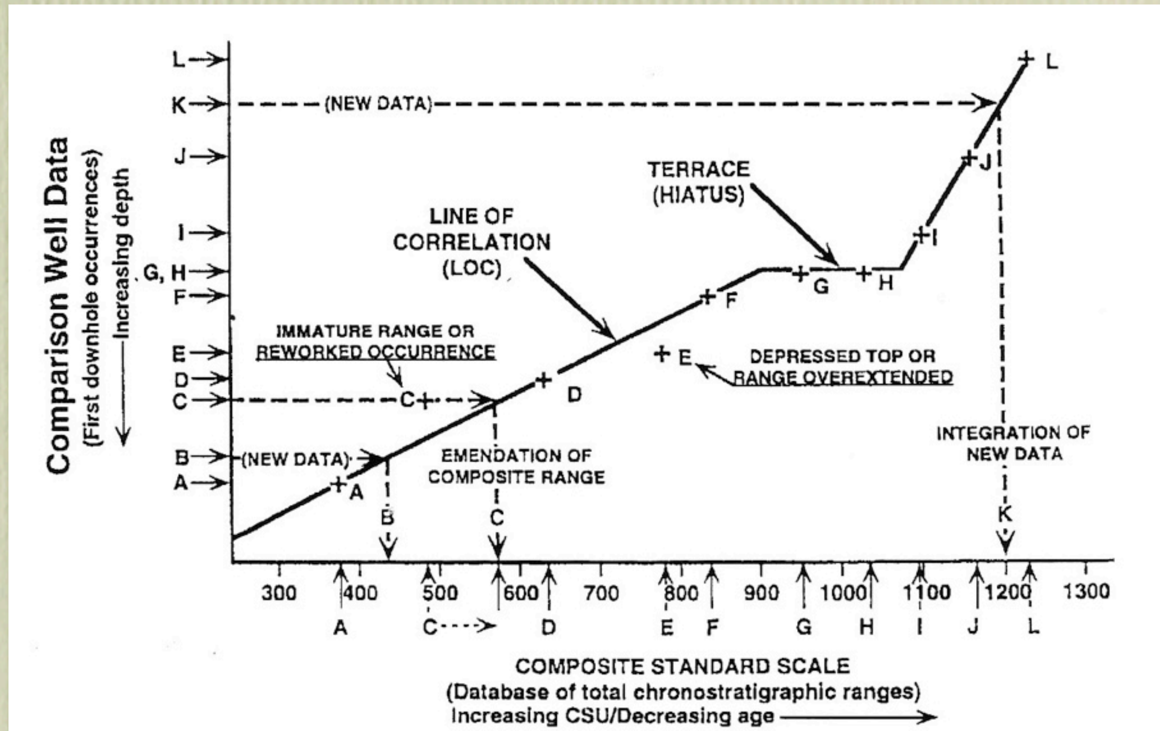
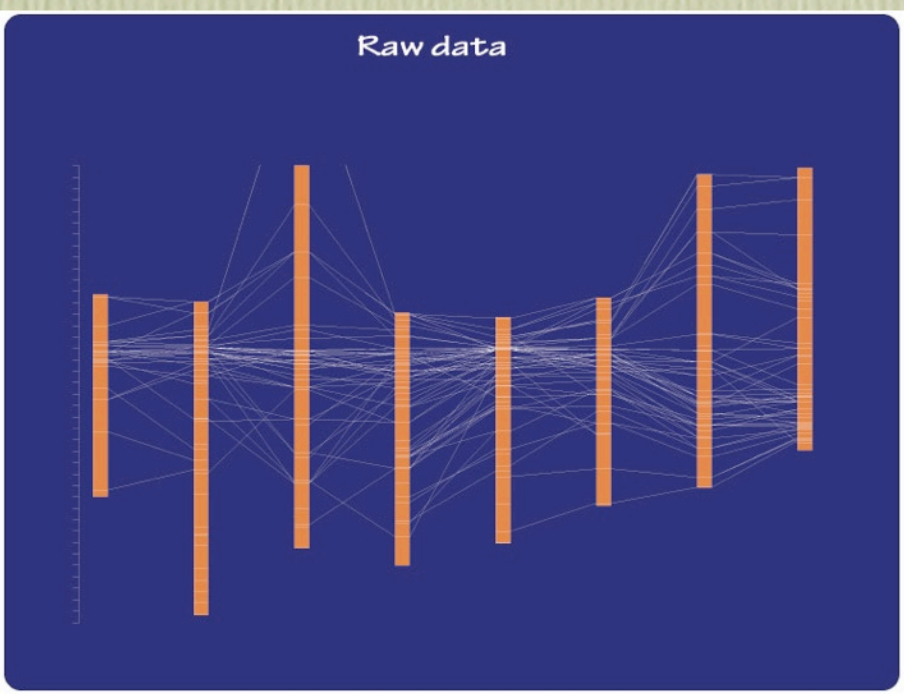


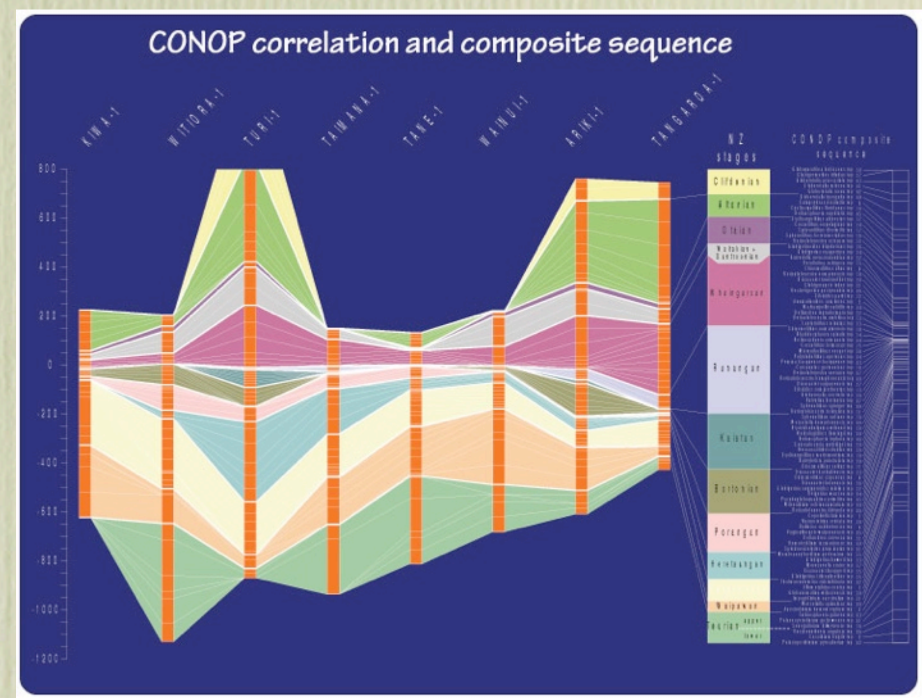
Figure 3.9 Graphic correlation (Neal *et al.*, 1988, Fig. 2.

(CONOP) CONstrained OPtimsation

CONOP9's primary purpose is to correlate stratigraphic sections which contain fossils. It finds the best sequence of first and last appearance of fossil taxa, can handle large amounts of data from many sections, and be used to construct a composite range chart for the taxa

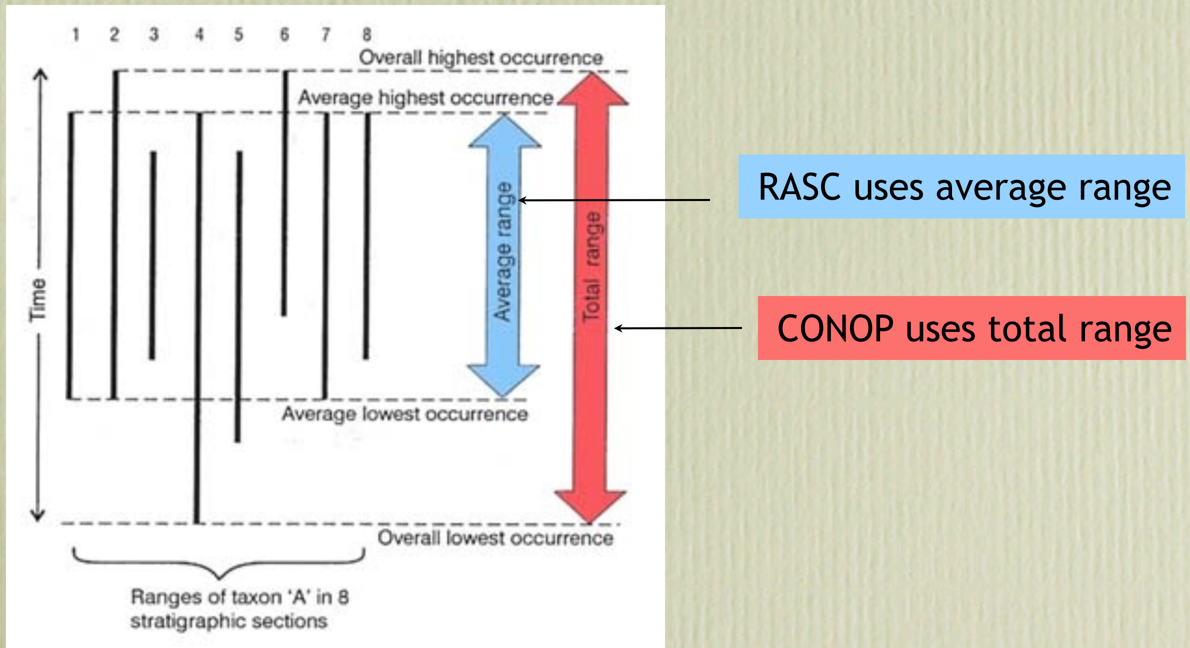
- Differs from graphic correlation in being necessarily computer-based with testing of hundreds of different solutions heuristically (by trial and error) rather than building up the composite standard sequence by sequential incorporation of data from different sections.
- Scaling of the event sequence is given by stratigraphic spacing of events in the sections. This scaling can then be calibrated to time using external age data (eg plankton events, magnetostrat).
- Assumption of high quality data and low reworking arguably makes the method more suitable for academic work (and macrofossils) than for industrial micropalaeontology





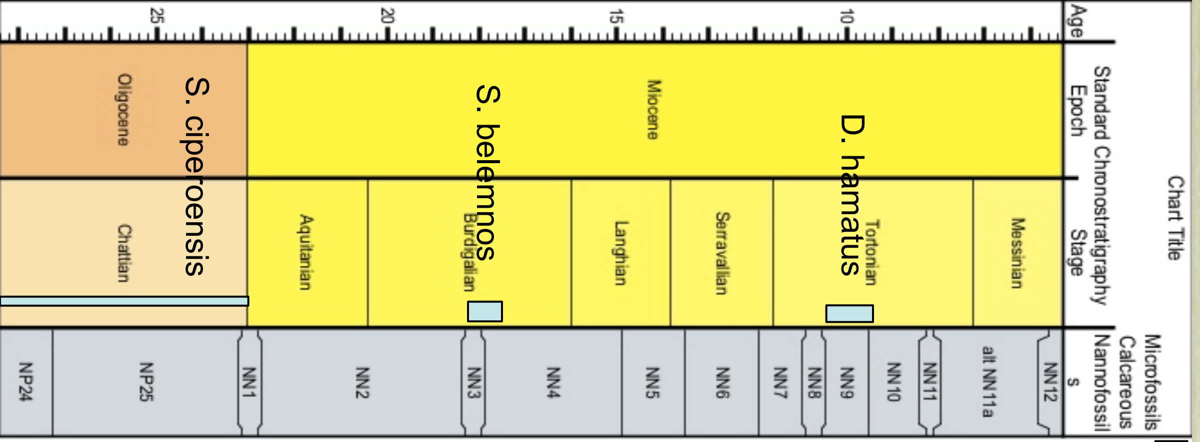
Ranking and Scaling (RASC)

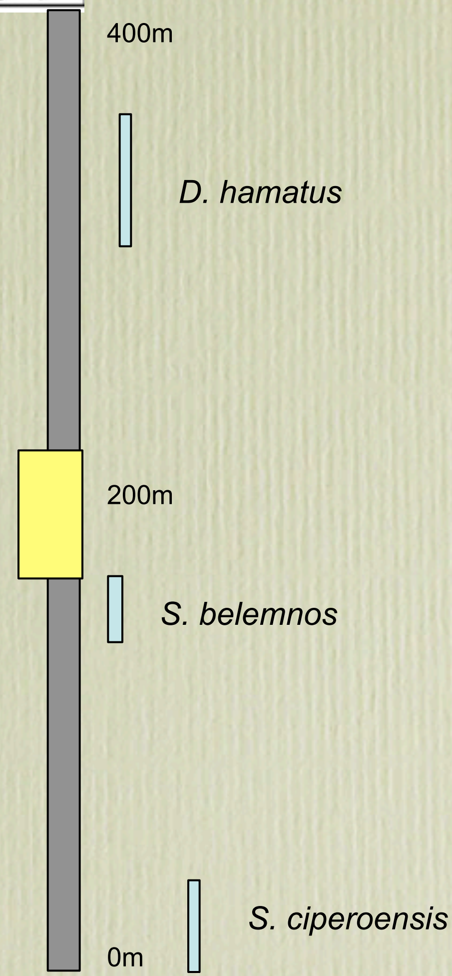
- Ranking and Scaling (RASC and CASC). As with CONOP this method tries to construct a most likely sequence of events from analysis of a database of occurrence data (relative succession of first and last occurrences of taxa in boreholes/sections). It differs in assuming that much of the inconsistency in the data will be a result of noise due to reworking, misdeterminations, caving etc. and so that simply determining the top & bottom occurrences of taxa loses data. So uses probabilistic methods - essentially takes pairs of events and compares their relative sequence in all wells to determine most likely sequence =ranking.
- Scaling to time achieved by analysing frequency of cross-overs of events,
- The scaled sequence can then be calibrated using age data from e.g. planktonic foram events of known age.
- RASC = program to produce the zonation
- CASC = program to apply zonation to a set of wells.
- Method is widely used in basin analysis.



Age-depth plot

plot stratigraphic data vs depth on one axis and time on the other to develop “age model” for a section or core





Age-depth plot

plot stratigraphic data vs depth on one axis and time on the other to develop “age model” for a section or core

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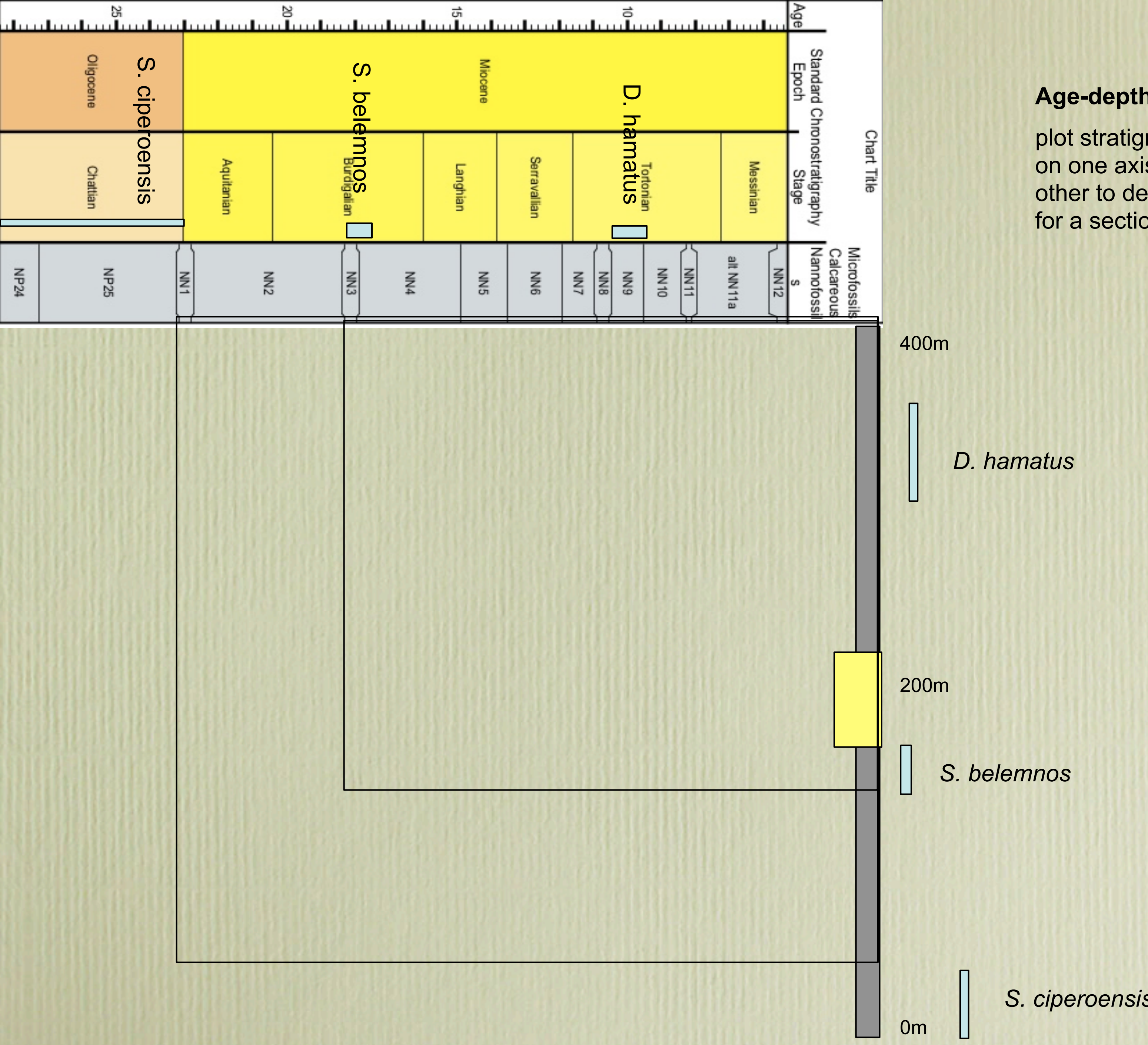

Age-depth plot

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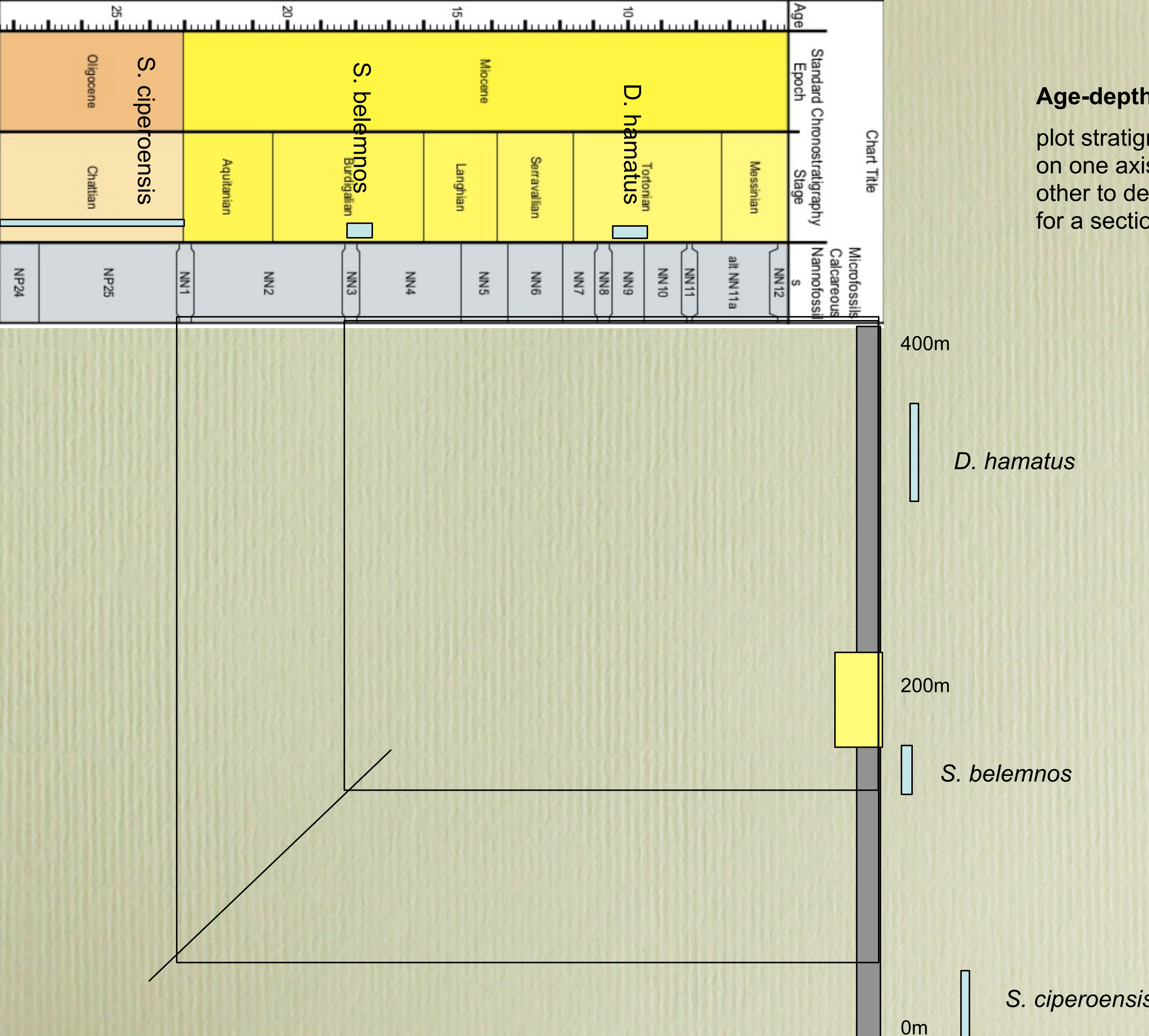

Age-depth plot

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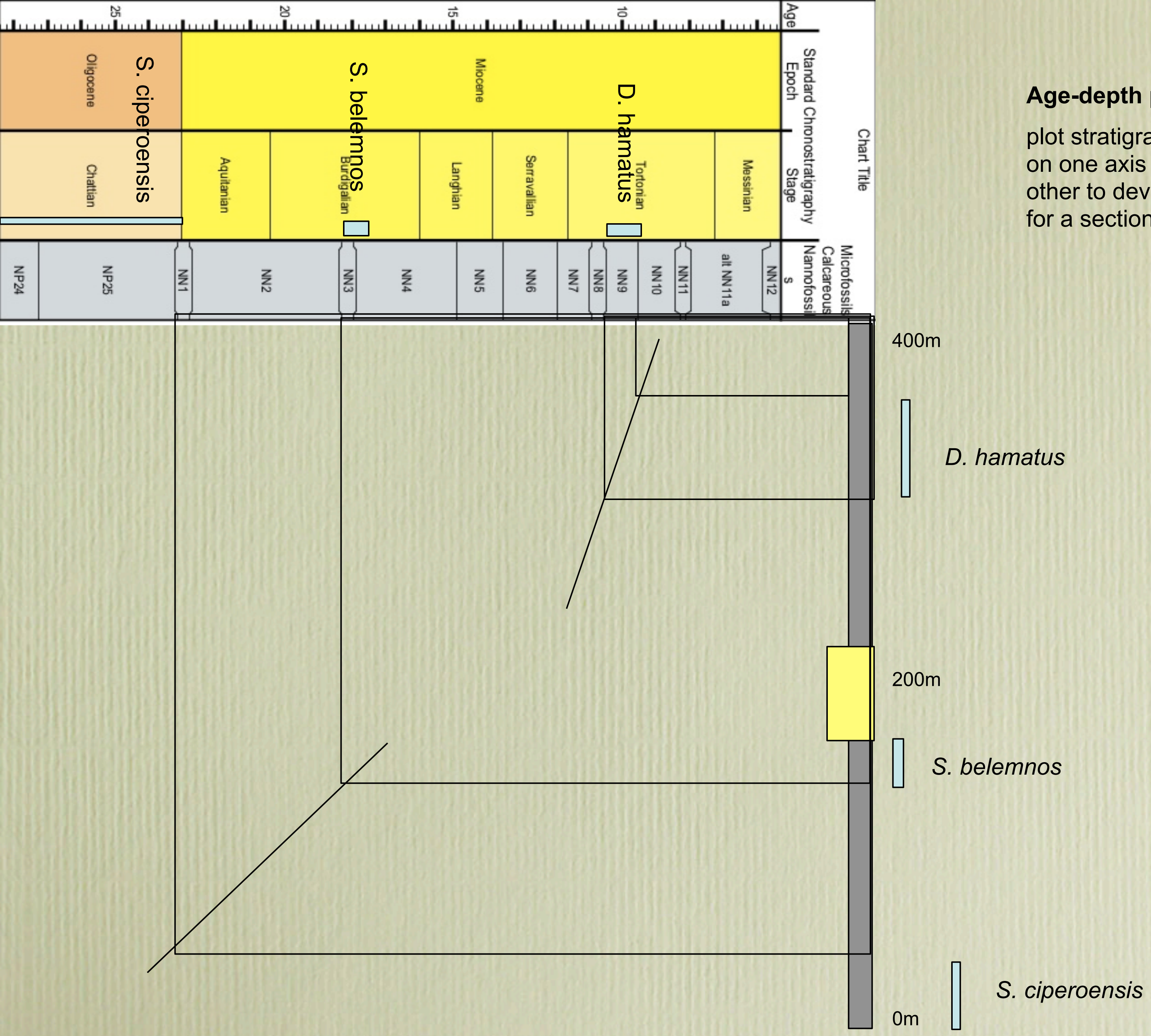
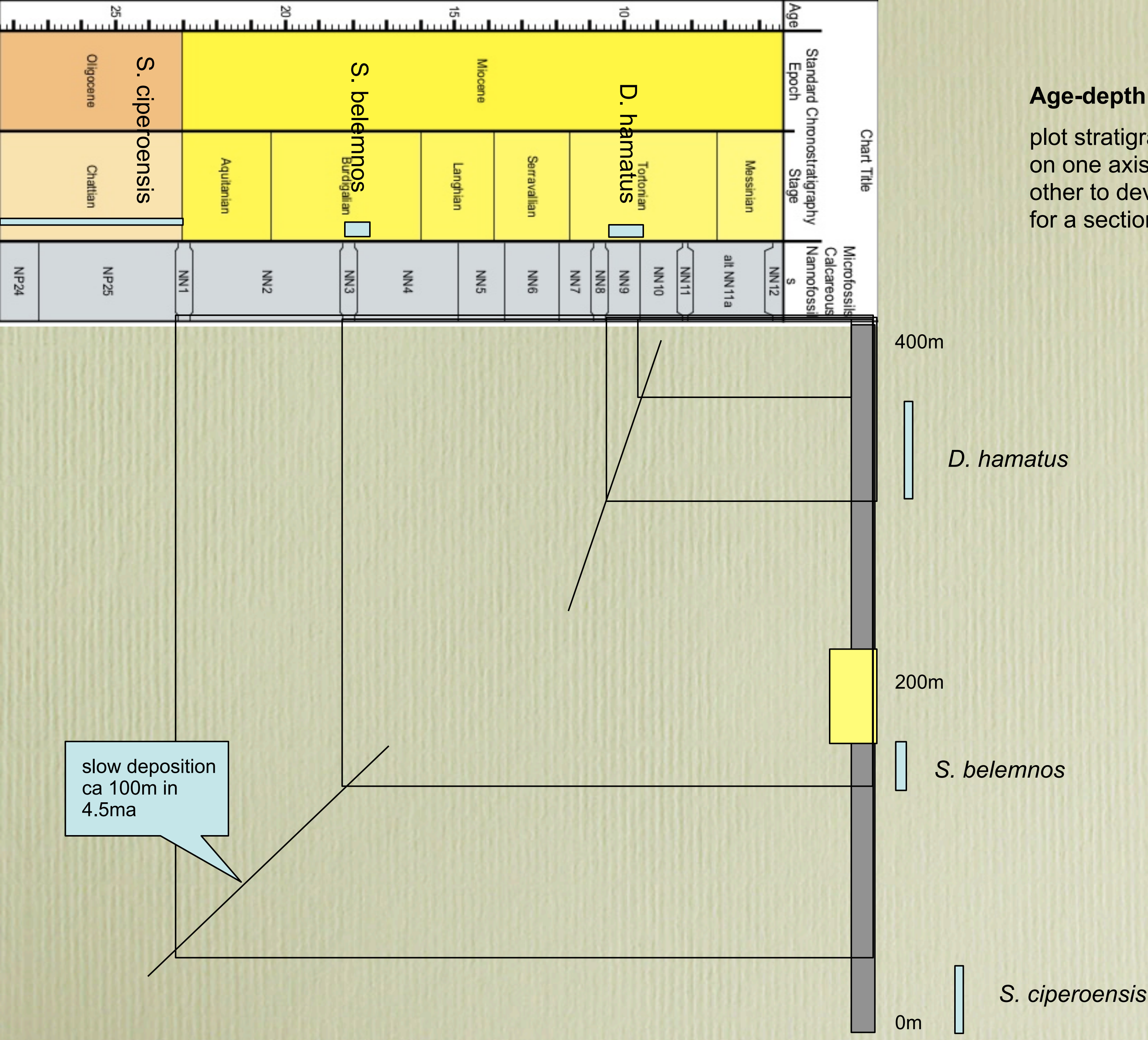


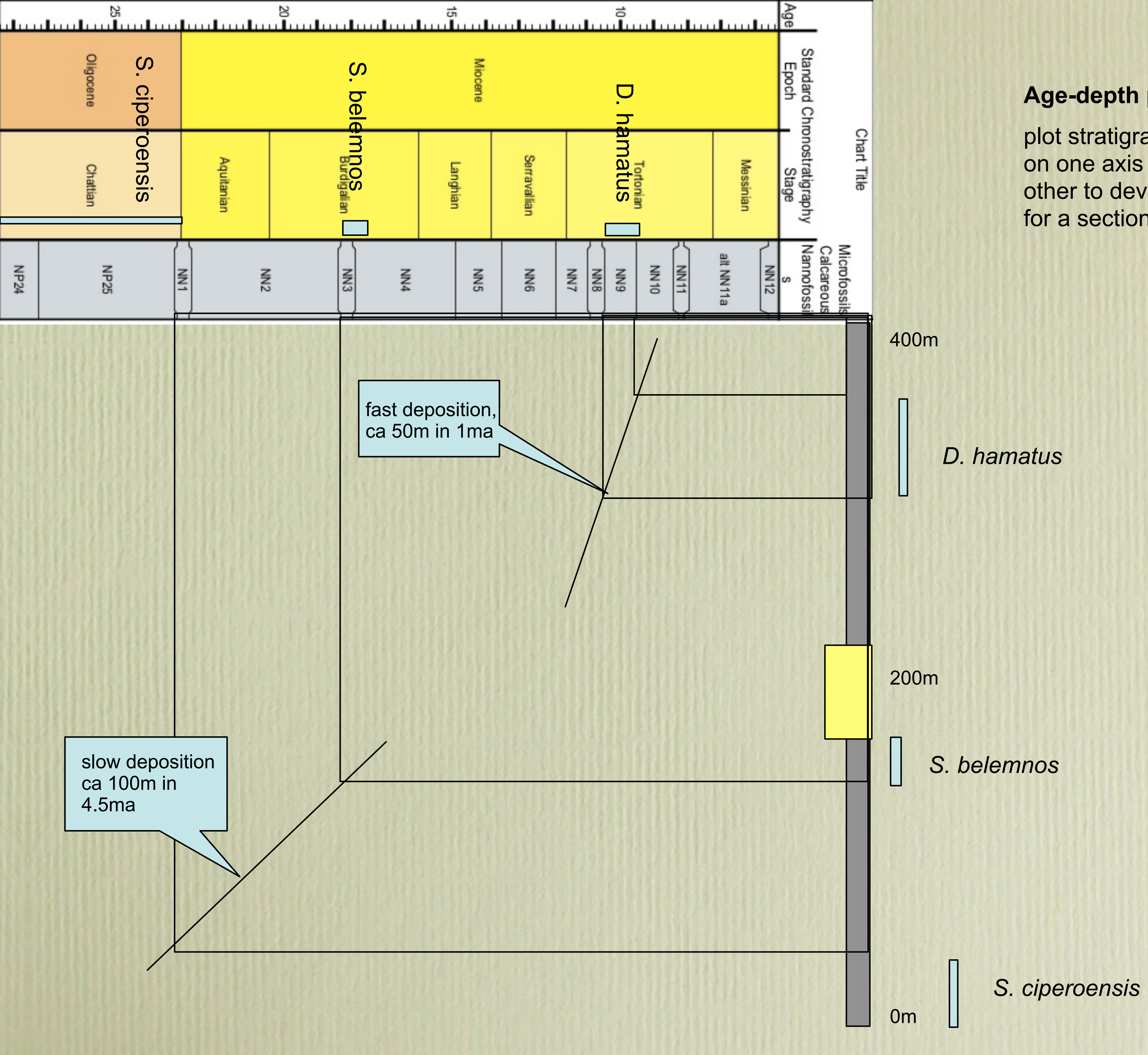
Age-depth plot

plot stratigraphic data vs depth on one axis and time on the other to develop "age model" for a section or core



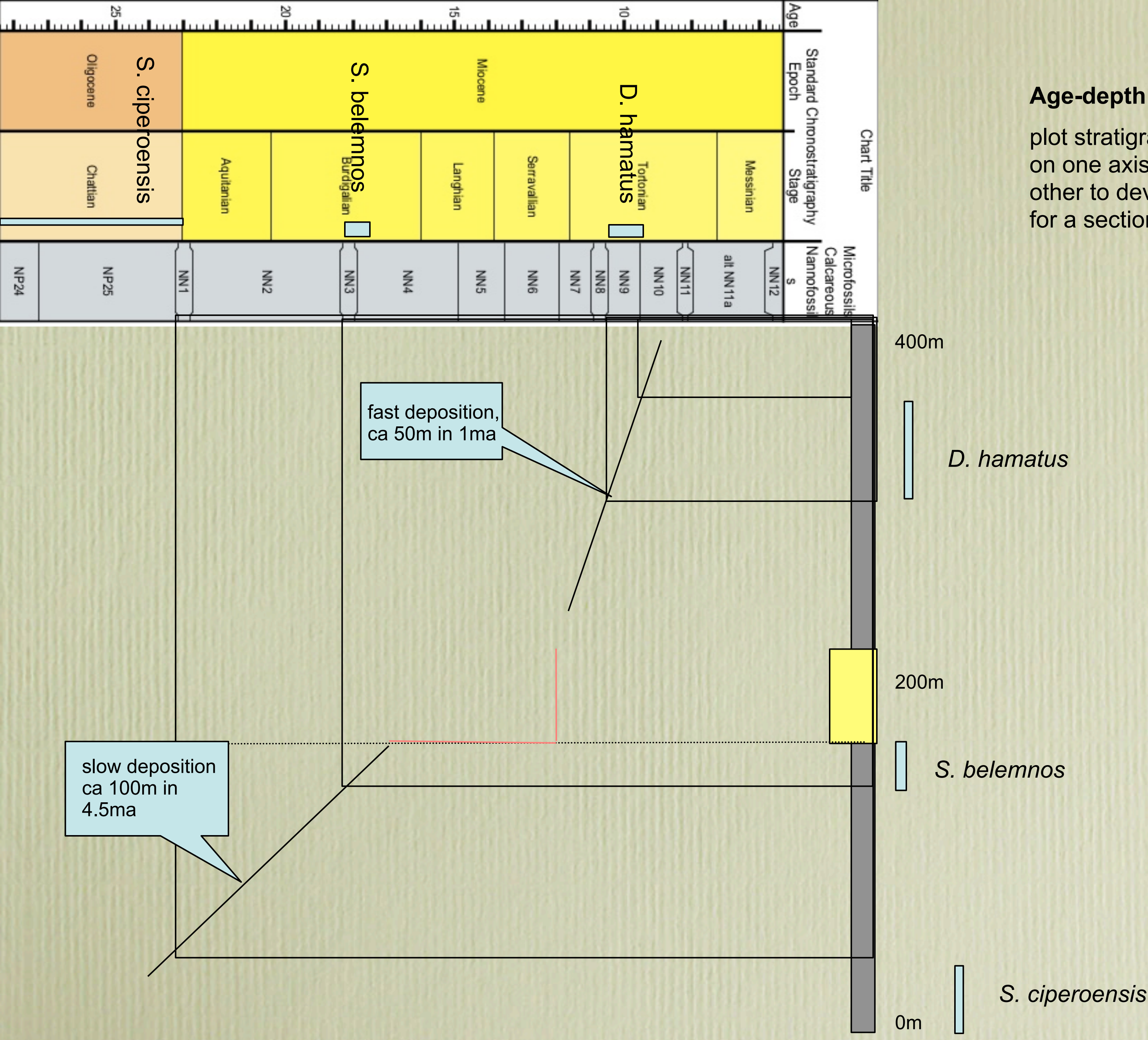
Age-depth plot

plot stratigraphic data vs depth on one axis and time on the other to develop “age model” for a section or core

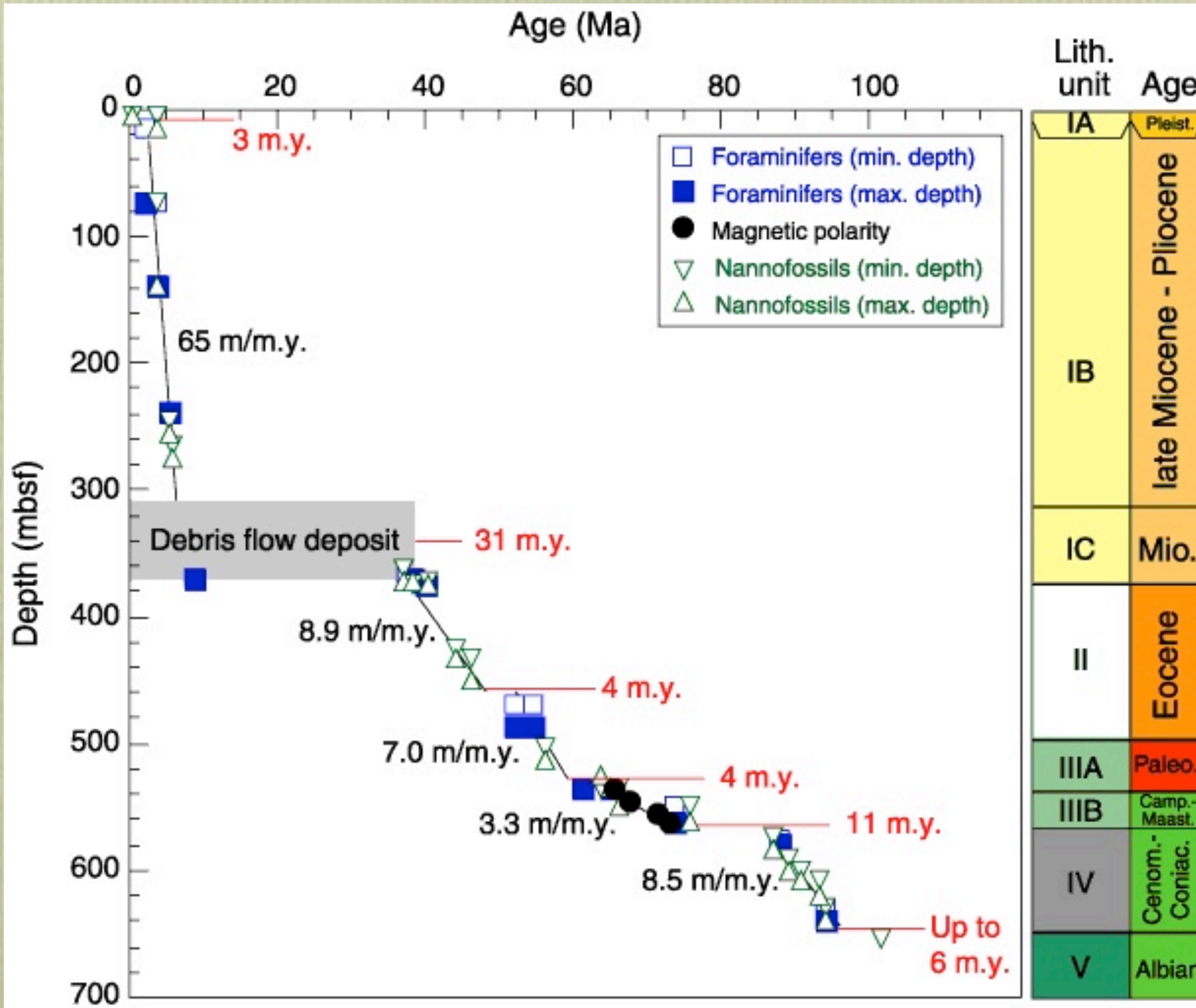


Age-depth plot

plot stratigraphic data vs depth on one axis and time on the other to develop “age model” for a section or core

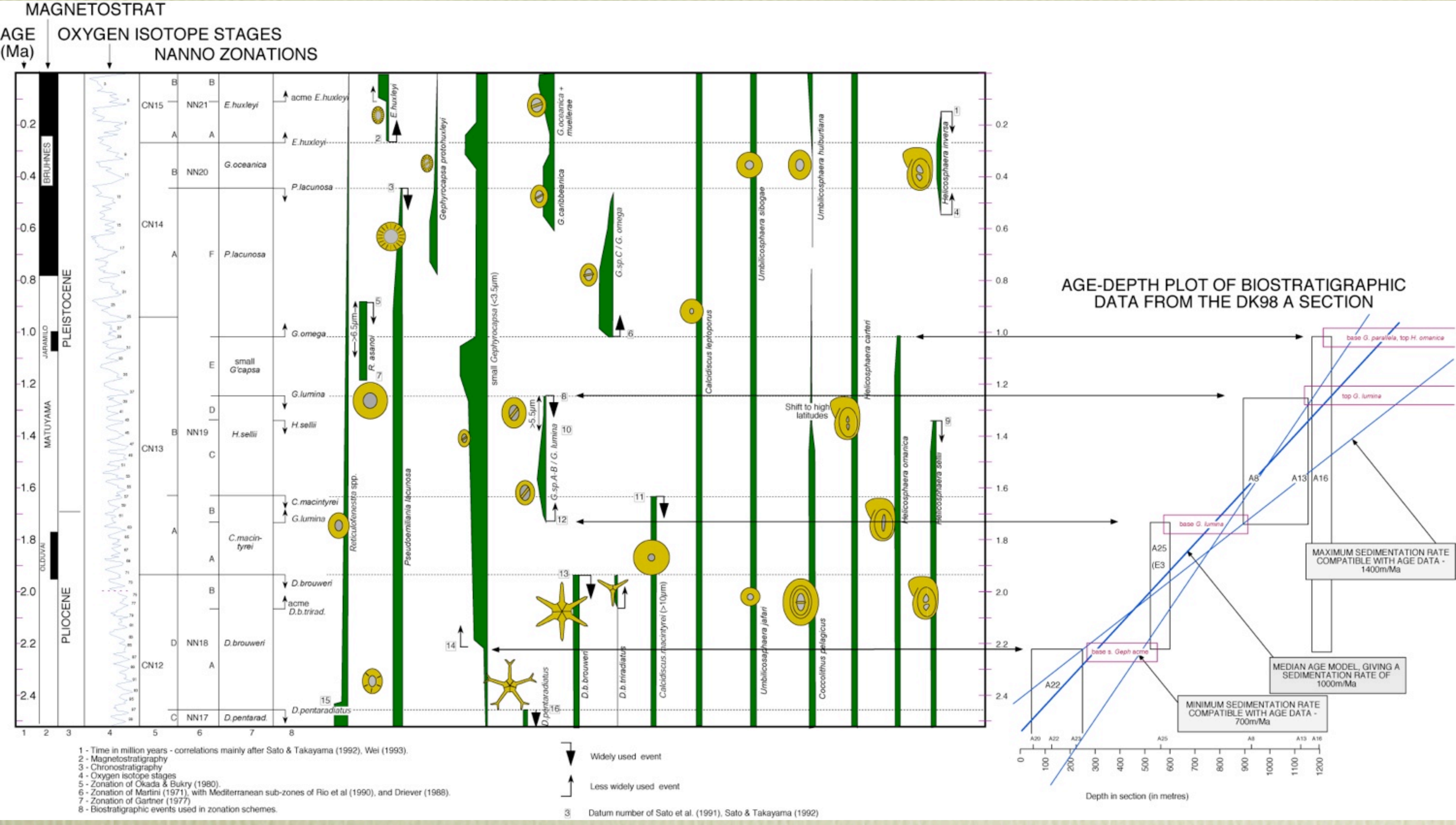


ODP age depth plot



eaxample from Ocean Drilling Project, with large amounts of data

Age-depth plot example



example of use of age-depth plot to maximise value of really limited data - 7 poor samples from a 1.2km section