QUE ES SECUENCIAS ESTRATIGRAFICAS?

SECUENCIAS ESTRATIGRAFICAS ES UNA SUBDISCIPLINA DE LA ESTRATIGRAFIA, QUE TRATA DE DEFINIR LA HISTORIA GEOLOGICA DE LAS ROCAS ESTRATIFICADAS...

ES LA SUBDIVISION DE LAS CUENCAS SEDIMENTARIAS EN PAQUETES GENETICOS LIMITADOS POR DISCORDANCIAS Y CONCORDANCIAS...

SECUENCIAS ESTRATIGRAFICAS ES EL MARCO UTILIZADO PARA DEFINIR LA CRONOESTRATIGRAFIA POR CORRELA-CION Y MAPEAR LAS FACIES SEDIMENTARIAS Y REALIZAR PREDICCIONES ESTRATIGRAFICAS....

UCV
FACULTAD DE CIENCIAS

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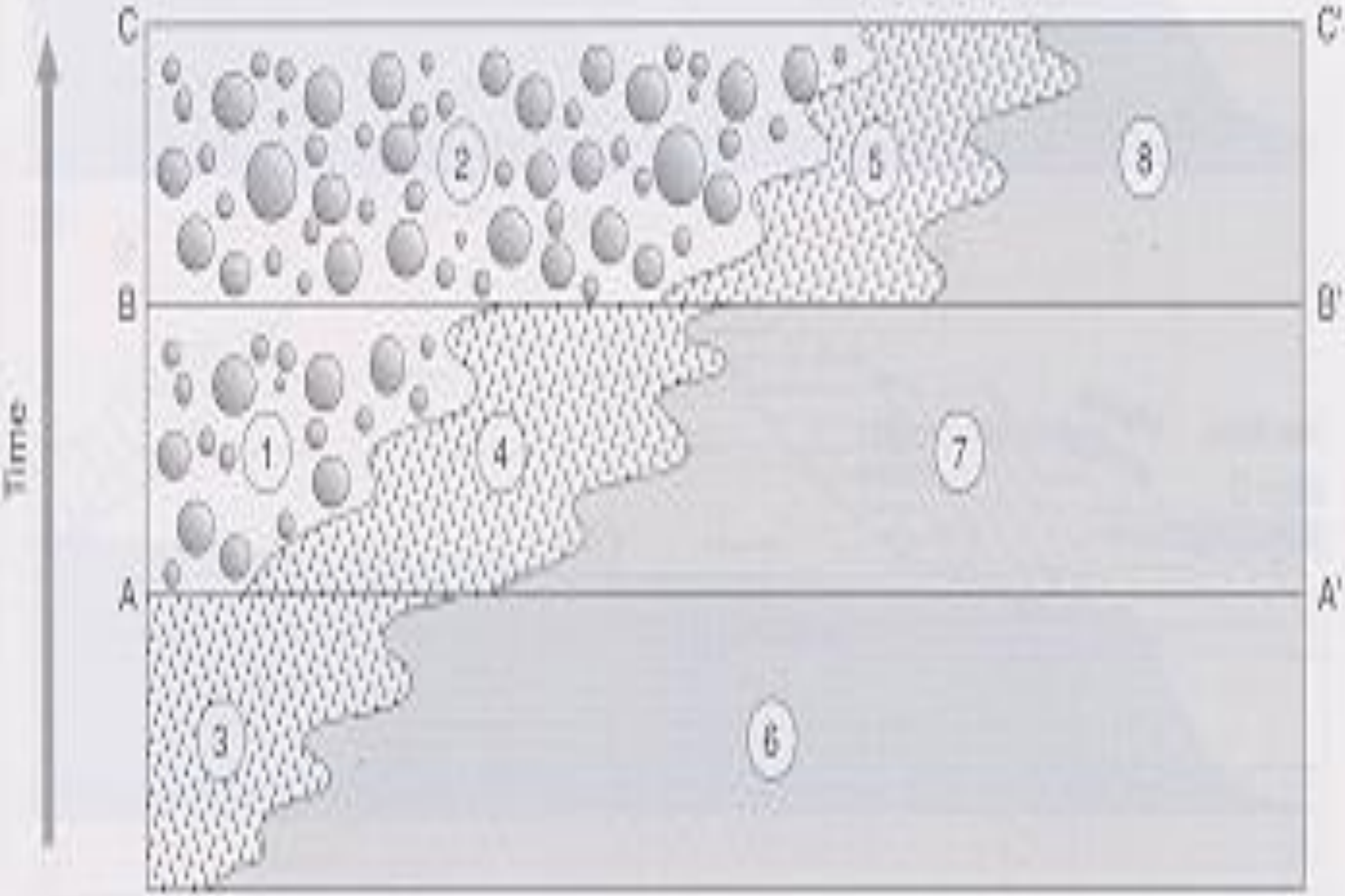


Time
C
C'
B
B'
A
A'
1
2
3
4
5
6
7
8

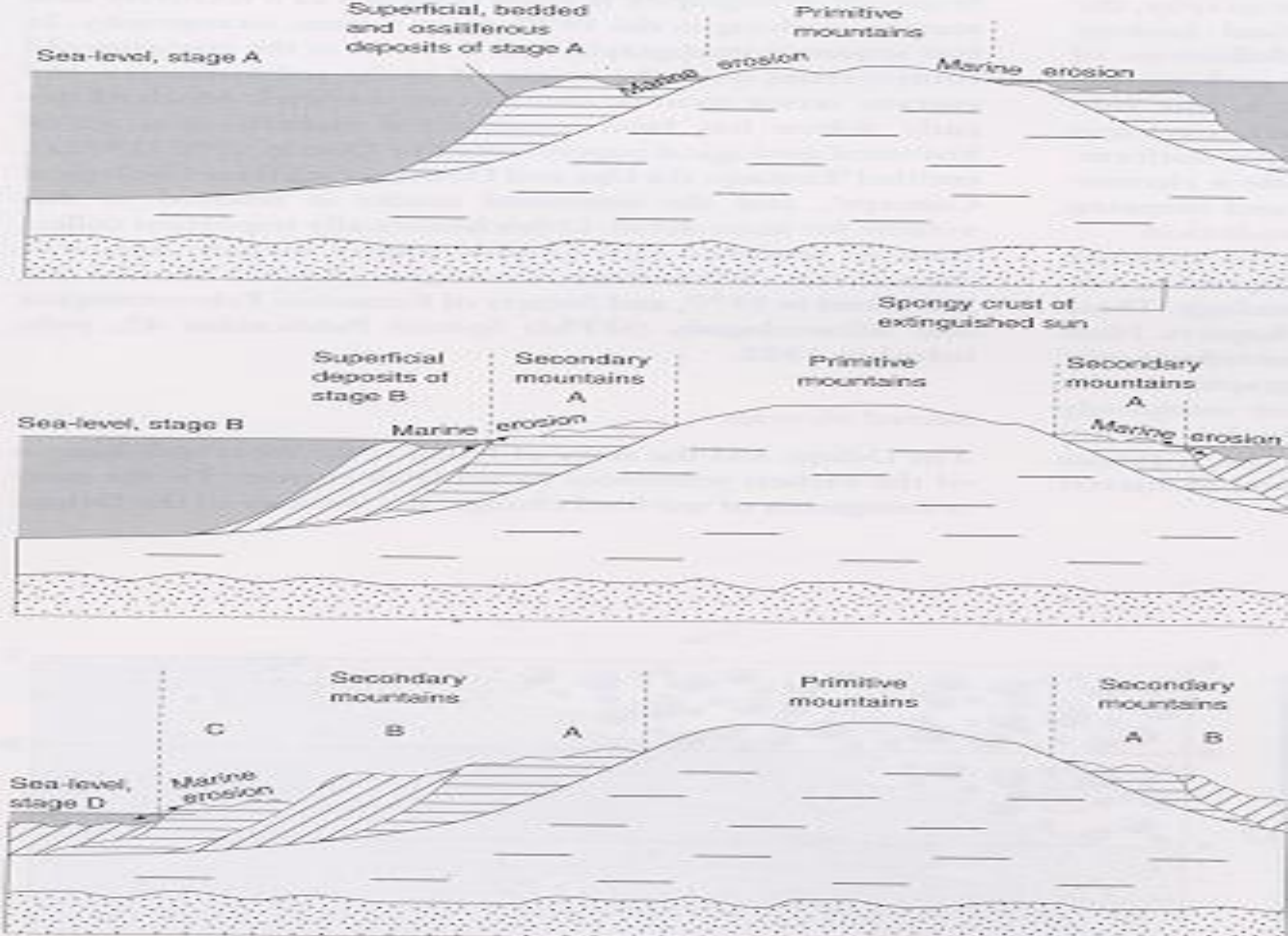
QUE DISCIPLINAS UTILIZAMOS?

NUMEROSAS DISCIPLINAS GEOLOGICAS CONTRIBUYEN A CREAR EL MARCO APROPIADO PARA DESARROLLAR UN ESTUDIO DE SECUENCIAS ESTRATIGRAFICAS.

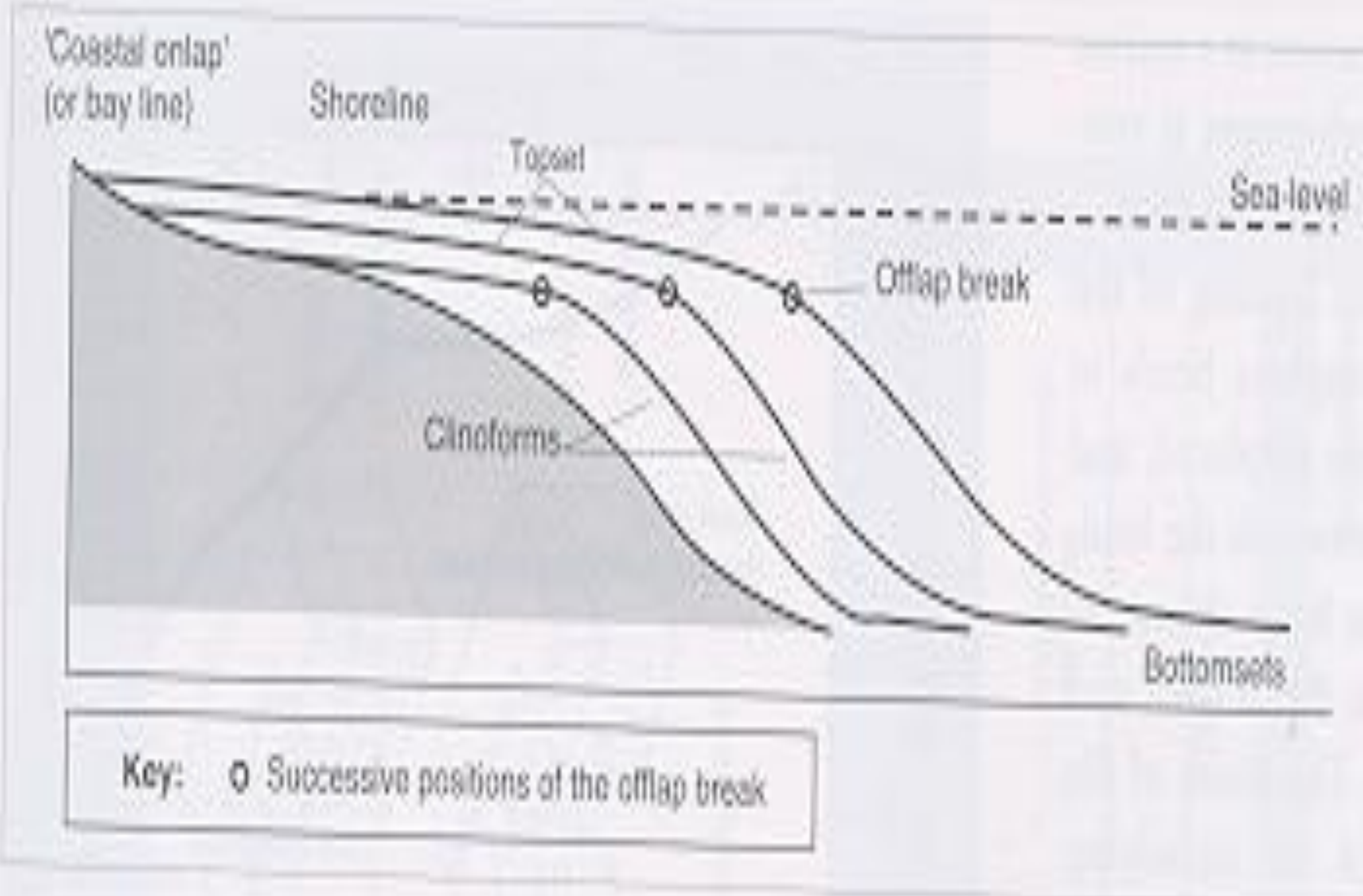
LAS PRINCIPALES SON SISMICA, BIOESTRATIGRAFIA, CRO-NOESTRATIGRAFIA Y SEDIMENTOLOGIA.

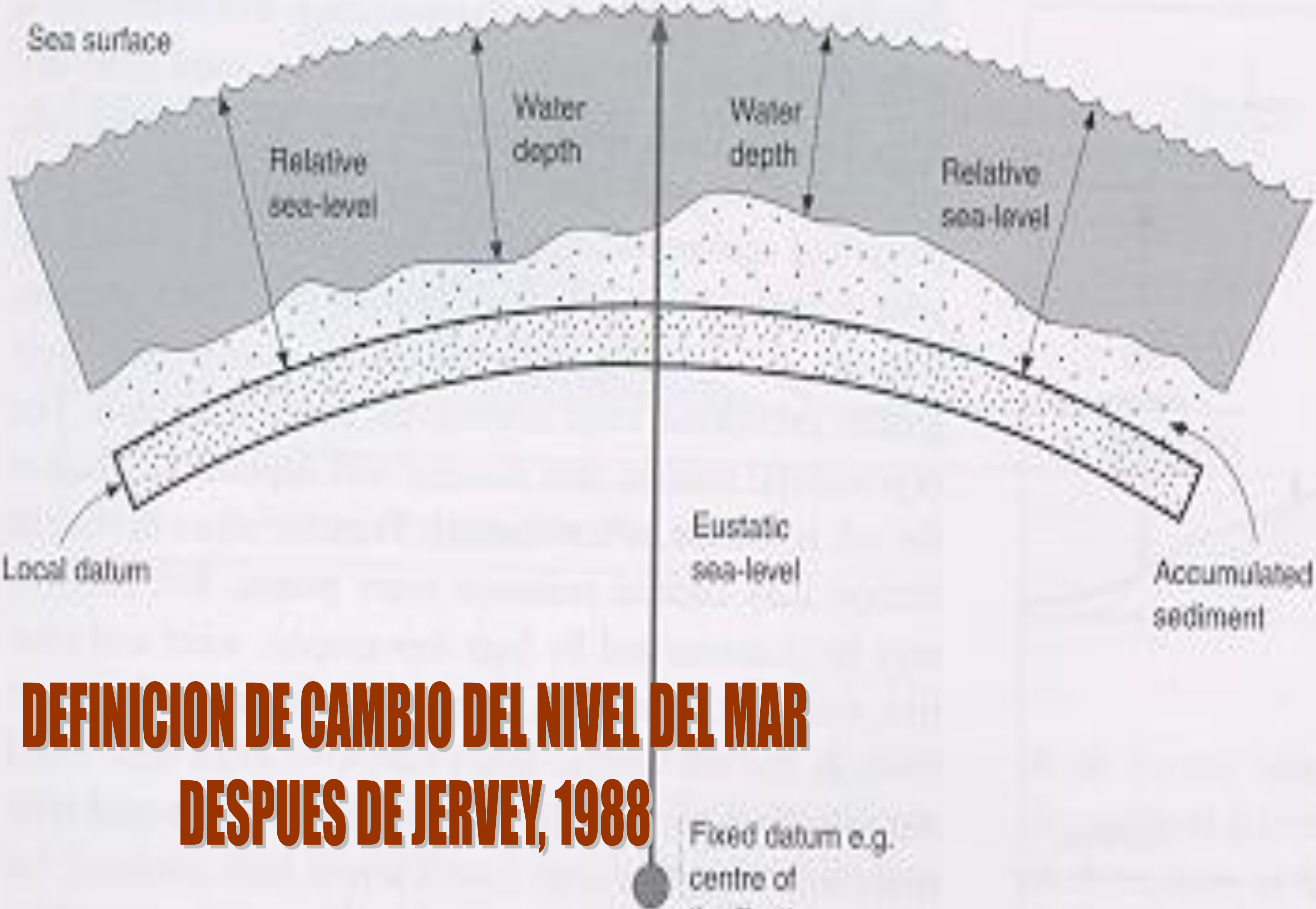
CUANDO SE COMIENZA A UTILIZAR?

ES UNA CIENCIA RELATIVAMENTE NUEVA QUE COMIENZA SU AUGE EN LOS AÑOS SETENTA, DEBIDO AL DESARROLLO DE LA DENO-MINADA ESTRATIGRAFIA SISMICA.



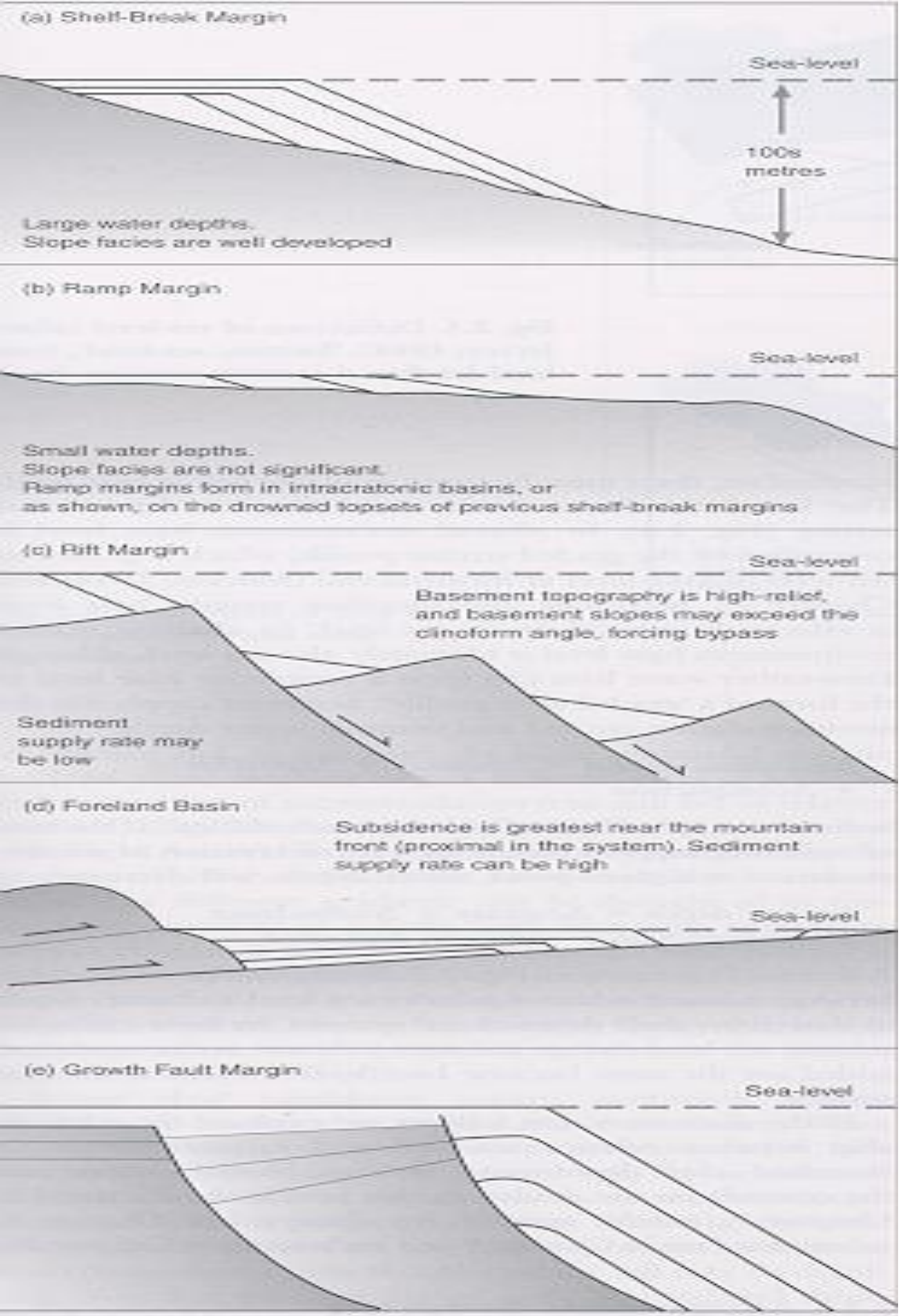
Superficial, bedded and ossiliferous deposits of stage A
Primitive mountains
Sea-level, stage A
Marine erosion
Marine erosion
Spongy crust of extinguished sun
Superficial deposits of stage B
Secondary mountains A
Primitive mountains
Secondary mountains A
Sea-level, stage B
Marine erosion
Marine erosion
Secondary mountains
C
B
A
Primitive mountains
Secondary mountains
A
B
Sea-level, stage D
Marine erosion


'Coastal onlap'
(or bay line)
Shoreline
Topset
Sea-level
Offlap break
Clinoforms
Bottomsets
Key: o Successive positions of the offlap break



DEFINICION DE CAMBIO DEL NIVEL DEL MAR DESPUES DE JERVEY, 1988

PRINCIPALES TIPOS DE MARGENES



SHELF BREAK MARGIN

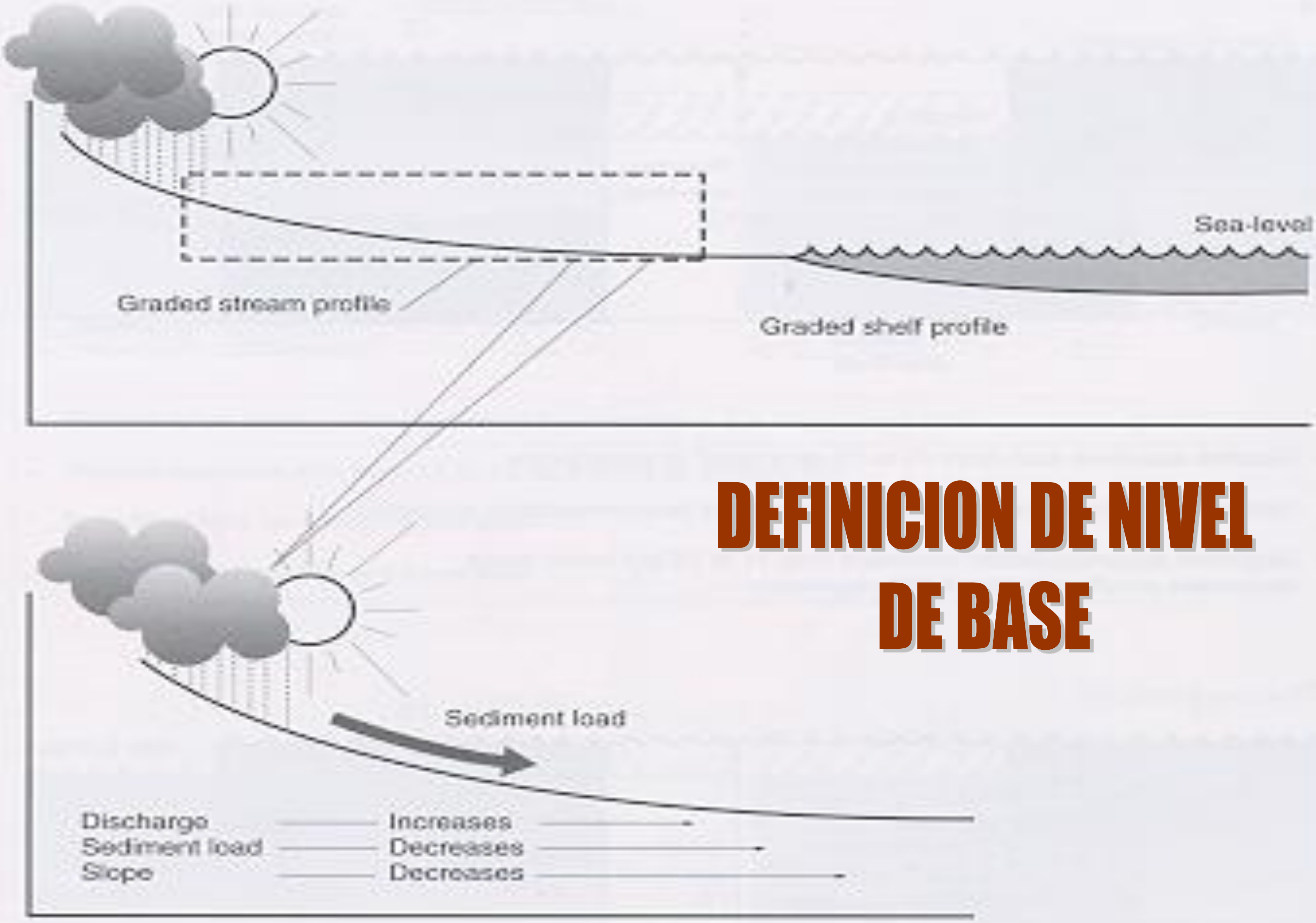
RAMP MARGIN

RIFT MARGIN

FORELAND BASIN

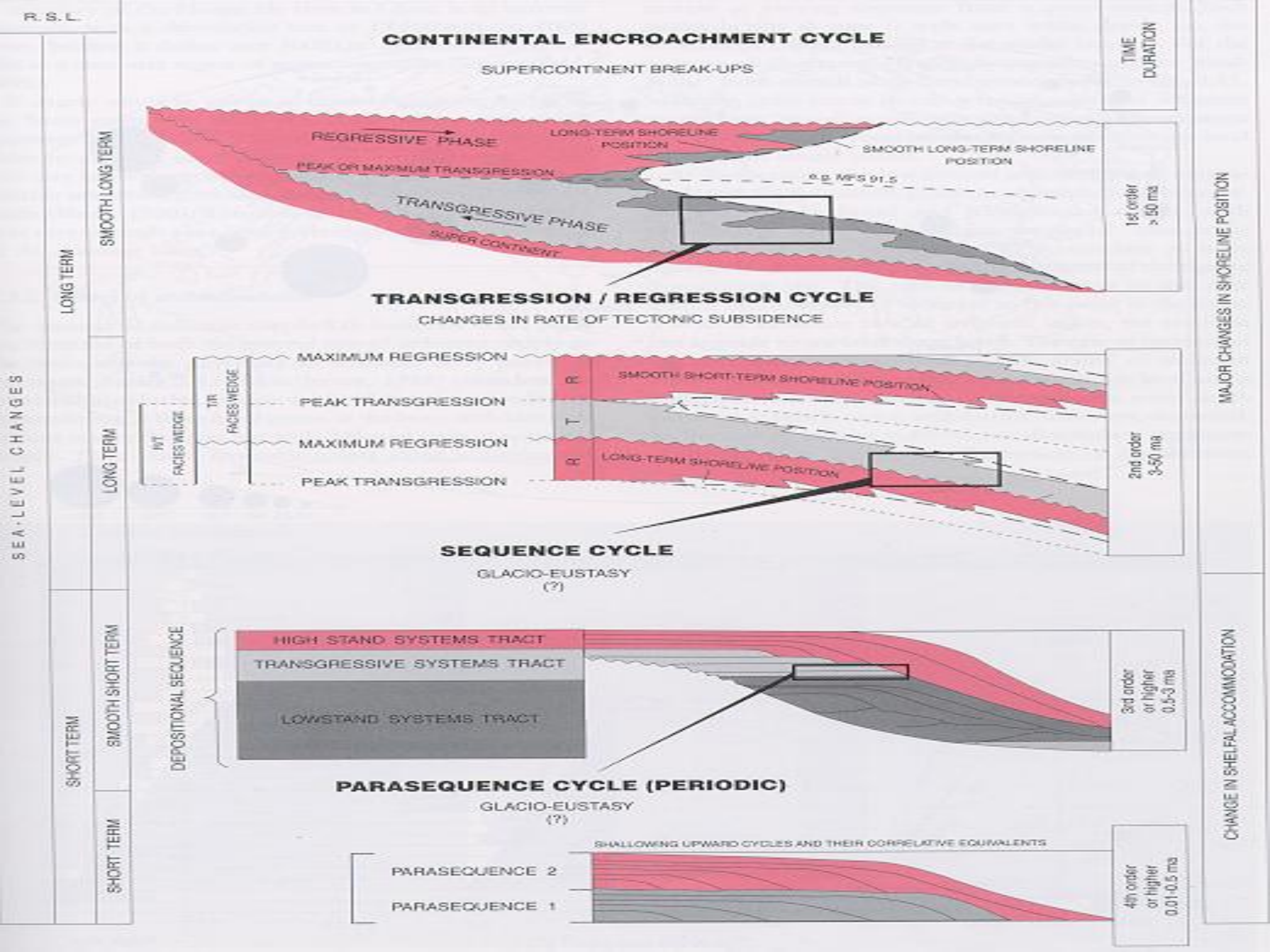
GROWTH FAULT MARGIN

DEFINICION DE NIVEL DE BASE



JERARQUIAS DE LOS CICLOS ESTRATIGRAFICOS

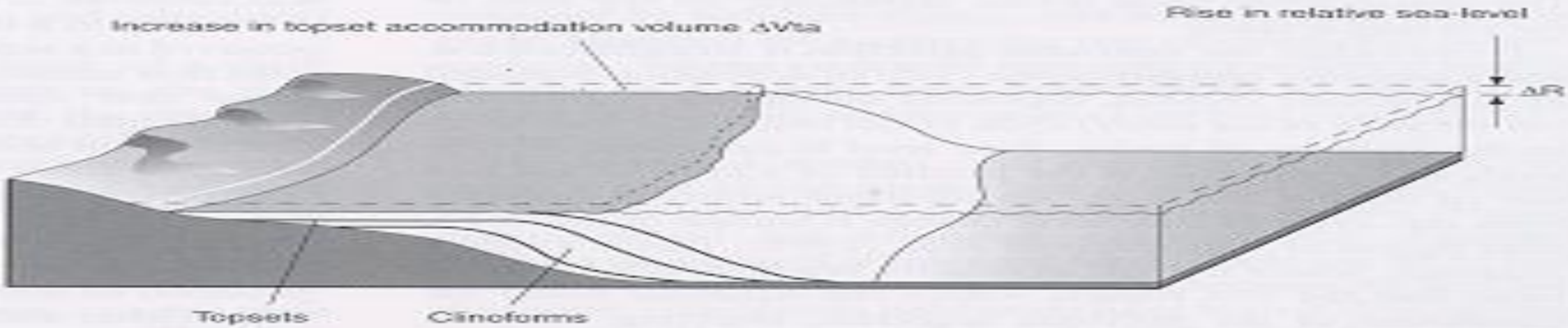
Despues de DUVAL et. al., 1992



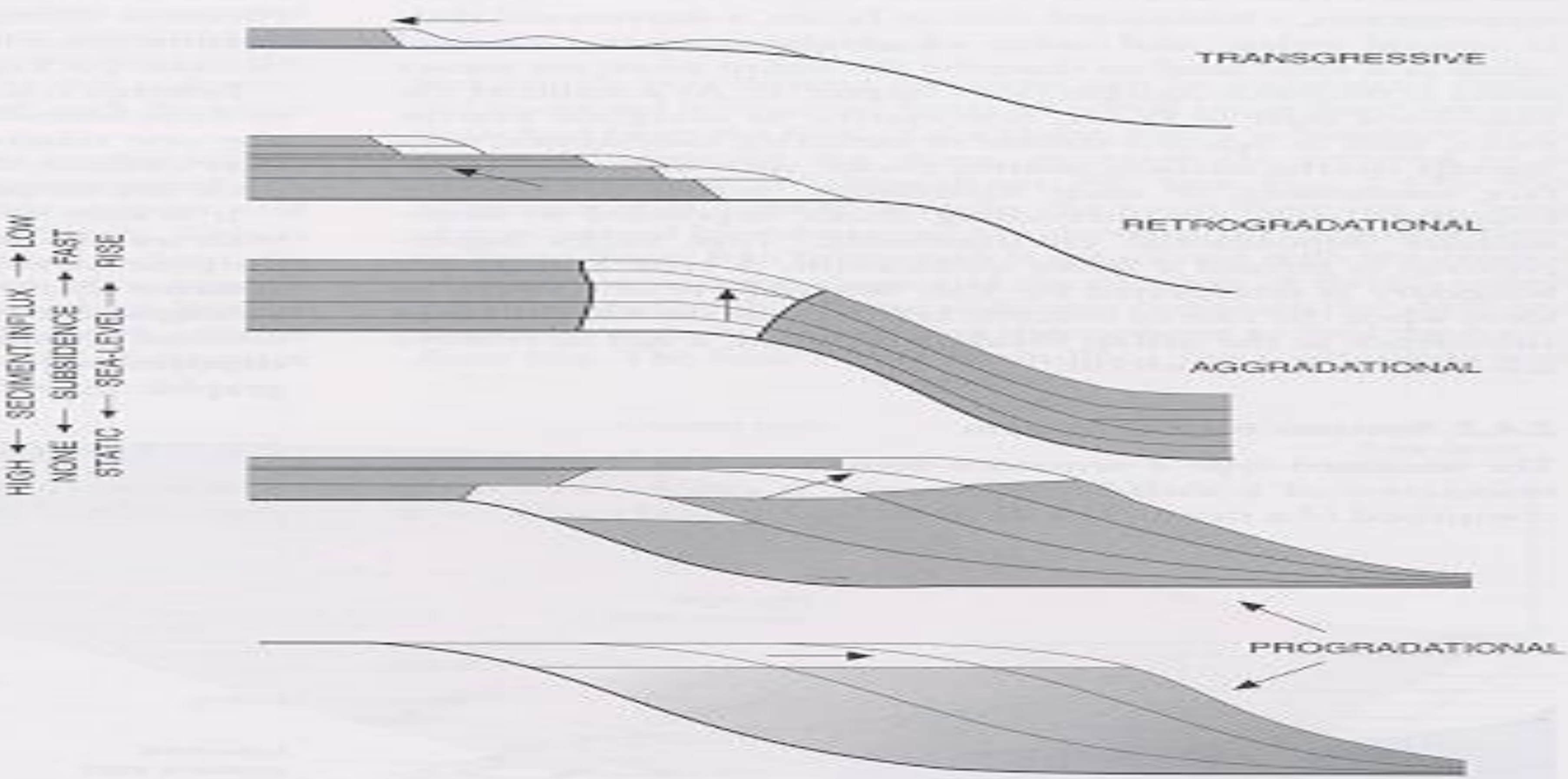
R. S. L.
SEA-LEVEL CHANGES
LONG TERM
SMOOTH LONG TERM
LONG TERM
SHORT TERM
SMOOTH SHORT TERM
SHORT TERM
CONTINENTAL ENCROACHMENT CYCLE
SUPERCONTINENT BREAK-UPS
REGRESSIVE PHASE
LONG-TERM SHORELINE POSITION
SMOOTH LONG-TERM SHORELINE POSITION
PEAK OR MAXIMUM TRANSGRESSION
e.g. MFS 91.5
TRANSGRESSIVE PHASE
SUPER CONTINENT
TIME DURATION
1st order > 50 ma
TRANSGRESSION / REGRESSION CYCLE
CHANGES IN RATE OF TECTONIC SUBSIDENCE
MAXIMUM REGRESSION
PEAK TRANSGRESSION
MAXIMUM REGRESSION
PEAK TRANSGRESSION
R/T FACIES WEDGE
T/R FACIES WEDGE
R
T
R
SMOOTH SHORT-TERM SHORELINE POSITION
LONG-TERM SHORELINE POSITION
2nd order 3-50 ma
MAJOR CHANGES IN SHORELINE POSITION
SEQUENCE CYCLE
GLACIO-EUSTASY
(?)
DEPOSITIONAL SEQUENCE
HIGH STAND SYSTEMS TRACT
TRANSGRESSIVE SYSTEMS TRACT
LOWSTAND SYSTEMS TRACT
3rd order or higher 0.5-3 ma
CHANGE IN SHELFAL ACCOMMODATION
PARASEQUENCE CYCLE (PERIODIC)
GLACIO-EUSTASY
(?)
SHALLOWING UPWARD CYCLES AND THEIR CORRELATIVE EQUIVALENTS
PARASEQUENCE 2
PARASEQUENCE 1
4th order or higher 0.01-0.5 ma

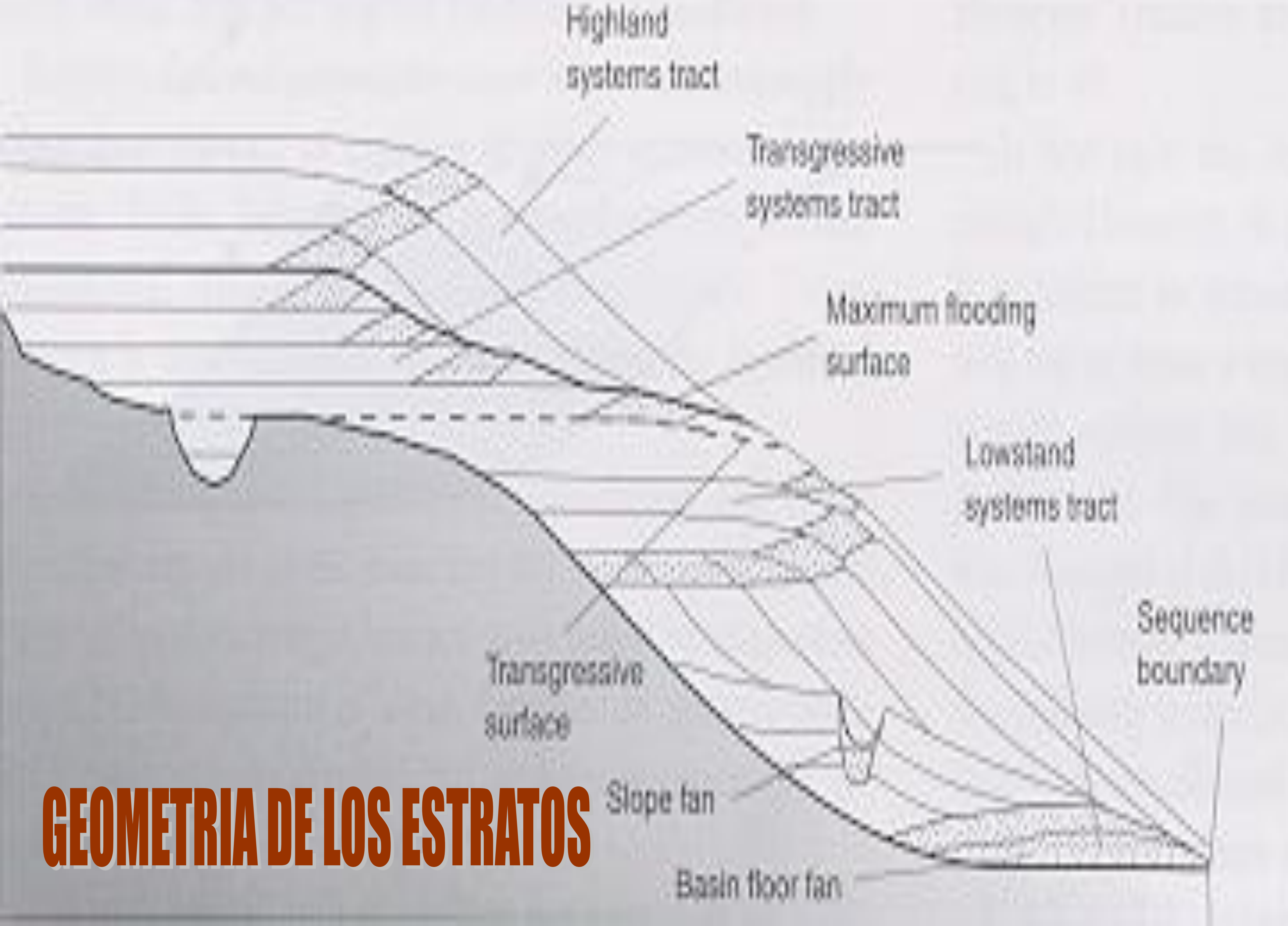
ARQUITECTURA DEPOSITACIONAL COMO UNA FUNCION PARA ACOMODAR EL VOLUMEN DE SEDIMENTOS

Despues de GALLOWAY, 1989

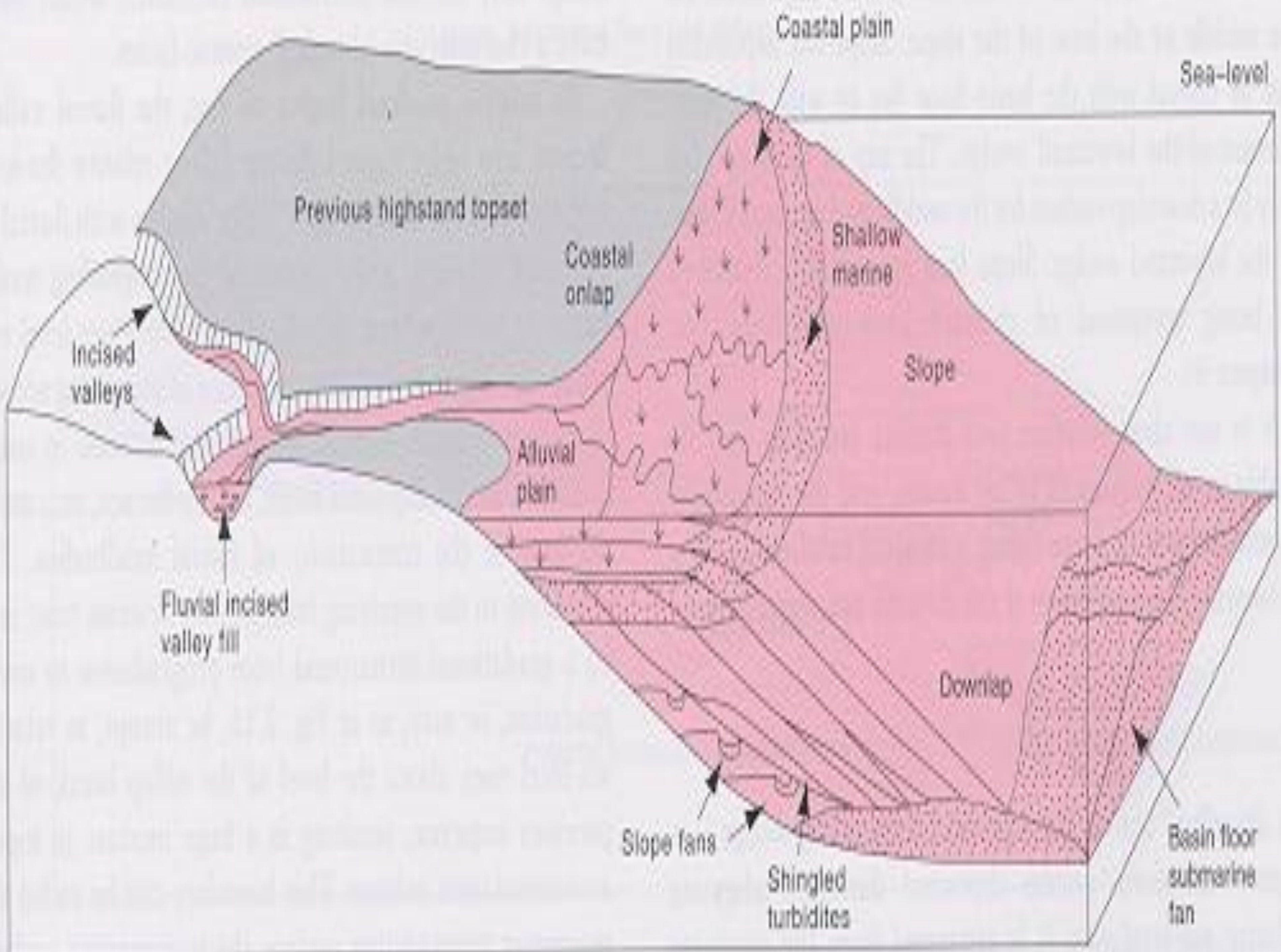


The increment of topset accommodation volume ΔVta caused by a rise in relative sea-level ΔR is equal to the product of ΔR and the topset area

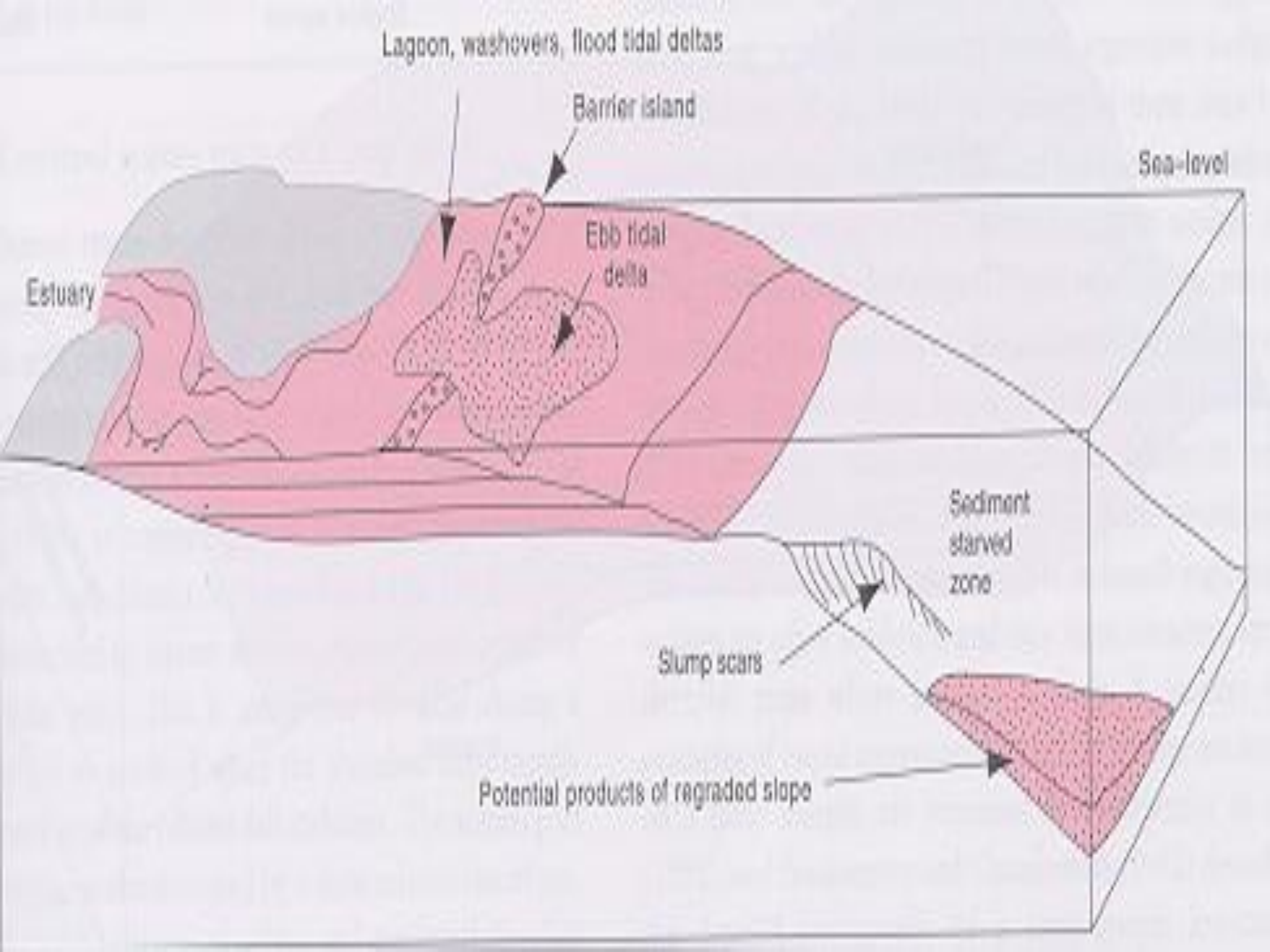


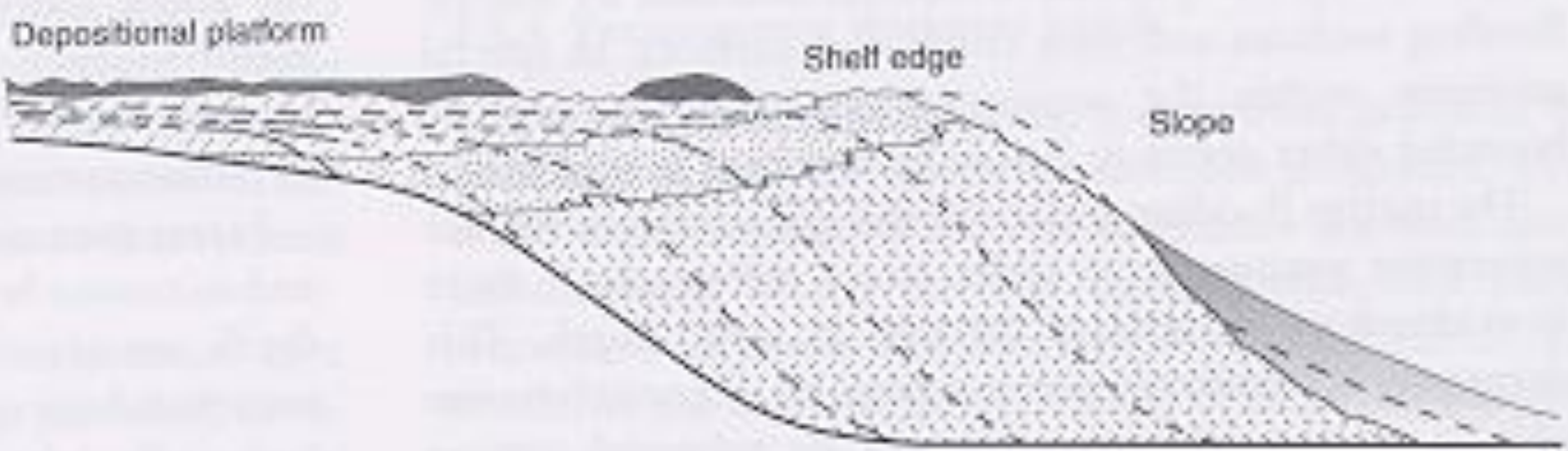


GEOMETRIA DE LOS ESTRATOS

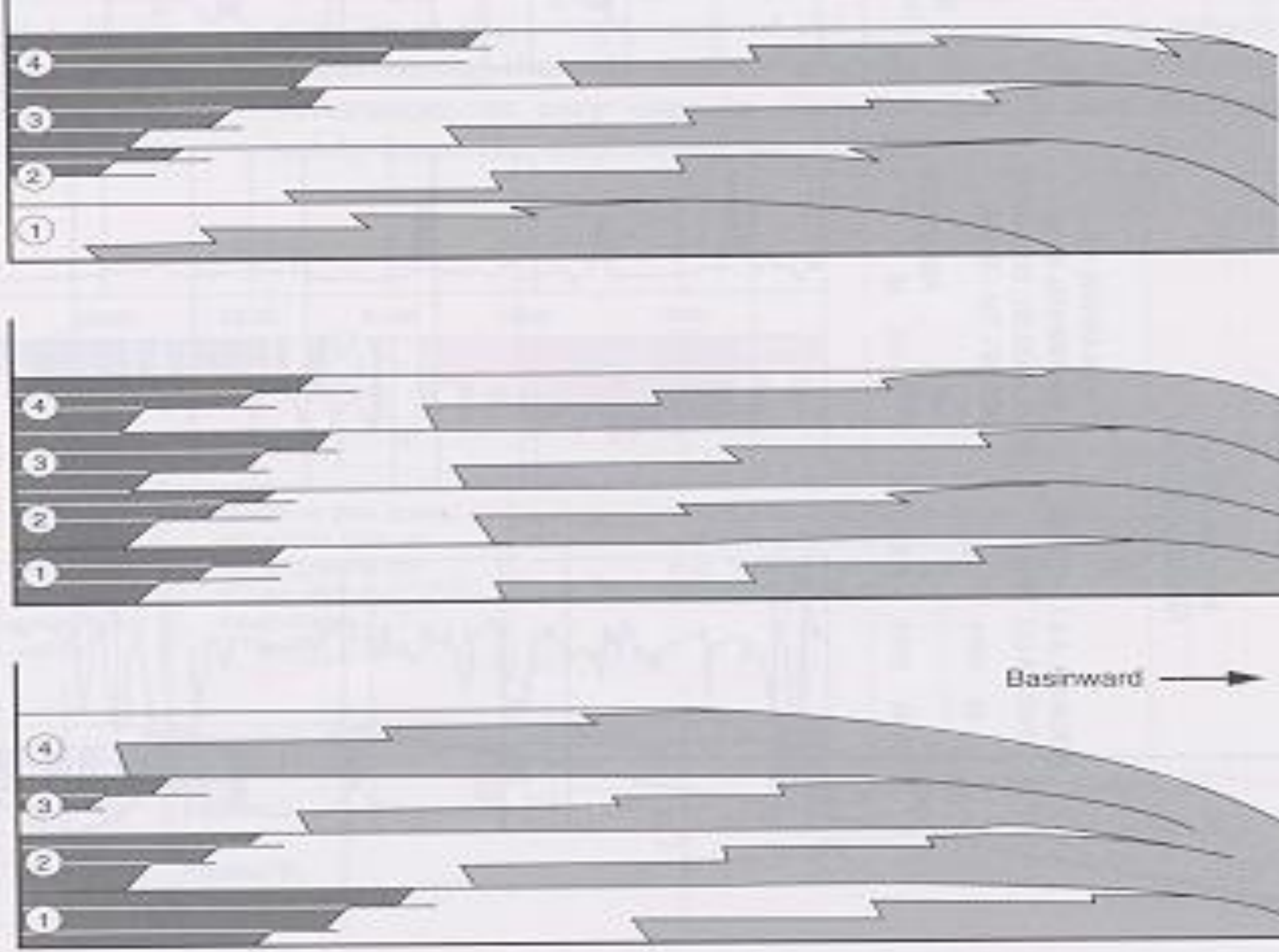


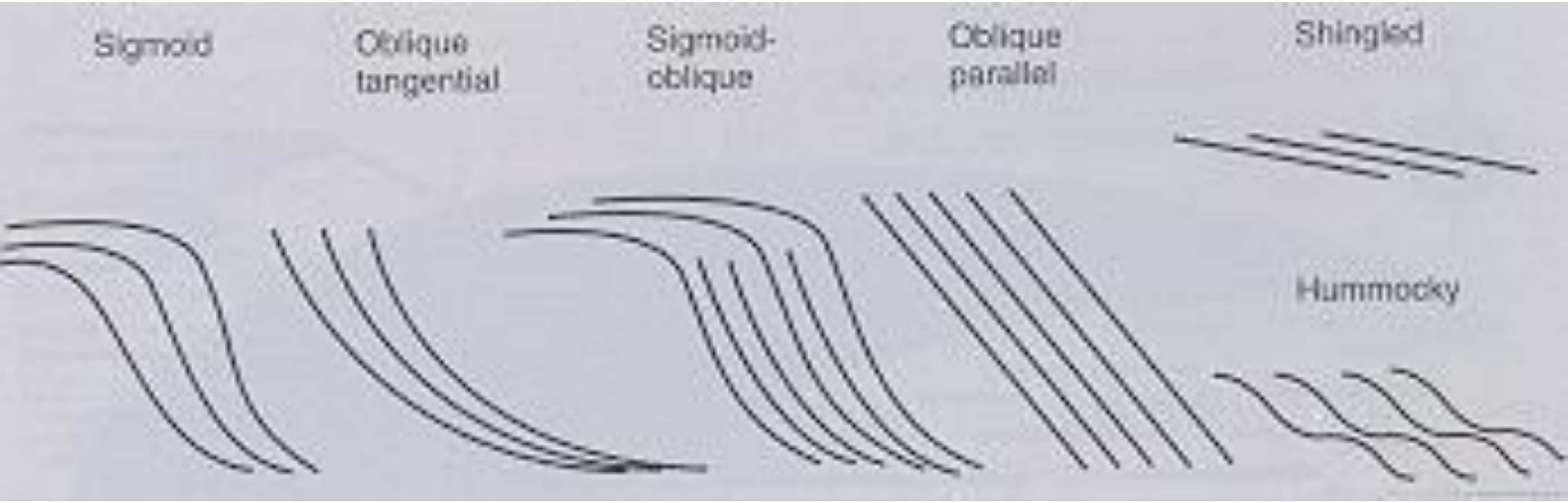
Coastal plain
Sea-level
Previous highstand topset
Coastal onlap
Shallow marine
Incised valleys
Slope
Alluvial plain
Fluvial incised valley fill
Downlap
Slope fans
Shingled turbidites
Basin floor submarine fan

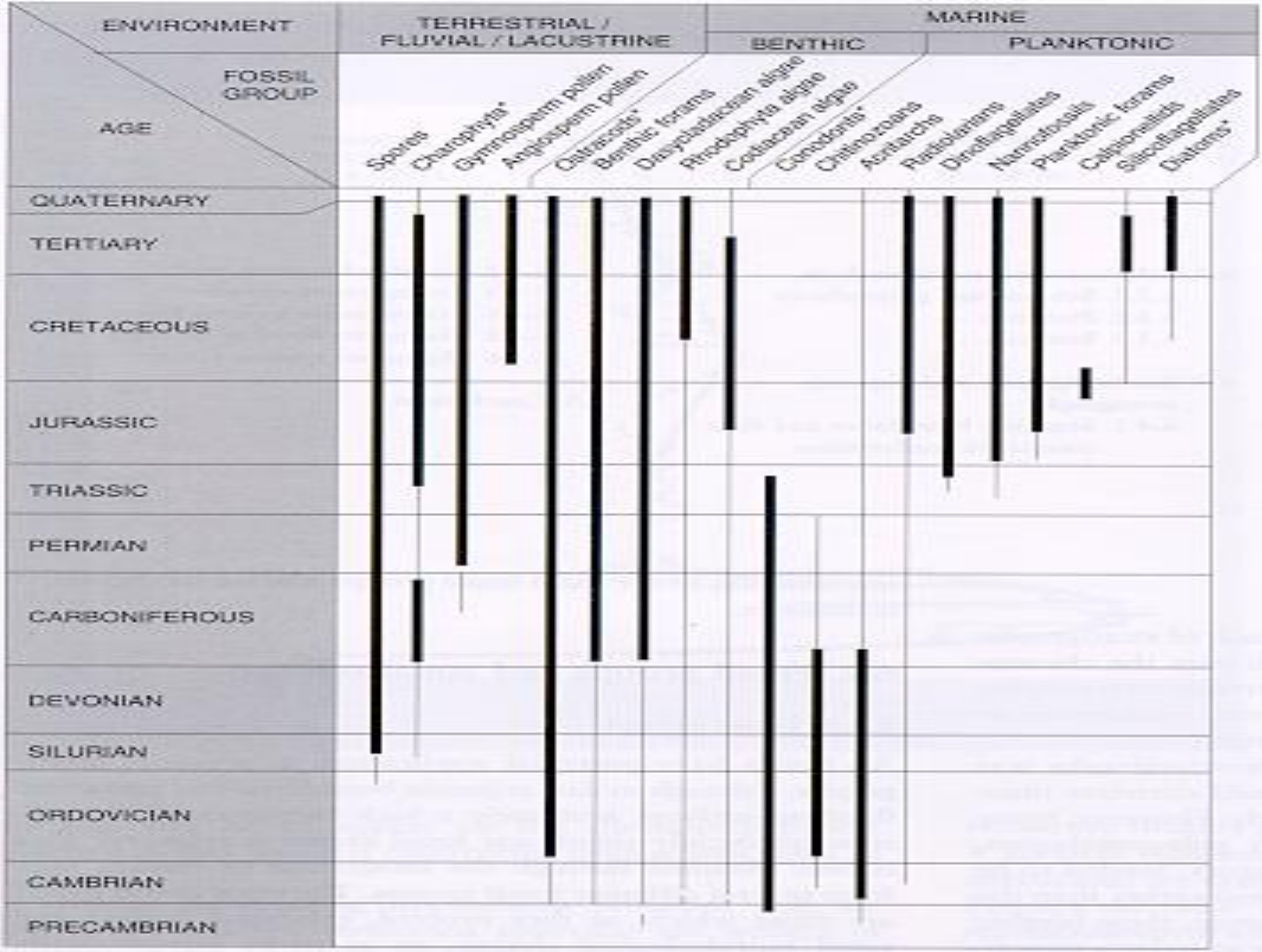

Lagoon, washovers, flood tidal deltas
Barrier island
Sea-level
Ebb tidal delta
Estuary
Sediment starved zone
Slump scars
Potential products of regraded slope

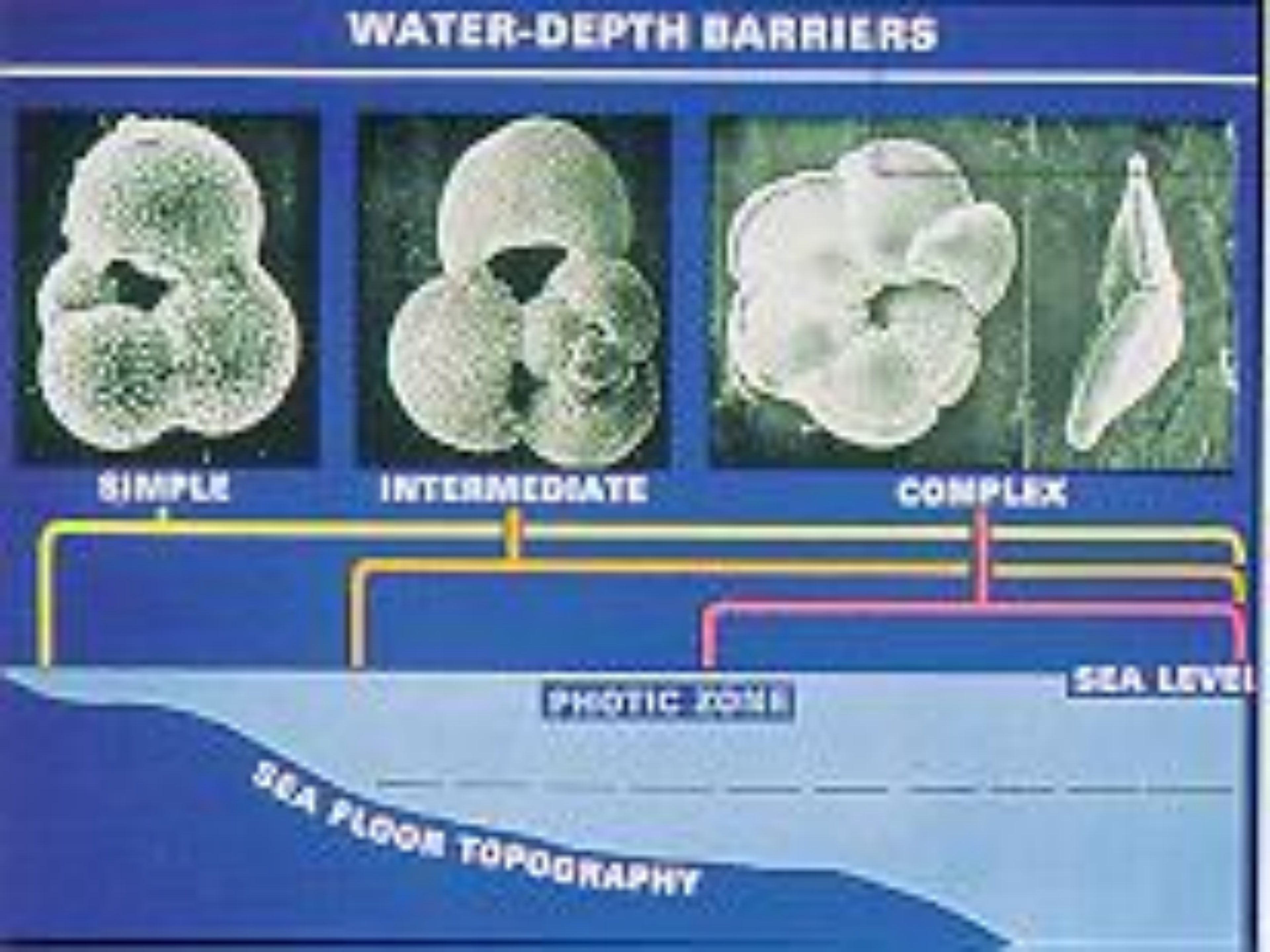


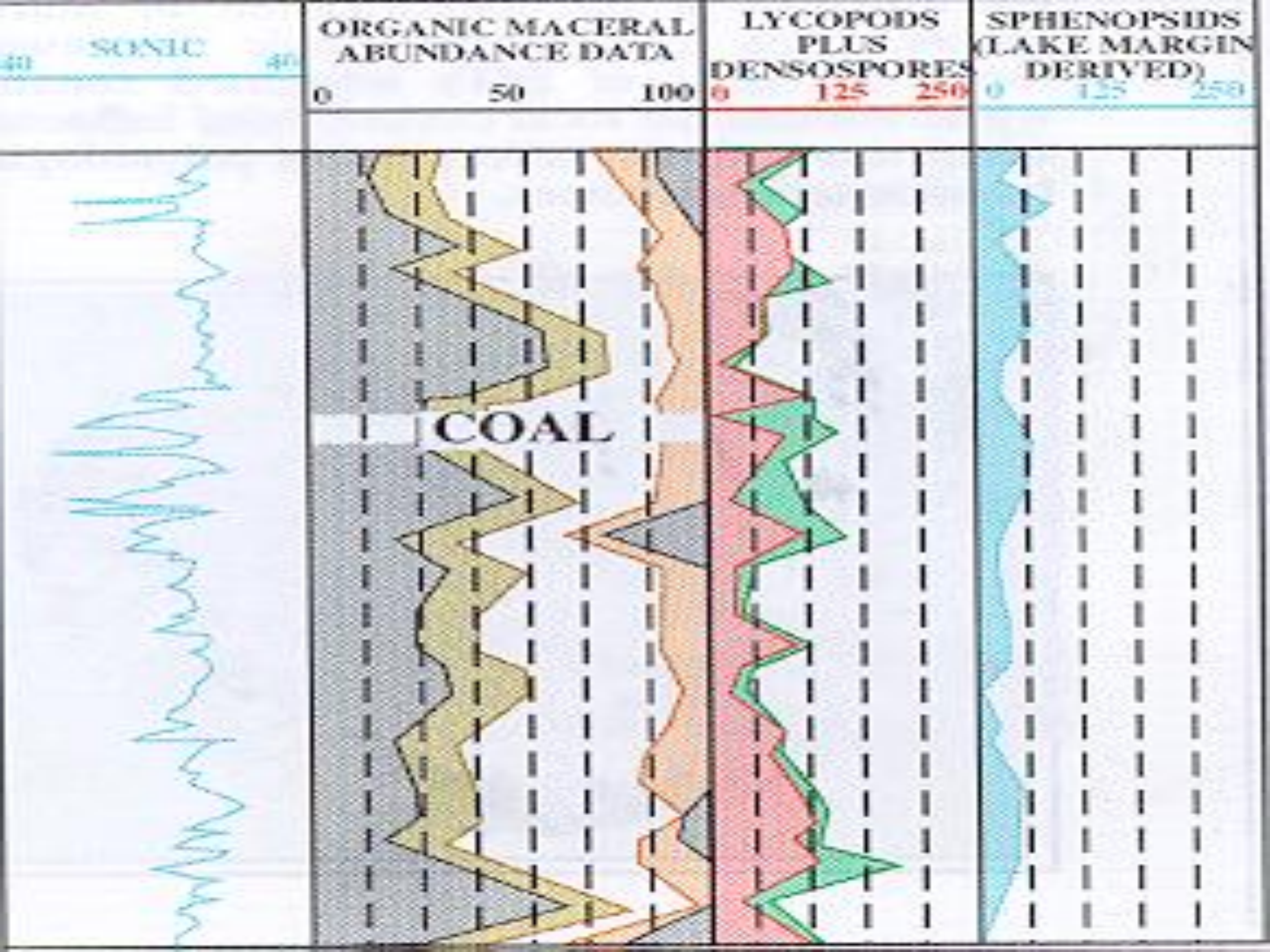
Depositional platform
Shelf edge
Slope


4
3
2
1
4
3
2
1
Basinward
4
3
2
1


Sigmoid
Oblique tangential
Sigmoid-oblique
Oblique parallel
Shingled
Hummocky

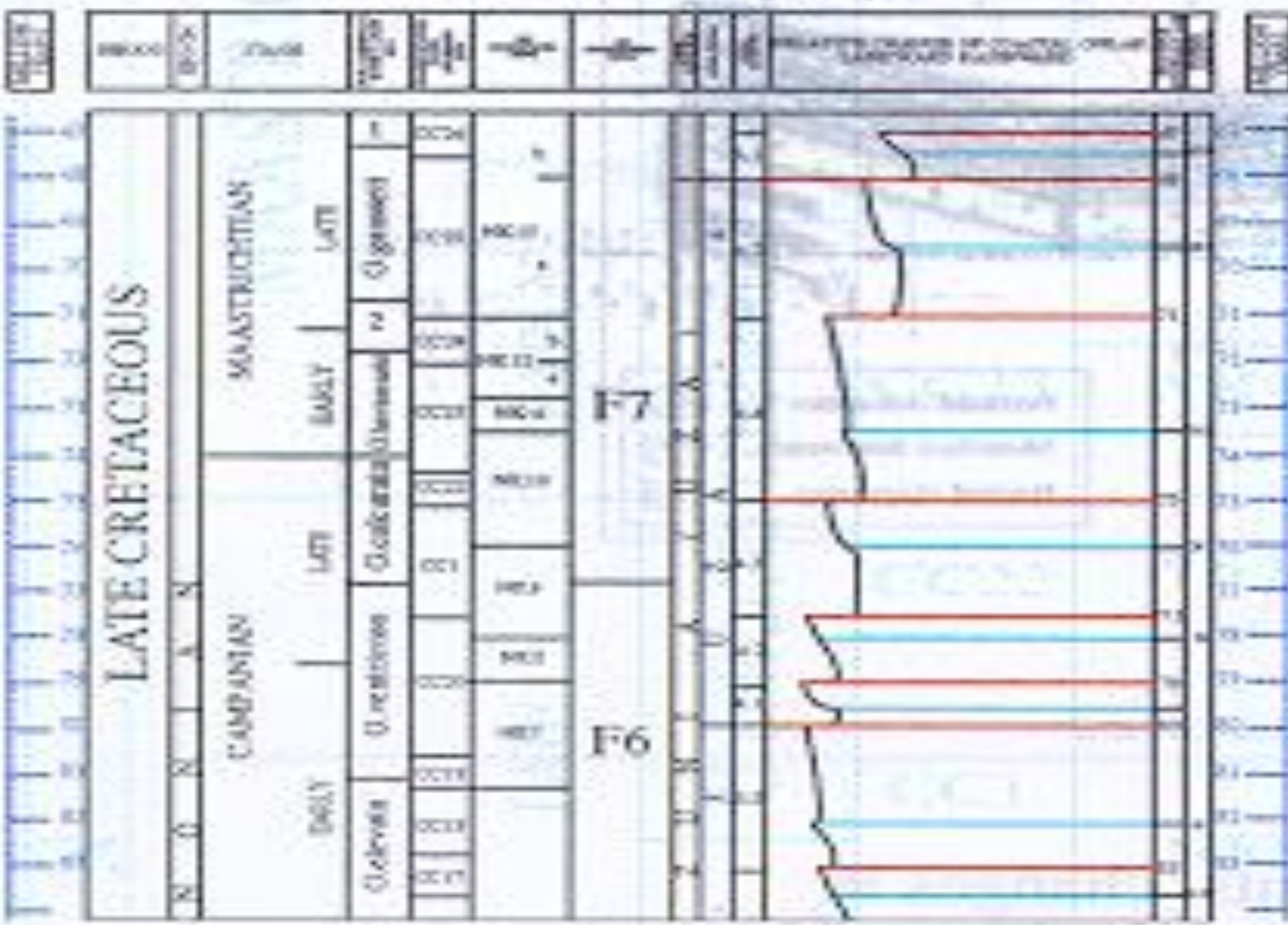

ENVIRONMENT
TERRESTRIAL / FLUVIAL / LACUSTRINE
MARINE
BENTHIC
PLANKTONIC
FOSSIL GROUP
AGE
Spores
Charophyta*
Gymnosperm pollen
Angiosperm pollen
Ostracods*
Benthic forams
Dasycladacean algae
Rhodophyta algae
Codiacean algae
Conodonts*
Chitinozoans
Acritarchs
Radiolarians
Dinoflagellates
Nannofossils
Planktonic forams
Calpionellids
Silicoflagellates
Diatoms*
QUATERNARY
TERTIARY
CRETACEOUS
JURASSIC
TRIASSIC
PERMIAN
CARBONIFEROUS
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
PRECAMBRIAN

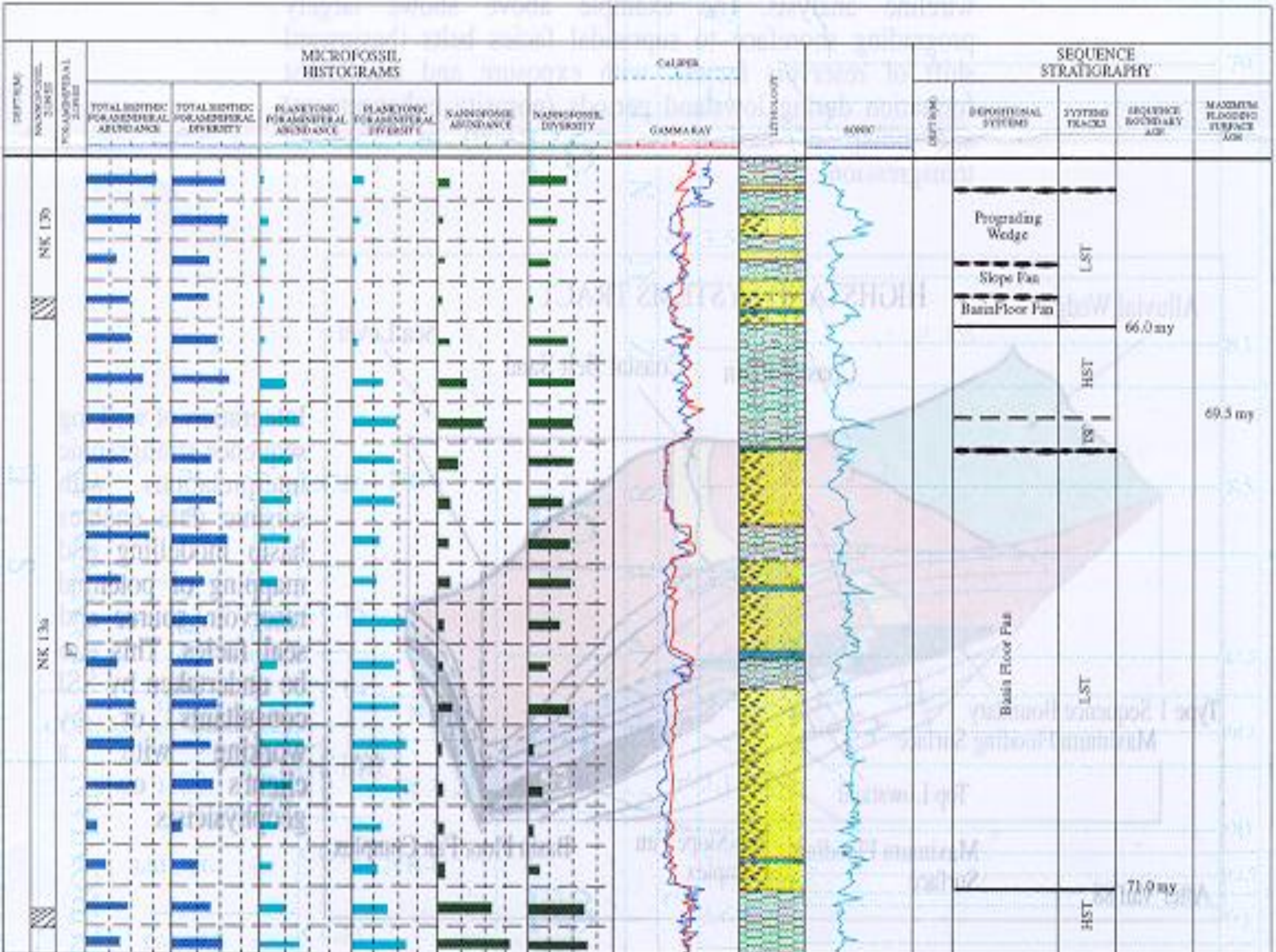

WATER-DEPTH BARRIERS
SIMPLE
INTERMEDIATE
COMPLEX
SEA LEVEL
PHOTIC ZONE
SEA FLOOR TOPOGRAPHY



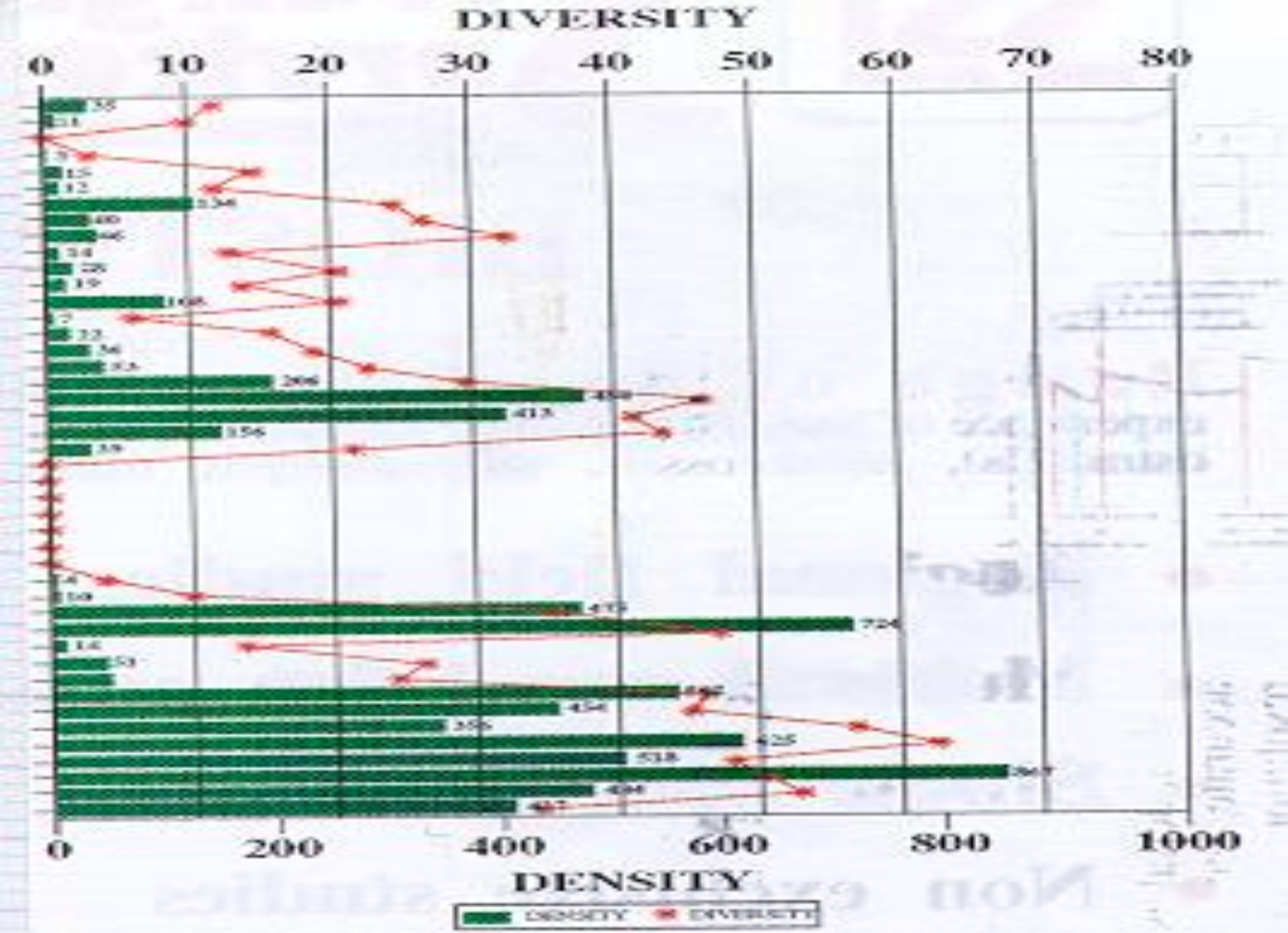
SONIC
40
40
ORGANIC MACERAL ABUNDANCE DATA
0
50
100
COAL
LYCOPODS PLUS DENSOSPORES
0
125
250
SPHENOPSIDS (LAKE MARGIN DERIVED)
0
125
250

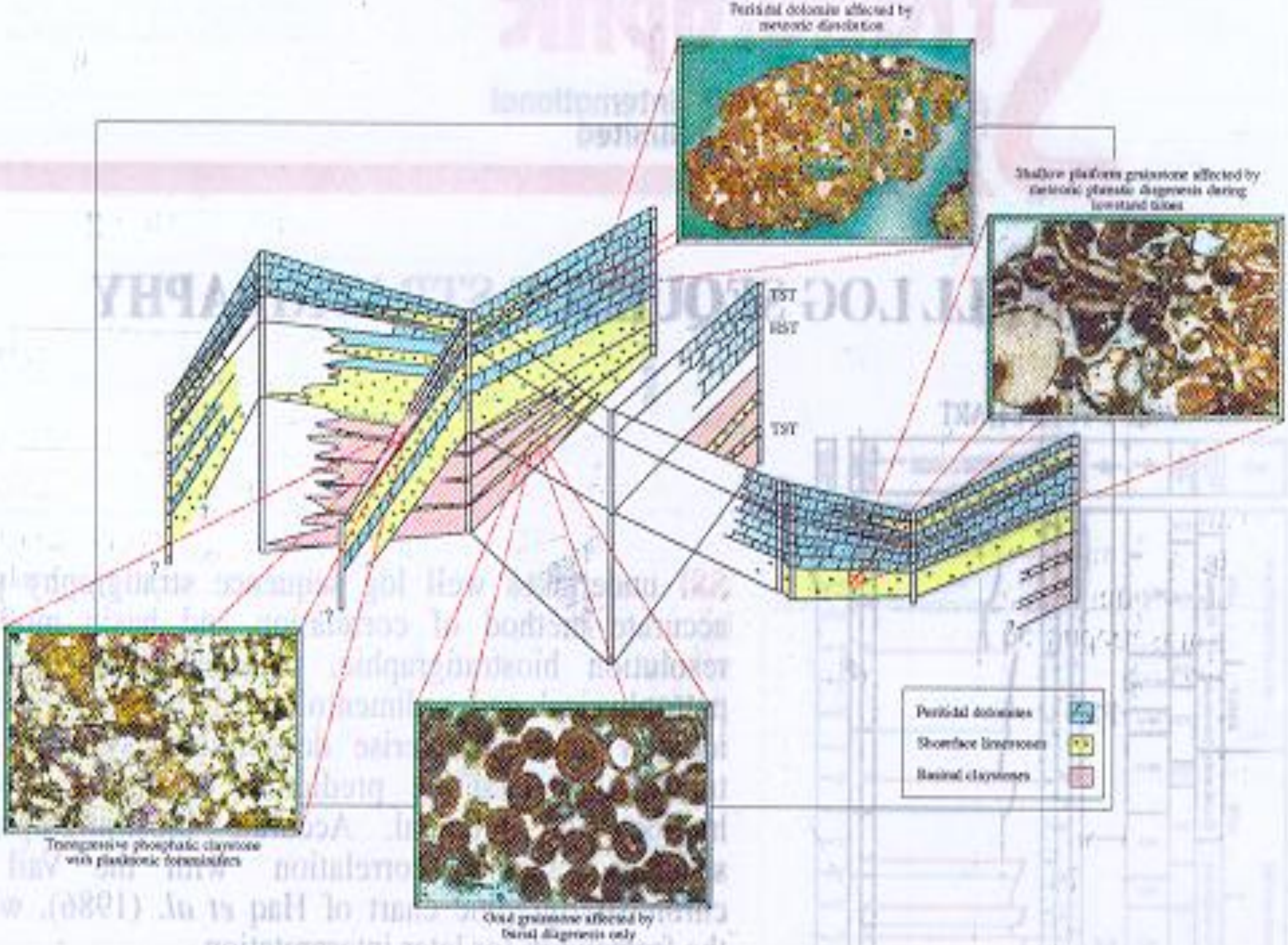
MESOZOIC CYCLE CHART





MICROFOSSIL HISTOGRAMS
TOTAL BENTHIC FORAMINIFERAL ABUNDANCE
TOTAL BENTHIC FORAMINIFERAL DIVERSITY
PLANKTONIC FORAMINIFERAL ABUNDANCE
PLANKTONIC FORAMINIFERAL DIVERSITY
NANNOFOSSIL ABUNDANCE
NANNOFOSSIL DIVERSITY
CALIPER
GAMMA RAY
LITHOLOGY
SONIC
SEQUENCE STRATIGRAPHY
DEPOSITIONAL SYSTEMS
SYSTEMS TRACKS
SEQUENCE BOUNDARY AGE
MAXIMUM FLOODING SURFACE AGE
NK 13b
NK 13a
Prograding Wedge
Slope Fan
BasinFloor Fan
LST
HST
TST
66.0 my
69.5 my
Basin Floor Fan
LST
71.0 my
HST

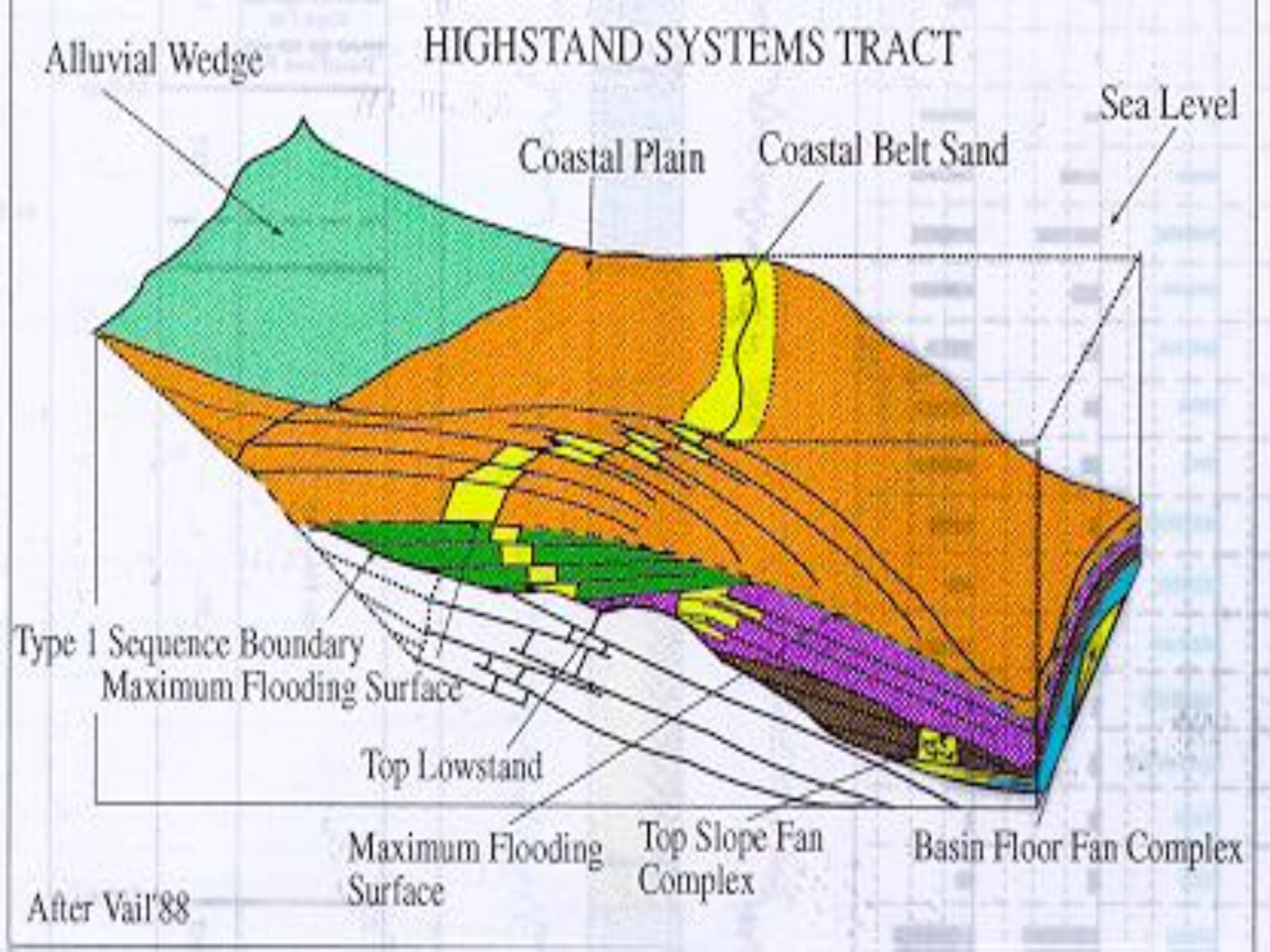

DIVERSITY
0
10
20
30
40
50
60
70
80
DENSITY
0
200
400
600
800
1000



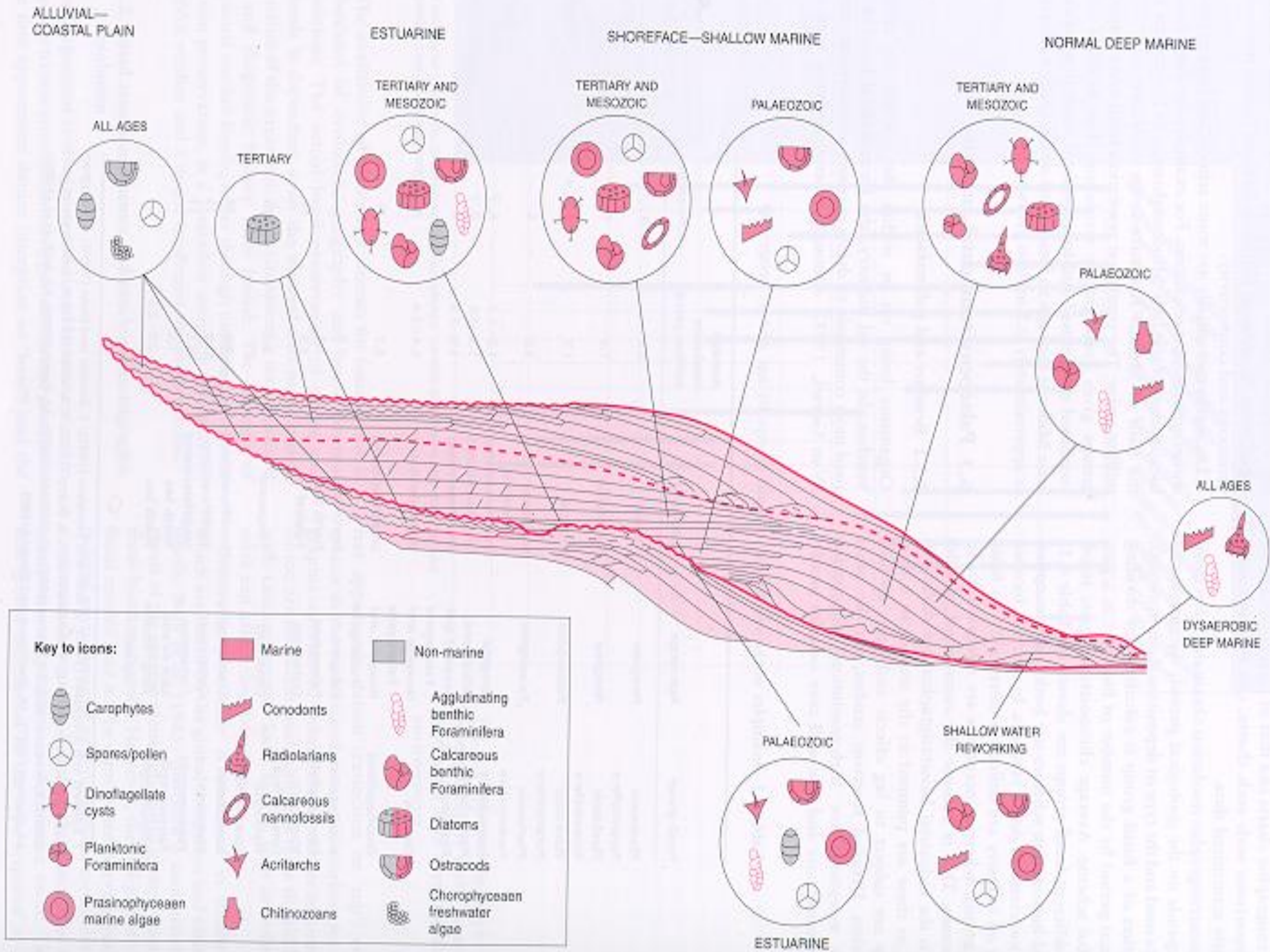
Peritidal dolomite affected by meteoric dissolution
Shallow platform grainstone affected by meteoric phreatic diagenesis during lowstand times
TST
HST
TST
Peritidal dolomites
Shoreface limestones
Basinal claystones
Transgressive phosphatic claystone with planktonic foraminifera
Ooid grainstone affected by burial diagenesis only

Table 6.1 Examples of the resolution of fossil groups by age and by geography

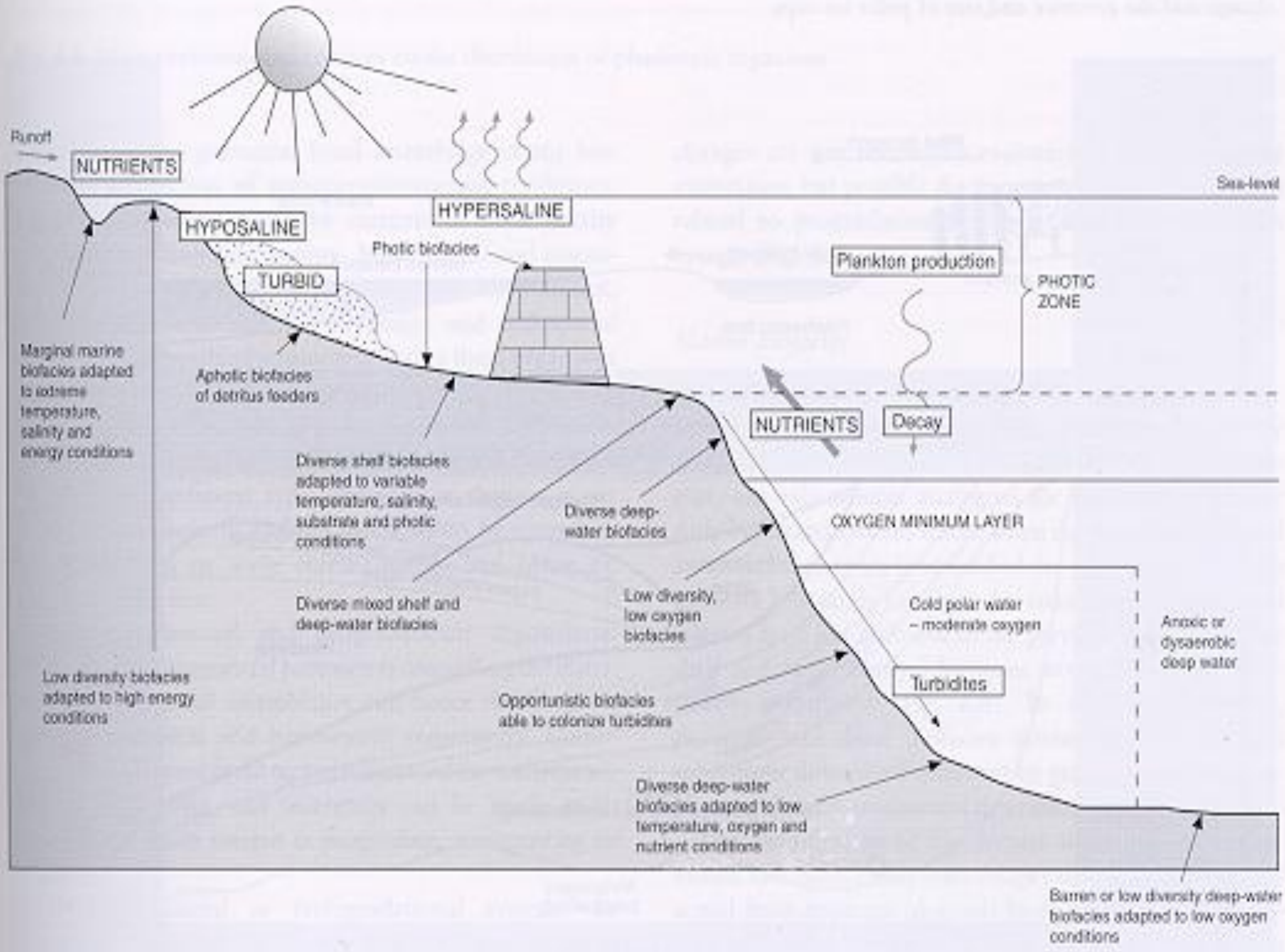
Fossil group	Age range	Geography	Average resolution (million years)	References
Planktonic Foraminifera	Neogene	Tropical	1.2	1
Planktonic Foraminifera	Neogene	Subtropical	1.4	1
Planktonic Foraminifera	Palaeogene	Tropical	1.7	2, 3, 4
Planktonic Foraminifera	Palaeogene	Southern temperate	3.0	5
Nannofossils	Neogene	Undifferentiated	1.0–1.3	6, 7
Nannofossils	Palaeogene	Undifferentiated	1.3–1.6	6, 7
Radiolaria	Neogene and Palaeogene	Undifferentiated	1.9–2.0	8
Diatoms	Neogene and Palaeogene	Undifferentiated	1.4–2.4	9, 10
Dinoflagellates	Neogene and Palaeogene	Undifferentiated	5.7	11
Dinoflagellates	Neogene	North Sea	3.3	
Dinoflagellates	Palaeogene	North Sea	1.1	
Planktonic Foraminifera	Cretaceous	Tropical	2.5	12
Planktonic Foraminifera	Cretaceous	Temperate	4.0	13
Nannofossils	Cretaceous	Undifferentiated	3.0	14
Radiolaria	Cretaceous	Undifferentiated	10.0	15
Palynomorphs	Cretaceous	Undifferentiated	6.5	11
Palynomorphs	Late Jurassic	North Sea	1.0	
Palynomorphs	Early–Middle Jurassic	North Sea	2.0–2.5	



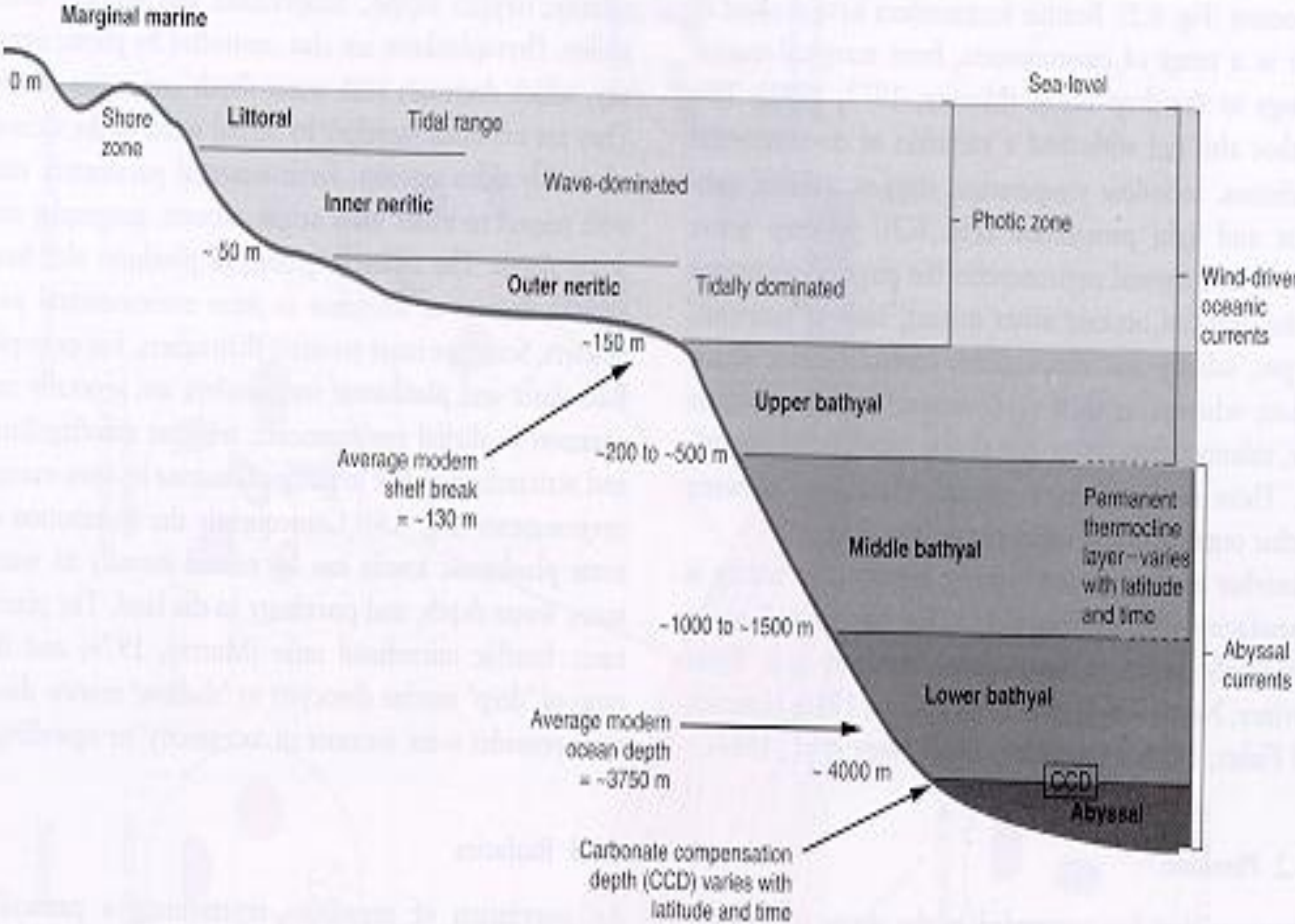
HIGHSTAND SYSTEMS TRACT
Alluvial Wedge
Sea Level
Coastal Plain
Coastal Belt Sand
Type 1 Sequence Boundary
Maximum Flooding Surface
Top Lowstand
Maximum Flooding
Surface
Top Slope Fan
Complex
Basin Floor Fan Complex
After Vail'88



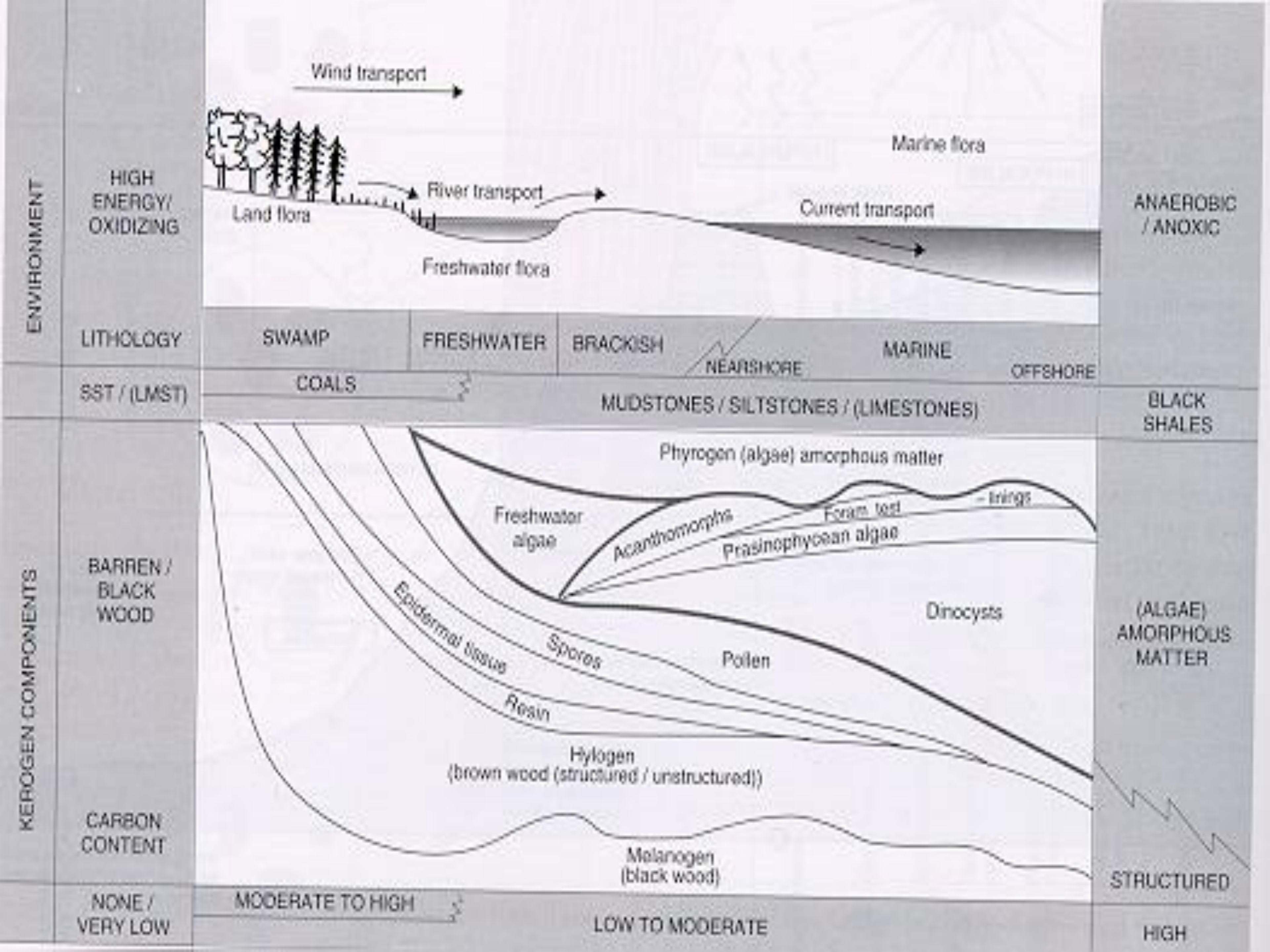
ALLUVIAL—
COASTAL PLAIN
ESTUARINE
SHOREFACE—SHALLOW MARINE
NORMAL DEEP MARINE
ALL AGES
TERTIARY
TERTIARY AND MESOZOIC
TERTIARY AND MESOZOIC
PALAEOZOIC
TERTIARY AND MESOZOIC
PALAEOZOIC
ALL AGES
DYSAEROBIC DEEP MARINE
PALAEOZOIC
SHALLOW WATER REWORKING
ESTUARINE
Key to icons:
Marine
Non-marine
Carophytes
Spores/pollen
Dinoflagellate cysts
Planktonic Foraminifera
Prasinophyceaen marine algae
Conodonts
Radiolarians
Calcareous nannofossils
Acritarchs
Chitinozoans
Agglutinating benthic Foraminifera
Calcareous benthic Foraminifera
Diatoms
Ostracods
Chorophyceaen freshwater algae



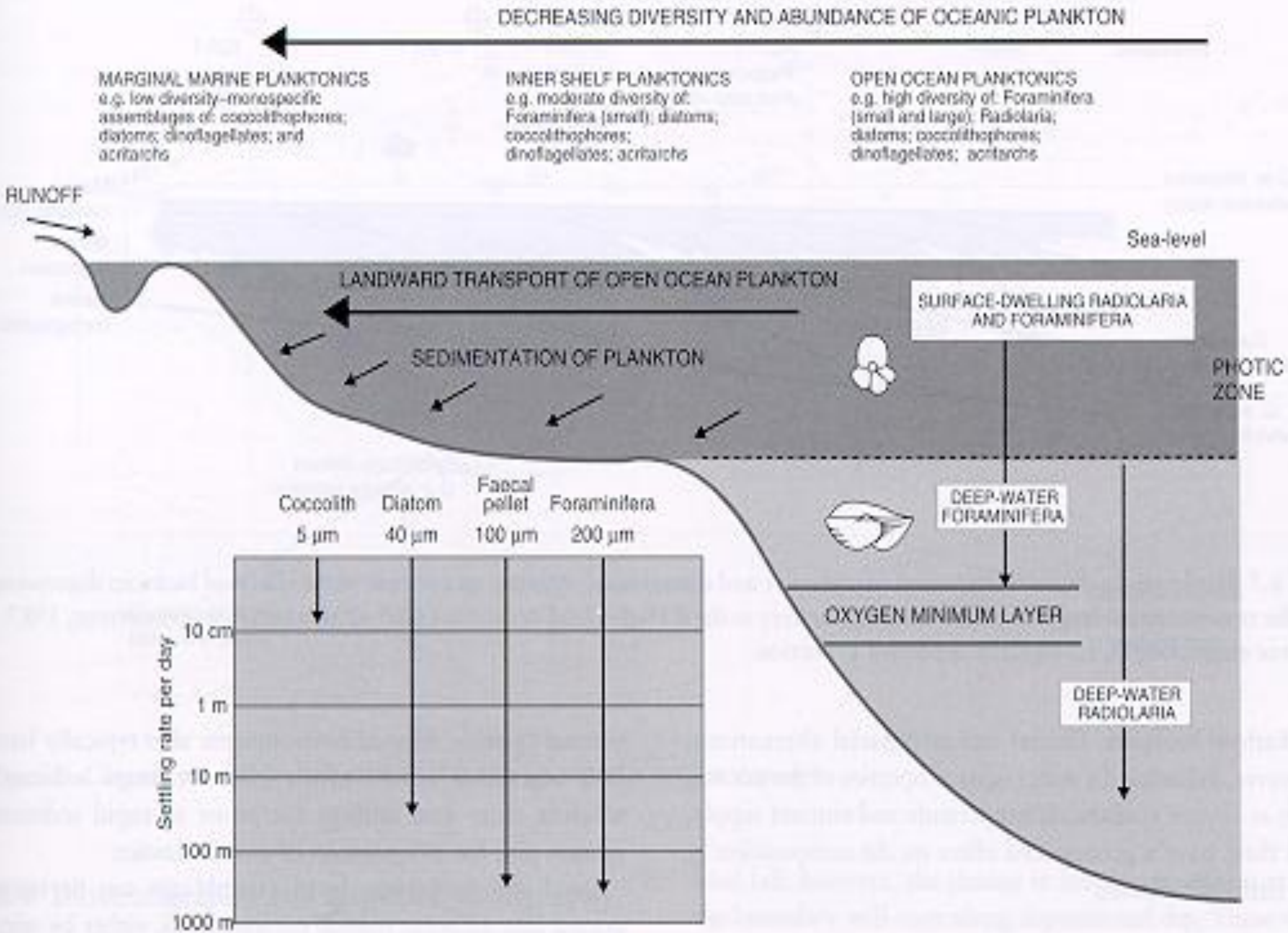
Runoff
NUTRIENTS
Sea-level
HYPERSALINE
HYPOSALINE
TURBID
Photic biofacies
Plankton production
PHOTIC ZONE
Marginal marine biofacies adapted to extreme temperature, salinity and energy conditions
Aphotic biofacies of detritus feeders
NUTRIENTS
Decay
Diverse shelf biofacies adapted to variable temperature, salinity, substrate and photic conditions
Diverse deep-water biofacies
OXYGEN MINIMUM LAYER
Diverse mixed shelf and deep-water biofacies
Low diversity, low oxygen biofacies
Cold polar water – moderate oxygen
Anoxic or dysaerobic deep water
Low diversity biofacies adapted to high energy conditions
Turbidites
Opportunistic biofacies able to colonize turbidites
Diverse deep-water biofacies adapted to low temperature, oxygen and nutrient conditions
Barren or low diversity deep-water biofacies adapted to low oxygen conditions



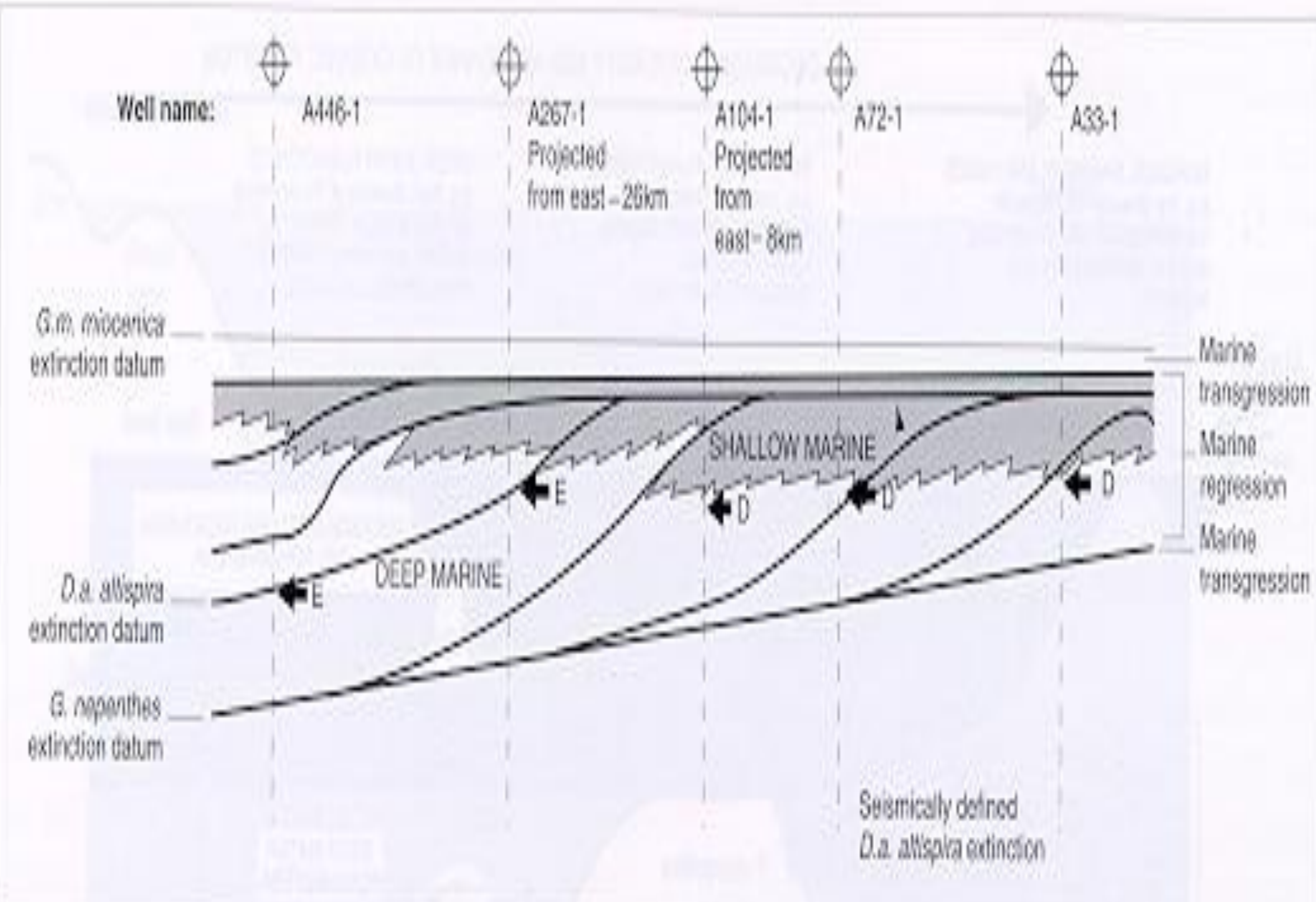
Marginal marine
0 m
Shore zone
Littoral
Tidal range
Sea-level
Wave-dominated
Inner neritic
Photic zone
~50 m
Outer neritic
Tidally dominated
Wind-driven oceanic currents
~150 m
Upper bathyal
Average modern shelf break = ~130 m
~200 to ~500 m
Permanent thermocline layer – varies with latitude and time
Middle bathyal
~1000 to ~1500 m
Abyssal currents
Lower bathyal
Average modern ocean depth = ~3750 m
~4000 m
CCD
Abyssal
Carbonate compensation depth (CCD) varies with latitude and time



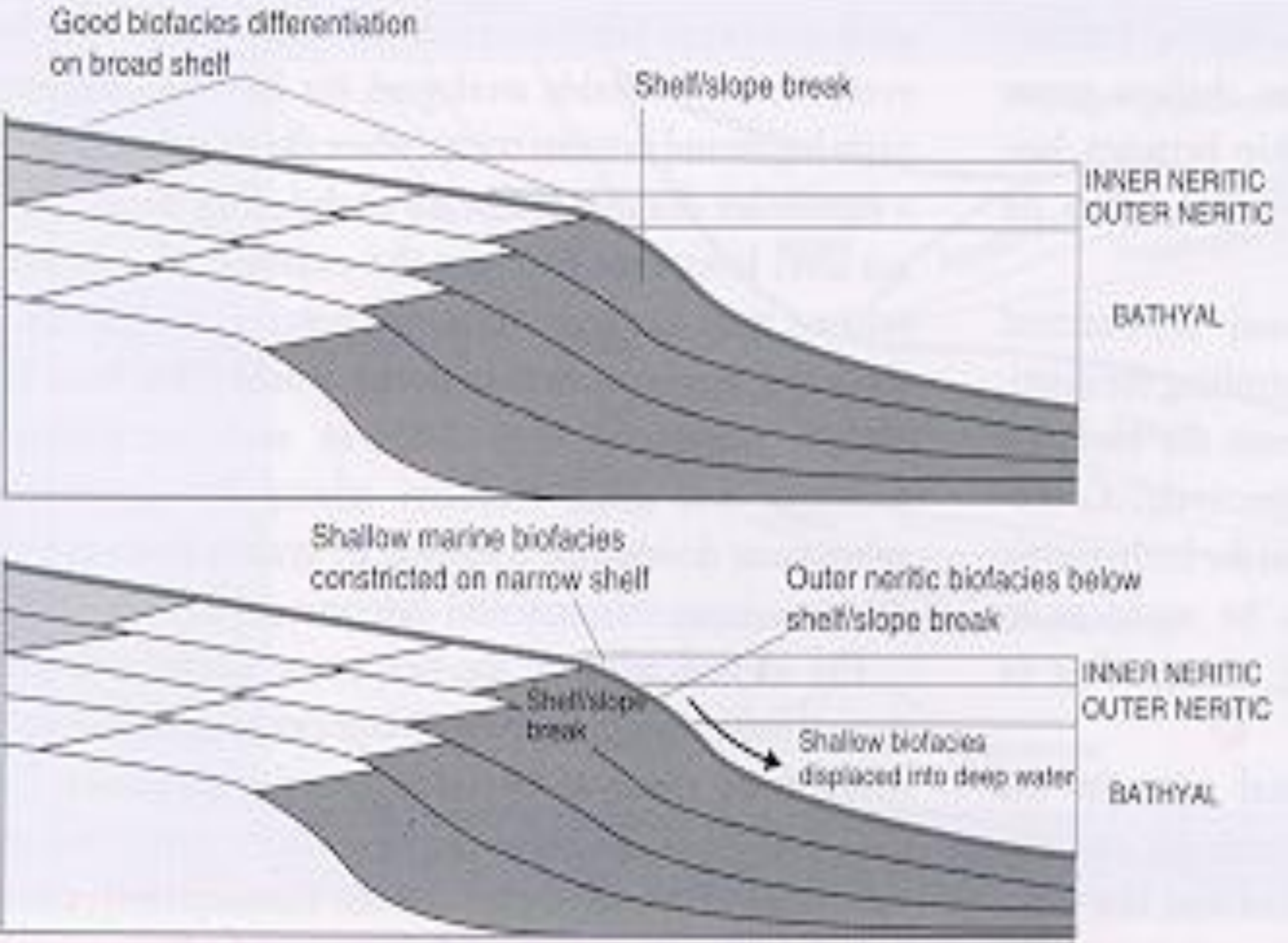
ENVIRONMENT
HIGH ENERGY/ OXIDIZING
Wind transport
Land flora
River transport
Freshwater flora
Marine flora
Current transport
ANAEROBIC / ANOXIC
LITHOLOGY
SWAMP
FRESHWATER
BRACKISH
NEARSHORE
MARINE
OFFSHORE
SST / (LMST)
COALS
MUDSTONES / SILTSTONES / (LIMESTONES)
BLACK SHALES
KEROGEN COMPONENTS
BARREN / BLACK WOOD
Phyrogen (algae) amorphous matter
Freshwater algae
Acanthomorphs
Foram test
- linings
Prasinophycean algae
Dinocysts
Epidermal tissue
Spores
Pollen
Resin
Hylogen
(brown wood (structured / unstructured))
Melanogen
(black wood)
(ALGAE) AMORPHOUS MATTER
STRUCTURED
CARBON CONTENT
NONE / VERY LOW
MODERATE TO HIGH
LOW TO MODERATE
HIGH



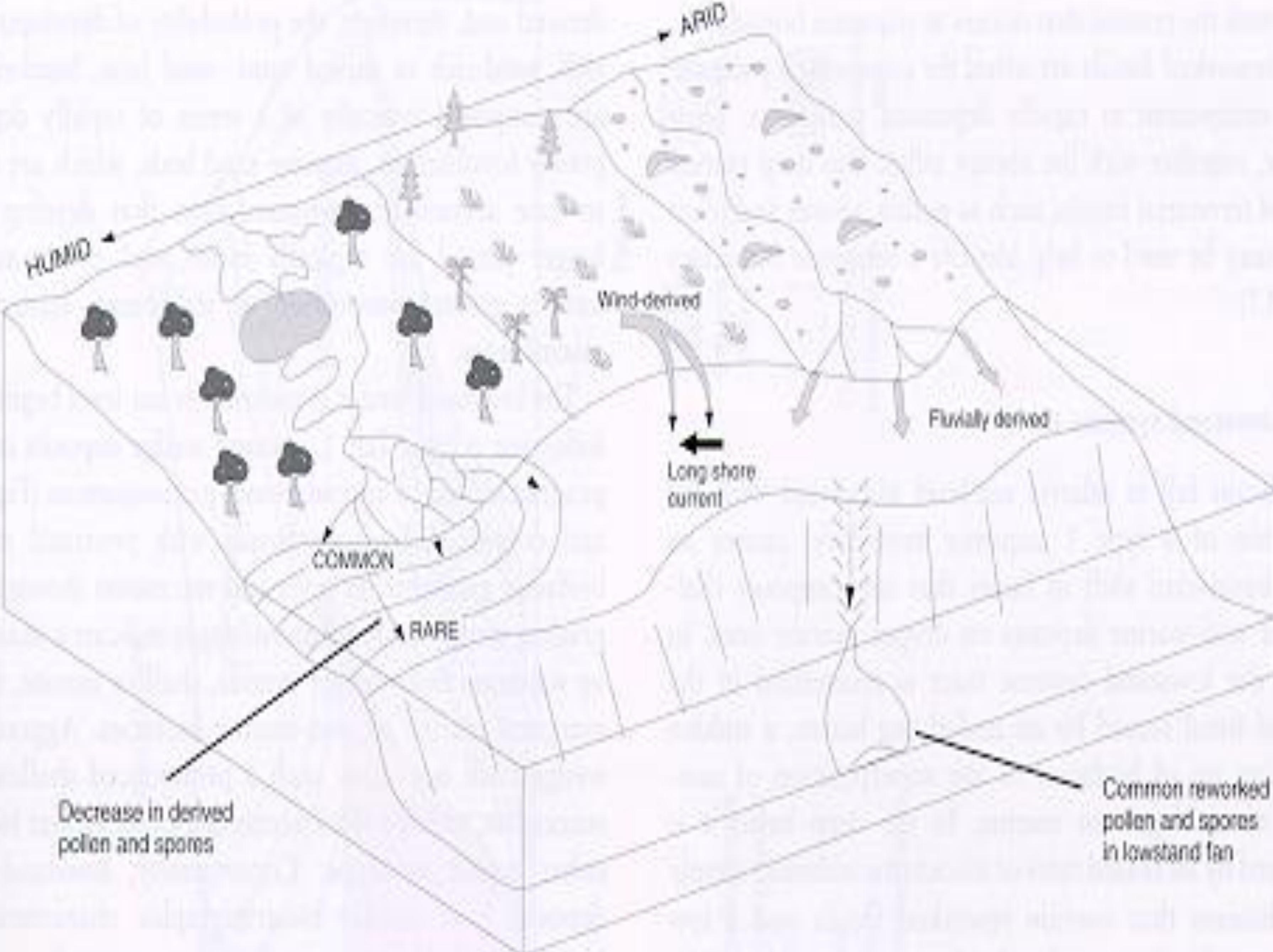
DECREASING DIVERSITY AND ABUNDANCE OF OCEANIC PLANKTON
MARGINAL MARINE PLANKTONICS e.g. low diversity–monospecific assemblages of: coccolithophores; diatoms; dinoflagellates; and acritarchs
INNER SHELF PLANKTONICS e.g. moderate diversity of: Foraminifera (small); diatoms; coccolithophores; dinoflagellates; acritarchs
OPEN OCEAN PLANKTONICS e.g. high diversity of: Foraminifera (small and large); Radiolaria; diatoms; coccolithophores; dinoflagellates; acritarchs
RUNOFF
Sea-level
LANDWARD TRANSPORT OF OPEN OCEAN PLANKTON
SEDIMENTATION OF PLANKTON
SURFACE-DWELLING RADIOLARIA AND FORAMINIFERA
PHOTIC ZONE
DEEP-WATER FORAMINIFERA
OXYGEN MINIMUM LAYER
DEEP-WATER RADIOLARIA
Coccolith 5 µm
Diatom 40 µm
Faecal pellet 100 µm
Foraminifera 200 µm
Settling rate per day
10 cm
1 m
10 m
100 m
1000 m



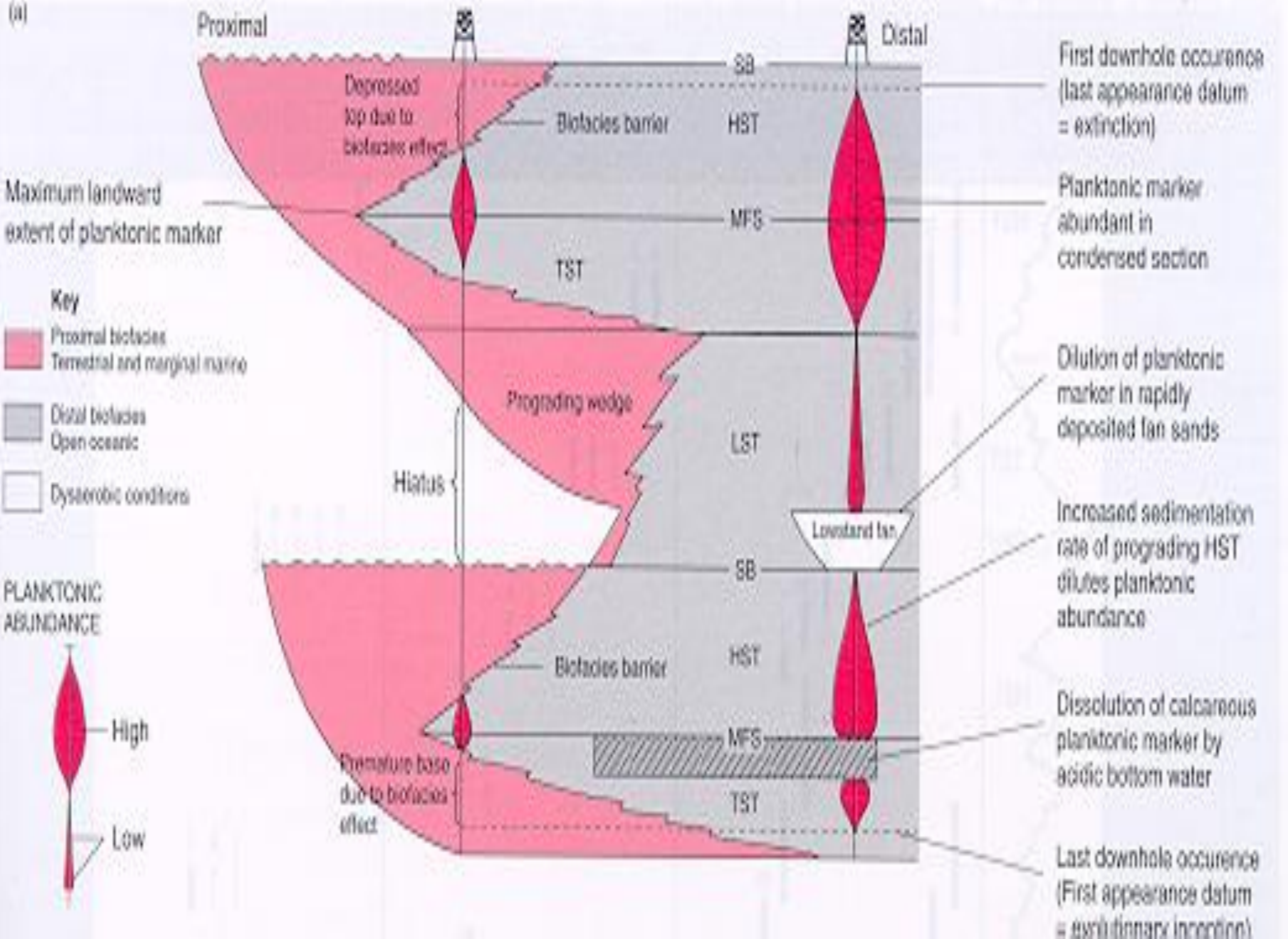
Well name:
A446-1
A267-1
Projected
from east - 26km
A104-1
Projected
from
east - 8km
A72-1
A33-1
G.m. miocenica
extinction datum
D.a. altispira
extinction datum
G. nepenthes
extinction datum
Marine
transgression
Marine
regression
Marine
transgression
SHALLOW MARINE
DEEP MARINE
E
E
D
D
D
Seismically defined
D.a. altispira extinction



Good biofacies differentiation on broad shelf
Shelf/slope break
INNER NERITIC
OUTER NERITIC
BATHYAL
Shallow marine biofacies constricted on narrow shelf
Outer neritic biofacies below shelf/slope break
Shelf/slope break
INNER NERITIC
OUTER NERITIC
Shallow biofacies displaced into deep water
BATHYAL

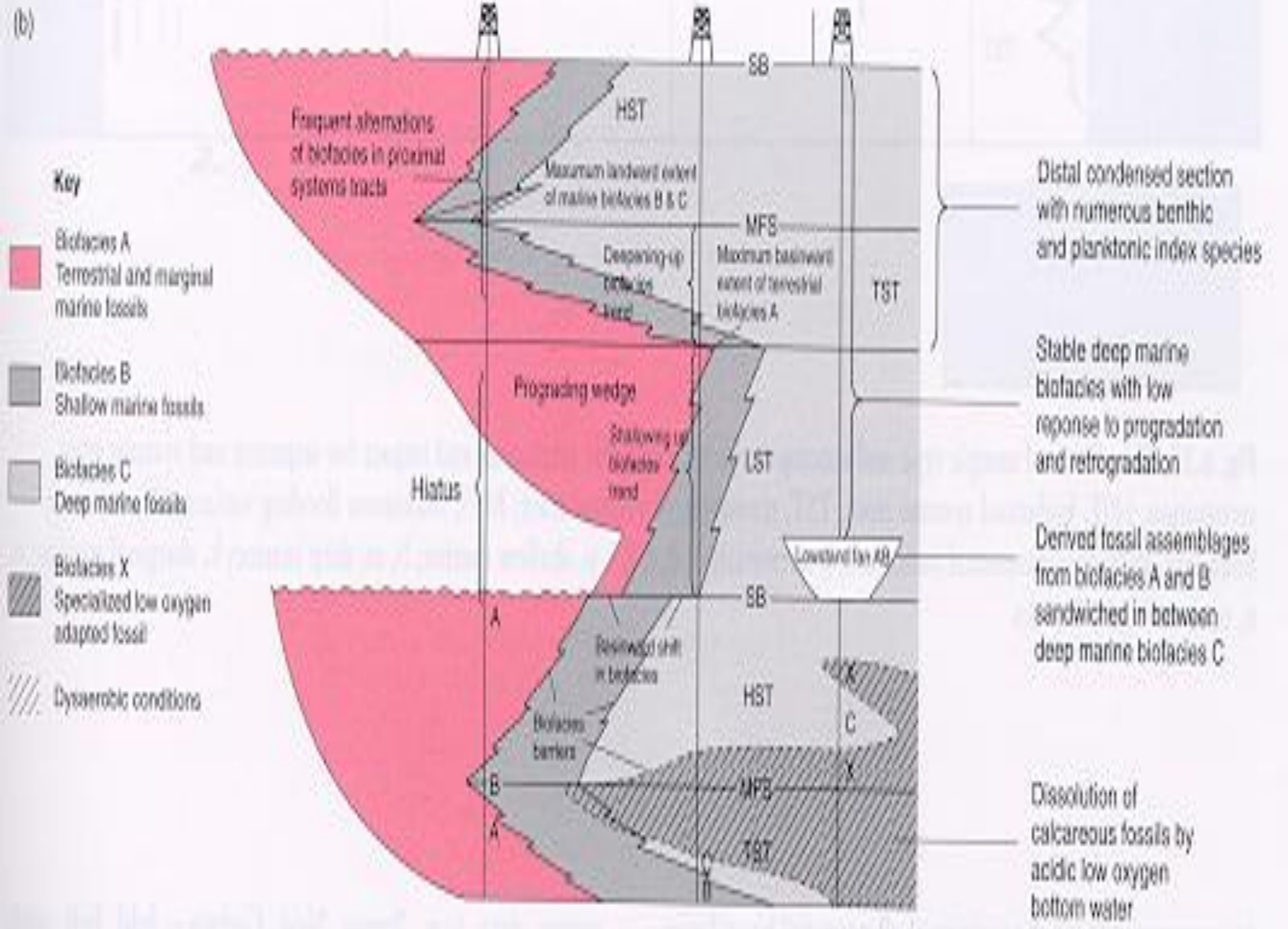


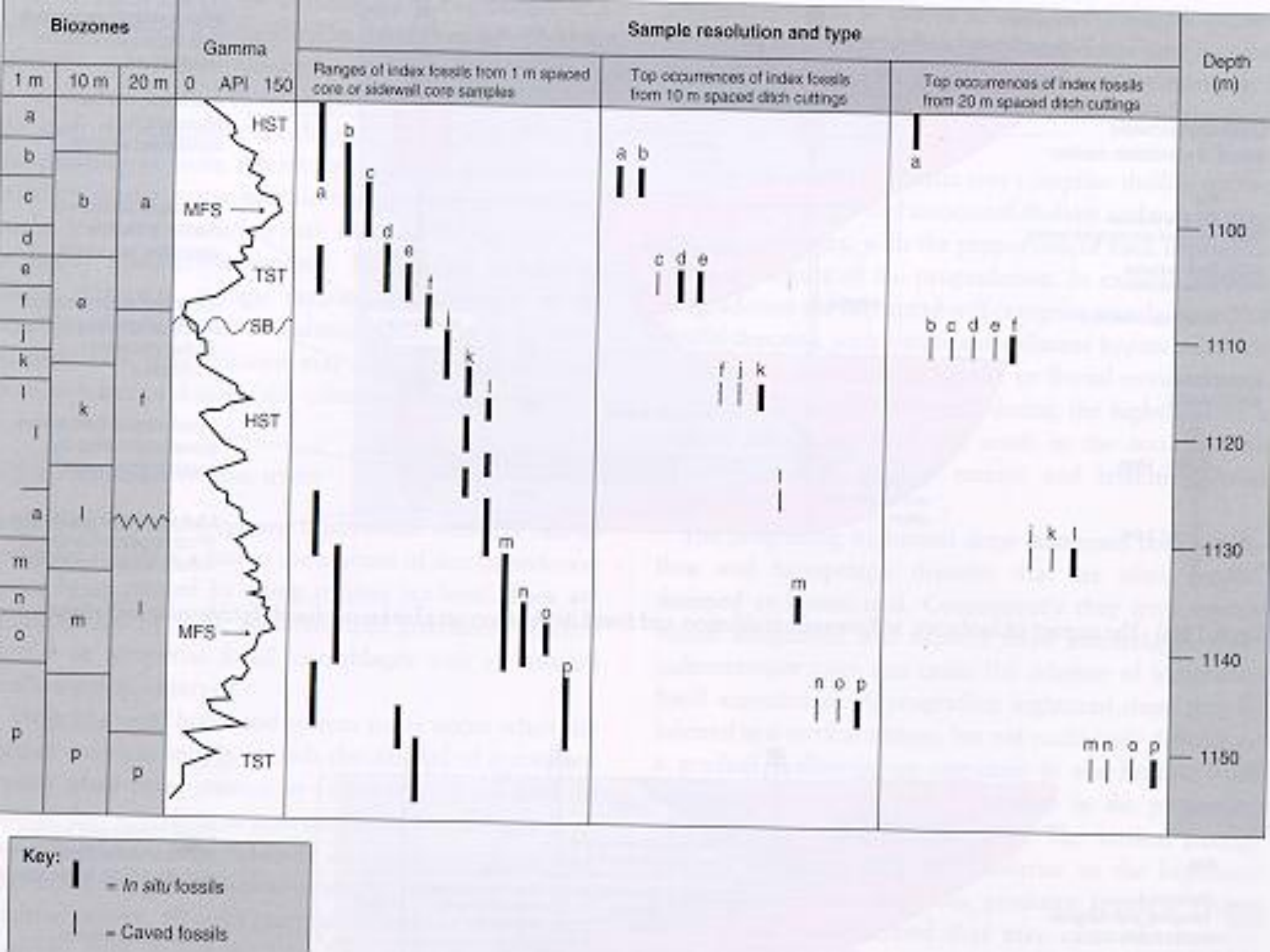
ARID
HUMID
Wind-derived
Fluvially derived
Long shore
current
COMMON
RARE
Decrease in derived
pollen and spores
Common reworked
pollen and spores
in lowstand fan



(a)
Proximal
Distal
SB
HST
MFS
TST
LST
SB
HST
MFS
TST
Depressed top due to biofacies effect
Biofacies barrier
Maximum landward extent of planktonic marker
Key
Proximal biofacies Terrestrial and marginal marine
Distal biofacies Open oceanic
Dysaerobic conditions
Prograding wedge
Hiatus
Lowstand fan
Biofacies barrier
PLANKTONIC ABUNDANCE
High
Low
Premature base due to biofacies effect
First downhole occurence (last appearance datum = extinction)
Planktonic marker abundant in condensed section
Dilution of planktonic marker in rapidly deposited fan sands
Increased sedimentation rate of prograding HST dilutes planktonic abundance
Dissolution of calcareous planktonic marker by acidic bottom water
Last downhole occurence (First appearance datum = evolutionary inception)

(b)


SB
HST
Frequent alternations of biofacies in proximal systems tracts
Maximum landward extent of marine biofacies B & C
MFS
Deepening-up biofacies trend
Maximum basinward extent of terrestrial biofacies A
TST
Prograding wedge
Shallowing up biofacies trend
LST
Hiatus
Lowstand fan AB
SB
A
Basinward shift in biofacies
HST
X
C
Biofacies barriers
X
B
MFS
A
TST
Key
Biofacies A
Terrestrial and marginal marine fossils
Biofacies B
Shallow marine fossils
Biofacies C
Deep marine fossils
Biofacies X
Specialized low oxygen adapted fossil
Dysaerobic conditions
Distal condensed section with numerous benthic and planktonic index species
Stable deep marine biofacies with low reponse to progradation and retrogradation
Derived fossil assemblages from biofacies A and B sandwiched in between deep marine biofacies C
Dissolution of calcareous fossils by acidic low oxygen bottom water


Biozones
1 m
10 m
20 m
Gamma
0 API 150
Sample resolution and type
Ranges of index fossils from 1 m spaced core or sidewall core samples
Top occurrences of index fossils from 10 m spaced ditch cuttings
Top occurrences of index fossils from 20 m spaced ditch cuttings
Depth (m)
HST
MFS
TST
SB
HST
MFS
TST
1100
1110
1120
1130
1140
1150
Key:
= In situ fossils
= Caved fossils

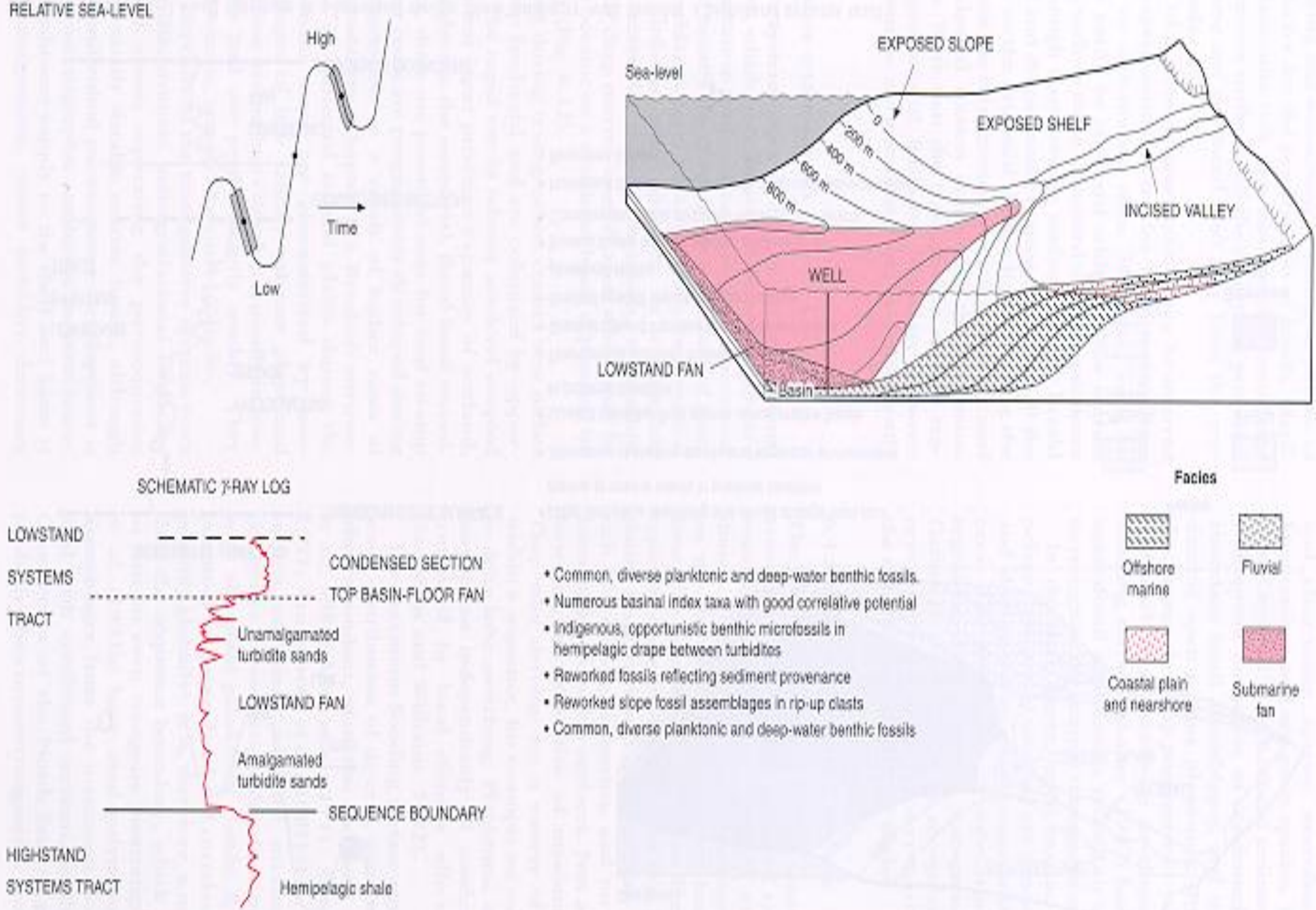
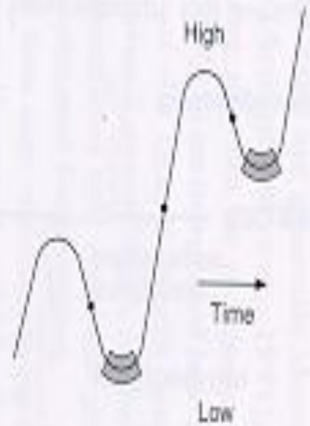
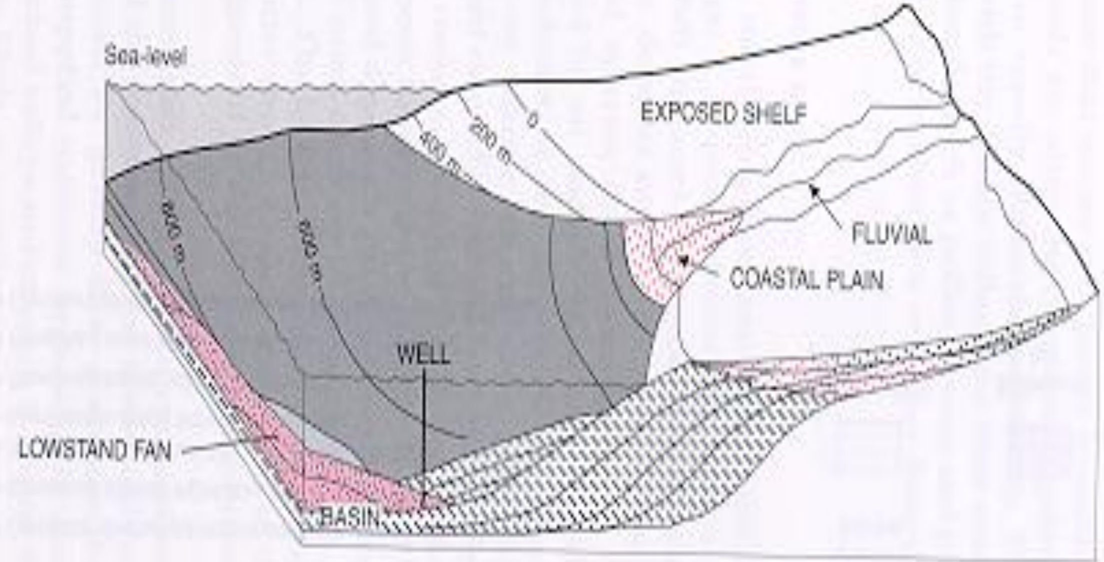


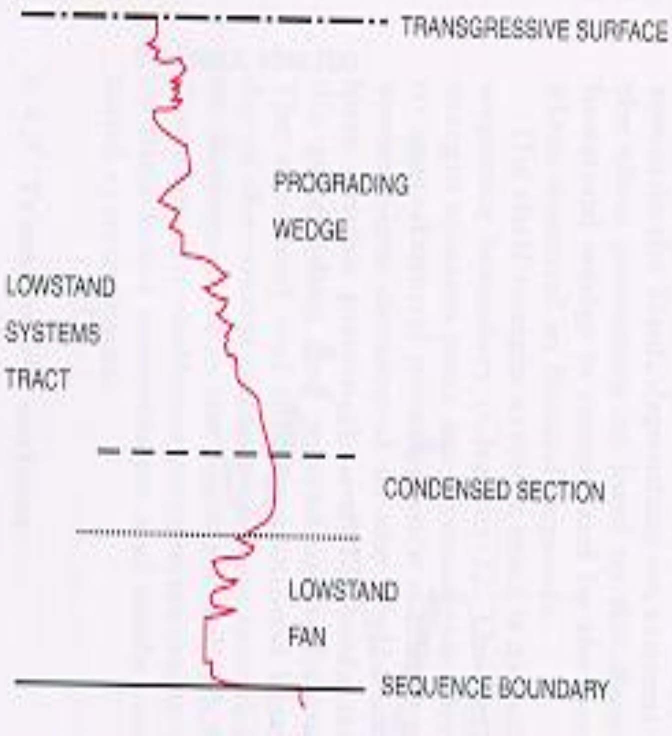
Fig. 6.10 Generalized fossil signature in a lowstand fan

RELATIVE SEA-LEVEL



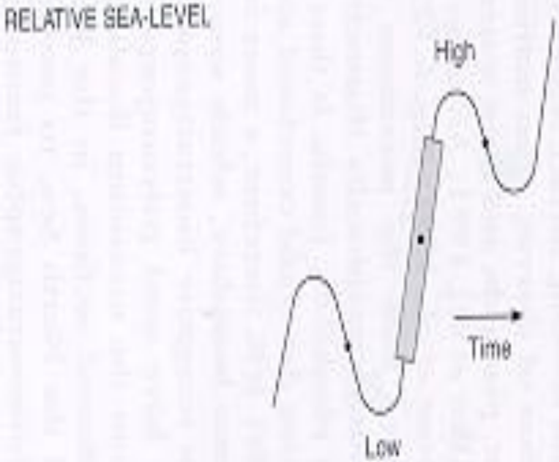


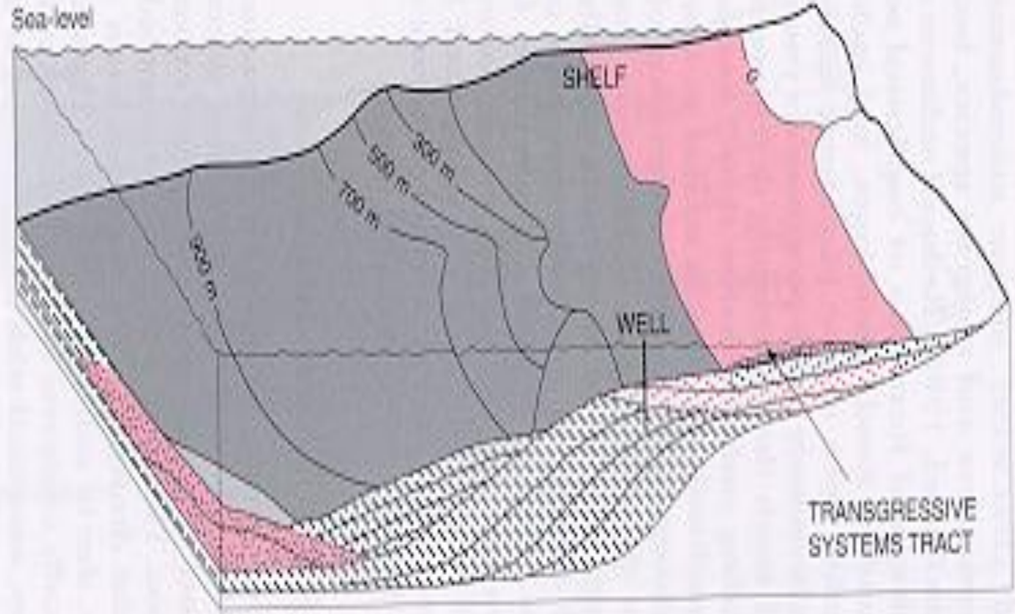
SCHEMATIC γ-RAY LOG

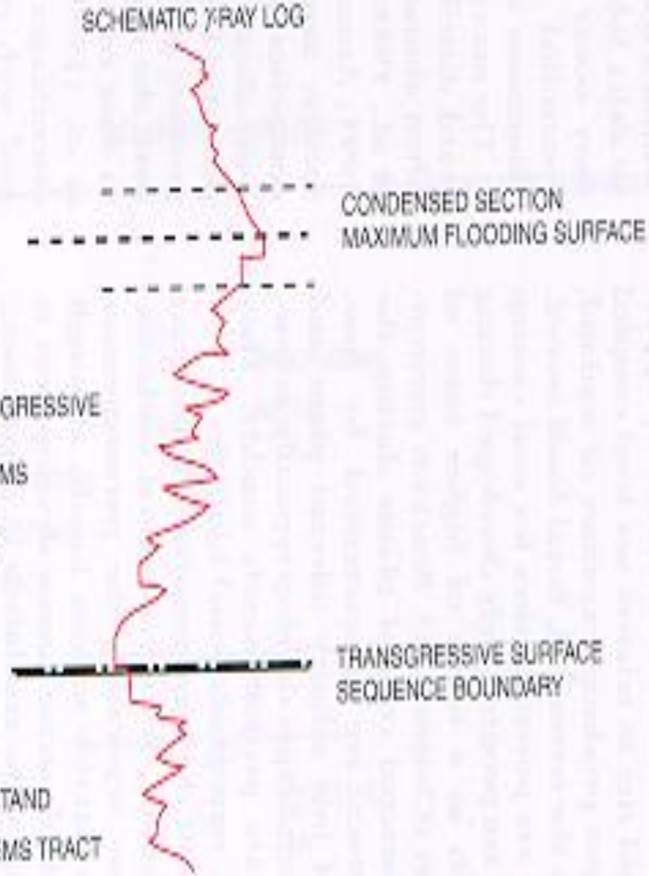


- Local shoreface reworking and abrupt change from non-marine to marine fossils in proximal locations
- Alternation of shallow marine and terrestrial environments
- Upward transition from marine to non-marine fossils in proximal locations
- Diachronous biofacies boundaries
- Gradual upward increase in land-derived fossils
- Gradual upward reduction in open ocean planktonic fossils
- Benthic fossils indicate gradual shallowing-up
- Common planktonic and deep-water benthic fossils
- Numerous basinal index taxa with good correlative potential
- Reworked fossils

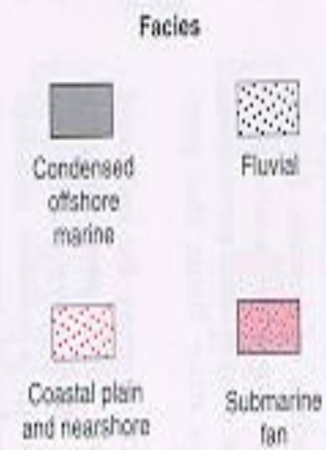
Facies

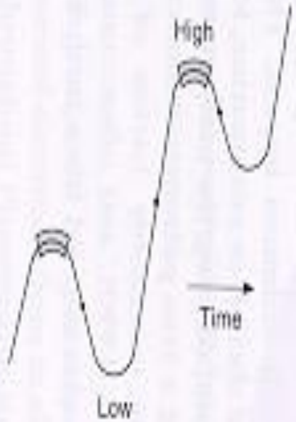


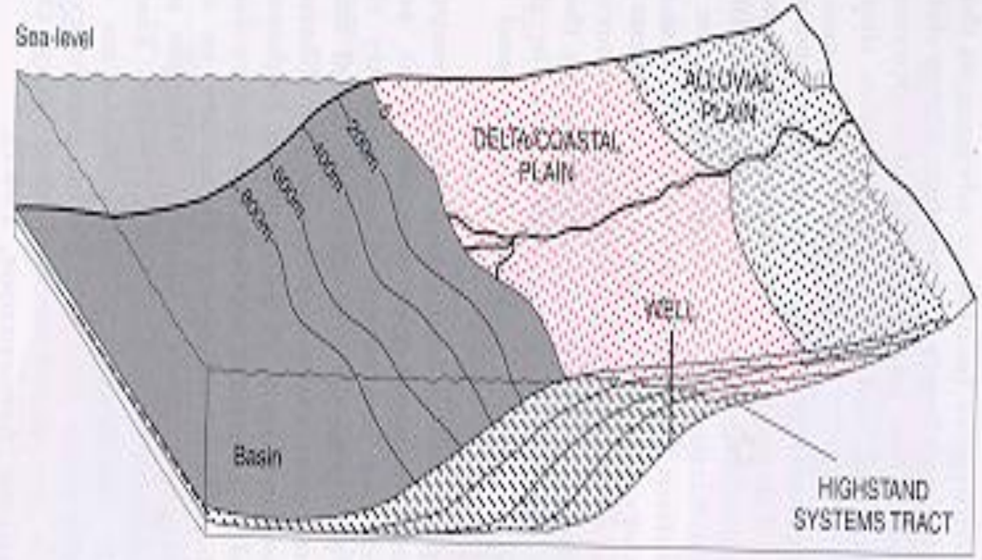


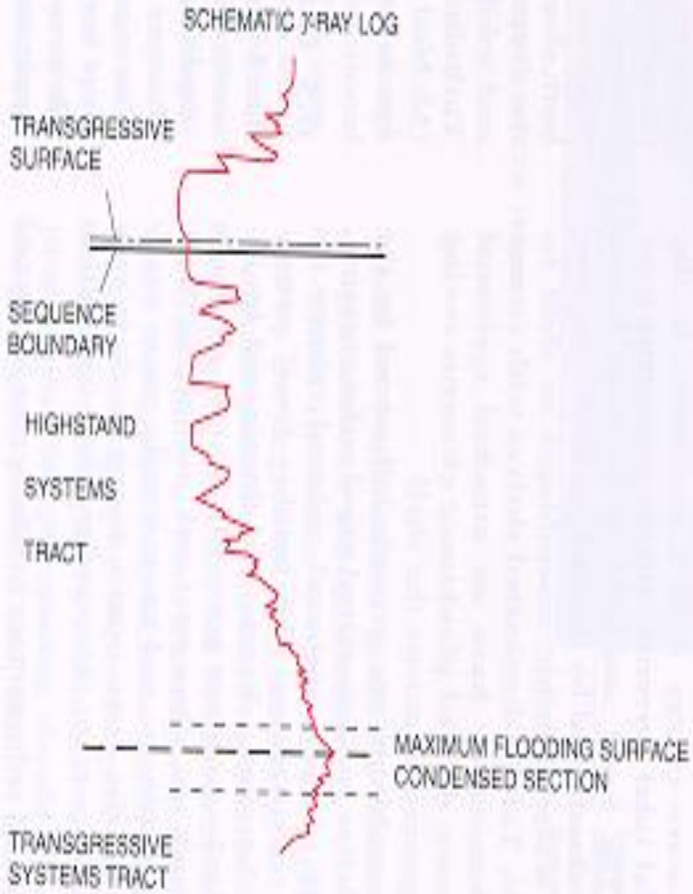


- Common, diverse planktonic and deep-water benthic fossil assemblages
- Numerous regional index taxa with good correlative potential
- Gradual upward reduction in derived terrestrial fossils
- Benthic fossils indicate deepening-up plus increase in open ocean planktonic fossils
- Diachronous biofacies boundaries
- Local shoreface reworking and abrupt change from non-marine to marine fossils at transgressive surface
- Possible hiatus in fossil record

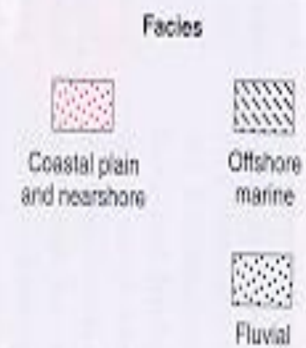








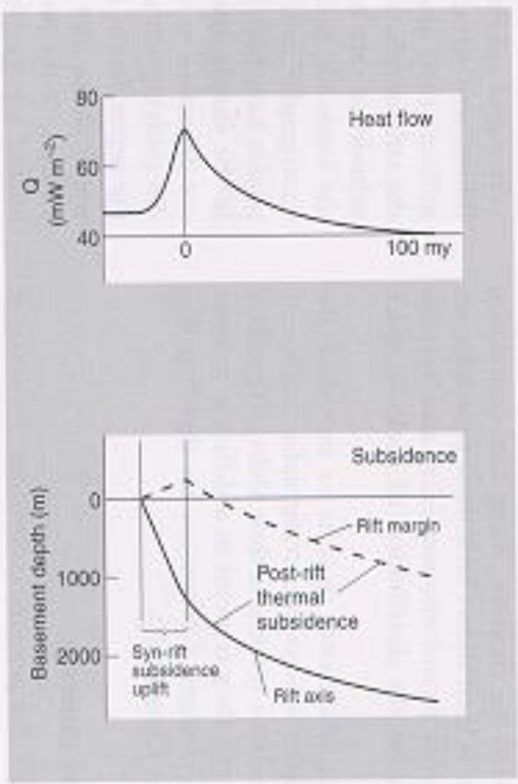
- Possible hiatus in fossil record at sequence boundary unconformity
- Alternation of shallow marine and terrestrial environments
- Transition between shallow marine to brackish water to terrestrial fossil assemblages
- Diachronous biofacies boundaries
- Gradual upward increase in derived terrestrial fossils
- Benthic fossils indicate gradual shallowing-up
- Gradual upward reduction in open ocean planktonic fossils
- Common, diverse planktonic and deep-water benthic fossil assemblages
- Numerous regional index taxa with good correlative potential



EXTENSIONAL (RIFT)

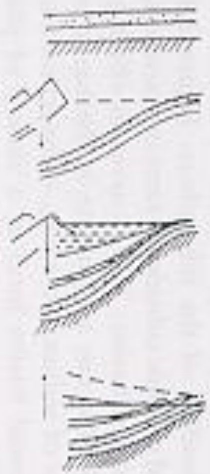
McKenzie (1978)—uniform stretching

(a) Tectonic model



(b) Heat flow and subsidence (single point, rift axis)

COMPRESSIONAL (FORELAND)



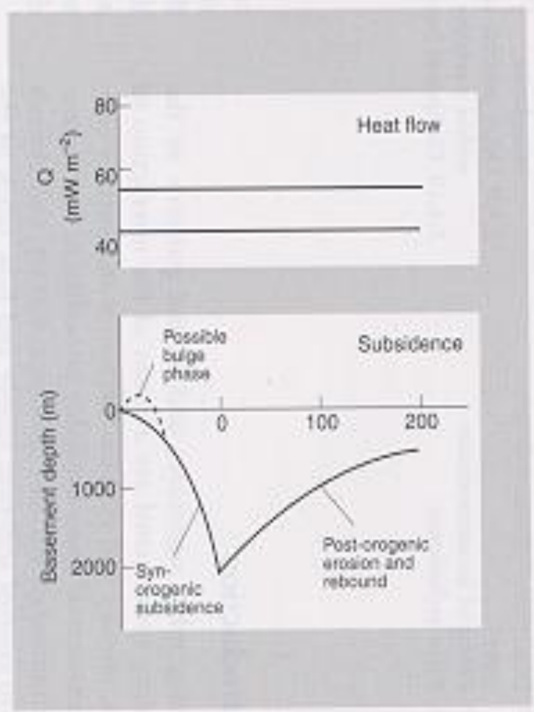
(i) Initial stratigraphy (need not be layer cake)

(ii) Load applied, crust downwarped, margins uplifted

(iii) Load increases, erosion of thrust belt provides sediments for foreland basin

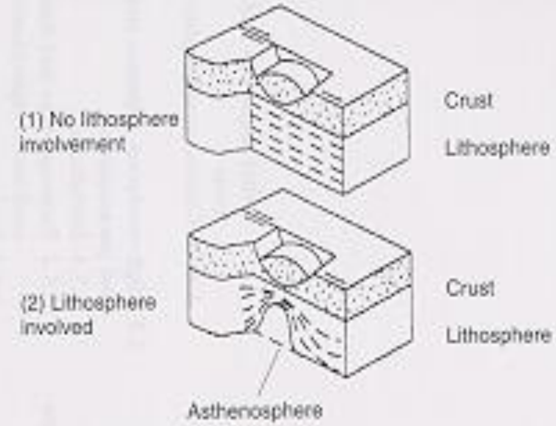
(iv) Thrusting stops, erosion continues = load reduced Isostatic rebound of foothills and basin – erosion of foreland basin

(a) Tectonic model

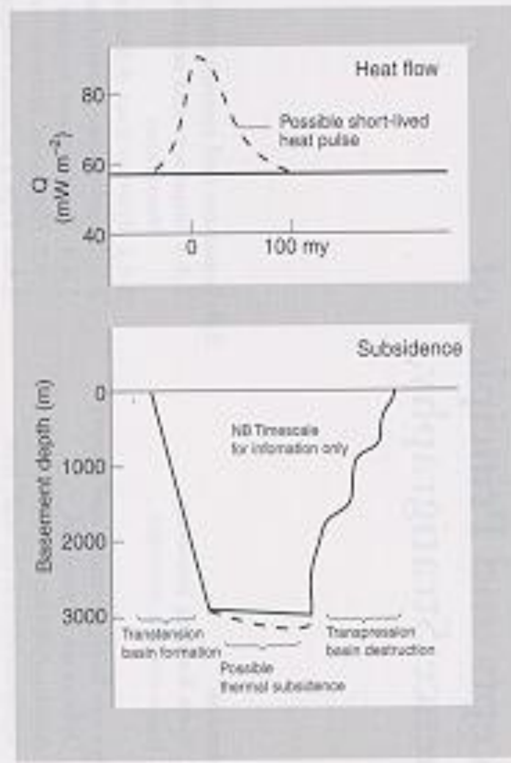


(b) Heat flow and subsidence

STRIKE-SLIP



(a) Tectonic models



(b) Heat flow and subsidence

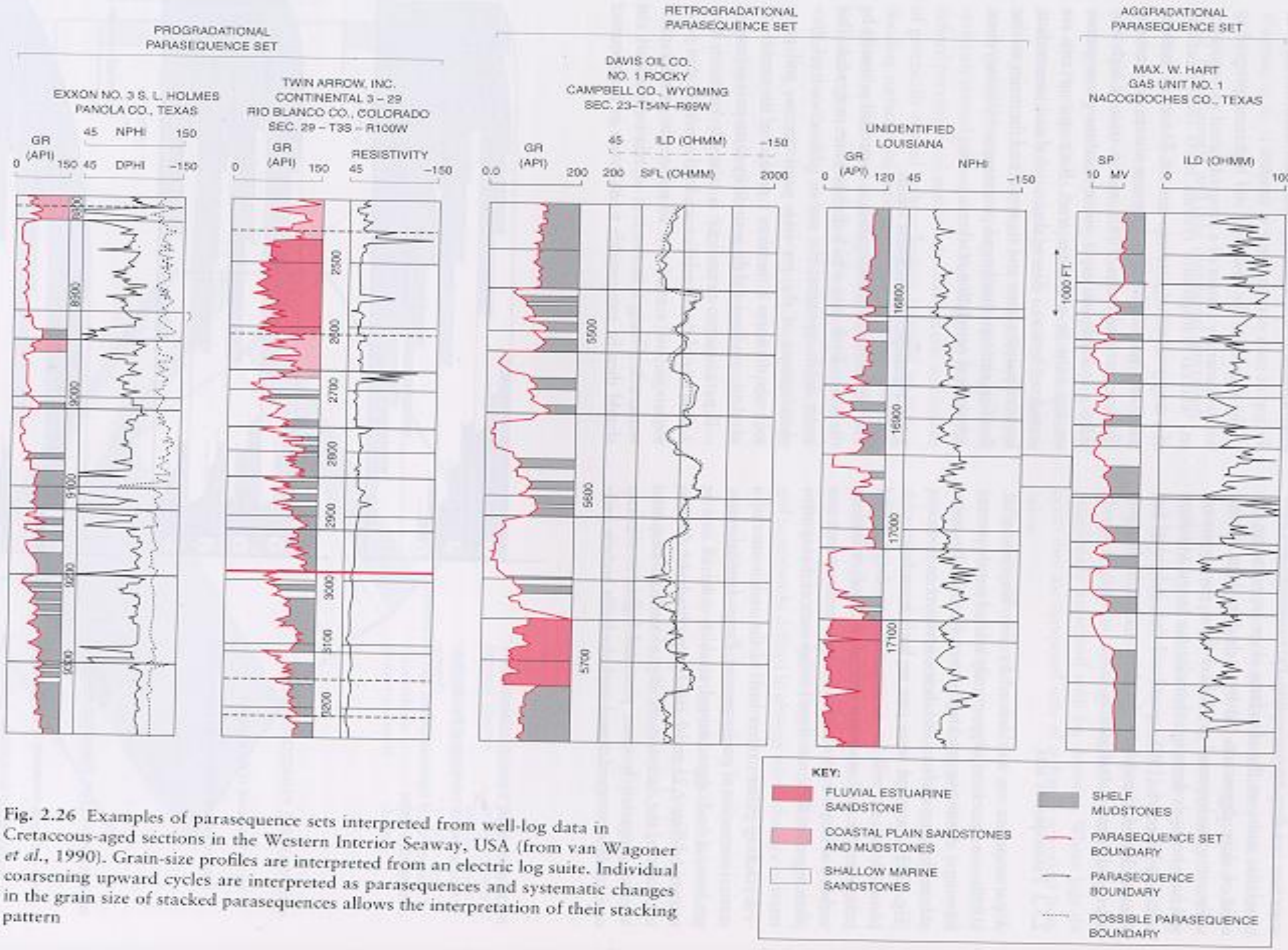
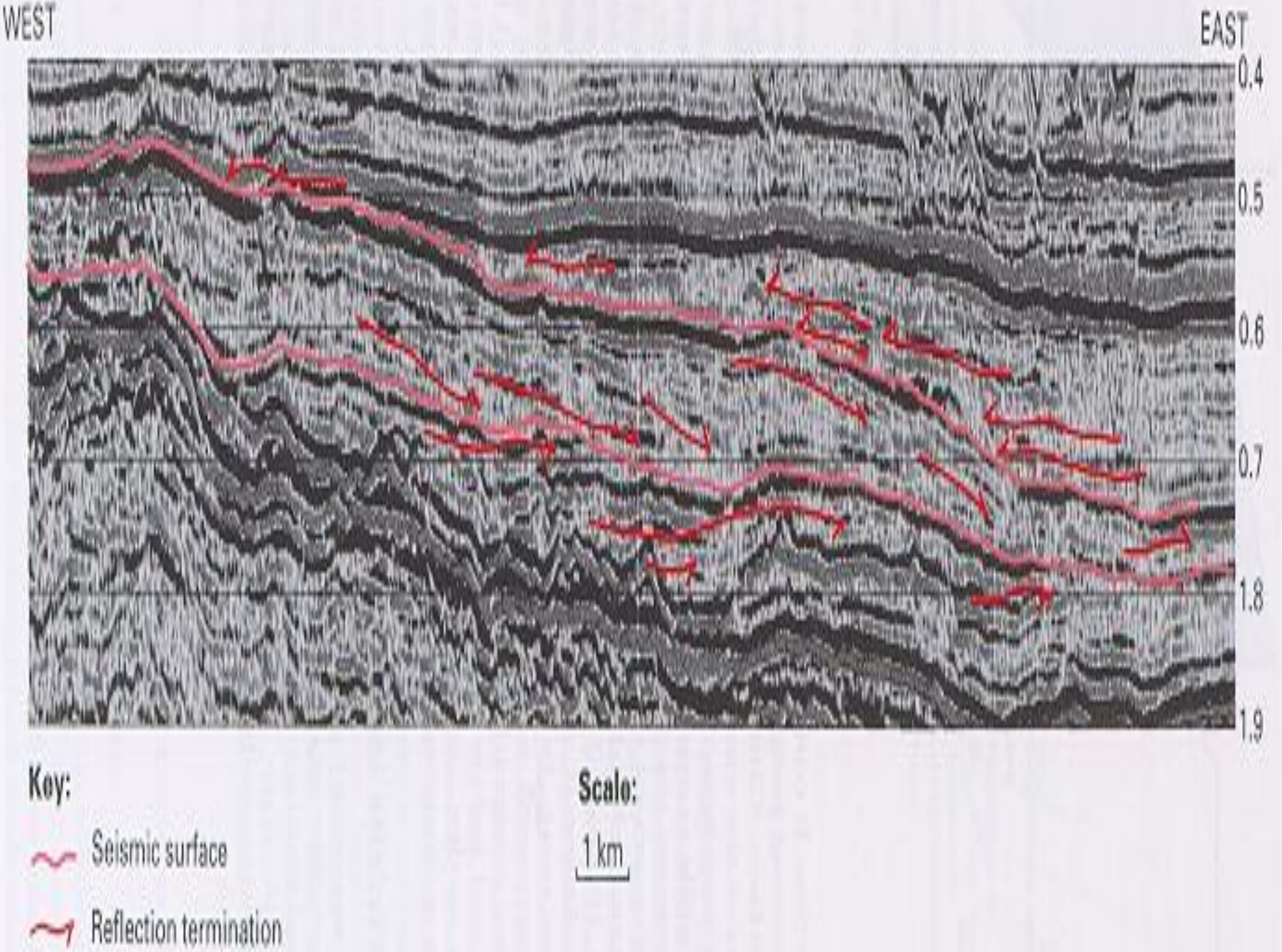
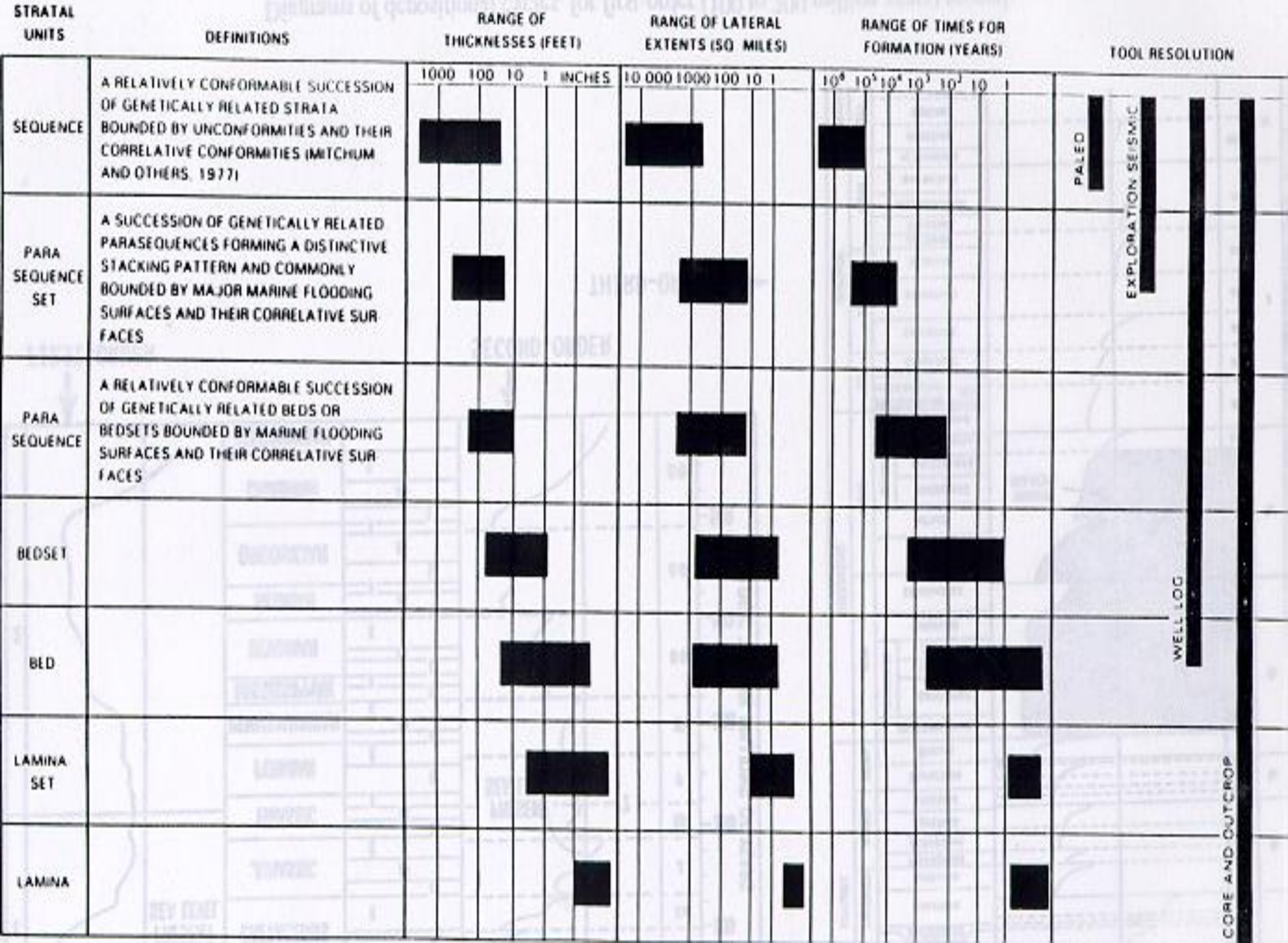
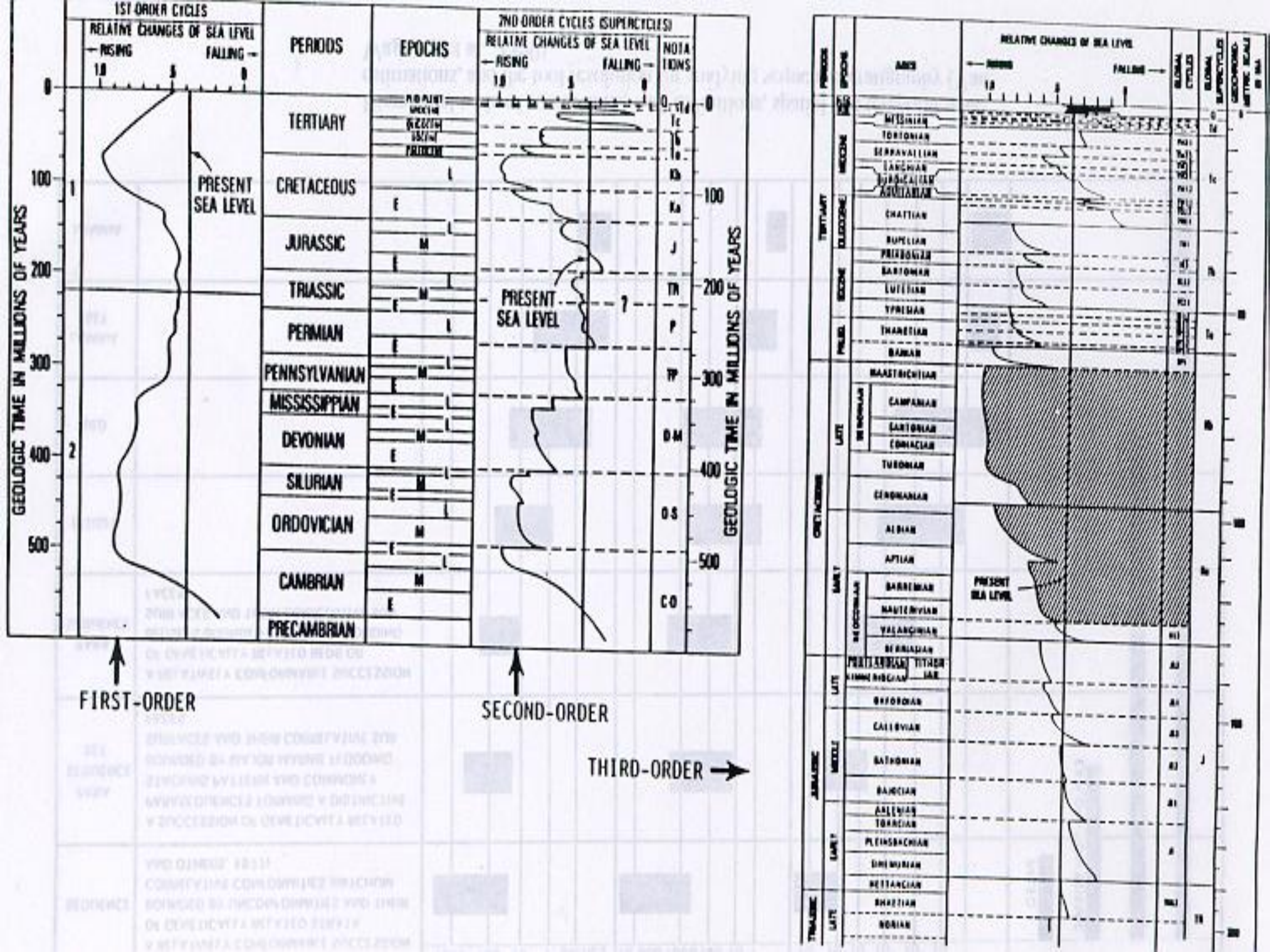


Fig. 2.26 Examples of parasequence sets interpreted from well-log data in Cretaceous-aged sections in the Western Interior Seaway, USA (from van Wagoner *et al.*, 1990). Grain-size profiles are interpreted from an electric log suite. Individual coarsening upward cycles are interpreted as parasequences and systematic changes in the grain size of stacked parasequences allows the interpretation of their stacking pattern

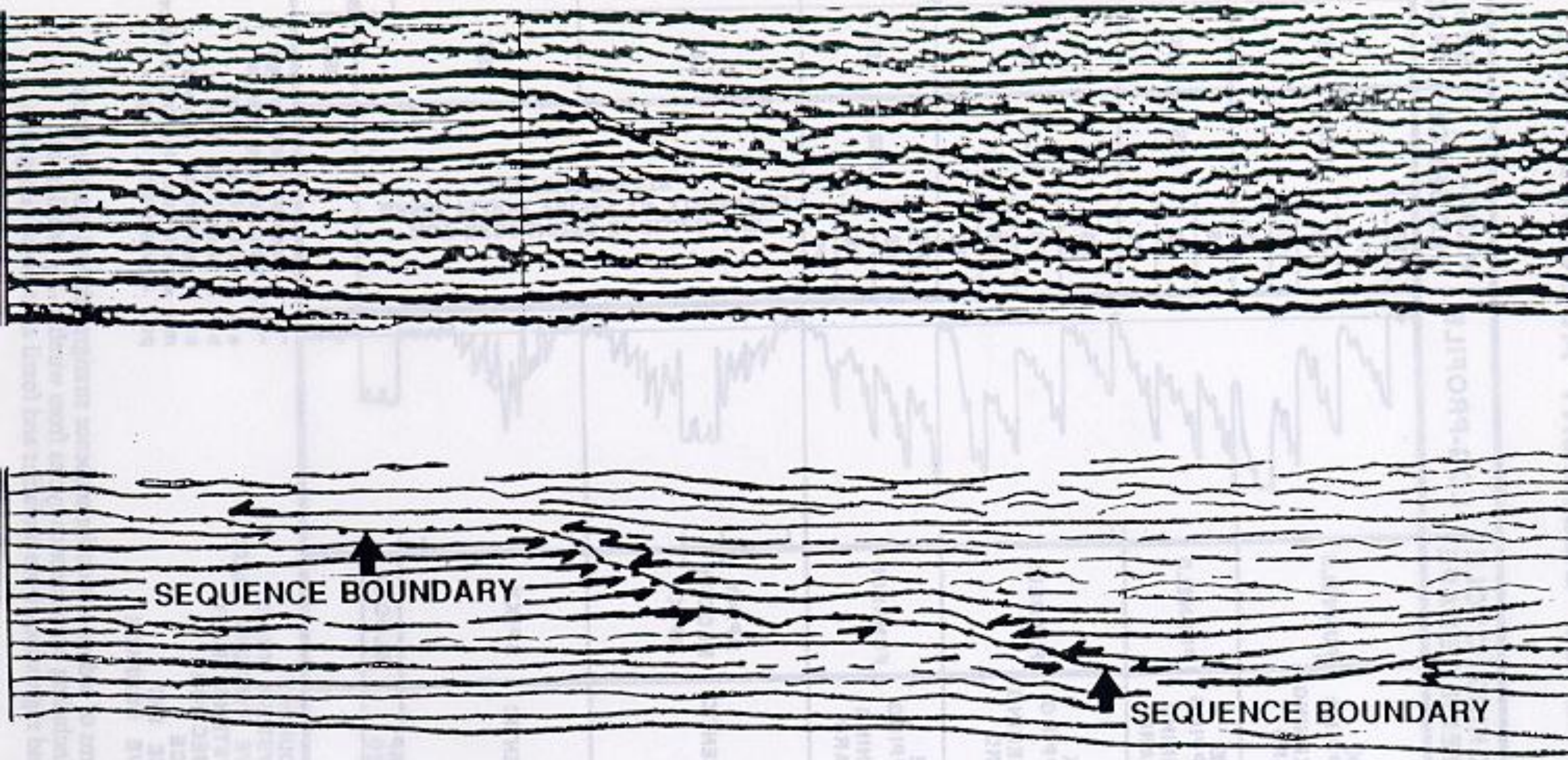


WEST
EAST
0.4
0.5
0.6
0.7
1.8
1.9
Seconds TWT
Key:
Seismic surface
Reflection termination
Scale:
1 km


STRATAL UNITS
DEFINITIONS
RANGE OF THICKNESSES (FEET)
RANGE OF LATERAL EXTENTS (SQ. MILES)
RANGE OF TIMES FOR FORMATION (YEARS)
TOOL RESOLUTION
1000 100 10 1 INCHES
10 000 1000 100 10 1
10^6 10^5 10^4 10^3 10^2 10 1
SEQUENCE
A RELATIVELY CONFORMABLE SUCCESSION OF GENETICALLY RELATED STRATA BOUNDED BY UNCONFORMITIES AND THEIR CORRELATIVE CONFORMITIES (MITCHUM AND OTHERS, 1977)
PARA SEQUENCE SET
A SUCCESSION OF GENETICALLY RELATED PARASEQUENCES FORMING A DISTINCTIVE STACKING PATTERN AND COMMONLY BOUNDED BY MAJOR MARINE FLOODING SURFACES AND THEIR CORRELATIVE SUR FACES
PARA SEQUENCE
A RELATIVELY CONFORMABLE SUCCESSION OF GENETICALLY RELATED BEDS OR BEDSETS BOUNDED BY MARINE FLOODING SURFACES AND THEIR CORRELATIVE SUR FACES
BEDSET
BED
LAMINA SET
LAMINA
PALEO
EXPLORATION SEISMIC
WELL LOG
CORE AND OUTCROP

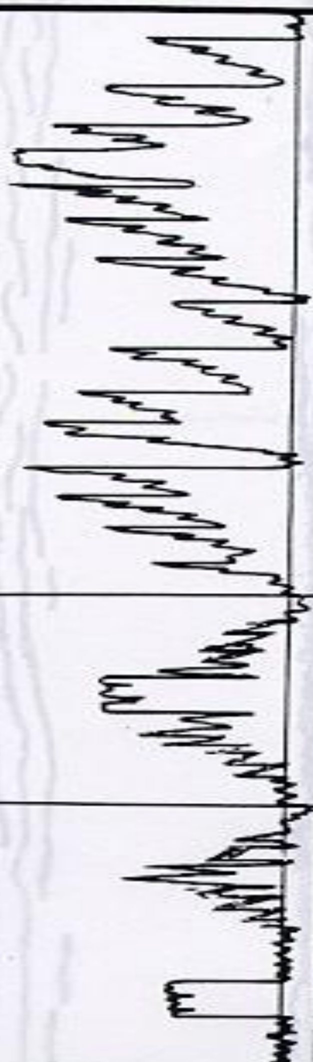


1ST ORDER CYCLES
RELATIVE CHANGES OF SEA LEVEL
← RISING
FALLING →
PRESENT SEA LEVEL
GEOLOGIC TIME IN MILLIONS OF YEARS
PERIODS
EPOCHS
TERTIARY
CRETACEOUS
JURASSIC
TRIASSIC
PERMIAN
PENNSYLVANIAN
MISSISSIPPIAN
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
PRECAMBRIAN
2ND ORDER CYCLES (SUPERCYCLES)
RELATIVE CHANGES OF SEA LEVEL
← RISING
FALLING →
NOTATIONS
PRESENT SEA LEVEL
GEOLOGIC TIME IN MILLIONS OF YEARS
FIRST-ORDER
SECOND-ORDER
THIRD-ORDER →
RELATIVE CHANGES OF SEA LEVEL
PERIODS
EPOCHS
AGES
MESSINIAN
TORTONIAN
SERRAVALLIAN
LANGHIAN
BURDIGALIAN
AQUITANIAN
CHATTIAN
RUPELIAN
PRIABONIAN
BARTONIAN
LUTETIAN
YPRESIAN
THANETIAN
DANIAN
MAASTRICHTIAN
CAMPANIAN
SANTONIAN
CONIACIAN
TURONIAN
CENOMANIAN
ALBIAN
APTIAN
BARREMIAN
HAUTERIVIAN
VALANGINIAN
BERRIASIAN
KIMMERIDGIAN
OXFORDIAN
CALLOVIAN
BATHONIAN
BAJOCIAN
AALENIAN
TOARCIAN
PLEINSBACHIAN
SINEMURIAN
HETTANGIAN
RHAETIAN
NORIAN
PRESENT SEA LEVEL



SEQUENCE BOUNDARY
SEQUENCE BOUNDARY

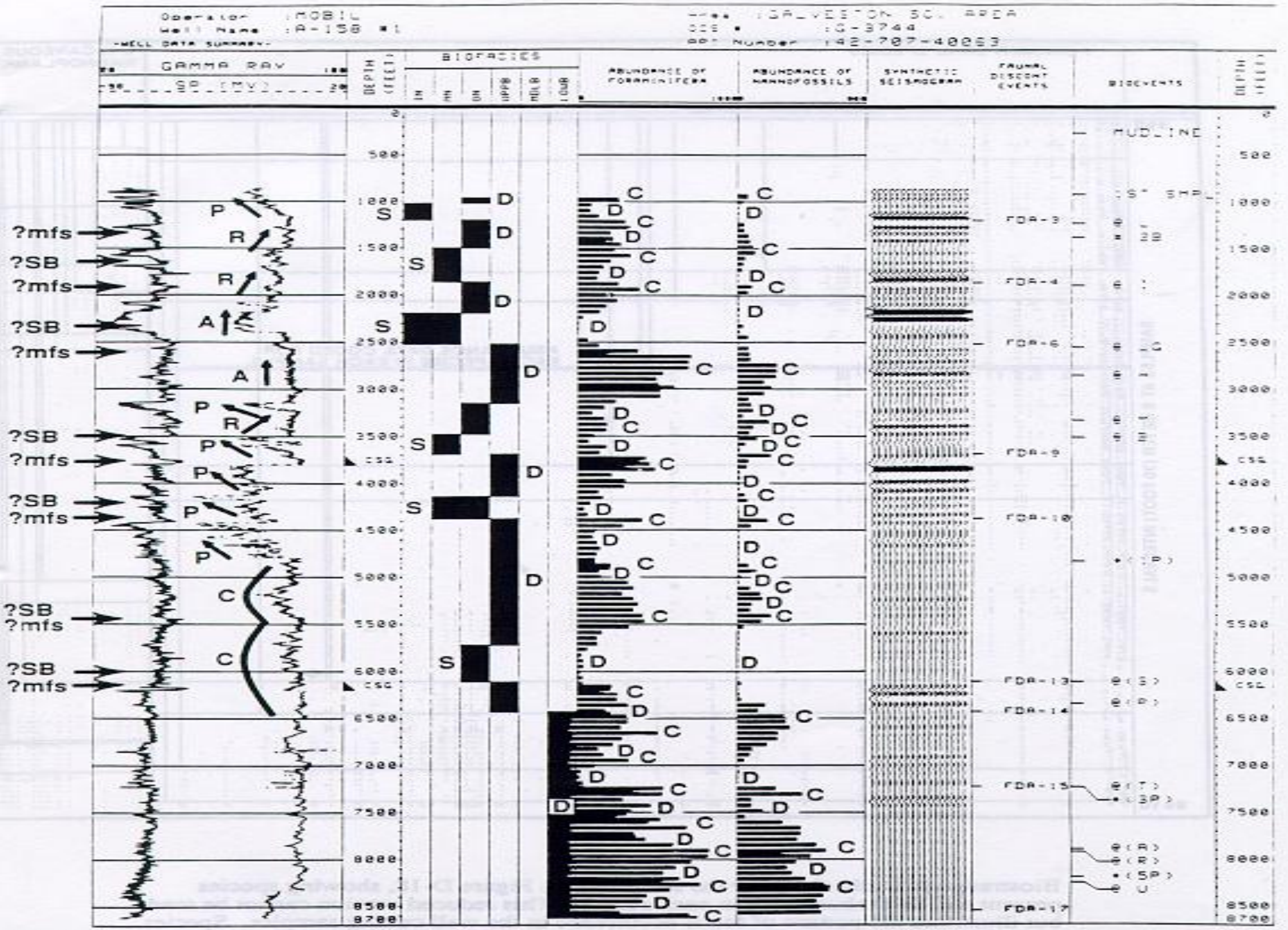
PATTERNS OF SEDIMENT ACCUMULATION



BIOFACIES	STACKING PATTERN	CYCLE SHAPE	LOG-PROFILE	PARA-SEQUENCE		SYSTEMS TRACT	
MIDDLE NERETIC INNER NERETIC	BACK STEPPING THICKENING UPWARD	FUNNELS		PS PS PS PS PS	PSS	TST	"bw"
						SB	
INNER NERETIC MIDDLE NERETIC	FORE STEPPING THINNING UPWARD	FUNNELS		PS PS PS	PSS	HST	"fw"
ci						mfs	CDS
INNER NERETIC MIDDLE NERETIC	BACK STEPPING THICKENING UPWARD	FUNNELS		PS PS PS PS	PSS	TST	"bw"
						TS	
MIDDLE NERETIC OUTER NERETIC	FORE STEPPING THINNING UPWARD	FUNNELS		PS PS PS PS	PSS	LST	pc
ci							
UPPER BATHYAL	CRESCENTIC	SPIKY BLOCKY SPIKY		NOT RECOGNIZED IN SLOPE AND BASIN FLOOR FACIES OF LOWSTAND SYSTEMS TRACTS		LST	sft
ci							
UPPER BATHYAL	CRESCENTIC	SPIKY				LST	sft
ci							
BATHYAL	SHARP BASED	BLOCKY					bft
						SB	
						HST	

SB = SEQUENCE BOUNDARY
HST = HIGHSTAND SYSTEMS TRACT
TST = TRANSGRESSIVE SYSTEMS TRACT
LST = LOWSTAND SYSTEMS TRACT
CDS = CONDENSED SECTION
PS = PARASEQUENCE
PSS = PARASEQUENCE SET
TS = TRANSGRESSIVE SURFACE

"bw" = back-stepping wedge
"fw" = fore-stepping wedge
sft = slope-front thick
bft = basin-floor thick
ci = condensed interval
mfs = maximum flooding surface
pc = prograding complex



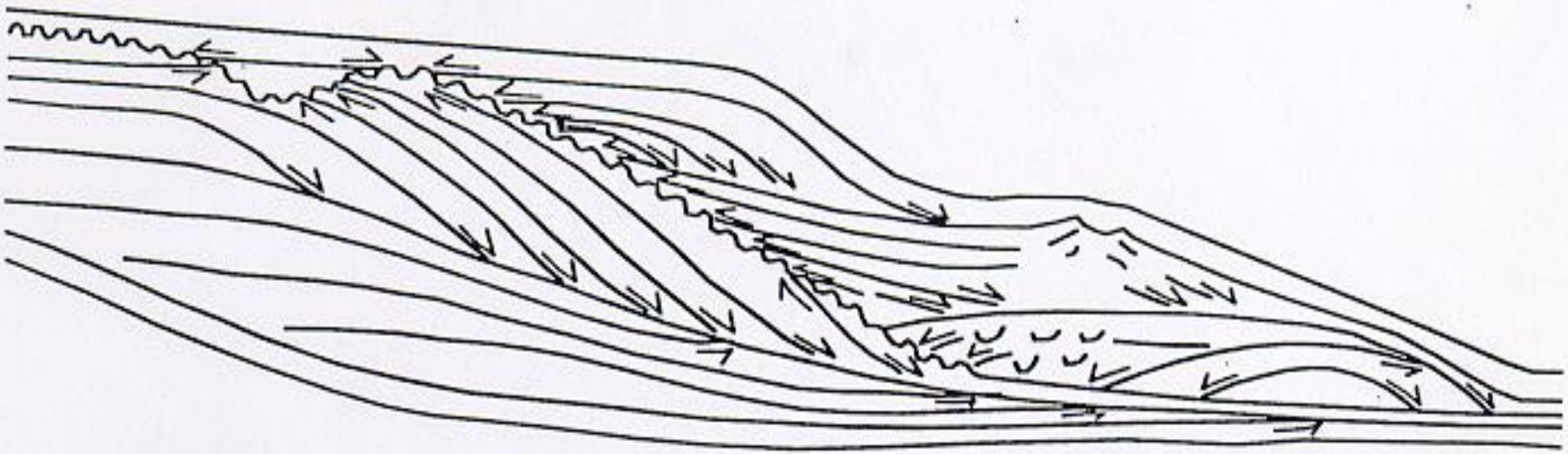
SURFACES
SB = SEQUENCE BOUNDARY
mfs = MAXIMUM FLOODING SURFACE

ELECTROFACIES
P = PROGRADATIONAL
R = RETROGRADATIONAL
A = AGGRADATIONAL
C = CRESCENTIC

BIOFACIES
S = SHALLOW
D = DEEP

ABUNDANCES
C = CONCENTRATED
D = DILUTED

REFLECTION TERMINATIONS

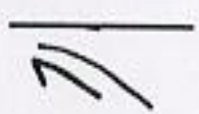


LAPOUT:

BASELAP:

ONLAP: 

DOWNLAP: 

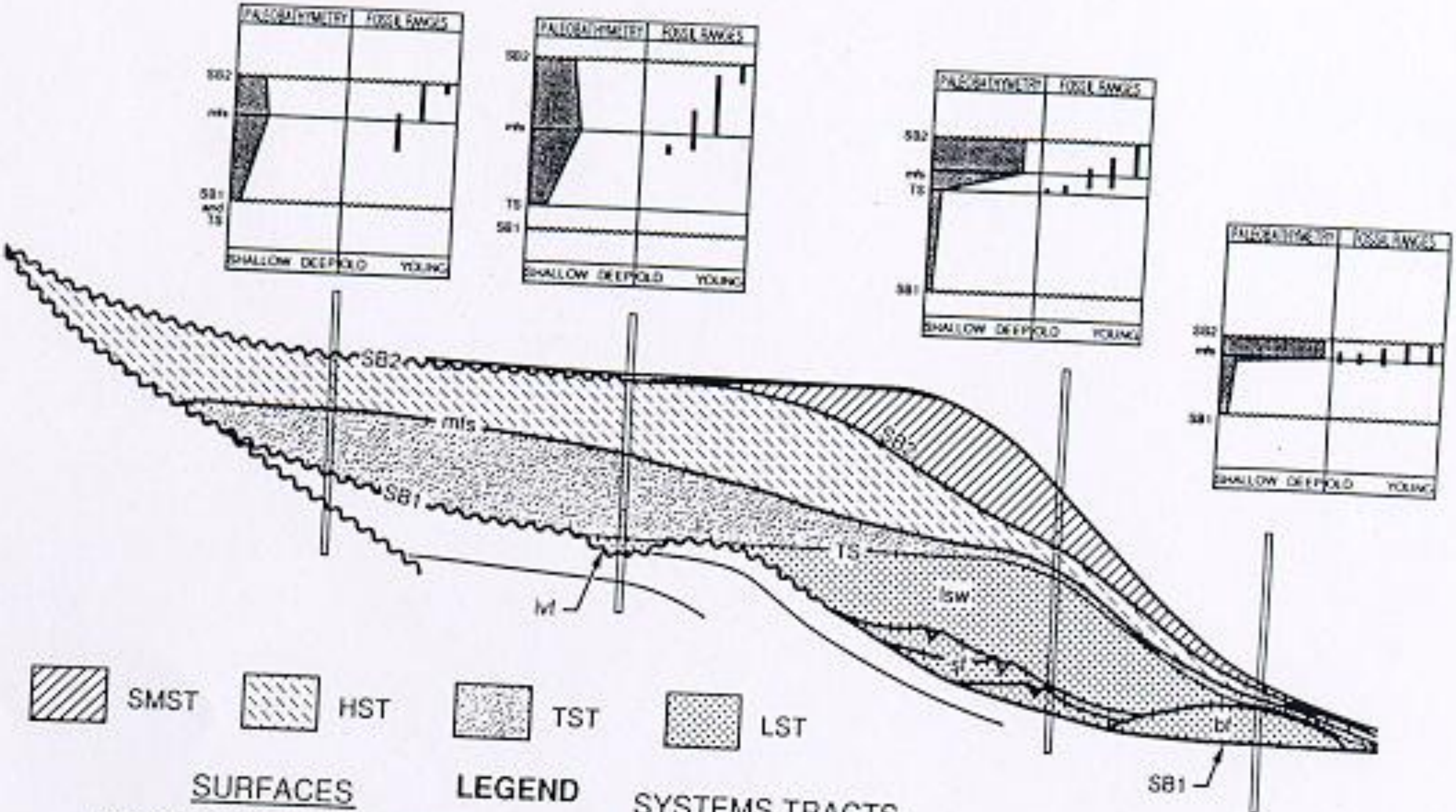
TOPLAP: 

TRUNCATION:

EROSIONAL: 

STRUCTURAL 

CONCORDANCE: NO TERMINATION



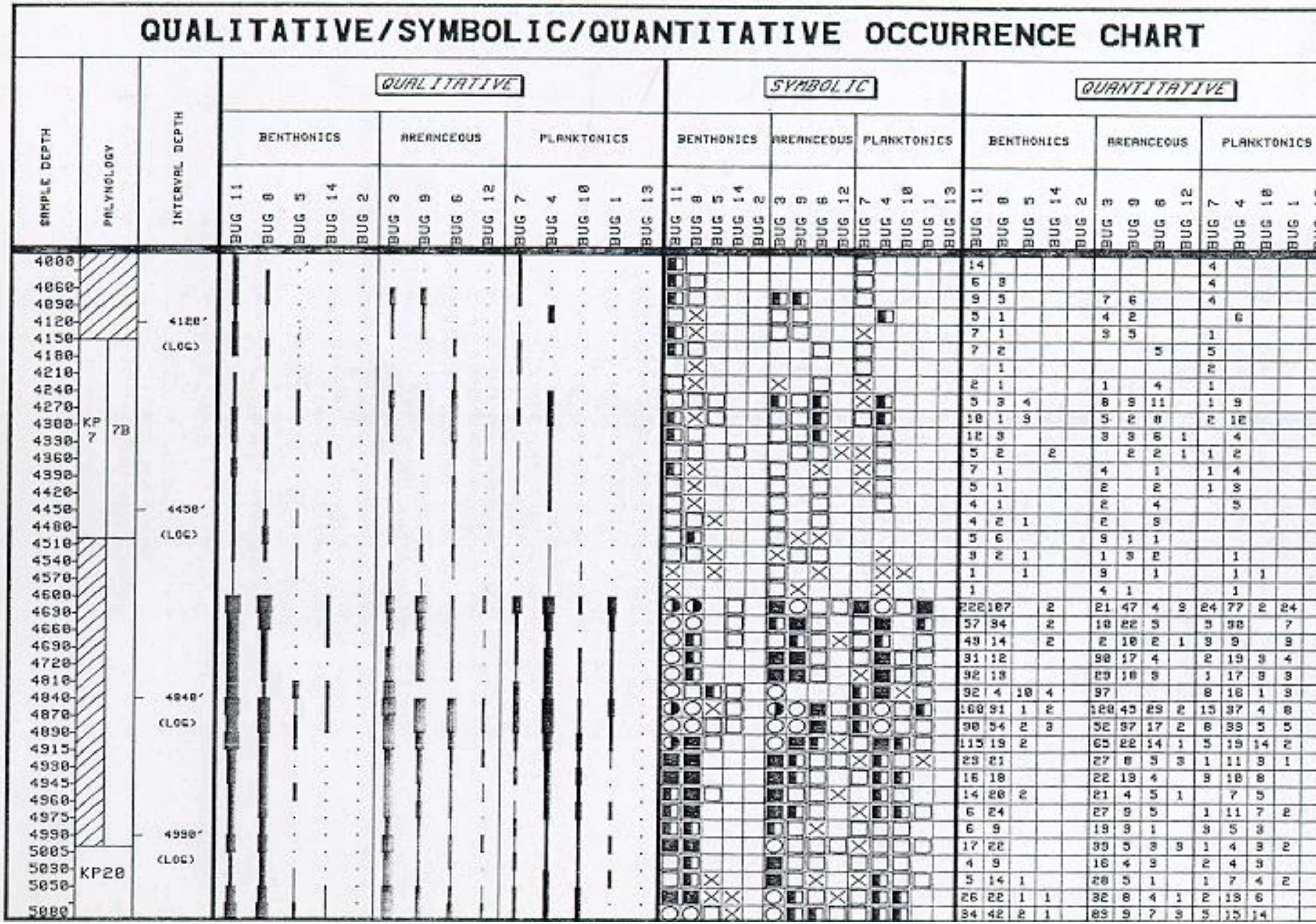
SURFACES

LEGEND

(SB) SEQUENCE BOUNDARIES
(SB 1) = TYPE 1
(SB 2) = TYPE 2
(mfs) = maximum flooding surface
(TS) TRANSGRESSIVE SURFACE
(First flooding surface above maximum progradation)

SYSTEMS TRACTS

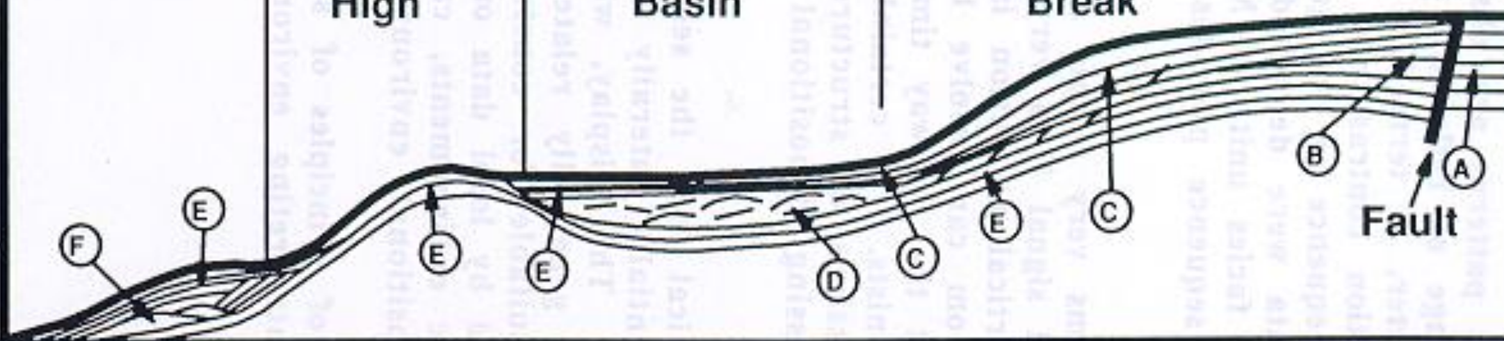
HST = HIGHSTAND SYSTEMS TRACT
TST = TRANSGRESSIVE SYSTEMS TRACT
ivf = incised valley fill
LST = LOWSTAND SYSTEMS TRACT
ivf = incised valley fill
lsw = lowstand wedge-prograding complex
sf = lowstand slope fan
bf = lowstand basin floor fan
SMST = SHELF MARGIN SYSTEMS TRACT



QUALITATIVE/SYMBOLIC/QUANTITATIVE OCCURRENCE CHART
QUALITATIVE
SYMBOLIC
QUANTITATIVE
SAMPLE DEPTH
PALYNOLOGY
INTERVAL DEPTH
BENTHONICS
AREANCEOUS
PLANKTONICS
BUG 11 BUG 8 BUG 5 BUG 14 BUG 2
BUG 3 BUG 9 BUG 6 BUG 12
BUG 7 BUG 4 BUG 10 BUG 1 BUG 13
KP 7
7B
KP20
4120' (LOG)
4450' (LOG)
4840' (LOG)
4990' (LOG)

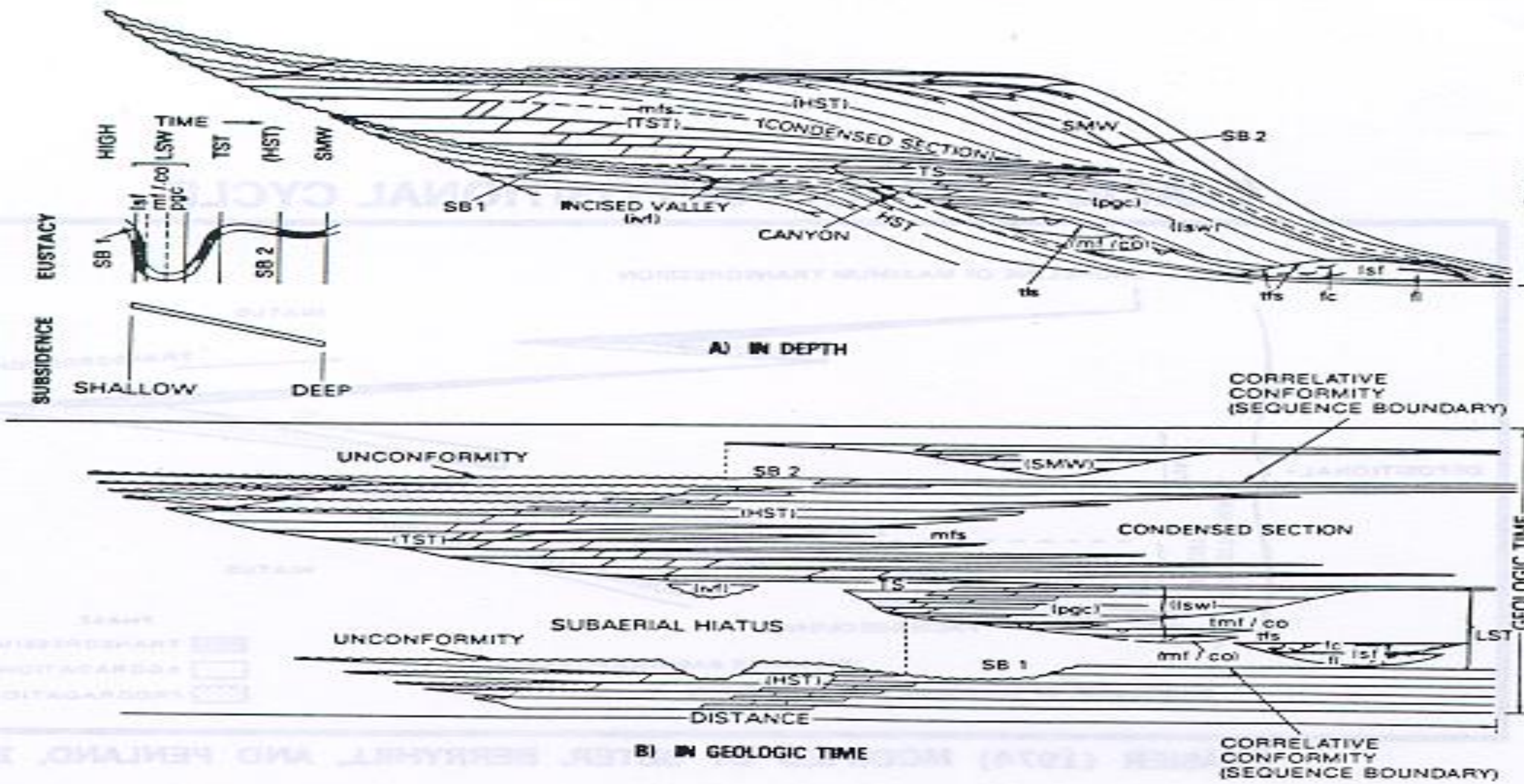
Physiographic Area	Basin	Slope High	Intraslope Basin	Slope/Shelf Break	Shelf

Seismic Reflection Character



External Form	(F) Mound	(E) Sheet Drape	(D) Chaotic Basin	(C) Slope-Front Fill	(B) Wedge	(A) Tabular
Internal Configuration	Hummocky	Concordant	Chaotic to Hummocky	Clinoform	Divergent	Concordant
Reflection Continuity	Discon-tinuous	Continuous	Discon-tinuous	Continuous	Continuous	Continuous
Reflection Amplitude	Variable	Moderate to High	Variable	Moderate to High	Moderate	Moderate to High
Upper Reflection Terminations	Onlap of Upper Surface	Concordant	Apparent Truncations & Onlaps	Toplap	Toplap &Truncation	Local Toplap
Lower Reflection Terminations	Bidrirectional Downlap	Some Onlap	Random Downlap	Downlap	Downlap	Local Downlap

SEQUENCE STRATIGRAPHY DEPOSITIONAL MODEL
SHOWING SURFACES AND SYSTEMS TRACTS



LEGEND

SURFACES

(SB) SEQUENCE BOUNDARIES
- (SB 1) = TYPE 1
- (SB 2) = TYPE 2

(DLS) DOWNLAP SURFACES
- (mfs) = maximum flooding surface
- (tfs) = top fan surface
- (tmf / co) = top mass flow / channel overbank

(TS) TRANSGRESSIVE SURFACE
(First flooding surface above maximum regression)

SYSTEMS TRACTS

HST = HIGHSTAND SYSTEMS TRACT

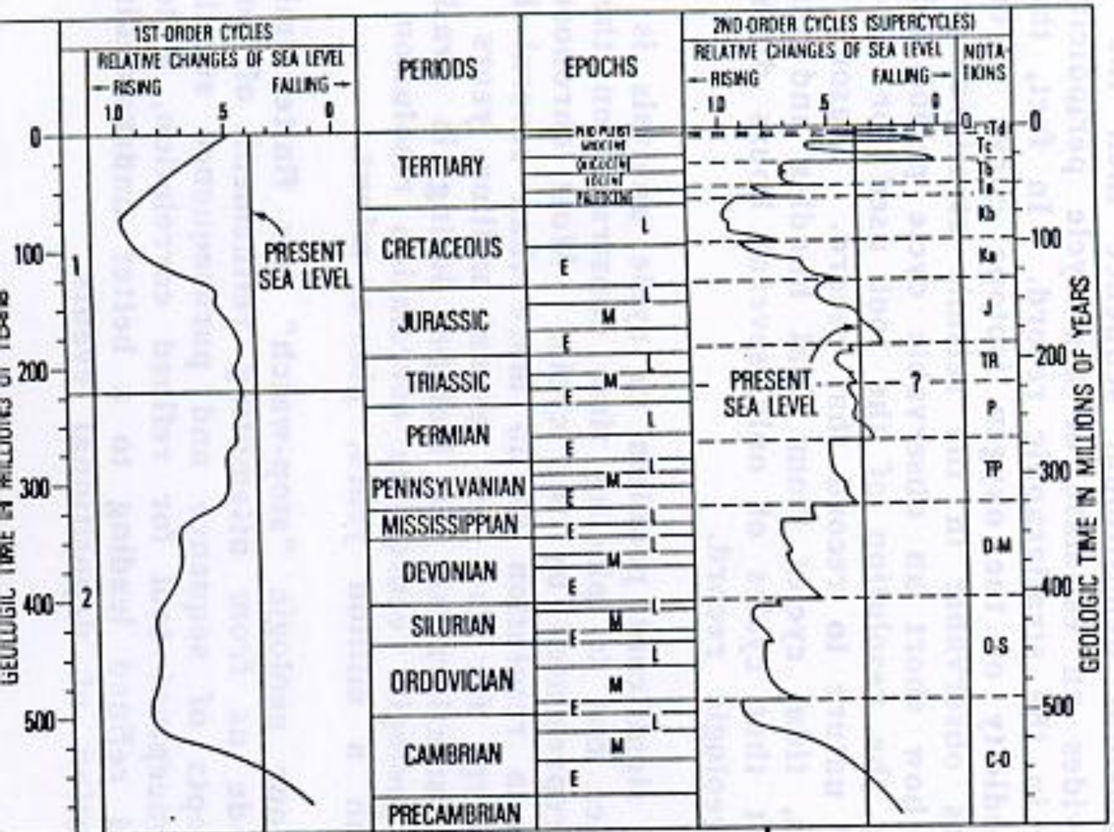
TST = TRANSGRESSIVE SYSTEMS TRACT
- ivf = incised valley fill

LST = LOWSTAND SYSTEMS TRACT
- ivf = incised valley fill
- lsw = lowstand wedge
- pgc = prograding complex
- mf / co = mass flow / channel overbank deposits
- lsf = lowstand fan
  - fc = fan channels
  - fl = fan lobes

SMW = SHELF MARGIN WEDGE SYSTEMS TRACT

DEPOSITIONAL CYCLES: (from Mitchum, 1977): FIRST-ORDER CYCLE: 100 to 200 million year duration.
SECOND-ORDER CYCLE: 10 to 80 million year duration.
THIRD-ORDER CYCLE: 1 to 10 million year duration.

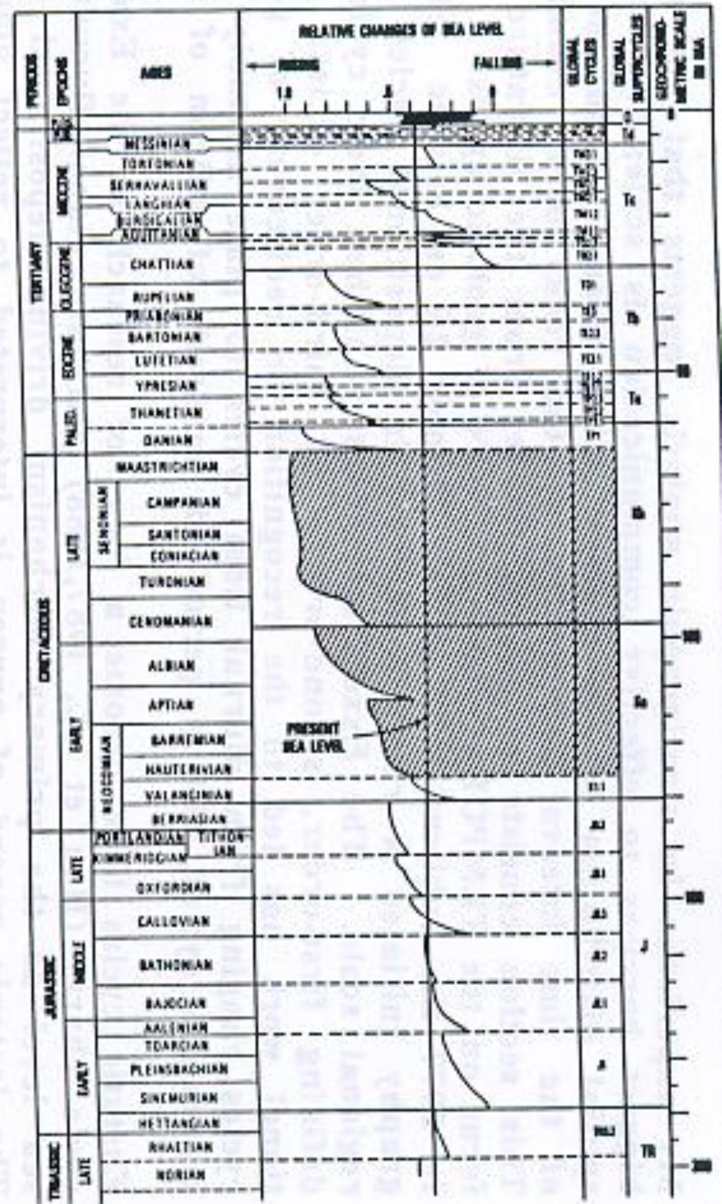
[1]Informally Defined: Forth-Order Cycle: 100,000 to 1 million year duration.
Fifth-Order Cycle: 10,000 to 100,000 year duration.



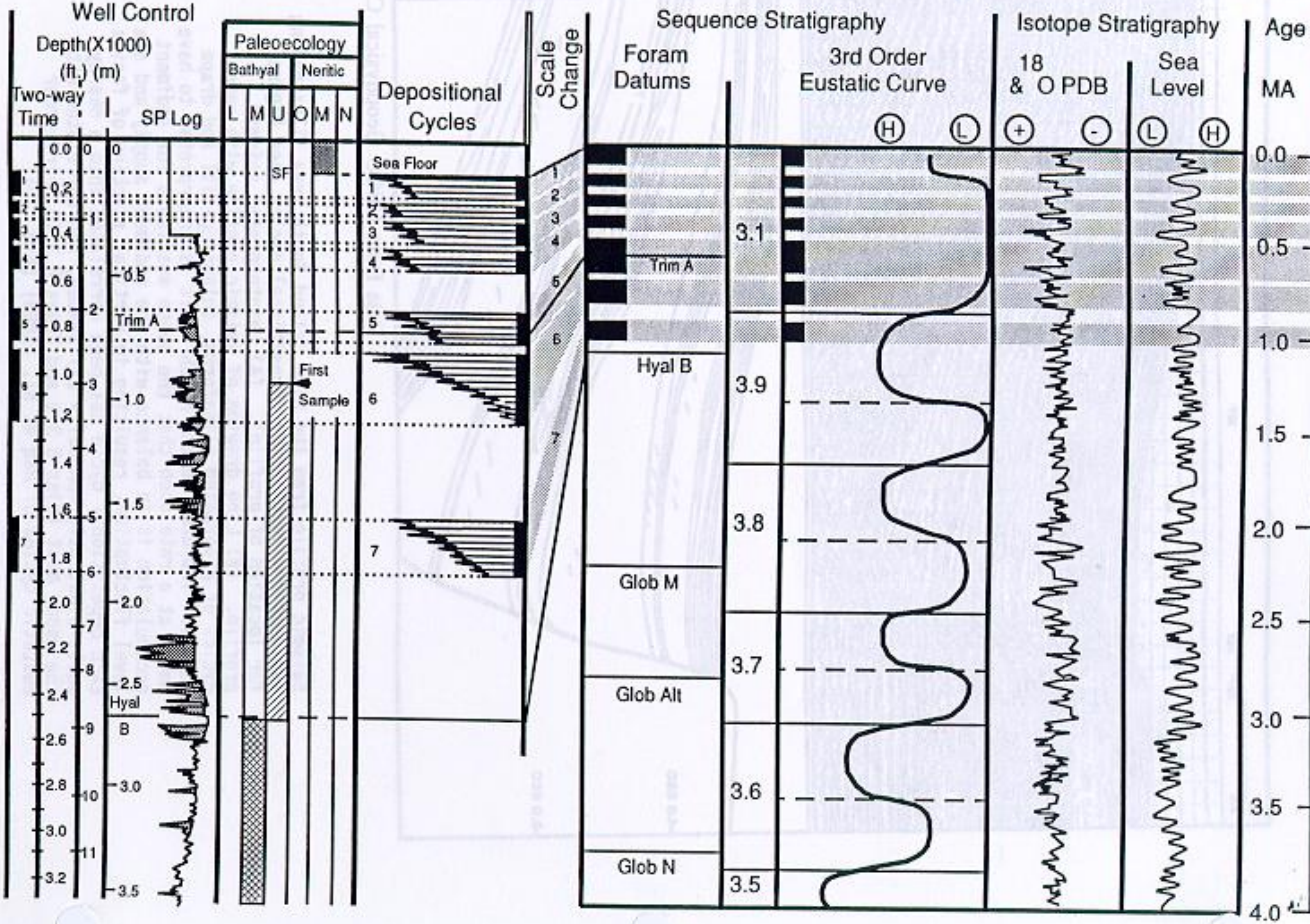
FIRST-ORDER

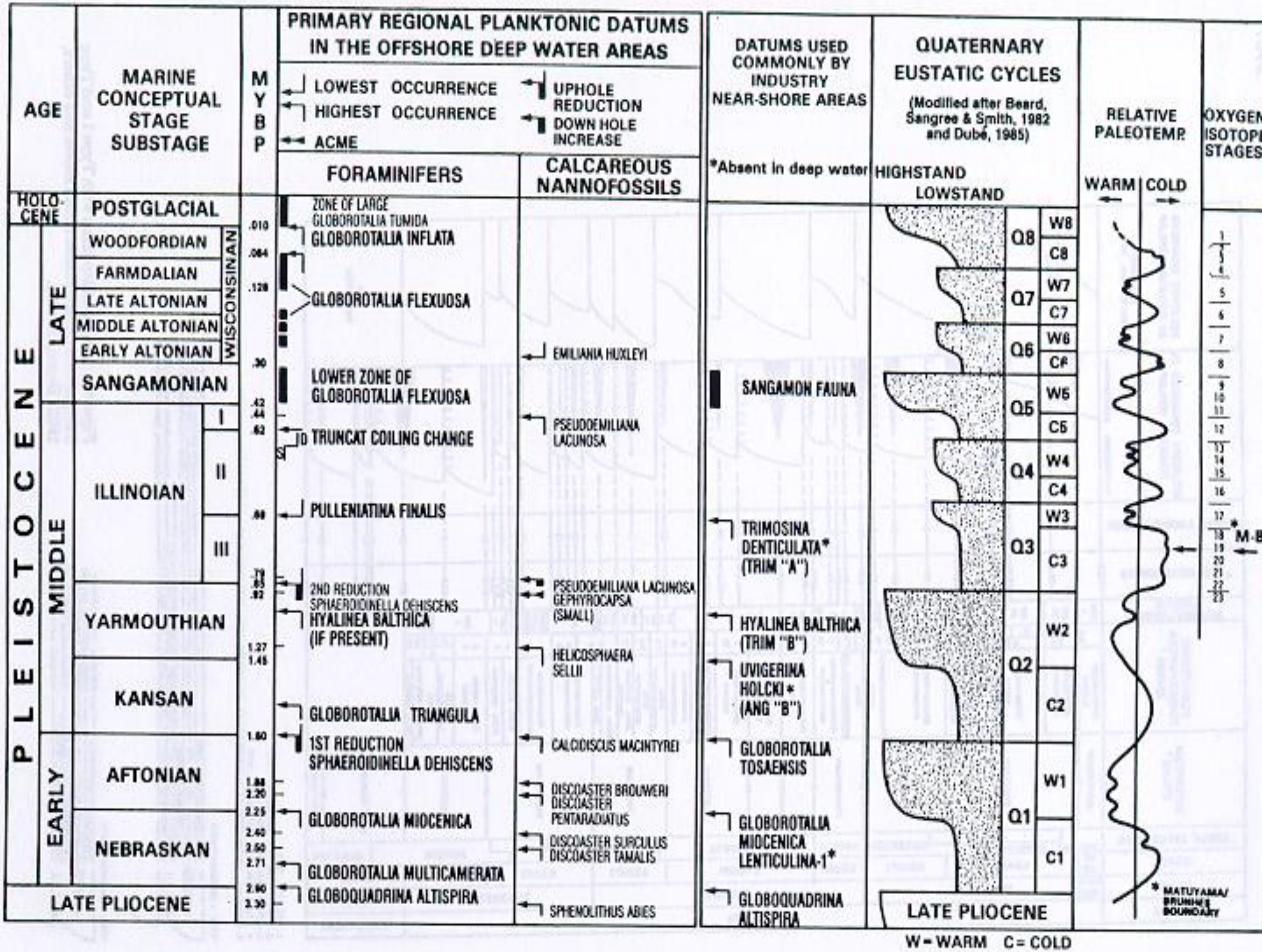
SECOND-ORDER

THIRD-ORDER →



Correlation Of Local Cycles With Global Cycle Curves




AGE
MARINE CONCEPTUAL STAGE SUBSTAGE
MYBP
PRIMARY REGIONAL PLANKTONIC DATUMS IN THE OFFSHORE DEEP WATER AREAS
LOWEST OCCURRENCE
HIGHEST OCCURRENCE
ACME
UPHOLE REDUCTION
DOWN HOLE INCREASE
FORAMINIFERS
CALCAREOUS NANNOFOSSILS
DATUMS USED COMMONLY BY INDUSTRY NEAR-SHORE AREAS
*Absent in deep water
QUATERNARY EUSTATIC CYCLES
(Modified after Beard, Sangree & Smith, 1982 and Dubé, 1985)
HIGHSTAND
LOWSTAND
RELATIVE PALEOTEMP.
WARM
COLD
OXYGEN ISOTOPE STAGES
HOLOCENE
POSTGLACIAL
PLEISTOCENE
LATE
MIDDLE
EARLY
WOODFORDIAN
FARMDALIAN
LATE ALTONIAN
MIDDLE ALTONIAN
EARLY ALTONIAN
WISCONSINAN
SANGAMONIAN
ILLINOIAN
I
II
III
YARMOUTHIAN
KANSAN
AFTONIAN
NEBRASKAN
LATE PLIOCENE
.010
.084
.128
.30
.42
.44
.62
.88
.79
.85
.92
1.37
1.45
1.60
1.88
2.20
2.25
2.40
2.50
2.71
2.90
3.30
ZONE OF LARGE GLOBOROTALIA TUMIDA
GLOBOROTALIA INFLATA
GLOBOROTALIA FLEXUOSA
LOWER ZONE OF GLOBOROTALIA FLEXUOSA
D
S
TRUNCAT COILING CHANGE
PULLENIATINA FINALIS
2ND REDUCTION SPHAEROIDINELLA DEHISCENS
HYALINEA BALTHICA (IF PRESENT)
GLOBOROTALIA TRIANGULA
1ST REDUCTION SPHAEROIDINELLA DEHISCENS
GLOBOROTALIA MIOCENICA
GLOBOROTALIA MULTICAMERATA
GLOBOQUADRINA ALTISPIRA
EMILIANIA HUXLEYI
PSEUDOEMILIANA LACUNOSA
PSEUDOEMILIANA LACUNOSA
GEPHYROCAPSA (SMALL)
HELICOSPHAERA SELLII
CALCIDISCUS MACINTYREI
DISCOASTER BROUWERI
DISCOASTER PENTARADIATUS
DISCOASTER SURCULUS
DISCOASTER TAMALIS
SPHENOLITHUS ABIES
SANGAMON FAUNA
TRIMOSINA DENTICULATA* (TRIM "A")
HYALINEA BALTHICA (TRIM "B")
UVIGERINA HOLCKI* (ANG "B")
GLOBOROTALIA TOSAENSIS
GLOBOROTALIA MIOCENICA LENTICULINA-1*
GLOBOQUADRINA ALTISPIRA
Q8
W8
C8
Q7
W7
C7
Q6
W6
C6
Q5
W5
C5
Q4
W4
C4
Q3
W3
C3
Q2
W2
C2
Q1
W1
C1
LATE PLIOCENE
W = WARM C = COLD
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
*M-B
* MATUYAMA/BRUNHES BOUNDARY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AMOCO

A M O C O

HACIA DONDE VA?

EL FUTURO DE LA DIRECCION A TOMAR EN EL DESARROLLO DEL ESTUDIO DE SECUENCIAS ESTRATIGRAFICAS ES DIFICIL DE PRE-DECIR, DEBIDO A LA TURBULENTA HISTORIA DE LOS CAMBIOS DEL NIVEL DEL MAR.

POR LO PRONTO SE SABE, QUE LOS SISTEMAS CARNONATICOS REQUIEREN ESTUDIOS ESPECIALES PARA DEMOSTRAR LA IMPORTANCIA DE OTROS CONTROLES ADEMAS DE LOS CAMBIOS DEL NIVEL DEL MAR.

SE DEBE CONTINUAR EL ESTUDIO Y DESARROLLO DE METODO-LOGIAS PARA LOS AMBIENTES NO MARINOS

Sequence Stratigraphy

Edited by D. Emery and K. J. Myers

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